Introduction to Aircraft Design
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Lecture - 86
Guest Lecture on Air Power & Multi-role Fighter Aircraft-Part 02

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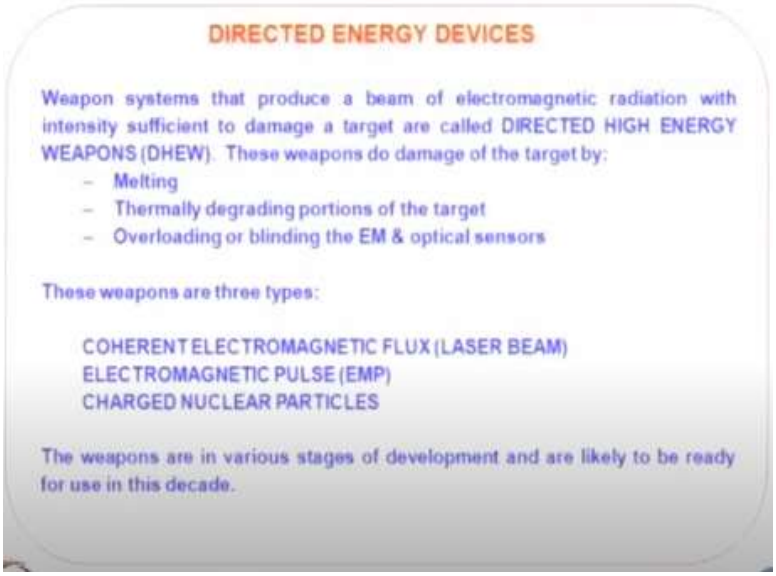

But one area which we are now looking at is directed energy weapon. There is no aircraft, nothing. You have a surface-to-ground. You have a very intense laser beam or you have electromagnetic pulse. So with that, you are now able to now destroy the aircraft. Only think is these are very heavy. It cannot be carried on a fighter.

It cannot even be carried on a bomber but lot of work is going on whereby they want to reduce the size of these fellows to a level where at least in a big aircraft it can be carried. So they are going to be the future threat, okay.

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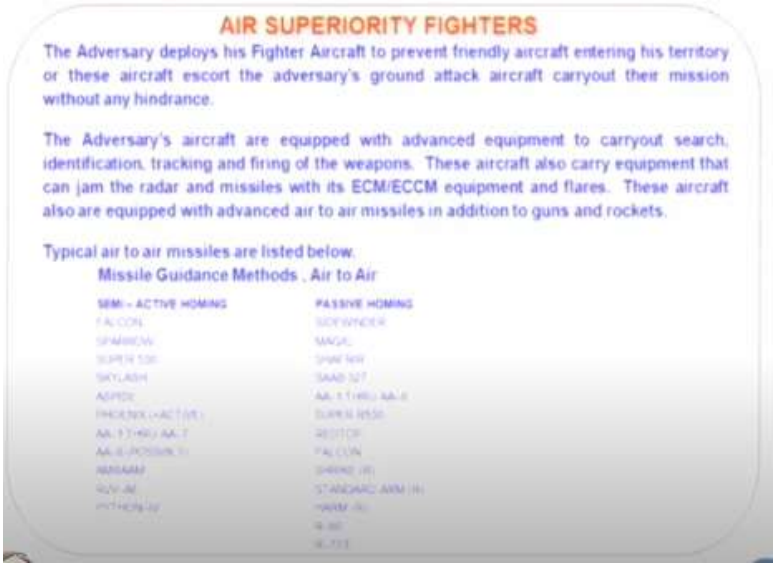

So let us see, we have lots of air superiority fighters, I talked. There are lot of missiles or air-to-air missiles, okay.

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Huge number for airborne weapons and sometimes we do not teach about weapons in our classes but an aircraft is as good as the weapon it carries, okay. So you must have a feel of what kind of weapons we are doing, what kind of radars we are carrying, okay. That is what it is.

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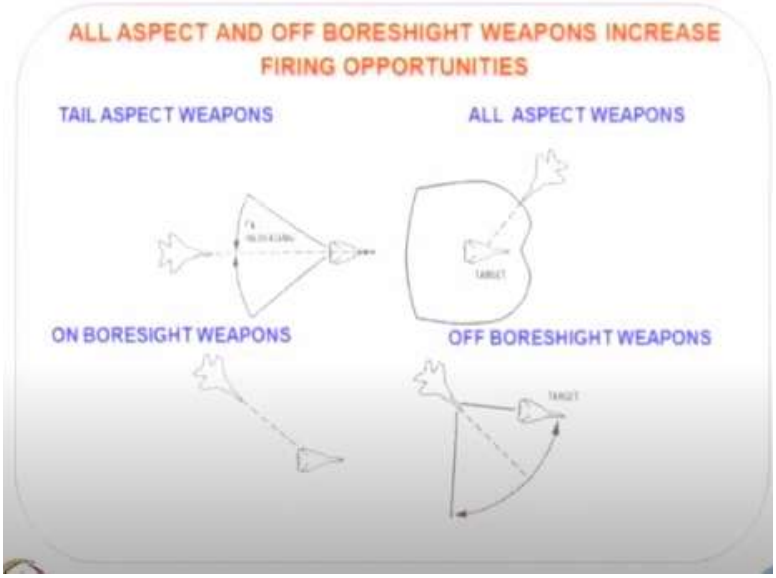

And there are two things that happens. This I thought you should know because it determines the kind of aircraft. There are what you call tail aspect weapons. That means the infrared missiles what used to have they will sense the infrared signature. The hotter the what you call the surface the hottest part is the engine, okay. So from rear only they were able to catch them okay.

So those days the aircraft will go rear of the adversary's aircraft and fire the infrared missile. But later on the missiles become so good, even a 30, 40 degrees temperature difference they are able to detect. Then they come to what you call all aspect weapons. That means from any direction they are able to fire. Now all the missiles what we are talking there all are all aspects, okay.

There are two types and called on boresight weapons and off boresight weapon. So you have to do a boresight what you call there to do this kind earlier. But now there are off boresight. My boresight is looking at but I can fire on the other direction, okay. So you can see not only aircraft, the weapons have now come to such a level you are able to do all aspect, you are able to see from a distance.

So the old close combat or dogfight is only now left to the dogs, okay. No fighters are required to do any dog fights, okay. Okay, that is the kind of thing because weapons and radar plus jammers these electronics, these three fellows have changed the way we fight a war, okay. And unmanned aircraft change the way whether the man is going to be inside or eating sandwich and fighting the war. So that is what it is okay.

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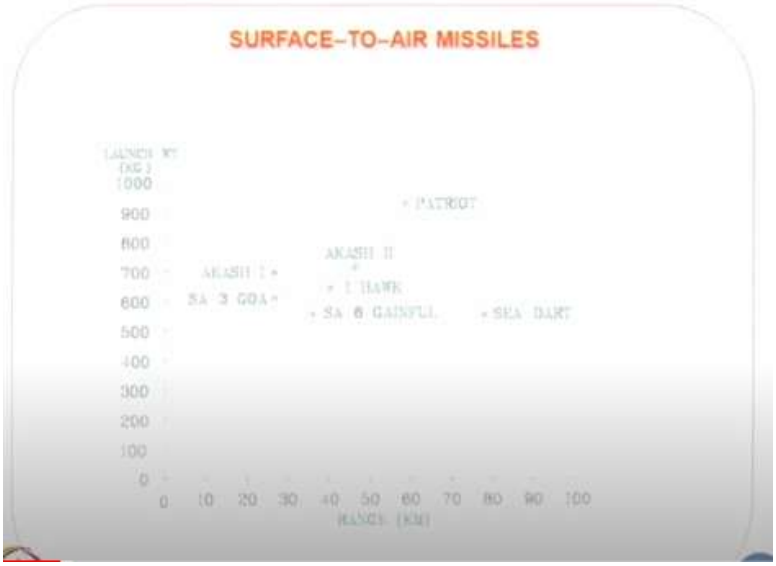

So you see surface-to-air missile, for example Akash. It is a beautiful missile, Akash-1, Akash-2 and all. They are surface-to-air missiles, multi-barrel, multi thing very active. Suddenly from today the Army, Navy, Air Force not only in India, all over the or all around us they are asking for this missile. This is what our friends in DRDL has developed. And the need is now in thousands, okay.

In fact, there are at least two dozen industries have been established just to make this missile. So that is the kind of scenario where we are.

Do we sell Akash, I mean do we sell missiles? Do we sell missiles to other countries?

They are thinking. Now, see the government is now thinking that they can certainly sell to some of the friendly countries, okay.

They are thinking. They are very much in consideration. Only our Army, Air Force, Navy says give us before you give to others. See that is where we have a problem of what you call scaling up. See, it is one thing to make some 20 missiles per year and do trials and all. Suddenly if the trials are successful and you are the, the 20 it should become 200, 200 should become 2000, 2000 should become 20,000.

Can you scale it up? That is the thing. There manufacturing technology come. I have talked about that. How do I scale up? The way you design, design for manufacturing is

that is what we have to do so that I can scale it up. The great thing about the Americans was during the Second World War was they were able to scale up to such a level, per day an aircraft was coming out.

Per day they were making five, simple aircraft no doubt, but that that was the kind of scale. Whereas Europe could not do that, okay. So that is how the dominance came from them, okay. This is the kind of kill zone what you call. With each what you call missile they are all the types of missiles we are talking.

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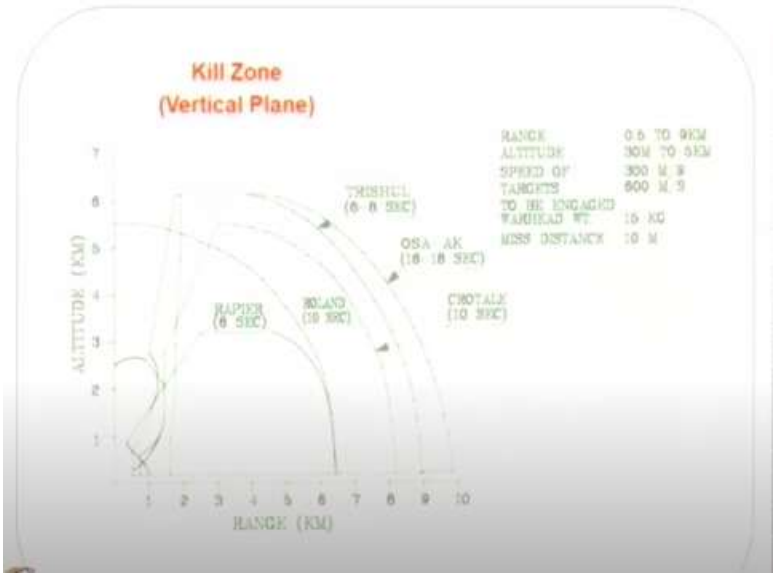

Crotale, Trishul I have given here, okay. This is the time, this is the zone, okay. Altitude. This range, in this area they are protecting your area, okay. Beyond that only anyway aircraft can enter.

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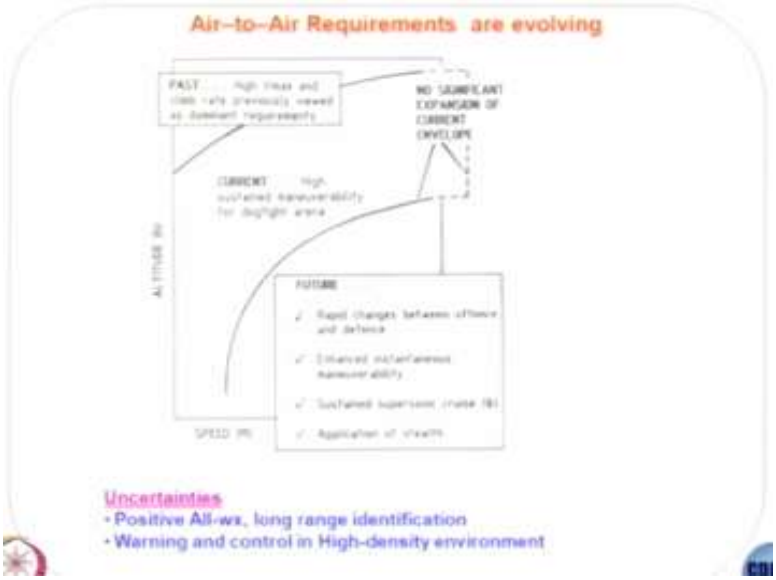

You need to know what these kind of things are. Now let us see this fellow. What are the air-to-air requirements they are evolving. Past high speed Vmax and climb rate previously viewed as dominant requirement because enemy aircraft used to come at high altitude. You go up like MiG-21 aircraft and all. You climb up as fast as possible. And first you reach there and intercept him. So that were the characteristics.

Speed okay, rate of climb. These are the kind of things which are there. Now, then we talked about dogfights, air-to-air combat, close combat what you call. There with a high sustainability for a dogfight because you have to sustain yourself some two minutes three minutes five minutes they used to say. The fellow who is able to sustain for a longer time he is able to win the war.

Because you take longer time and you are going beyond the enemy where you are firing the missile. Until you go beyond him you cannot fire. That fellow also trying to go beyond you. The one who can stay longer and fight then what happen the situation I do not have to go beyond if I can point my missile toward him for few seconds because the missile sensor what you call it should lock on.

Until you lock on I must hold him, okay. Then over okay. That is what we have to do. So it has changed, okay. Now, then what you are talking about rapid changes between offense and defense. You go on changing the positions and enhanced instantaneous maneuverability. Suddenly I must be able to turn without getting into a posture, okay. I must and point for just that couple of seconds.

If I am able to do I won the war, okay. Sustained supersonic. Now what they are talking about, can I go at such a high speed so that before the enemy radar can detect, identify and say I am the enemy. You are asking that question am I. That will take a one second, half a second. But before that happens my supersonic aircraft has escaped and stealth. One is I am strong, stealthy, I am supersonic.

So what happened? So before I am detected once let us say that fellow also is capable of detecting. By the time he detected I am my speed is so much I left that place. I damaged it and disappeared, DND okay. So that is what happens. So now what we are talking fifth generation fighter what you are talking, F-35, F-22 they are talking of supersonic cruise and stealth is required, okay.

These are the kind of things, okay. This is what we are calling about, supersonic cruise means, afterburner they are on means what will happen, the signatures will increase plus their endurance will come down, okay. That is what we are talking about. So that means engine technology. It is no longer we are talking of aircraft, we are talking of engine. So what we are talking? What are the uncertainties?

Positive all long range identification, warning and control in high density and all. The question what you are asking. So many fighters are there, so many helicopters are there, so many fellows are there. Who is my friend, who is my enemy? I do not know yeah. How do I know that? Though while I am telling information friend and foe good concept being used for last 50 years, but still it has its limitations.

Somebody can what you call jam that fellow. So far it is not easy. Because it is a see jamming bandwidth is high you can easily jam. If the bandwidth is very low it is difficult to jam. So those kind of issues are there. But they are the problem. They are the real problems what we are talking.

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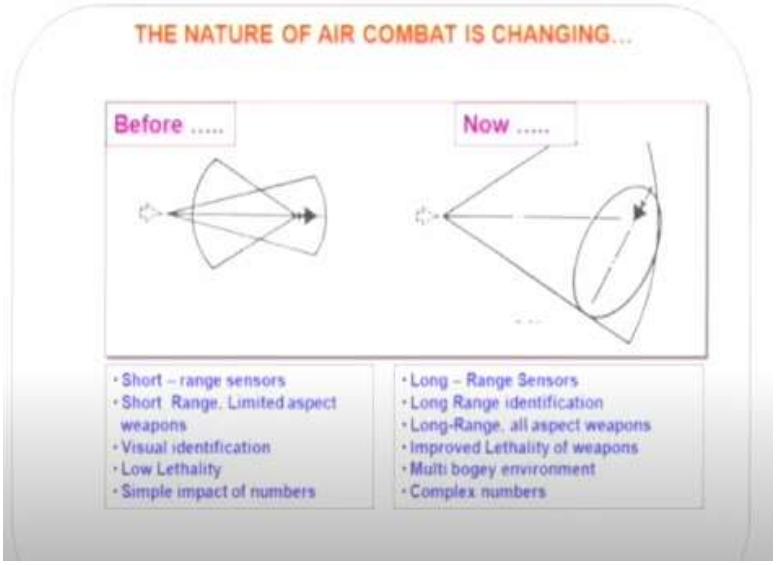

So before short range sensors, short range limited aspect weapons, visual identification, low lethality, simple impact of numbers, now long range, long range identification, all aspect mission, improved lethality weapons, multi-bogey environment and complex numbers. That is what we are talking about.

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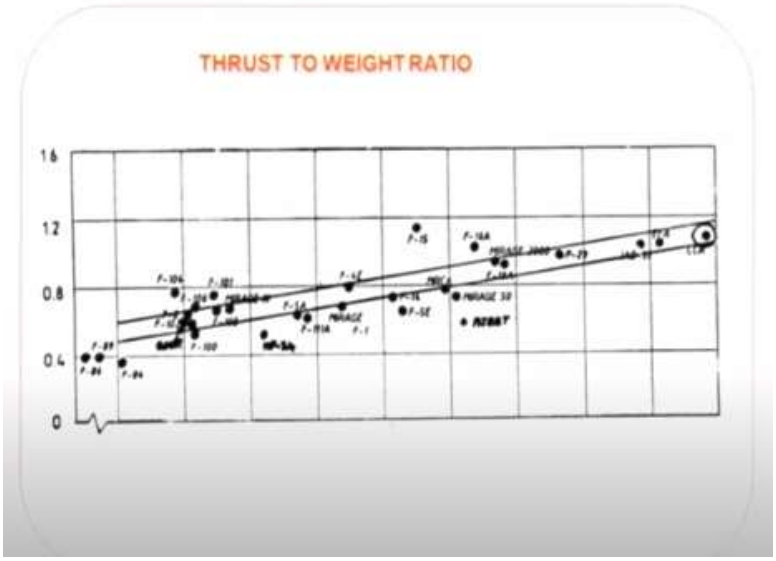

So normally, this is what you all were been taught. We are told if thrust to weight ratio is high for an aircraft, it will have very good rate of climb, it can speed what you call, rate of acceleration will be good and so they should be there. But when I want a very high thrust to weight ratio, then you have other limitations. You have to have engine weight will increase. How do you do that? These are the technological problem. But this is what a good guidance.

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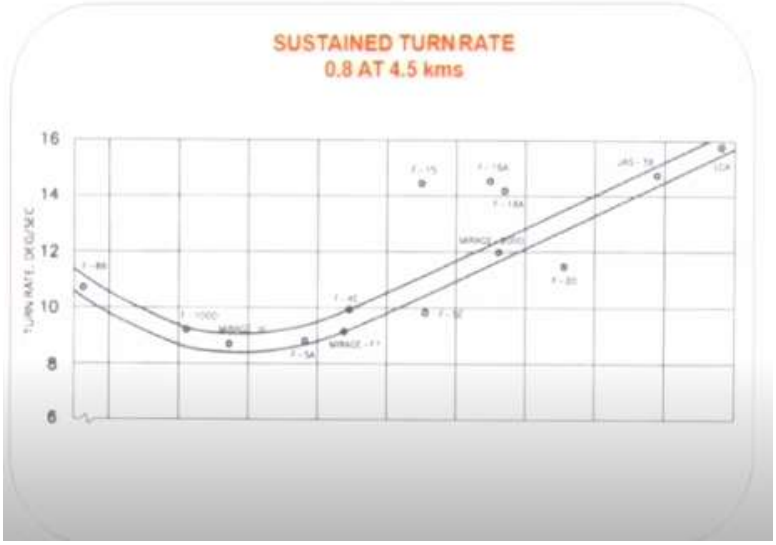

Then we are talking about sustained turn rate, okay. So there used to be very high turn rates earlier. Then they have come down. But now, they have all reached a plateau. Nobody is going beyond this, okay. Nobody is talking because all aspect missiles and all. In fact, this is no longer such a big thing, okay.

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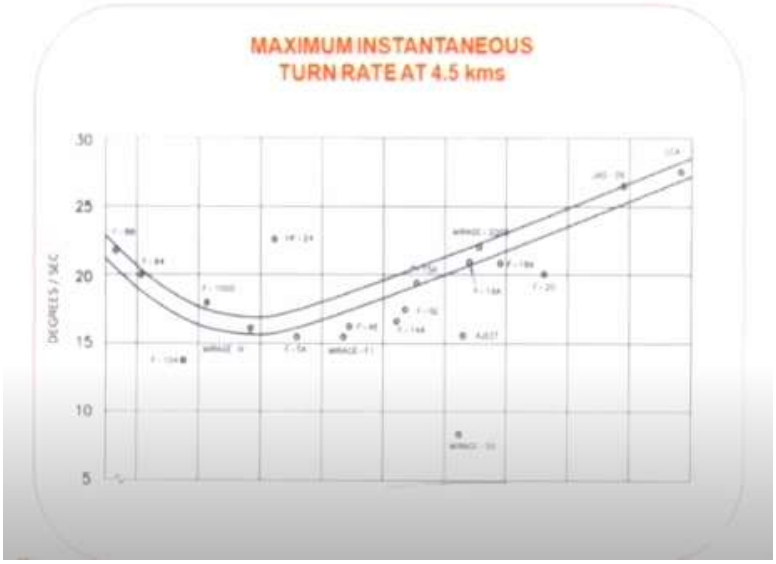

Now what is important is this fellow. For a fighter what you call instantaneous. I must be able to turn fast for that short period. Even if I lost my speed or my height, but I am able to turn and point my missile towards the adversary for that short few seconds. I mean, so this becomes an important point.

That is this is something to do with the aircraft characteristics. The previous one is aircraft plus engine. But here is purely aircraft. So that is what is important, okay.

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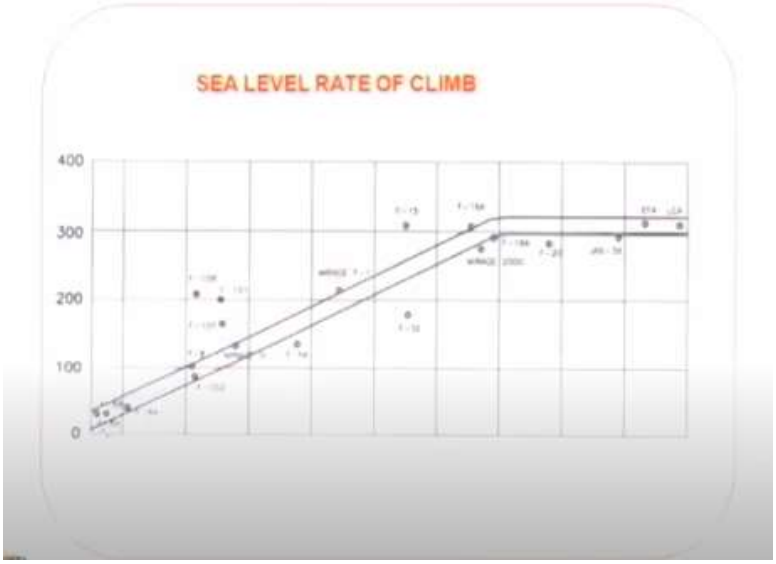

Then I talked about rate of climb, okay. Now this you can see for last 30 years, the rate of climb has not increased, because it is no longer nobody is going to 30,000 feet altitude to intercept. There is nobody to intercept there. Everybody is doing or if he is coming there he has stealth, so you cannot even detect him. So that is the situation.

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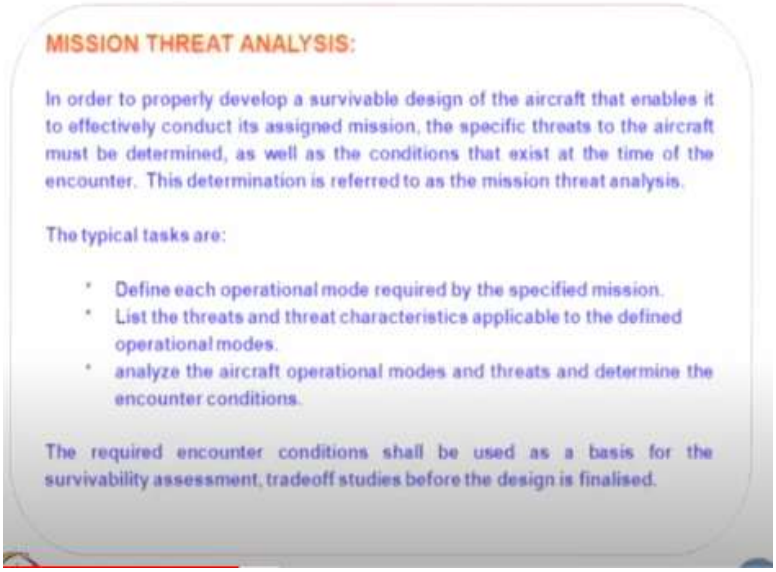

So now I talked about threats, talked about weapons, talked about radar, talked about aircraft, and talked about that. How do I put them all together? How do I know which combination is the right thing? Cannot say the best of everything. Not possible, okay. It is so prohibitively expensive. Technology may not be available with you. So you have to have that.

So what we are talking is properly develop a survivable design of the aircraft that enables you to effectively conduct its assigned missions. The specific threats to the aircraft must be determined as well as the condition that exists at the time of the encounter. You should be able to determine. The determination referred to as mission threat analysis, mission threat analysis. That word.

The typical tasks are define each operation mode required by the specified mission. List the threats and threat characteristics applicable to the defined operational mode. Analyze the aircraft operational modes and threats and determine the encounter conditions. And then the required encounter conditions shall be used as basis for the survivability assessment, tradeoff studies before the design is finalized.

This is the key point. For a transport aircraft only market we are looking at. Here you are looking at threat. Of course there also the threat from competition, okay. But this is the evolving threat, changing threat. This is a threat analysis. That is what I thought my talk today I want to bring to your notice.

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A typical, as I mentioned this is the way air combat is done, okay. Any book you see it will show you that.

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This is the flight path of a close air support aircraft. It goes like that. These are the kind of. See now what happens the whole battle area is full of vertical surface-to- air, weapon, tanks, all those kind of thing. That fellow has to wear through that and still come out, okay.

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So now, what you call the forward edge of the battle. I showed you that line. That is called the forward edge of the battle, okay. FEBA, we call it. It drops down aircraft near that, drop down into a valley to take advantage of terrain masking, I mentioned to you. A self-propelled radar directed aircraft system is in the vicinity, detects the aircraft with scanning radar, he will detect you.

The observer inside that vehicle looks at the approaching aircraft through an optical tracker and identify aircraft as enemy. Optically he has done. There is no other way he has done. Say in this case. This radar is then switched to the target tracking mode. Meanwhile the radar warning received in the aircraft detected the scanning signal from this aircraft radar and alerted the pilot as to the type, location, and status of the threat the aircraft fellow is knowing.

The pilot immediately ejects chaffs, attempts to break the lock of the tracking radar by maneuvering the aircraft. There is some chaff what you call. Moment he throws it, that increase the signature or infrared signal so much that that fellow will be directed towards that, okay. The radar receiver of the aircraft sees the chaff and starts to track it rather than the aircraft. This is what I am thinking.

That fellow can say the track is going the chaff is going too slow. He will say this is not the aircraft. This is another he will detect it. Then you have to. Now they are making chaff which is having its own propulsion system. So that fellow will go more faster. So very interesting life is there, okay.

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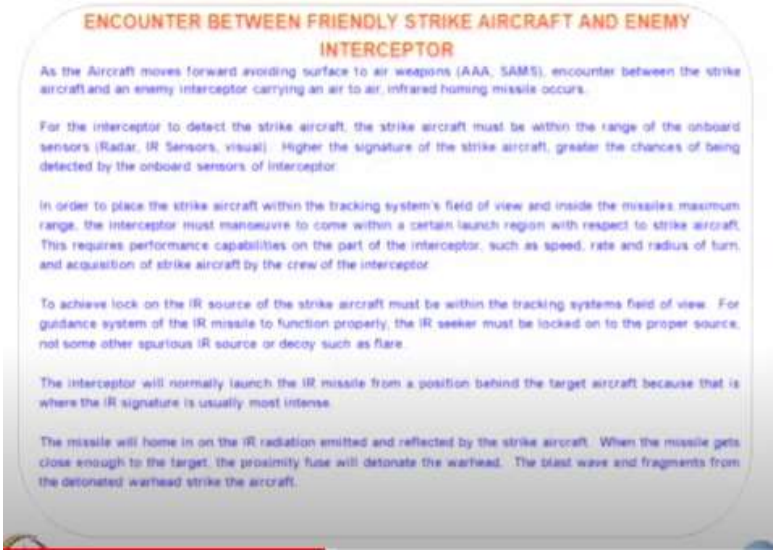

So encounter we can I was talking as a this is a typical mission. How in a threat what happens? I am just showing. You can read through there.

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So let us see the characteristics of aircraft weapon system. What you are talking is a study of the scenario reveals that the ability of the aircraft weapon system to accomplish assigned task is dependent upon what? The availability of weapon system for the mission. It should be available. Is not easily being maintained. It should be available for you to fly. Aircraft performance capabilities and handling qualities.

Sometimes the handling qualities are not good, the pilot gets fatigued too fast. Then he cannot fight a war, okay. Then target acquisition capability. We discussed. The type, effectiveness and number of weapons carried. The command, control, communications and other supporting system available. The aircraft signatures and countermeasures applied, okay. Those chaff is a countermeasure okay, signature.

Then tactics used and terrain and weather conditions. Ability of the aircraft to take a hit and survive, okay. With all that you got a hit. Let us say you are still survived okay, to fight for another day. That also is an important thing to look at. These are all the things we have to look okay.

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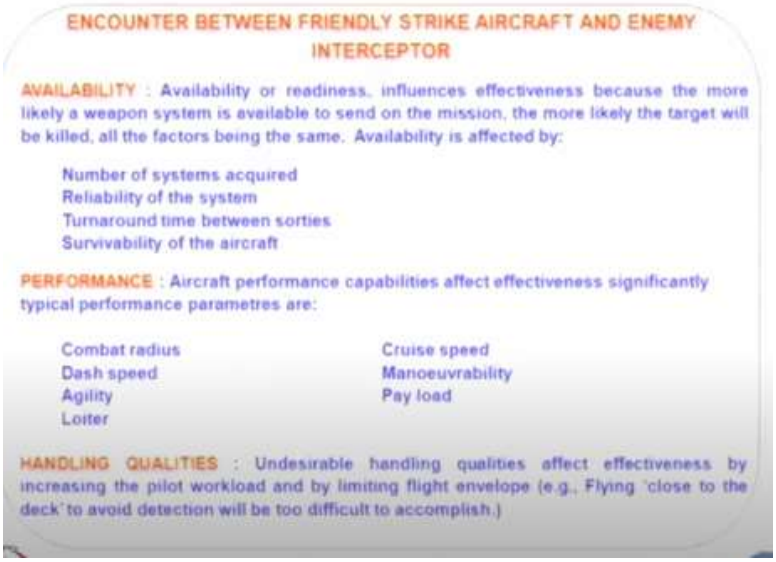

Then so what are the things we are talking? We are talking about availability, number of systems acquired, reliability of the system, turnaround time between sorties, survivability of the aircraft. This is what determines the availability. The second fellow's performance, we are familiar. Combat radius, dash speed, agility, loiter, cruise speed, maneuverability, pay load, all are the performance.

Then third is the handling qualities, I mentioned to you. It is important because otherwise the pilot will get fatigued.

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Sir, about the availability, I remember one incident during this battle, aircraft was available but it could not fly in the night. It did not have the, It could not fly in the night.

See we used to have, still have an aircraft called Jaguar. It does not have a radar inside, okay. It is a we call it as Mahabharata aircraft.

That means after it is daylight, sun, bugle, you know Mahabharata with a bugle the war starts. With the bugle the war starts. This Jaguar has been designed for Mahabharata time. So I tell you why we bought that aircraft, okay. Handling qualities and other thing. Then you talk about targets, target acquisition. Navigation and targeting, visual field of view from the cockpit, onboard radars for forward looking infrared signal.

It should be able to detect this. Radar is only electromagnetic whereas FLIR how do you do? There are flights who do. The flight vectoring assistance for airborne platform. Suppose you have a fellow. He is seeing from the top. He will say you move like this and come here. It is a great advantage for you. And of course forward air controller. There is our forward air controller fellow who is sitting there.

He will tell you, you come there and you bomb here. So that is what they call and weapons. We have discussed it enough about weapons, you have bombs, you have missiles, you have guns, you have rockets, okay. Each has a particular range and effectiveness, okay. Olden days in 1960s people thought I got infrared missile, I got missiles, what is the need for gun?

In fact, the initial MiG-21 aircraft which came to India, also Russian had no gun. But then in 65 what our fellows found the gun is the fellow who has really saved the NAT aircraft. So we quickly modified the aircraft, put a gun underneath. Now gun is something you know you always have. Whether you use or not no but it must be there, okay. It is a kind of a make the pilot feel something.

MiG-27 has a very good canon.

Yeah, now it is a powerful cannon. But people now ask what is the use of carrying this bloody 250 kilograms of dead weight yeah. Because if you are fighting a war you are seeing the enemy 100 kilometers away, missile is doing 50 kilometers away what for this fellow is there, okay. That is the kind of a thing.

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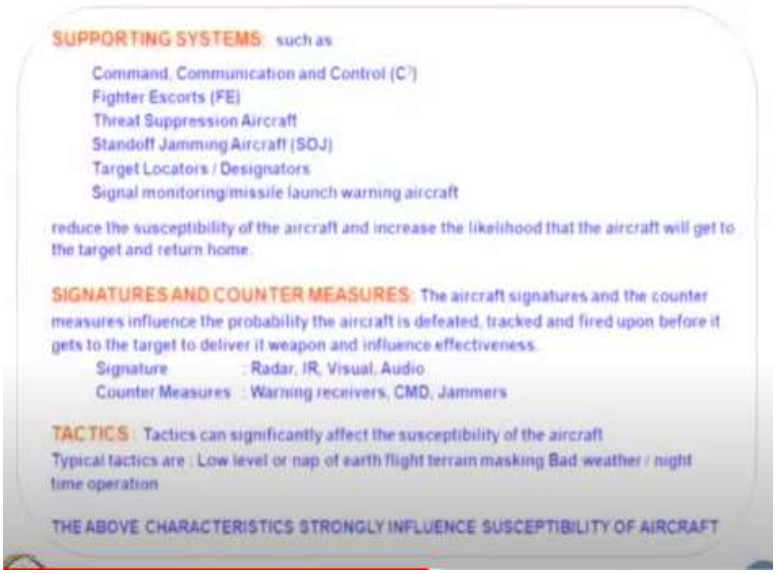

And the supporting systems are mentioned. Command, communication, fighter escorts, threat suppression, standoff jamming, target locators, these are and signature and counter measures, very critical fellows, okay. Measures and counter measures, okay. This is the kind of things. You have signatures, radar, IR, visual, audio, okay. And counter measures warning receivers, CMDs, jammers and all above all tactics.

You may have the best aircraft but if you do not have the right tactics, you fall threat okay. So that is what is there. The above characteristics strongly influence susceptibility of an aircraft. This is what we call as susceptible.

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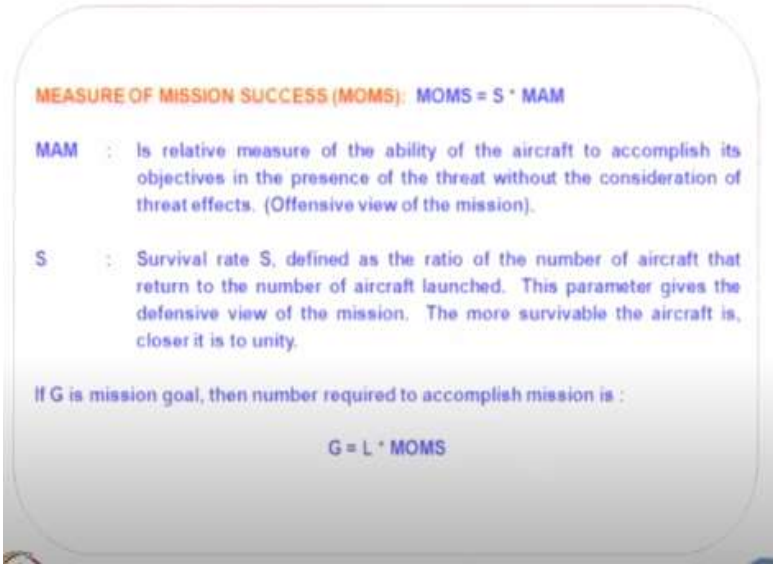

So normally what do we do? Would do what you call a measure of mission success, MOM. Here also mom is there. Without mom you cannot manage, okay measure of

mission success. It is called S into MAM. This is a relative measure of the ability of the aircraft to accomplish objectives in the presence of threat without the consideration of threat effects.

We are not worried about if the threat what it will damage he will do. Then S is this threat effect survival rate defined as the ratio of number of aircraft that return to the number of aircraft launched. You have sent 20 fellow and 2 have returned. That is what. This parameter gives the defensive view of the mission. The more survivable the aircraft is closer it is to unity, okay. More survivable means it is all.

If it is fully survivable means it is won, okay. So if G is the mission I want to destroy a particular area, so many dam, so many aircraft, so many things. So then what are the number of aircraft I need in order to accomplish mission. That is really the number. So G to accomplish the mission is the number of aircraft multiplied by MOMs, okay. So this is the kind of it is a very simplistic analysis I am showing.

So that is the way you do a detailed what you call threat analysis and then identify what type of aircraft. If I have x aircraft with x capability, how many such aircraft I must have? To support such an aircraft what kind of what you call what you call the surface-to-air missile system or air-to-air, or radar so fuel all those.

This is a complete what you call a system. It is not even a system, it is a system of systems. This is what we need to do that. And then only after that you are able to determine.

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That means I am looking at threat, TTT; threat, tactics, technology, okay. Geopolitical environment. This fighting is not independent because if he is a friend even if you have got very good aircraft it does not matter to me, but if he is adversary, likely adversary, then I have to worry. So be geopolitical. Then industrial capacity and capability. I have developed an aircraft, I have got an aircraft, I know the design, I have tested it.

But if I cannot produce the numbers I am again stuck, okay. And also having developed aircraft, I must now think about the next generation aircraft. You continuously you go on improve that one. Then what are your goals and ambitions? Do you want to be a world power? Do you want to be a regional power? Or you want to save your skin? What are your goals? What are your ambitions?

Depending on that you determine how many aircraft, type of aircraft, how you do? These are the kind of things what you are going to do, okay. Thank you. I bored you sufficiently. Ten minutes. We have ten minutes. Yeah. If any other question if I am capable of answering.

Some of these points with respect to the TEJAS aircraft, for example what kind of stealth features have been provided.

See basically it is a small aircraft. It has 90% surface area is composites. So what happen everything else being equal, a composite with better characteristics is there. And small

aircraft like NAT, a very small aircraft, same performance but small aircraft you have, small aircraft means small signature. That is the second thing.

The third thing is we have what you call coating, what you call the canopy and all are coated with some coatings whereby they prevent if radars something falls down there, it will absorb that energy. It does not allow that to happen, okay. Third, you can also put some what you call radar absorption RAMs they call, radar absorption materials they have been developed, okay.

That materials what you call high spot what you call hot spots you call. See if you see the shape of the aircraft it does not have any tail. Does not have any canard. See what happens in this infrared signature any 90 degrees angle, it will be generating huge amount of signature, okay. Now if I have a canard that means I have added a surface with that fuselage generates huge signature, I do not have.

If you have a tail also, the horizontal tail, that also will generate; we do not have. So that means those things who generate this extra signature, they have been eliminated, thereby the signature comes down, okay. Small size. Second is this one. Third is you are able to reduce the number of flying surfaces, okay. Because they add to their signal. So you are trying to bring out.

Plus, you also can add certain amount of radar absorption materials whereby you can further bring down that. It is not a stealth aircraft, okay. It is a tactical aircraft, okay. But that is what you are now thinking about next generation fighter where you can do that and all that kind of thing. But in a tactical warfare, where you are talking about distances of about 2 to 300 kilometers around the border okay, maximum you use LCA for interdiction.

You go little deeper to prevent any supplies coming there. What do you do? You what you call destroy the bridges, destroy that vehicles coming, that kind of interdiction plus a tactical support to your army and have superiority over your friendly territory, okay. Or just around the border, you do that kind of. You are not going deep into it. Because it is a small aircraft. It is not meant to be there.

For deeper strike today you use Su-30, okay. That is the kind of. Is something like three times, three and a half times the size of LCA, okay. So you have what you call a light aircraft and a heavy aircraft, okay. LCA is a light aircraft. That is the thing.

I want to ask about the Rafael that India is having right now. I have Tejas now. We have Su-30MK.

It is a good question. I think we do not need it. That is a good question. You know, why I call a good question? I really do not know why you are buying that. Unless we love French people. We want French industries to prosper. Indians are very good. They want to see the whole world to be prosperous except themselves. They want British to be prosperous, Americans to the prosperous, Russian to be prosperous, French to be prosperous.

We do not want to discriminate anybody, everybody should be prosperous, except ourselves. You have rightly said, you have got an LCA with a light aircraft. I have a Su-30 or the heavy aircraft, I have a combination of these two for different missions. That is all. I do not need anything else. What we should put effort is how to produce more of them, how to increase the indigenous content, so that more and more things are done within the country.

I think that is exactly what is required, okay. Somebody asking me why do you not write an article on that subject? So somebody also reminded me you are no longer in the government you can write. But your question is the correct. This is the right thing, we do not need it. Just do not need it at all, but we have to produce more LCAs.

We might not need it in the future but right now the squadrons are falling down, the number of squadrons that are required for

This is a very interesting story. I must tell you another story for this, you have another few minutes, okay for stories.

See in those days, a few years back maybe 10 to 11 years back we used to have in Times of India, you know they have on the left and the right you know on the top some they

used to have, one more MiG-21 has fallen down. They used to write there, okay. One more, one more. We do not make and all that you know except showing the videos, photo everything else they have done, okay, they have done that.

Then what happened? People said our pilots are not getting trained. So MiGs are falling down. So I cannot find. Then they said what do you do? Train the pilots who to buy Hawk aircraft, okay. So we placed an order on the Hawk aircraft. After buying, placing a order not bought yet, we order suddenly Times of India, you never see anything telling you one more MiG is falling down.

That means this technology has gone to such a level that after placing an order itself accident rate has come down. Great know. I hope the answer is clear. When I fly more, I have 600 MiGs, if I fly more I will have more accidents. See there is a story about Bangalore, the Commissioner of Police he said that Bangalore traffic accidents has come down. They said how, what great things you have done. Simple.

Bangalore traffic is so heavy, a vehicle cannot move. If it move only you will make an accident know. It is like that story know. If we fly the aircraft only we will have accident. If we do not fly how will you have accident? Naturally we will have accident. Natural, yeah. One day or other we will have accident. But the rate of accidents are not increasing.

Only thing is the subscription of Times of India by that fellow, advertising money has come down. No longer he is paying money to write that one. Otherwise, if I place an order it is like telling or place an order on supercomputer your CFD codes have now started working by placing an order? That is right, that is the way. This is we have what you call vested interests trying to influence the thinking of the people.

MiG-21 is one of the finest aircraft ever designed anywhere in the world. Unique design, okay. It is a unique design. It is a beautiful aircraft. Of course it is old aircraft. You have to replace it. I am not telling hold on because your old grandmother you hold, I am not telling that. But it is a beautiful aircraft. How suddenly it become a widow maker? As if widows are in short supply. It is not so.

See what I am telling is there is a certain influence in the for mind telling that somebody you know when we flew the LCA in 2001 4th January, there was US sanctions, lot of things. Some Air Marshal, Air Chief Marshal comes, no we have bought all electronic items from Sweden. He said of all the fellows why I should buy from Sweden? Why should I buy? But that is what is right.

The idea is to tell, no we have nothing indigenous in this aircraft. Nowadays all advertisement you know. So that is the mindset. What I am telling is sometimes we do not think through, we get carried away by this subtle propaganda. When the LCA flew and within one month or so there was a what you call air show in Bangalore. So our fourth flight was in an airshow.

You do not fly an aircraft in an airshow where thousands of people, unless you are sure about the safety of the aircraft. So there was a British what you call BIA systems fellow who was sitting by my side he says, I lost order for 200 aircraft he said. Otherwise aircraft he would have bought from UK know. There are no better than us. So that is what happens. See that is what I am telling, never get carried away.

Have a scientific way of looking at things. Look at, I have to, you do not say I want the F-35. There is no meaning. That is why you need to do a threat analysis. My idea of agreeing to give a talk to Prof. Pant is not only to bore you but also to tell you it is the threat what you have to see. USA needs F-35, why do I need?

I have two adversaries. Immediately breathing down my neck is on west side and at a distance breathing it on the east side. And you plan your strategy, plan your aircraft, plan your tactics. Do that, that is what we should do, okay. That is what, do not get swept away. I hope my example has helped you.

Should we use satellite technology in the

Quite a lot, quite a lot because today all navigation is satellite based navigation. And in fact, in future we have that GAGAN called Wide Area Augmentation System. As a result today you can have a all-weather takeoff and landing capability, precision

navigation what you call it, precision navigation. You can just land without in all weather conditions.

Do we use GPS systems in army?

We use, but now India is developing what you call IRNSS, Indian Remote Navigation System. In this whole zone that fellow he will replace the GPS. So now you can what you call home on to that fellow. Wide Area Augmentation System supported by IRNSS will make us independent.

As of today you are still using GPS. And you use what you call GLONASS okay. That is the kind. Interestingly the best receiver, GPS receiver made in the world is some small company sitting in Bangalore and it supplies all over the world, okay. That is the fellow who is supplying, okay. Some of the thing you may not know. But something interesting is happening, okay. Thank you.