Introduction to Aircraft Design
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Lecture - 85
Guest Lecture on Air Power & Multi-role Fighter Aircraft-Part 01

Good morning to you. For here primarily I am talking about a fighter aircraft and more than a fighter aircraft, I am talking about why it is so important to have an aircraft as a fighting mission. It is very important we should know. And what is it that makes an aircraft such a dominant figure in the wars, okay that is the thing. So let me start with my first slide with war and technology, okay.

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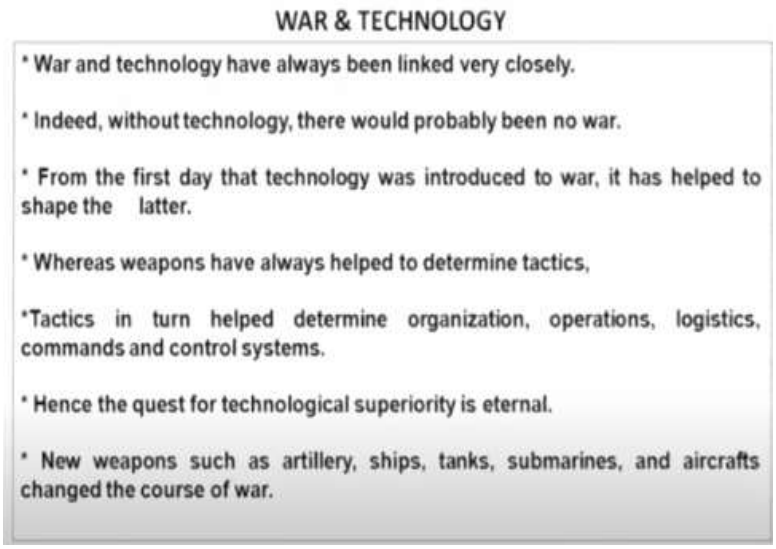

Whether we like it or not, if we have to protect ourselves, protect the country, protect your borders, you should be prepared for war so that you do not have a war, okay. If you are not prepared, there will be enough fellows to attack you. But they know you are powerful, you are strong, they would not attack you. So you will have a peaceful life. So you want to have peace you must be strong in ability to conduct a war you must be there, okay.

Now what is it that shaped the war? It is technology. Basically, it is technology which has done that. They have been always linked together, war and technology. Let us say for a while there was no technology, there would have been no war at all. Maximum we would have done is we would have lifted a stone and thrown on the other fellow.

Because there is no technology other than lifting the stone nothing else would have been there. So technology is the one which has really shaped the war. The weapons have always helped to determine the tactics, tactics about how you want to fight war, how you want to do that. And tactics in turn, help to determine organization, operation, logistics, commands and control systems.

The quest for technological superiority is eternal. In fact, the country which is supreme in technology, it has two other things, is also a rich country and also that is the country which has superior fighting capability. If you are afraid of reaching them because you know he has technology. So it is the technology which strengthen you. You enhance your, what you call offensive and defensive capabilities, security, and your wealth generation, okay.

That is the kind of thing. So new weapons such as artillery, ships, tanks, submarines and aircraft changed the course of war.

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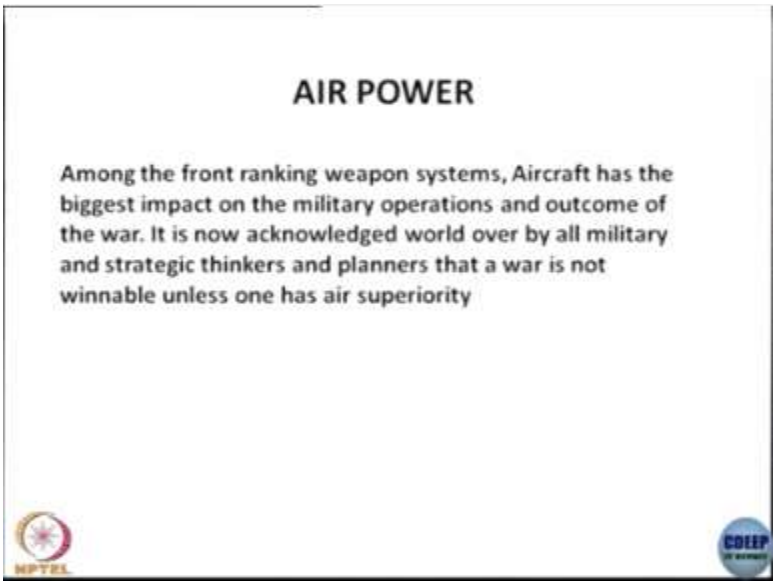

Now among these things, a front ranking weapon system aircraft had the biggest impact and the military operations and the outcome of the war. Now whole world it is a college that all military and strategic thinkers and planners that a war is not winnable unless one has air superiority. We will talk about air superiority a little later.

But if you have no capability in air war weapon, just no way we can win the war, okay. That is the thing. Now there are different grades of this air power.

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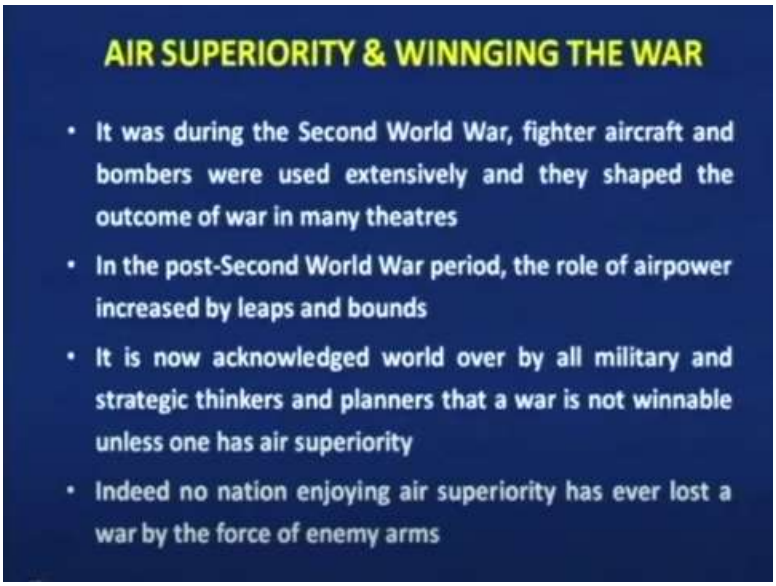

The first if you see this, the actually aircrafts were used as a weapons only Second World War. First World War they are using more like a reconnaissance, going round and all that kind of thing. But Second World War it is a major. If you go through some old war movies and all that you can see it has played massive role, okay. But after the Second World War, air became the dominant force.

In Second World War we were supporting the army, navy, and every fellow. But after the Second World War it is that. You can just give some examples here. In the post second war the role of air power increased by leaps and bounds. Now across world over all this is what I mentioned, no nation enjoying air superiority ever lost war by force of enemy arms. So that is the crucial role it has.

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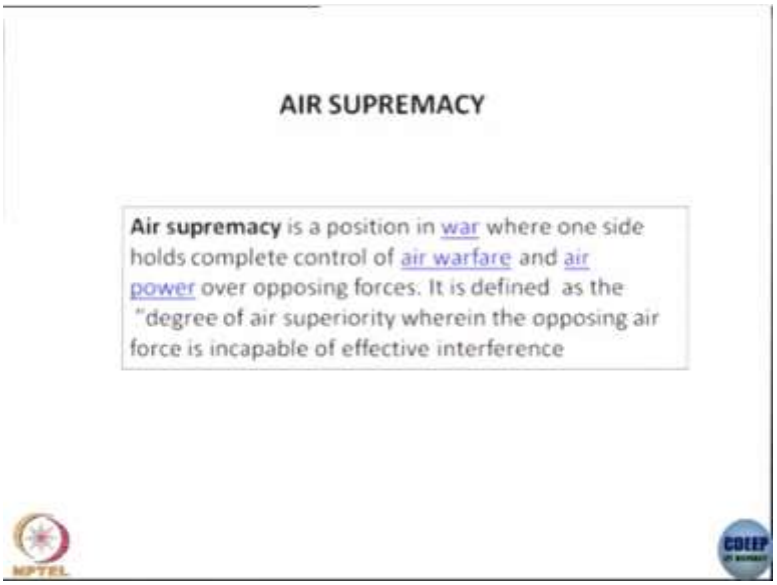

Now what is the first topmost grade? They call it as air supremacy. It is a position in war where one side holds complete control of air warfare, air power over opposing forces. It is defined as the degree of air superiority wherein the opposing air force is incapable of effective what you call interference. It just cannot do anything. I will give you a few examples to drill down that point, okay.

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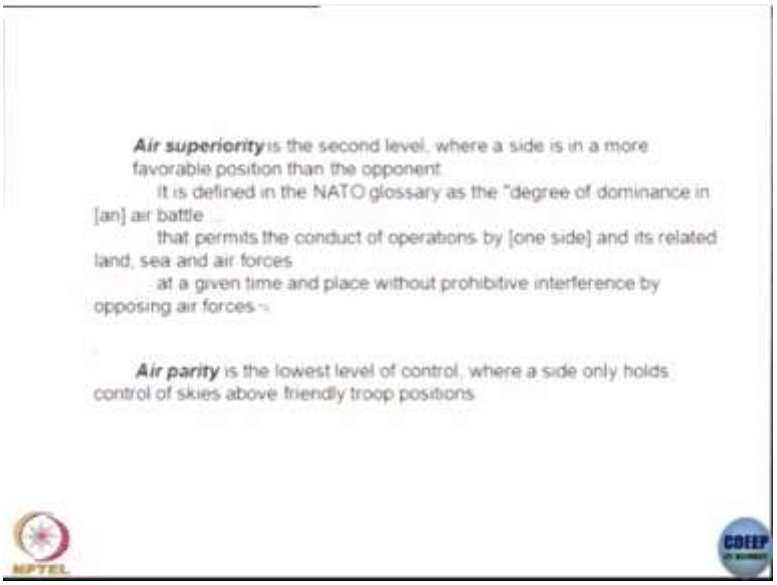

And air superiority is the next level where a side is more favorable position than the opponent. It is defined as what you call the degree of dominance in air battle that permits the conduct of operation by one side and related land, sea, and air forces and given time and place without prohibitive interference by opposing forces. The first is absolutely supreme. Here he has a dominant position, okay.

Air parity is the lowest level where a side holds control of skies above friendly, you are able to control your own territory, you are able to. But you are not able to control the enemy's territory. That is the basic point. This is called parity. He is taking care of his troops, you are taking care of your people. This is the kind of what you call parity.

Air superiority you not only are protecting your troops you are also able to penetrate into the opponents area and controlling that portion. Supremacy is that fellow is down, okay. That is the kind of. It is important you understand this point.

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Now if you see the Gulf War of 1991 the coalition force led by USA they decimated Iraq by using only air power. The total operation they lost only two soldiers that is all. But afterwards once they enter into the Iraq, they lost thousand fellows. But during the, they only lost two fellows, okay. Then Kosov campaign again there the US again won the war. Afghan war you know what is happening?

Let us back home there were Kargil War. What happened? The opponent was on the top of a hill, the Army was sitting. Our fellows were trying to walk and they just could not. There was a stalemate for months. Then fighter aircraft precision guided precision weapons went and hit that area. Then that whole place was destroyed. Then it was only a question of one day where the Indian Army could take over.

Until they used this fighter aircraft with precision weapons, India was at a great disadvantage. They just could not do anything. That changed the total what you call

face of the war. I want you, I do not know how many of you were there. 1971 there was war where India fought with our friend with Pakistan. There is East Pakistan and West Pakistan, okay. And the East Pakistan today now it is called the Bangladesh.

In matter of maybe two days the complete airpower and the surface-to-air missile everything was destroyed. They had nothing, okay. So our air force was taking transport aircraft with bombs and dumping bombs on them. Even transport aircraft because there is nothing to oppose them. There is nothing to surface as weapons which can destroy there are no aircraft which are, that is what you call as air supremacy.

But when it came to western side okay, I would say nobody will admit it, it is more like air parity. I think we are all holding operation. They were able to and we might have shot some aircraft, they must have shot some of our aircraft but more or less in the same condition, okay. 1965 the previous war okay, it was a more like parity is there. In 1962 the war we fought with China never used any airpower.

So you know what happened if you read the history what you will see that. So you can see that gradually what happened to India. So as now you can see that the role of air power even in our own context is increasing by leaps and bounds, okay.

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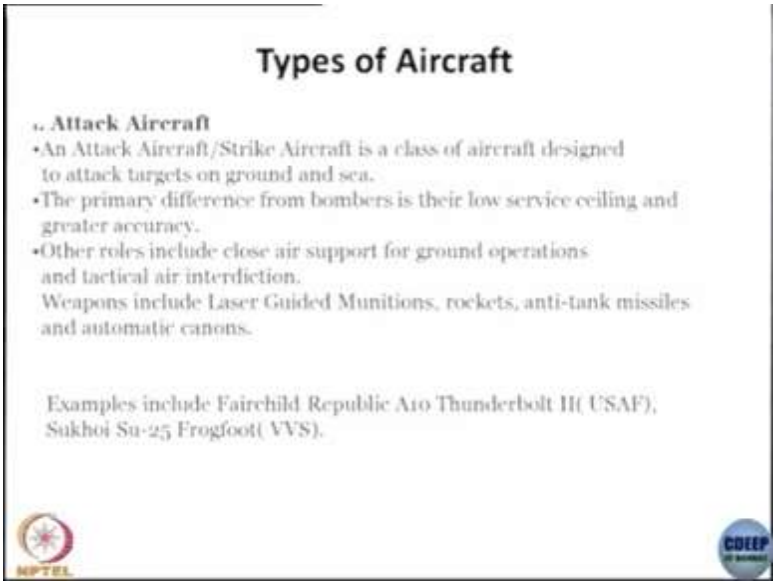

Now let us say before I say what this air power is, there are different types of aircraft which are used in this air power. Number one what you call is an attack aircraft. This attack aircraft or strike aircraft is a class of designed to attack targets on ground and

sea. Primary difference between bombers is there is low service ceiling and greater accuracy. An attacker can do a pinpointed accuracy.

If there is one small tank it can attack and destroy it. Or a fuel dump is there it can destroy, so much accuracy. Bombers normally they will dump huge number of bombs okay. There is a wide area damage but accuracy wise this fellow is better. The roles are closer support for ground operation, tactical Air interdiction. Closer support means your army is now your border is there.

Your army is trying to go down the other side. Your fighters are what you call escorting them and supporting them to prevent the enemy to what you call attack you, okay. That is what they do. That is called close air support. Close air support to the army operations. Interdiction is it go a little further you prevent the adversary supplying what you call ammunition, fuel, food and all to the army which is in the front end.

Suppose you prevent interdictor, stop that supply, that fellow can do nothing. Because he will lose his ability to fight a war. That is called interdiction, okay this one. They use weapons like laser guided munitions, rockets, anti-tank.

Close air support will be more suitable with helicopters? Also.

Actually not necessary. For example, the American use helicopters more often, lot of helicopters are used, but rest of the countries you see they use more what you call attack aircraft, closer support aircraft. Even Americans have an aircraft called A10 okay and then what you call the Russians have a Su-25. Africans use helicopters in a big way, but helicopter is a slow machine.

While it can do, it has certain capability of vertical takeoff, landing, observation and all that. But it has that inherent limitations, okay. So it is a tactics what we do.

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The second is called a bomber. Just now I talked to you and the bombers very area bounding, they go deep penetration. Today we use bombers to go deep into the enemy territory, and then bomb them. So why do you want to go deep into the territory? Normally the critical supplies, critical ammunition, critical or very critical your what you call aircraft they are all far away from the battlefront, okay.

And so if you can damage them or destroy them, not damage destroy them, then they lose the ability to fight a war. So bomber is used to go deep into it. And that is how you have the old B-52 is a very famous bomber. B-1B is also a famous bomber. F-1411 is also a bomber, B2 is also a bomber. And the Russians have Tu-160. Indians used to have a bomber called Canberra. It is a very old one.

We no longer have any bombers. We have only what you call air fighters. We no longer have. Many countries in the world apart from Russians and Americans they do not have any bombers now, okay.

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Then you see fighter what we are talking today my talk will be. Are a class of a design for air to air combat with other aircraft in an offensive or defensive. Either you go into enemy territory to attack or if an enemy is coming to prevent him to succeed you fight with him. They are light, agile, fast and highly maneuverable. They also have secondary ground attack capabilities.

Fighter aircraft capable of carrying missiles, rockets and cannons, guns, okay. They are categorized three types air superiority fighters, interceptors, and fighter bombers. And the famous Su- 30 MKI which India has from Russians. We have a Eurofighter Typhoon, Lockheed Martin F-22. And interceptor aircraft the MiG-21 which we have large numbers.

This has been designed as a it can go to high altitude, intercept a aircraft coming at a high altitude to do all that okay, that is there. And the MiG-31 is the one of the very famous Russian aircraft. And the Tornado one of the old European aircraft. These are the fighters, okay.

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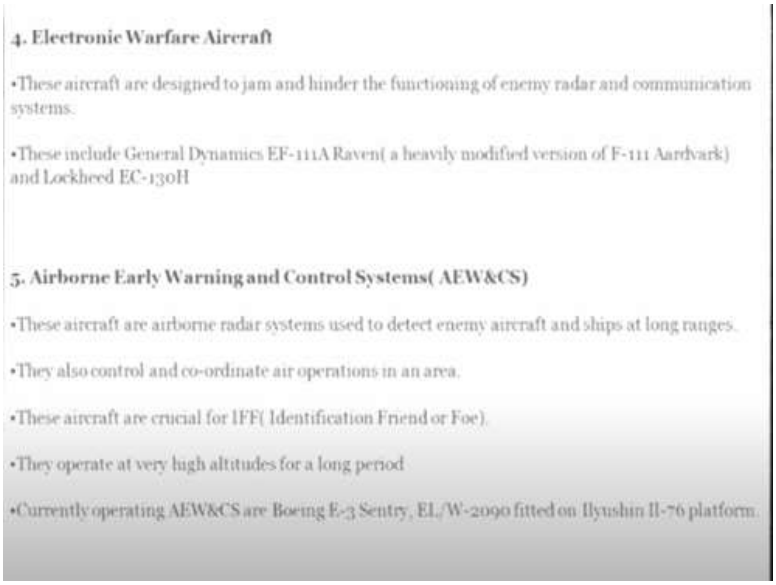

Now let us see the other one. Then electronic warfare aircraft. Today more and more ground forces, ground radars, they are the fellows, the ground radars are the ones who are tracking aircraft coming from outside, okay, they are tracking. If I can disable this ground radar then you they can track you. That is a very critical function which needs to be done.

So this fellow what he did, the electronic warfare aircraft that fellow will jam the ground system and once it is jammed it is like a blind person who are sitting there. You cannot do anything, you are blind if your radar is blinded. So that is the type. It is a highly specialized kind of aircraft. And another bigger fellow which is placing is called Airborne Early Warning and Control Systems.

These aircraft are airborne radar systems used to detect the enemy aircraft and ships at a long distance, something like 300 kilometers away, 400 kilometers they are able to because there at a very high height, something like 40,000 feet altitude. So you can see the amount of distance you can see that. They also control and coordinate air operation. That fellow is like a command center and above, okay.

From there they can control the whole area. They can even control the operations, tactics and all that kind of thing they can do. They have a very important thing are called identification friend or foe. What happens there are fighters, they all look alike there from a distance. How do you know that fighter is a friend or a foe, okay?

So they have this what you call they are another type of radars who will be able to send a message and if the message comes back in the way you are thinking then he is a friend. If it is not so that means he is an enemy okay. Then you can shoot him, that is the point. There operate at a very high altitude for a long period. They can operate for 12 hours, 14 hours, 16 hours, 18 hours like that they can stay there okay.

That is the thing. E-3 very famous one. This is fitted on Ilyushin. And this Ilyushin-76 is what India also has got. Some new early warning aircrafts are being developed in India and they are getting operational.

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Then of course transport aircraft. We all know that you need to take troops, you need to take supplies, you need to carry tanks, you need to carry guns, you have to carry all these things you need a transport. But also a transport aircraft is modified to be a tanker, a flying fuel tanker. So a fighter aircraft you know there are all, they cannot endure for too long. A tanker goes refuels it and thereby you continue the operation, okay.

So it is an important role it is playing and also as I was mentioning to you as India has done in the erstwhile East Pakistan, they carry the bombs and they dump there on the enemy territory when there is no opposition, okay. That is what also people have been using.

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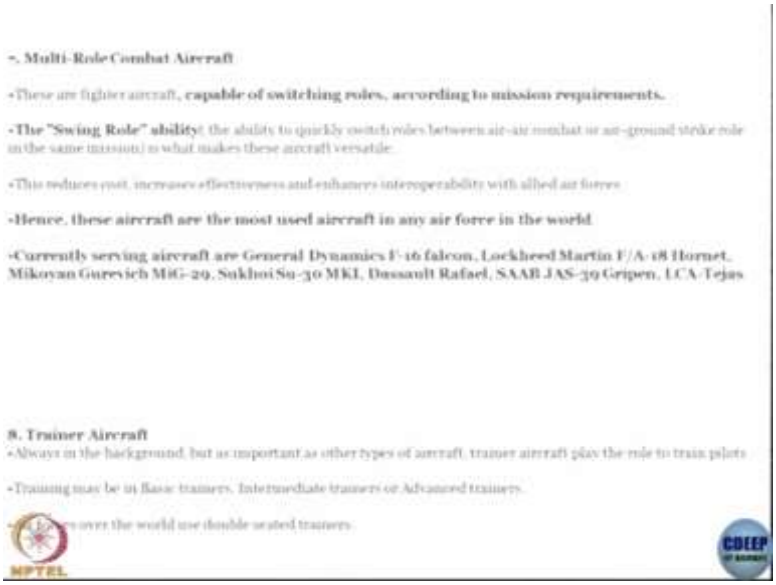

Now you have multi-role combat aircraft. The thing is I talked about air superiority fighter, I talked about attack aircraft, I talked about a interceptor aircraft and all. Initially there were all different types of aircraft. They are all, an attack aircraft is different, the interceptor is different, and a combat aircraft different and also wide varieties of aircrafts were being developed and all.

Then came the concept of what you call a multi-role aircraft whereby if he doing a ground attack, and suddenly he finds an enemy aircraft coming, he can convert himself from a ground attack into an air superiority fighter. That is what they call as switching roles according to mission requirement. Same aircraft, while flying, you can switch from one role to another. That is the important.

The swing roll ability, able to quickly switch roles between air to combat or air to ground strike role in the same mission is what makes this aircraft very versatile. And these aircraft the most used aircraft in any air force in the world. Currently serving are the F-16, F-18, MiG-29, Sukhoi-30, Rafael, SAAB JAS, Gripen and LCA-Tejas. These are all multi-role aircraft. You can fly as an air superiority fighter, fly as an attack aircraft. That is the kind of what you call benefit the aircraft.

So these are now becoming more popular, and slowly they are replacing the old generation aircraft, okay. Now of course trainer aircraft, I do not have to explain. If you want fly an aircraft you must first get trained. So these are very crucial things, okay. Now let us look at the slide to see how the fighters have evolved over periods, okay.

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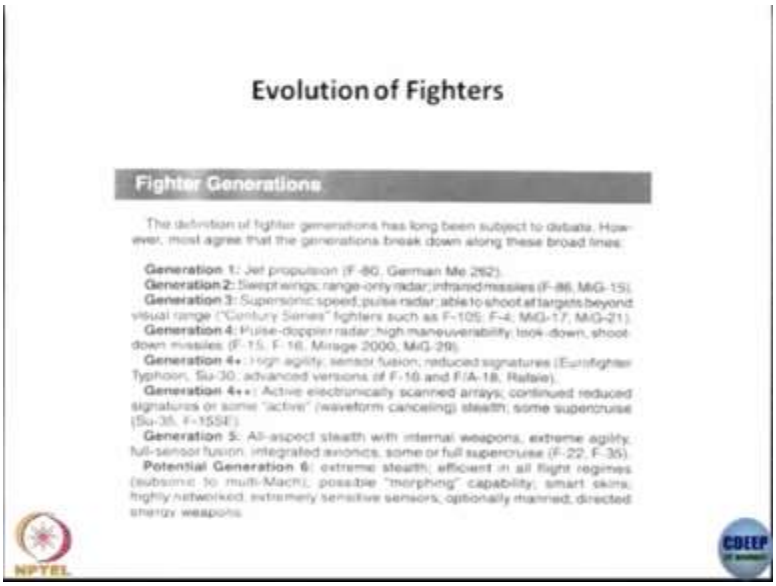

Normally you must be hearing about fourth generation fighter, fifth generation fighter, sixth generation fighter. What are they? The first, these are all post World War II. All the generation names have come post World War II okay. First is the jet propulsion. Just somewhere towards the end of the World War II jet propulsion started okay. There was one what you call Messerschmitt 262 and F-80 is the American.

They were the first fighters that have been designed with a propulsion or jet propulsion. They are subsonic aircraft, lower speeds okay but higher than the other ones. Then came generation 2. They have swept wings. So range-only-radar. The radar is able to detect the range-only infrared missiles, okay. Then the famous among these are the MiG 15 and F-86. In fact in the Vietnam War, this aircraft was used in Vietnam war.

Initially F-16 was not. There are F-104 and all that. So the MiG-15 was able to maneuver, able to fight the combat and all so much so the Americans have lost their aircraft heavily. Then they brought this 86 that may become parity, okay. That is what. Generation 3 is supersonic jets, supersonic speed, pulse radar, able to shoot a target beyond visual range. They are called the century series, F-15, F-14 they are all the kind.

These are all supersonic fighters, okay. These are all supersonic fighters. And they tried to build an aircraft of generation 3, what we call as a halftone 4. But basically, it was a generation 2 aircraft, the gen 2 aircraft only. Then came generation 4. This is pulse Doppler radar, high maneuverability.

What is pulse radar?

Pulse Doppler see if you know, Doppler you know, principle of Doppler. They send pulses and then they will be able to detect position and the speed of the other aircraft, okay. That is what the pulse Doppler concept is. They will be able to know even the size of the aircraft, type of the aircraft, the speed of the aircraft and the location of the aircraft.

Important thing is you should know the speed and location, thereby you would be able to know how much time is available before he reaches you or you have to reach him, okay. This is a crucial fellow. Previously only a range air only radar. That means I only know the distance. But that is not I do not know at what speed he is coming and what direction he is coming, but pulse Doppler will tell me that kind of a thing.

So it is a crucial thing, okay. That is the point. Then what happened generation, these are the aircraft know, all of you have heard F-15, F-16. India has got MiG-29 also India has got that one. Then generation 4+. This is high agility, sensor fusion, reduced signatures. These are the kind of aircraft which are there. Then generation 4++. It is active electronic scan. LCA comes to this generation 4+ okay.

Then generation 4++ is what you call as electronically scanned. The radars all up to now, they are mechanically the radar antenna is being scanned mechanically. Now they changed from mechanical to electronic scan. The antenna is staying there, but the phase change is occurring okay. So very important thing. Very important. That is what happens here.

Gen 5 is where stealth is the key thing, the high stealth, okay. There are only two aircraft which are there in the world F-22 and F-35. This is a gen 5. The Gen 6 is not there anywhere, okay? What you call as the future, it is only thinking, speculation, extreme stealth, efficient in all flight regimes, possible morphing capability, smart skins, highly networked, extremely sensitive sensors, optionally manned.

That means so far I am talking about manned fighters. Now they are talking about fighters who normally are unmanned, but if required, fellow can be pushed in okay, that

is the thing. So that means there is a shift that is occurring now from manned to unmanned, okay. Let us see what is that.

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They are expanding the role of unmanned air vehicles. While manned aircrafts have played decisive role in the conduct of war there is a definite shift to unmanned aircraft today. Unmanned air vehicles have exponential growth in recent history all over the world. Dull, dirty and dangerous missions are most suitable for UAVs.

Most dangerous, because if you put a man inside and he shot, the aircraft is shot and he lands in enemy territory, he is caught and you know what all the political implications and all. So such missions now, whether it is in Afghanistan or Iraq and all, USA is now primarily is using only unmanned vehicles for bombing and all that kind of a thing.

Advantage is the size of the aircraft is not constrained by life support element and size of the person, okay this is the advantage. And also the size is coming down. Even a soldier can carry a micro air vehicle and he can launch it, very small weapons that is small missiles, very small weapons and they can do it. It is like a backpack you are carrying.

You have a backpack aircraft to that level or you have an aircraft which can stay in the air for days. But there is no man, nothing to worry. You do not have to go to toilet, and nothing is recorded. Toilet free, food free, toilet free everything because that fellow he

can do it on the ground, okay. That is the great advantage you have. So slowly you can see that there is a change that is occurring.

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Now lots of different varieties of unmanned air vehicles are now coming. We have tactical aircraft, short range, they are operational. I think India has one aircraft called Nishant. It is about four hours of operation, primarily reconnaissance and all that, surveillance, recurrence it does that. Then you have a medium range. They have got an aircraft called Rustom-1 in advanced stage of development, okay.

It is about 8 to 10 hours of flying and all that. There is an aircraft called MALE. It is not male, female. MALE is medium altitude to long endurance vehicle. And there is aircraft called Rustom-2. And this is the one what you call that US is using that kind of aircraft go for 24 hours and all that. That is the fellow. There are lot of meaning. I am sure in IIT everywhere there are lot of many aircrafts are there.

Lot of them have been developed, lot of them are being used. And there are some vertical takeoff and landing aircraft, helicopters or you have quadcopter and all that kind where extensively they are not being used by not only military but paramilitary by police force, for civil applications, all of them. Last week I was discussing with a doctor in Chennai.

He wants some critical organs what you call to be transported from one place to other place within few minutes. So a quadcopter is the, so you are designing a quadcopter

where the payload is in an air conditioned cooled environment kept there and can come within 10 minutes and from one hospital to the next hospital and then is available. Today that is what. Postal and all is nice gimmicks.

But carrying critical organs is a critical thing. So that is one kind of work friends in IIT Madras and the doctors there they are working on that. So strike aircraft that is what I mentioned. They are able to carry weapons. And targets. Now surface to air, the army or the Navy all of them have to learn how to what you call home their missiles, how to home their guns, how to so you need a target fellow okay.

And you do target practice on that. So these are the targets which are used. We have some in India for that. And micro air vehicle very small, I told backpack you can carry, these are all micro air vehicles, okay. There are then nano much smaller, 300 grams, small size, okay. Another very important type what I must mention to is that unmanned combat air vehicle.

There is no man there but they can do combat and they can fight a war, they can drop weapons. Nowhere in the world it is available. But lot of countries are working including India, okay. We are trying to develop an unmanned fighter as a successor to LCA and all they are working in that kind. It is a very important technology. And there are also high altitude long endurance vehicles.

Like one week you want the aircraft to stay, unmanned air vehicle, solar power okay with battery solar powered and all. Lot of work is going on. Again, there is nothing operational yet, but hell of a lot of work is going on all over the world. So you can see there is a range of aircraft, unmanned air vehicles are coming up. So the prediction is in the next 10 years, maybe 50% of the fighting forces will be unmanned. So that is the kind of things it is.

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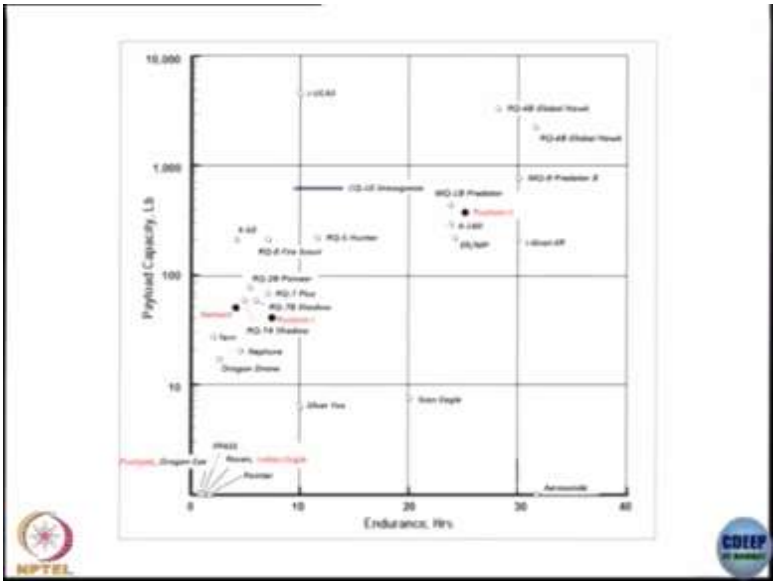

So if you see that,

Sir, one question. In your previous slide there is one column called BLOS. Beyond line of sight.

See line of sight is what I can see. Beyond line of sight is beyond what I see. That means your short length missile, I can see, gun I can see but long range missile is that is beyond line of sight that is what is there.

The long range missiles are bigger. Small vehicles cannot carry but big ones can do that. So this gives you an idea about operational one, payload capability in pounds and endurance. A very small one mini fellows are here. There is one Indian Eagle, Pushpak and all those things are there. I think Pushpak is the one. I think Pushpak also they have done that. Indian Eagle is done by NAL and all those kind of things you have.

This is a second bigger what you call higher endurance higher payload. There are two vehicles, Nishant and Rustom-1 okay. Both are developed by ADE, they are there. Then still higher levels you have Rustom-2. These are the kind. They are all operational fellows, is under development. But there is still big like Global Hawk you are talking. Their endurance levels is much higher, much higher.

We do not have anything near that. There is a need to develop something in that direction, okay. This is a area to look at.

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Oh one important technology critical for war fighting is what you call get connected, share information, achieved netcentric operations, no warrior fights now alone. Earlier there is a skilled fellow, he fought a one-to-one fighting and all. No. Now whole system, every fighter aircraft, every ground center, every unmanned air vehicle, every helicopter all are interconnected with each other with I showed you what you call airborne early warning system, okay.

They are all interconnected. So that information flow is available to all people and a decision is taken with knowledge and information available. But the problem there is net is now under attack. You are having cyber security problem. How do you develop what you call the software with the security element added to it. And moment I make it highly secure, the bandwidth increases, okay.

You have seen sometimes your radar control fails. Small all what you call interference come that fellow is out. Imagine you are fighting the war. This is a major problem in this net centricity. And second thing is Army, Air Force, Navy, they all are developed over hundreds of years. Each works in isolation from the other. How to make them work together. It is a challenge, not in India, anywhere in the world.

So that is a challenge. But this seems to be the only way you can win a war, okay.

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So what it means is the talking of integrated, interoperable between platforms, joint operations, coalition forces, worldwide network, secure, owned and leased, operation locations could be anywhere. This is the kind of a scenario what you are talking. So this is what is the future that we are working on.

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Now, having given this introduction, let me now tell you what are this.

Sir, a question. How do you secure during the joint missions like if you are doing the practice, joint practice missions.

That is where the secure codes are there, the whole all your codes are now we have a security embedded into it and only other side when he knows what are the what you call the codes he only will be able to operate.

Otherwise or he has to learn how to unscramble, what you call scrambling and unscrambling you know. Whenever there is a message I scramble first. That means I made coded it. The other side he has the way to unscramble it and read it. This scrambling and unscramble that is what is the kind of a technology you have to bring it, okay. That is what they do, just about in near real time this goes through all the friendly forces.

So they have now that code, okay. With that they will be able to unscramble the message. But this is another major problem, okay. It is a good question. That means I have no good answer for it, okay. This is how the real, suppose the other fellow has learned or code for unscrambling you have lost it, okay. This is the problem.

While net centricity is such a wonderful thing but how do you that is where some air forces or some armies and all they are little bit worried about how this will be protect the secrecy of that codes, okay, that is the problem. Now let us look at now the requirements what are the kinds of things we are talking. You see now under what conditions the fighting is going to take place?

See what you call developed scenarios, military goals, what are the targets, what are the threats, what are the air basis and what is the environment. All this you should know. You have to that means military intelligence is a seemingly important part of your war, okay. Then you develop scenarios.

Not only today's intelligence, you have to now extrapolate for next 10 years, 15 years what is going to be the kind of them including that adversaries' industrial capability, technological capability, what supplier capability. Where he is getting, what he is doing. That is the kind of scenarios you have to develop. Then formulate system concepts from the preliminary requirement. Then what to do?

You do a desired system character, conceptual design and aircraft sizing. If you have to have this kind of scenario, what kind of aircraft, what kind of weapon system it is. You do an aircraft sizing. Then you do what you call if I have this kind of a baseline aircraft, what is the effectiveness is thee. An effectiveness analysis have to be done. Am I now having certain edge over the adversary or not, it is an effective analysis.

Then with that it is an iteration we do. Then you come to a stage where you say if this is the next 15 years, the adversary is going to have this capability. The Fighter force I am now going to build should have this kind of edge over him, okay. This is the kind of thing that we are talking.

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Then normally I said a multi-role you have air-to-air, air-to-ground and air-to-sea.

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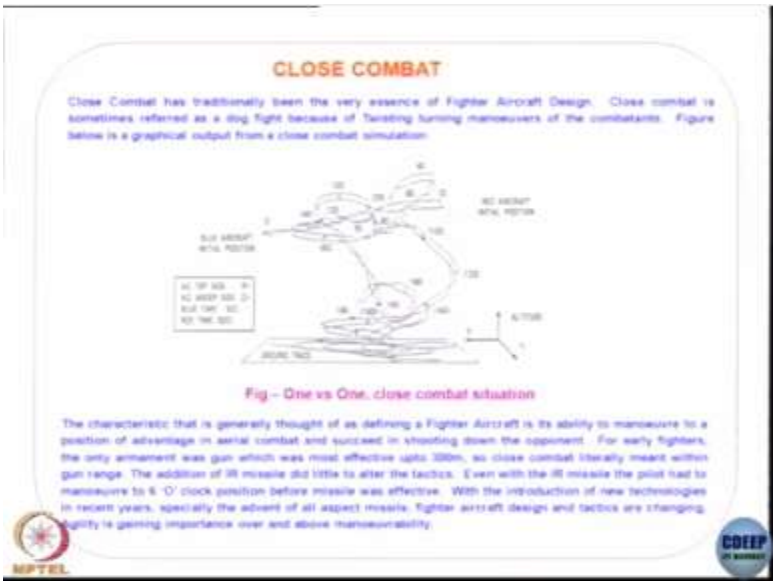

So one of the oldest things you have heard, you are seeing, you all must have seen lot of movies is called a close combat where two fighters are fighting with each other. They are called dog fight because it is like two dogs fighting with each other, very close run, seeing each other's face, and happening maybe something like 4 to 5 kilometers.

Beyond that they cannot see each other, okay. Within three nautical miles what we call it. So that is the kind of thing. In fact this is the trace of one such thing, okay. This is how olden days Second World War. After Second World War during Vietnam War, Korean War and all that and 1965 War of India and Pakistan this is what the dogfight so are very common thing.

We had one very wonderful small aircraft called Mat and they had an aircraft called F-86 okay, there used to be war. Mat is a very small aircraft. Other fellow cannot see this fellow, okay. And if you want to get into a Mat as a fighter pilot, you have to first reduce your weight, size, height, so that you can go inside. It is a very small aircraft, okay. And whereas the F-16 was a big fellow, okay.

So this fellow before that fellow seen this fellow this fellow used to shoot him. So there used to be tremendous victories in such a scenarios.

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Then these are the kind of things that aircraft do, combat air patrol. You are patrolling that area the fighter to see for any enemy fellow is coming. If you are coming now you engage him into war, into a combat. Then beyond visual range combat. That is what I was telling.

You have what you call a radar, a pulse Doppler radar, that was the question, whereby you are able to see from a long distance 100 kilometers away where it is normally about 100 kilometers, we are able to see him, we are able to see the speed, see the direction and roughly you are able to identify the type of aircraft. Once you are able to identify what type of aircraft you know what weapons it can carry and all.

And then if you have a beyond visual range missile, my missile will lock on to him and I deliver the missile. Same thing adversary will do, okay. The question is a question a few seconds. That maybe two to three seconds. If you have that two seconds, you are able to see him earlier he is out. Otherwise you go up. That is what will happen, okay. Then fighter escort.

There are some bombers who are going down or a fighter is going to bombing. As a combat aircraft, you are giving an escort so that nobody will attack him. Because with all bombs and all his maneuverability is very low. He cannot fight, he cannot move. So you need a fellow to protect him and move forward. And that is what they do, okay. Interception is an area where aircraft is, the olden days they used to come at a high altitude.

Even now they come at high altitudes, stealth aircraft and all. Let us say you are able to detect him. You go at a high altitude, intercept him before he enters into your territory. Before he enters into your territory you intercept him, prevent him enter into your territory. Destroy him in his own territory. That is what happens, okay.

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I have talked about close support. Interdiction, I have already talked. Deep strike is what I said we will go deep into enemy territory, destroy his critical support positions, critical manufacturing plant. Let us say he is manufacturing aircraft. If I destroy that plant, then he cannot do anything, okay. That is what it happens, okay.

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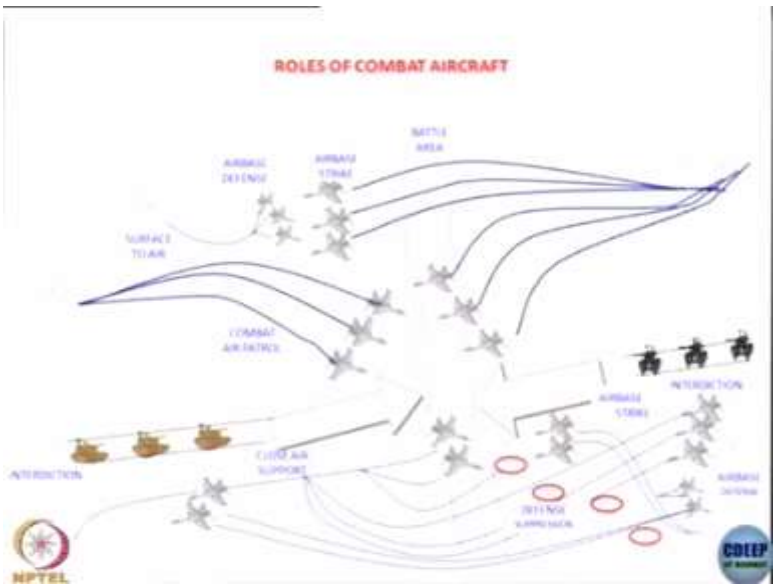

So this is the kind of a scenario what we are talking about. Here is what you call battle area. And you have air strike. The enemy aircrafts are coming. You have air base defense. Our aircraft are trying to defend, prevent them to enter into air. They will have combat air patrols, they are patrolling the whole area, okay. We have close support aircraft supporting our tanks and all.

Similarly that fellow also is trying to do that. It is a question of who has an edge over the other. It is a combination of weapons and tactics, it is a combination okay. That is what happen.

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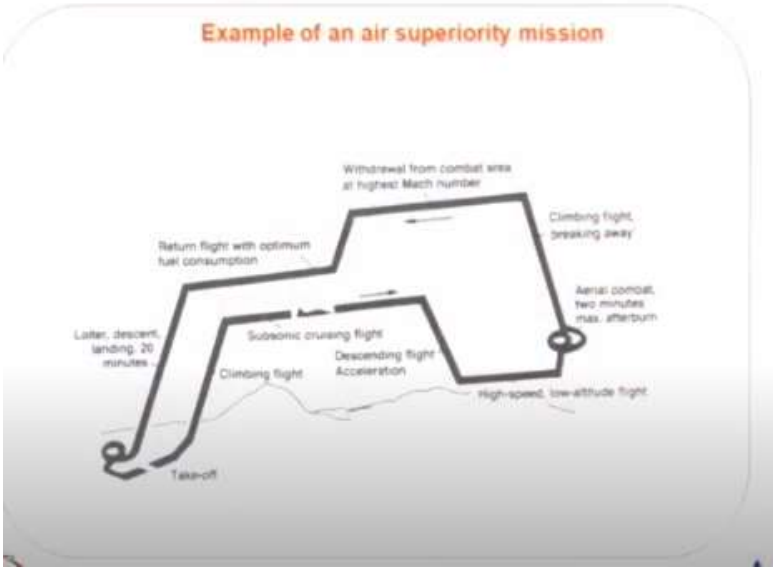

So typically, air superiority mission you take off, climb, you do a subsonic cruise flight, descend. What happens when the aircraft descend down because there is a ground is a big camouflage. Not only visually, but there is a lot of what you call radar noise. So the signal gets camouflaged inside the noise of the ground so that enemy radar is unable to detect you. Then you go into it, okay.

But once you are bombed at very low speed, and once you enter into enemy territory, you increase your height, reduce your speed, or throw all your bombs and all, have some combat, then come back. If you are lucky, you are back here, okay. If you are not lucky your adversary is lucky. We do not live another day to fight okay. That is the point.

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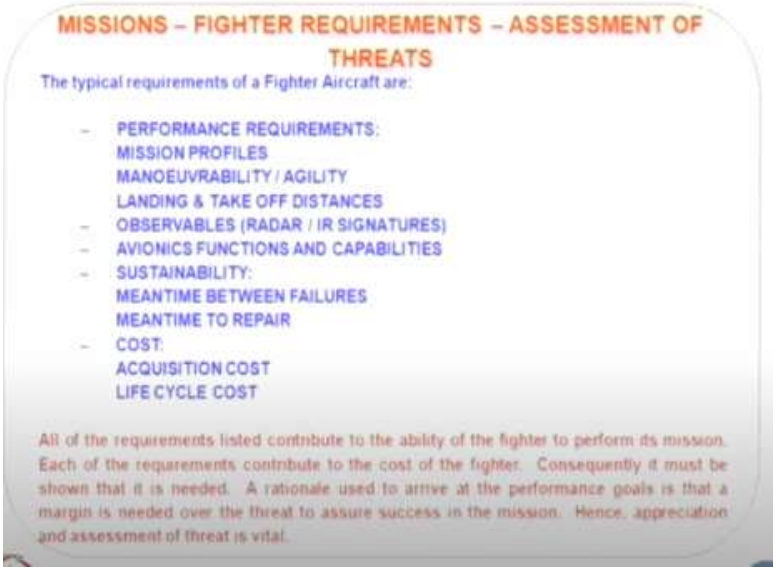

Now what are the characteristics that you need for such a multi-role fighter aircraft? Performance requirements, mission profiles, maneuverability and agility, landing and takeoff distances. These are the crucial, your agility and maneuverability and mission. Must be able to carry weapons, have to radar, have to carry fuel and he should be able to go long distances and observables radar, IR signatures.

Avionics functions, we are internal avionics for jammers, radar supplies and pilot must have a display. All that information should come to him. Then you must be able to sustain. The aircraft it should be having as minimum failures as possible. If you have too many failures, your aircraft is on the ground and that is trying to what you call you are busy in repairing and maintaining, okay.

And time taken to repair also should be like what you were talking even for a transport aircraft if time taken for repair is too long aircraft on ground is as good as not having them. That is what you use the word called availability, okay. That is there. Of course cost. Should be low cost so that you are able to handle this.

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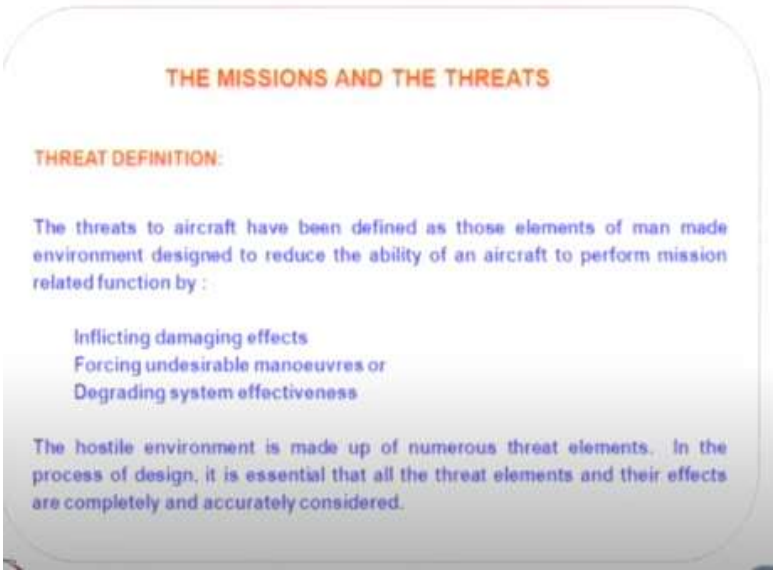

So what is the kind of thing that, let us look at the threat. I talked about enemy, adversary, threat and all. What are those threats? Let us look at that. The threat to aircraft have been defined as those elements of manmade environment designed to reduce the ability of an aircraft to perform mission related functions. What are they? Inflicting damaging effects, forcing undesirable maneuvers or degrading systematic effectiveness.

Anyway I have a radar, he has not killed me, but my radar become ineffective. I have become a blind fellow flying the aircraft. It is of no use. So on my system effectiveness got degraded and forcing undesirables. He will push you so that you make a tight maneuver. You are all aircraft people. If you go into a, you cross the stall region, you lose control is it not, you lose control.

So he will force you to do that. Then also you are out. And of course damage done or missile fires against you, you are out, okay. You cannot, no more you can fight. At most you can escape from run away, okay. That is the kind of thing. What is it that you use, okay? There are three elements.

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What are they? One is, types of threats are what you call non-terminal and terminal. What are non-terminal threat detection? That fellow is able to detect you. Identification. He is identifying you. Tracking you and communications. He is tracking you and he is communicating to his what you call family forces that this is your these are your things will there. So this is also a threat, okay.

And second is terminal propagator and platform. Projectiles, missiles, radiation okay and platforms are guns surface launchers, airborne interceptor, we have discussed so far and direct energy devices. We will talk a little bit of each one of them, okay. If you look at this projectiles, we are talking about small arms anti- aircraft systems, missiles or surface-to-air missile, air-to-air missiles.

Radiation is laser and EMP electromagnetic pulse electromagnet pulse. These are the I have already indicated, they are the kind of these are the kind. It is not good enough you have an aircraft. It is not good enough you have a what you call radar. You must have a weapon, okay and what type of weapon you can carry. These are the kinds of things which are important.

Now, we talked about terminal and non what you call non-terminal threats we said detection, early warning, target identification, target tracking, electronic counter countermeasures. If he is trying to what you call jam my radar how electrons will jam his radar. So it is depends upon which fellow is better than the other fellow. That is air technology comes, okay. Okay, if mine is a next generation fellow, he is drowned.

I may wallop, okay, that is right. Then fire or weapon controls. Then communication system. They can be land, sea or air based. It can be any one of them. The terminals I have already talked.

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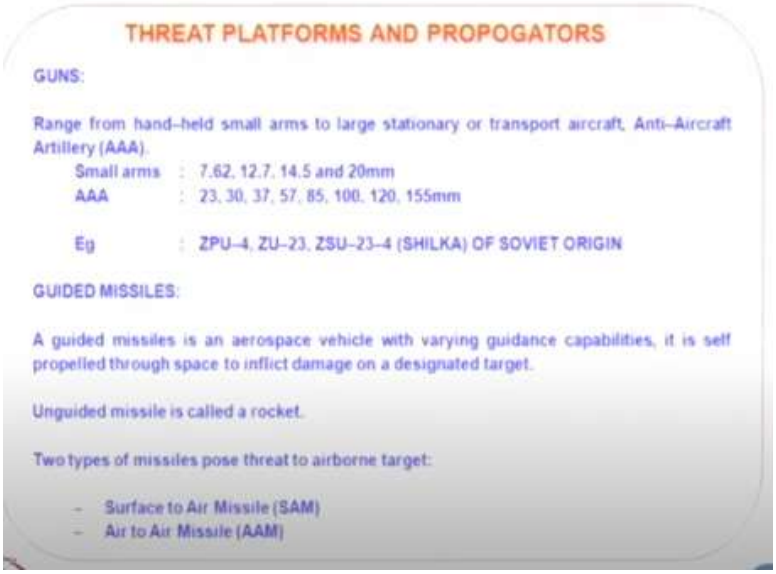

So what are the kind of things? We have different types of guns, small arms, aircraft guns. You have seen all our movies. When the aircraft comes surface-to-air guns we use, okay. Then you have guided missiles, okay. Lot of missiles, surface-to-air missiles, air-to-air missiles, both of them.

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So typically, if you see that you have different types of what you call surface-to-ground weapons, weapon carriers and all. So and there are different types of guidance systems.

Even a kind of guidance is also important for surface-to-air. What are the guidance we are talking? It is called command guidance, okay. There is a command and the missile takes the command and follows that.

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Second fellow, we call it a single beam rider missile. There is a beam. The missile will ride over the beam. It does not have its own capabilities. If the beam is pointing towards a threat an aircraft and all this missile will ride over that and hit it, okay. If I am putting the laser beam, a laser-guided missile will go and hit that one. So others are all what you call autonomous.

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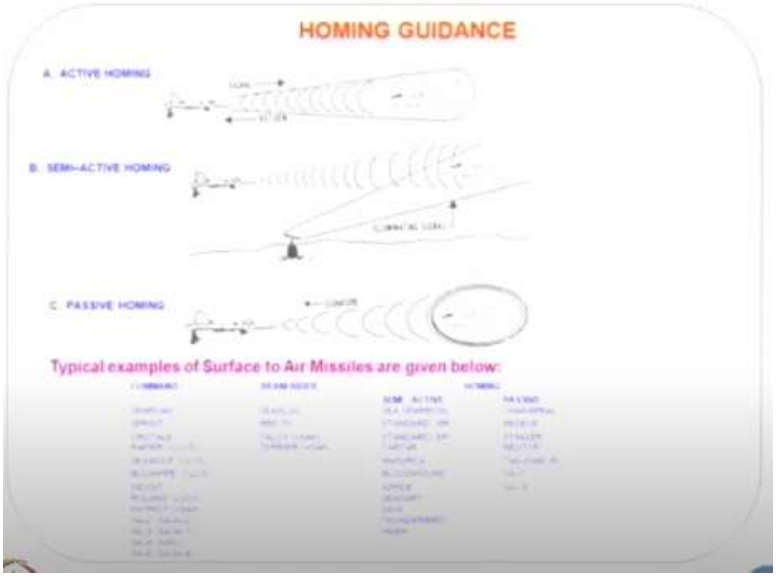

They have all of their own, okay. Active homing, semi active homing, passive homing. There are a large number of this. This missiles have totally changed the whole scenario about the threat. Threat is totally changed.

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And that is where I think the Russians have done a lot. These are some of the pictures of what you call land based things.

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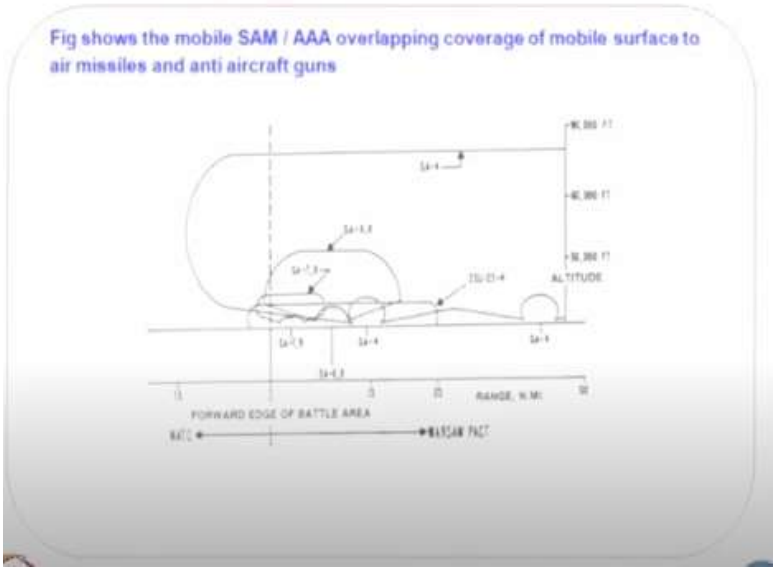

I want you to see this fellow. There are various type surface-to-air missiles. There is a zone of effectiveness as a function of altitude. It is interesting for you to say if I have only these type of missiles with, let us say I have got only a gun. It is it can go only up to this much altitude, 15,000 feet also. It cannot go beyond that. If I have surface-to-air

called SA-6 aircraft, they are all Russian types and all, they can go right up to something like 35,000 feet altitude and 40,000 feet altitude.

If you have SA-4 missile it can go right up to this altitude. That means if all these missiles up to this height, enemy cannot enter easily without encountering this fellow. So what people are doing the Reconnaissance aircraft like SR-71, U-2 and all, they were flying at 100,000 feet altitude, above this 90,000 fellow. So even though you have missiles you know that fellow is going, you can do nothing.

He is happily photographing you, taking all the things Reconnaissance and running away. That what the thing. So initially they manned fighter like, after that they changed to unmanned U-2, okay. Very famous fellow. That is what they are still being done. Although they were still being done you know they are all flying but you cannot do anything. So that is the benefit you have if you have such very high altitude things, okay.

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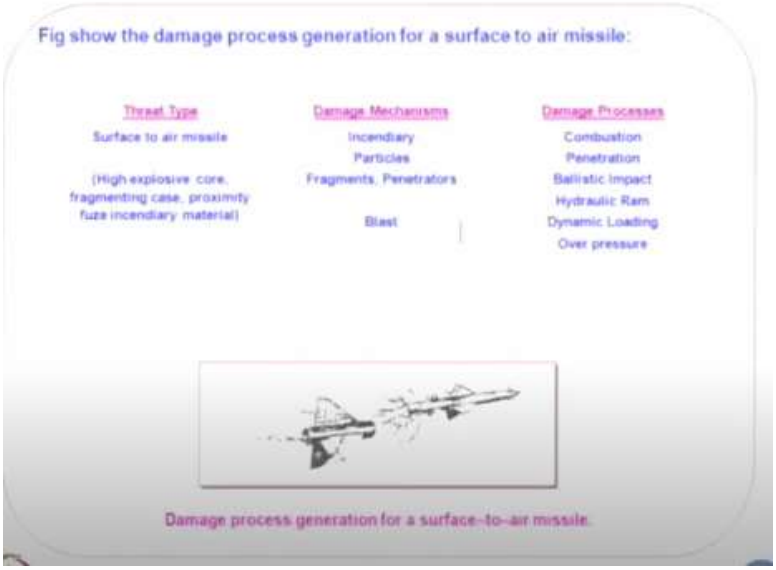

So I mentioned to you this three types what you call surface-to-air missiles. You have damaged mechanism is here. I do not want to go too deep into it. Damage processes, how is the damage process? Combustion, penetration, ballistic impact, hydraulic ram, dynamic loading and just over pressure. I generate so much pressure, the whole thing will explode.

I just go in and generate the pressure so it goes inside your cockpit into your tank, the whole fuel tank, it will explode. Because the pressure, there is nothing else is there. Just he generates huge pressure. So this is the kind of things what they do, okay.

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Sir, a question. What kind of missile are we developing for air-to-air.

It is called what you call short range and beyond visual range, Astra is the missile. First time we are developing a air-to-air missile called Astra. This missile is beyond visual range missile. Has something like about 50 kilometers of range, okay.

And lot of trials have been done. It seems to be doing quite well. But you know, any missile, any aircraft you need huge amount of testing before it becomes ready, okay. But that is the thing. So far our attempt has been surface-to-air missiles, but now air-to-air missile development is going on. That is the Astra one.

Do we have dedicated test planes.

Test planes yeah we have, we have. There is one organization called AST in Bangalore. They it is a dedicated place for testing all aircraft, okay, they are the people who. Missile is done by the missile development group itself. They have one place in on the coast of Orissa, okay. They have the very advanced test facilities. All over thing.

Missile has to be tested from Sukhoi or something like that.

But then they use that facility because they have tracking facilities, instrumentation, it is called an instrumented range. Then you that is where what you call targets. You have

a target. It is like another aircraft but is unmanned one. That fellow is flying and from surface to. You have a air-to-air missile on a Sukhoi or a mirage 2000 LCA. You fire that one and you see how effective it is because that target is instrumented, this fellow is instrumented, and the range is instrumented, okay.

Totally all three dimensional you are instrument the whole thing and that is the reason why they do that, okay. That is the location and it is a vast sea. They are able to do this because it is a vast sea there, okay.

How do you know if an enemy is actually entering into your territory?

That is what you call, you know there is an aircraft entering in. That is I have mentioned to you there is an equipment called IFF, identification friend or foe. So your own aircraft have this equipment. So they will have the code. The code will continuously be changing. But at that any instant you will have the code.

So you will send a message to that aircraft and that fellow if he what you call returns the message with some code data, you know he is a friend. Then you do not shoot him.

we say interceptor has to intercept a vehicle in the enemy's territory right?

Even then enemy's territory also suppose your four interceptors from our side are going, you may be seeing the radar, not only his aircraft, your own aircraft also, okay. There are four. It is not one aircraft normally does not go. Minimum of two, sometimes four. So then your radar sees all aircraft. Radar does not know he is enemy or friend, okay. So this IFF is the one which will tell you he is enemy or friend.

No, how do we know if he is actually coming with an intention to

That is what. If he responds in a positive way to my message, that means he has no negative thing. No his question is suppose this is a transport aircraft or something like that.

No, let us say I have like Pakistan India border. So they might be doing some kind of practice maneuver but close to the border.

No, if he is doing the practice maneuver there is an understanding they will say we are doing a friendly, we are doing our own things, we are not. See, you also see in which direction he is coming.

And we also know we are in a state of war or peace. So all this are information, okay. That is right, okay. But sometimes we make mistakes. Recently Ukraine versus Russia. I have a feeling the Russian or supported forces have fired a missile against a Malaysian aircraft. It is a mistake, you have lost. So mistakes do happen. You have various what you call systems and processes, but sometimes mistakes will happen and that is how you lost that.

It is a case of because why should these fellows destroy a Malaysian aircraft. A passenger aircraft with 200 or something like passengers and all, it is a mistake that has happened. It does happen, okay.