Blues Skies Podcast
Season 1, Episode 42

LCA Part 1: Programme Overview with Air Marshal Philip Rajkumar

Tejas - First Flight - 04 Jan 2001

What just heard or video if you saw it on YouTube. It's a real audio from the first flight of India's light combat aircraft stages with Wing Commander Rajiv Kothyal on the controls almost 21 years ago to the day. Over the next few episodes, we're going to interview test pilots and a flight test engineer who were involved with the development of that impressive aircraft to learn what it was like to build a modern fourth generation fighter aircraft with little prior experience to go on, strap in and hold on because it's going to be quite a ride.

2:01
Ganapathy:
Hello and welcome to the Blue Skies Podcast. I'm PR Ganapathy, your host.

2:22
Ganapathy:
Our first interview in this series is with an old guest of the program, Marshal Philip Rajkumar, veteran test pilot and the head of the national flight test center (NFTC) that was set up specifically to manage the flight test program for the LCA Tejas. Let's welcome Air Marshal Rajkumar to the program.

2:43
Ganapathy:
Welcome again to the program, sir, for the third time. So nice of you to spend time with us today. We're going to be speaking about the Tejas, and we'll start off maybe with understanding the Airstaff requirement. I know you were the director of staff requirements. What was the air staff requirement like for the Tejas and you could take us from there. Your involvement with the project, which I think lasted for many years,

3:13
Air Marshal Philip Rajkumar :
It all started with the Subramaniam committee in 1969 which said that India should develop an Indigenous fighter because after the HF-24 Marut program, nothing had been done and the 70's

was a very turbulent period in India because of the Pokhran nuclear explosion and political instability and the Junta government and all that. So this whole thing went on the back burner. The IAF was looking for replacement for the Mig 21 and the Ajeet, the Ajeet fleet being the improved version of the Gnat. So the scientific community said we will be able to develop in the Indigenous fighters. And these talks went on between the DRDO, HAL and the IAF and the staff target was issued to form up the requirements, teams went out to Europe and the UK and four companies they visited, Mr. Smith, Bolkov Blom in Germany, Dasso in France, SAAB in Sweden, British Aerospace in the UK. Early Delta wing design was sort of firmed up. And though there was a lot of, what shall I say, bickering between the Air Force and DRDO and HAL And all that, eventually the program, it was decided that we'll go ahead with the program. The government decided then. I've written about all this in the book.

5:24
Ganapathy:
Yes, of course. And I'll add a link to the book, which is just a great detailed exposition of what it takes to build. But one question for you, sir, when a fighting arm like the Air Force is thinking about its requirement, it's thinking maybe 2030 years ahead and it's looking at the threat environment, it's looking at the sort of aircraft that our enemies are getting and they are developing that requirement now. It just boggles the mind to see how far ahead one has to think and plan when developing some of these requirements. It's just really Crystal ball, very futuristic thinking that's required. How does that happen?

6:12
Air Marshal Philip Rajkumar :
Yeah. So it needs a certain vision. It needs an intelligence of what the other countries are doing, mainly our countries opposed to us. How far will they get ahead? And you must have a good grasp of which way technology is headed. So fortunately for us, we chose to use the digital flight control Fly-By-Wire system. We chose that which was to become a world standard now and also the digital avionics. So the cockpits, all the round dial instruments vanished and screens came into the cockpit. But essentially it is a slight matter of understanding technology, understanding which way Aeronautics is moving. It can't be done by any single organization. It needs the industry, it needs the R&D establishment. It needs the user service.
The user service is focused on the front line. The industry is focused on ease of manufacture. R&D wants to develop the latest technologies. So there is always a lot of, what should I say, interaction between these agencies, all of which is not always cordial. There's a little bit of bickering in between. Anyway, finally ADA (Aeronautical development Agency) was set up in 1984

7:54
Ganapathy:
Let me ask you that question of why a separate agency felt necessary and not just entrust HAL with the prime contractor job or the prime development job.

Air Marshal Philip Rajkumar :
You see, for so many years, right through the 70s and the half of the 80s, HAL had made no move to acquire any of these new technologies. That is, flyby technology, composite technology, glass cockpit technology. There was no move by HAL and HAL. I feel it is always stymied by the fact that unless a project meant for the services sanctioned by the government, they don't undertake independent R& D because of fund constraints, financial constraints, it's all controlled by the Ministry of Defense production. The chairman of HAL reports to the Ministry of Defense Production and the R&D environment wasn't there. And the DRDO at that time had a very powerful scientific advisor called Dr. Arunachalam. He was on a very good wicket with the government of the day and he was able to persuade them that we need an independent organization with a special financial path, special policies to be able to take on a task like this. It required the harnessing of national capabilities across a whole range of technologies, requiring the involvement of many agencies. Eventually something like 300 industries and organizations have participated in the program. So for all these reasons ADA was set up and for the project definition phase, DASO was chosen as a partner. DASO people came down in 87 and sat here for a year and produced a 1000 page document which was called the PDP .They worked with a team of ADA and HAL engineers to produce this document. This document reached the Air HQ where my old friend Air Cmde Krishnaswamy was director of staff requirements. He and the plans branch put out 300 page observations, all the drawbacks in the suggested project definition. And it says quite categorically that in the time and cost mentioned in the report, it will be impossible to develop an aircraft of this capability. So to resolve this, another committee was set up. And even after six sittings the Air Force did not change its mind. But since a lot of work had already taken place, therefore said, we will allow you to go ahead with the technology demonstration program. You please prove these four technologies, fly by wire, composite material, glass cockpit and digital monitoring, health monitoring of systems. So that's what happened: the Air Force gave it okay for the technology demonstration program. And then we took the help of Prime Minister Rajiv Gandhi who had gone to the United States as Prime Minister and met President Ronald Reagan and he had asked for help in the LCA program. And Regan really agreed. We got the American engines and Lockheed Martin The American company helped us with the development of the fly by wire system. Right. ADE, the Aeronautical Development Establishment in Bangalore was the nodal agency for the fly by wire, National Aerospace Laboratory has also got into the act and a national control law team was formed. And the fly by wire control law was developed by this team

12:58
Ganapathy:
Right. So just in very late terms, if you can explain what control law is and why it needs to be developed, how is it developed?

Air Marshal Philip Rajkumar :
Yeah. Now the control law basically decides how much the controls have to be deflected in flight for a particular flight condition to meet pilot demand. So there's something called gain. Gain is the amount of control deflection that the system will allow depending on flight

condition. Now, you understand that at low speeds, you need large control deflections. Now, at high speed, you apply those same large control deflections, you're asking for serious trouble. So you have to make sure that these control movements are tailored to meet flight conditions and pilot demand. Of course, pilot demand also doesn't go beyond a certain limit because limitations are put in place to avoid exceeding angle of attack limits, G limits, speed limits, and so on. Right. The other thing is fly by wire makes flying extremely safe because it prevents people from getting into trouble because of the limiters I spoke about. At the same time, it brings below average pilots up to a certain level and very exceptional pilots also brought down to a certain level, everybody will be able to extract the same performance from an aircraft. It's sort of a great leveller of skills. Otherwise, there was always this thing about so and so and so Pilot is a hot shot pilot, and he does wonderful things as an aircraft which others cannot do. But with the fly wire system. By and large, everybody will be able to do the same thing.

15:15
Ganapathy:
Hmm, And for us as an Air Force, the Mirage 2000 was our first fly by wire aircraft. And I don't know why. The LCA seems to have a lot of inspiration from the Mirage 2000, would you say that's correct?

Air Marshal Philip Rajkumar :
Yes. For starters, both are from the Dassault stable. Remember, LCA also, the project definition was done by Dassault. That's right. Yeah. So they're very fond of the Delta platform right from the Mirage-III days. And the LCA is slightly different in that it is a crank Delta. It's got two sweeps, a shallow sweep in the beginning and a greater sweep after the mid portion of the wind. It's called a compound Delta. And the other thing was the Mirage 2000 has got an analog flyby wire in which the computer is a hard wired analog computer, whereas the LCA flight control computer is a digital computer, which is software control hardware. Hardired computers are very difficult to reprogram, whereas the LCA digital flight control system can be reprogrammed fairly easily. You can play around with the control law. It's much easier than in an analog system.

16:44
Ganapathy
And I think your book has some examples of where a new piece of software was developed and then uploaded into the aircraft just minutes before or days before a particular critical demo or a flight, and just shows the flexibility that a digital system can provide.

Air Marshal Philip Rajkumar :
Yeah, I've written about it because when we went to the Bahrain Air show in 2016, that's what happened. The software was changed to give the full capability to the demonstration pilots. 8G Capability was given. Yeah. After this, the technology demonstration program

started. Initially, the ADA signed up Flight test agreement with HAL. They said HAL will do the flight testing of the prototypes. But between 91 and 94, nothing much happened because the aircraft hadn't been built. There was nothing to do. And others felt that a stage of development had been reached for full time involvement of Flight Test school is required. So that is why the National Flight Center was formed. And I was pulled out from Vayu Bhavan and sent here. So that is a big story.

18:24
Ganapathy :
So you had a dedicated set of test pilots and flight test engineers who are only dedicated to the LCA ?

Air Marshal Philip Rajkumar :
It was a small group, but we had nothing else on our plate. We had no secondary duties. We had nothing else to look at, and we only had to go ice down on the LCA. And we interacted very regularly with the control law team , glass cockpit team and the general system designers. We had to develop the flying manual. We had to sit with the engineers and discuss the emergencies, develop the emergency checklist, the normal checklist, the emergency checklist. And we had to do a lot of work on the simulator to check out various versions of the control law as they were coming out. And we went to the company called Calspan in Buffalo, New York to try out the control laws, first on the Lear jet, then on the T-33, and then the F-16. So those evaluations gave us a lot of confidence that we were going on the right track.

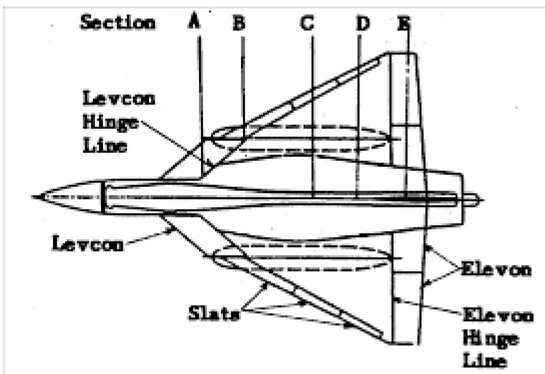
19:39
Ganapathy:
Right. So I was reading that, and it just boggles the mind that you can use one aircraft control laws on another aircraft to test its effectiveness. How does that work?

19:50
Air Marshal Philip Rajkumar :
Yeah. Now, the handling qualities that the pilot experiences depends on the behavior of the aircraft. In the first, second or two after he makes a control input, how does the aircraft respond to a control input? That is his main criteria in assessing handling qualities Because the aircraft is a different planform, the steady state response, of course, will be different. Now, the control law can only be checked out within the flight envelope of the mother aircraft. So keeping these things in mind, you can make a good evaluation of the efficacy of a control law by assessing its handling qualities against standard rating scale called the Cooper-Harper Rating Scale, where the ease of handling, the ease of performing a mission are all given various ratings from one to ten means you will crash the aircraft, one means it excellent. It doesn't need any change. The idea is to get it into a bracket of either one, two, or at first three, which meets both handling requirements as well as mission requirements. So there's a lot of subjective thinking there. So each pilot has his own opinion. So we had to

make out something like ISO opinion plots and so on and see which was acceptable to everybody. Interesting exercise. And finally, the big blow was after the Pokhran explosions of 1998. The United States and all the Western Nations withdrew all support. So we were left high and dry. Even some of the equipment which was lying with Lockheed Martin in New York, was impounded. Our scientists were sent back and we were all well and truly on our own. And in spite of that, we managed to fly the aircraft in January 2001, even though US sanctions had been in place for 31 months before first flight. Right.

22:24
Ganapathy:
I'm going to come back to the first flight, but before that, you talk a lot about this iron bird. What is the iron bird and what use was it in this testing process?

22:36
Air Marshal Philip Rajkumar :
Yeah. Now, the way the fly-by-wire system is developed is you first develop a control law and try it out on the simulator. The pilots evaluate it in the simulator. We, of course, went one step further. We made a small simulator in NAL itself where first cut evaluation was done by test, where it was attached to the NAL team. And then after that initial refinement process, the control log came to the main simulator at ADE. It was tested by the test pilots. Now, we are okay, we know that the aircraft is behaving properly. Now, how do you know how the whole system will work? Now, the system consists of hydraulic actuators. You have hydraulic pumps pumping hydraulic parts with hydraulic actuators. You have other services being operated like the undercarriage and the airbrakes. Then you have all the warnings of the flight control system coming out on the screen. So their warnings have to go through the mission computer. So how do you check out all of this before going on to the aircraft? So you build an iron bird, which is basically in the LCA’s case. It's a triangular metal frame sort of grouted onto the ground. And then on which all these actuators are fitted, the elevon actuators, the air brake actuators, the rudder actuator, the undercarriage, the air brakes, everything. The mission computer is modeled. A software model of the mission computer is put in place and then the flight control computer is also put there. And then a basic model called a point mass model of the aircraft is made available to the iron bird. And the pilot cockpit is also given the pilot can sit in the cockpit and fly the aircraft and operate the actuators by moving the stick and the rudders. See how the



Various flight control surfaces in a Delta Wing Aircraft.
Image courtesy : [Delhi Defence Review]

actuators operate? Undercarriage operates. Now, when the undercarriage is sucking in a lot of hydraulic power, is there enough hydraulic power left to operate the flight controls? And then the various failure States. What if one hydraulic pump fails? What if one elevon fails? All those matrix of tests are done on the ironbird. When you finally take this whole hardware onto the aircraft, you have a fair amount of confidence that the system as a whole works well. And then we did one more test. We put the flight control computer for 50 hours of fault free running. We ran it continuously for 50 hours to make sure that it didn't fail. In between, we use that same computer for the first flight. Ironbird is a standard technique for checking out fly by wire systems where all the components of the flight control system are put in place and checked out in unison as it would happen on the actual aircraft. So that's the iron bird.

26:32
Ganapathy:
Let me ask you a couple of questions. When I think about it as a management problem, which is twofold. One is you have all these agencies and I saw in your book from the central vehicle establishment that makes stuff for tanks, they were developing something for you and all sorts of CSIR labs all over the country. What management process do you follow to make sure they're all harmonizing? So what one person develops, talks to or fits in with the equipment somebody else has developed, they're doing it on the right time schedule. The testing of components as well as the system as a whole is happening. What processes were you following to just keep this whole Orchestra playing together from the same sheet of music and getting their timing right?

27:20
Air Marshal Philip Rajkumar :
So the master conductor of this Orchestra was Dr Kota Harinarayananhe did a magnificent job as program director he was the man who was sort of having an overview on all these developments and of course the various project directors were directly involved with each of these agencies and the certification agency CEMILAC (center for military airworthiness and certification) their scientists were also involved when HAL was developing some system it was very easy because HAL was an aeronautical company so they knew all the aeronautical quality requirements and so on but some of the other civilian agencies they have to be brought up to speed so this was a huge multidisciplinary exercise and it took time now everybody says LCA it took so long, it took too long when you start with zero base you try to build from scratch it takes time and this happens in every country I told you the French were already flying a fly by wire system in 1972 before they flew the Mirage in 1980 we were

trying to do everything in one go because we had not done anything for 30 years and naturally all this took time and also there was a great time we could have bought out a lot of these items off the shelf from Western agencies but a conscious decision was taken to Indigenous to the maximum extent possible personally because when the sanctions hit us we said listen, this is not the way to go these guys will always put the squeeze on us so it is better to be independent to the extent possible So that is why this massive exercise of Indigenous by Doctor Kota with the full backing of Doctor Kalam and the subsequent scientific advisers

29:41

Ganapathy:

Second question was which is kind of a lead off from your answer is, your book is just full of this exceptional talent women, men from all over the country who've just given their lives to the project and learned so much as a result of their engagement with the project So what did you do to attract, train, retain talent to inspire people to pull together in this Grand National project?

Air Marshal Philip Rajkumar :

You know the strange thing is that this group of people who didn't even know each other got together and they got motivated by the scale of the project and the challenge A lot of young people came and joined the program because they wanted something challenging I've quoted the example of Nitin Jadhav who is now the director of NALI he had a very good job in BEL (Bharat Electronics) but he gave up and came and took up a position at the lower salary saying that I want challenge, I want something challenging and he did a great job with ADA for about 15-16 years before going to NAL so people get motivated by challenges that is one thing the second thing is there is a huge untapped potential amongst the women of India they are very sincere, they are very dedicated, they're very intelligent and others made the conscious attempt to tap into that source as well and they made a big contribution.
The other thing is anybody who came there over a period of time got fired up. I've seen that in NFTC, I've seen it with other scientists. Anybody who is given a big challenge, we must do it, we must achieve it. And also the leadership provided by Doctor Kota Harinarayana was instrumental in firing the imagination of people. Because you say come on, of course we can do it, we can do it, we can do it. This lot we can do was hammered into the heads of the entire team. I will give full credit for doing that.

32:20

Ganapathy:

So now the related question is how do we ensure that this capability that has been built up is both passed on as well as preserved, enhanced and we don't go into another long period of cold storage where we lose these skills and these talents.

Air Marshal Philip Rajkumar :

We started with our virtual zero base, now we've reached a certain level and to go to the next level we need more projects. And so those projects have to be on the anvil, the TEDBF (Twin Engined Deck based fighter) the LCA Mk2, the advanced medium combat aircraft, they're all in the pipeline and I hope the personal policy is followed by DRDO allow the retention of talent and similarly NFTC also has to retain talent. We can't forever be depending on people, on deputation. A lot of changes are required for this to tap into this, what do you call it? Capability which has been developed at such enormous cost and time? I wouldn't say cost too much of course, because the whole project from start to finish (1986-2020) we spent only 14,293 crores (INR) considering the amount spoken of in newspapers, about the thousands of crores which are non performing assets in banks and the thousands of crores being scammed by scamsters spending 14,293 crs the country has established a firm aeronautical base. It put an aircraft fourth generation fighter into service. A 5000 sortie test program has been conducted safely. So I think the return on spending that money has been enormous and also because most of it, more than 50% of it has been spent in the country in building up infrastructure in the country, mainly in HAL. So it's money extremely well spent.If you remember your College math, there's something called transfer functions. There is an input and an output. The transfer function in this program was very high. You put in something and you got far more out of it.

35:08
Ganapathy:
Yeah. And we've seen from your book that there's a lot of private sector involvement too. So there's capability that was built there and the culture of building everything in house I think was broken. And you involved the private sector and their innovative capabilities.

Air Marshal Philip Rajkumar :
Yes the private sector has a problem because if they depend only on orders from the indigenousl aeronautical industry they may not be able to sustain themselves. Volumes matter so they have to get into the export market and we get into the export market. They have to be competitive in both design quality and price. So the Indian industry is slowly trying to get there, but it's going to take time.

35:55
Ganapathy:
Two major areas of where we could have done better, the engine and the radar. What is your assessment of why it's been so difficult to develop an engine for this aircraft, and what do we need to do to get to that point?

Air Marshal Philip Rajkumar :
I'll start with the radar first. The radar, though we didn't succeed with the mechanically scanned array radar, which is now flying in the LCA, the phased array radar (UTTAM)

UTTAM Aesa Radar. Photo from Wikipedia

which is already undergoing flight trials, I think we've cracked the radar problem. On the radar side, we should be all right. The engine is one of the most complex pieces of engineering that you can think of. A large number of disciplines involved. You have aerodynamics, thermodynamics, metallurgy, hardware, software, all kinds of disciplines have come together. Now, one of the mistakes we made is we didn't do anything and wanted to do something very big. Having never built an engine, we wanted to build an eight kiloton engine. So that, I think, was a flawed adoption. Second is in spite of all that, we managed to do about 55 or 60 hours in the flying test within Russia, and we should have taken that to the logical conclusion, completed the 100 hr test program that we had, taken care of all the problems, and then put it into an LCA airframe and flown it. Forget about the performance. This flight in an aircraft doesn't matter if it doesn't go as high or as fast as possible, but at least you'll get confidence. You will get a lot of data on behavioral, engine and actual flight at various speeds. So part of the thing is we were too ambitious and we didn't manage the program.

38:22
Ganapathy:
Great. Sir, I've taken so much of your time, but I want you to just recall two specific moments. The first is the first flight. You chaired the committee. There were all sorts of questions and concerns, but you took the executive call to say, hey, we've gone over this stuff. I think we're ready. Let's do it. And you know your experience of the first flight and then your flight in a Tejas when you flew it, which you've described in your book. I'd love for you to just put us on your shoulder during these two moments, the decision and the first flight, as well as your flight in a Tejas.

Air Marshal Philip Rajkumar :
Yeah. Now, about a year before the first flight, Dr. Kota set up something called the Flight Readiness Review Board. This is something we learned from the Americans before they fly a prototype. They have this Flight Readiness Review Board, which consists mainly of outsiders. They come and take a very close look at what all has gone on, and then they give

a verdict on whether they think something needs to be changed or not changed. So we put together this pool of outside experts on the flight controls. We had Dr. BN Suresh who came from the Vikram Sarabhai space center. Then we had scientists coming from Hyderabad, from the various DRDO laboratories in Hyderabad .Experts, academics from IIT Bombay, Indian Institute of science, IIT Madras, IIT Kharagpur and so on. And all these experts came together. Then they went through all that had gone on with a fine tooth comb. And finally, during this time, while all this FRRB work was going on, the aircraft got ready and we started the taxi runs and in a graded manner. We had gone up to 200 km/hr . And before going any further, we had to decide whether the aircraft was to fly because there was always a danger of an accidental first flight, as it happened in the case of the F-16. We went through this whole motion for a full year. And at the same time, while FRRB was looking at it, the certification agency CEMILAC was also extremely busy because they had to go through a huge pile of documents, each item which had been developed as its own design documents. And they had to study through these documents and they had to certify. They had to come out with something called an FCN flight certification note, which CE, CEMILAC had to sign. Now, CE CEMILAC said, I want Dr. Kota and the general manager of the HAL design also signed. So Mr. Srivatsan and doctor Kota and Mr. Nagaraj, the CE CEMILAC, signed this flight clearance note. And finally, the call to whether to fly or not was with NFTC. So Dr. Kota said, you be the chairman of the FRRB because you're the one who's going to fly. So I said, all right. And I followed the proceedings of the FRRB for a full year. And at the final meeting at the end of 24th December, 2000, I had even called chief Marshal Tipnis to come for that. And after listening to everybody, Dr. BN Suresh said the flight control is fine.
Mr. Prasad said the software is fine. Some of the professors and IISC signed, cleared their systems. And then, of course, a first flight is always a leap of faith. You have to believe that the thing will fly. And somebody had to take that call. So I bit the bullet and said that we can begin the high speed steering and taxi runs leading to the first flight.. And finally, on 31st December, I said, yes. Now we are ready to go. Now, on the day of the first flight, when I went with Kothyal to the aircraft, the DG Aeronautical quality assurance had to sign the release for the flight document. It's called the form 1090. Right now the Inspector was standing there and he said, I want you to sign. So I said, okay, I'll sign it. I'm quite confident it'll fly. So I signed it. And I think this is the first and probably the only time a serving Air Marshal signed the release for flight of a prototype. So that was the thing. And then finally, unfortunately, when I retired at the age of 62 from ADA, there was no trainer and I wasn't able to fly it. Though I had done a lot of flying on the simulator and the inflight simulation aircraft, I had to flow on the Tejas. So when I was writing, when I almost finished writing the book, I approached Dr. Sateesh Reddy, director general of DRDO One of his visits to Bangalore. And I said, I want to fly because in the meantime Tejas was giving joy rights to journalists at AeroIndia in Yelahanka, at that time even the Badminton player PV Sindhu had got a ride and I said, what the hell is this, SIndhu has had a flight and I haven't had a flight. Right. I requested Dr. Reddy. He said, Go ahead and fly. So I flew it. And when I sat in the cockpit, I said, my God, what a long way we have come from. Where the airplane was when I was there, the manufacturing finish was better. The glass was a full glass cockpit. The ergonomics was very good. The placement of the levers and switches and all that. When I taxied the aircraft, the nose wheel steer and the brakes and everything was functioning very well. And then the aircraft handled very well. Then I looked at some of the weapon naming modes that were impressive. I did a wee bit of handling. Now, I hadn't flown for about 20

years, so I wasn't too. And I was also 78 years old, so I didn't want to tax my 78 year old ticker by pulling G. I just did a roll and a barrel roll because I didn't want to do a loop, because loop, you probably have pulled 5G. And finally, when we fed in the autopilot, I checked out the autopilot functions and finally we did an autopilot, hooked on the autopilot to the ILS and fed into the ILS and landed off the ILS. Of course, I didn't do the landing. The front pilot Gp. Capt Deepak did it, but it's a different class of Airplane. It's something extraordinary compared to the MiG 21. It's far superior in every metric.

47:10
Ganapathy:
You must feel a deep sense of satisfaction. You would have got to have seen it to this point.

Air Marshal Philip Rajkumar :
Yeah. And one more thing. I must say that the LCA program is the one aeronautical program which has had the maximum amount of criticism and attacks by all and Sundry by the print media, by the electronic media, by journalists, by analysts, by everybody but everybody. My request to all those people is please read ‘Radiance in Indian Skies’.

47:48
Ganapathy:
Yeah. Fully recommend that. Riveting reads from cover to cover. It's a really lovely book. Very well put together. Thank you so much for speaking today, sir. It's just been a delight to go over this ground with you and want to thank you again for your service. And thank you for your time today.

Air Marshal Philip Rajkumar :
Thank you for giving me this opportunity.

Well folks that’s all we have time for this week. Join us again next week. In the meantime sign up for updates at https://blueskiespodcast.com/.

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