Blues Skies Podcast
Season 1, Episode 46

LCA Part 5 - PK Raveendran - Flight Test Engineer for the LCA

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

1:01
Ganapathy:
In this episode, I'm really happy to be able to interview a past guest to the program Wing Commander PK Raveendran, who you would recall, trained as a flight test engineer at Epner in France and then participated in a lot of flight testing throughout the Air Force. Commander Raveendran was then selected to participate in the LCA program as a flight test engineer. And that's where we are going to pick up the threads within them. I'm sure you're going to enjoy this conversation.

So fast forward a little bit, sir. You've had a very fulfilling career in the Air Force. And then Marshal Rajkumar called you about the LCA project. What was that initial call like and what was your thinking when he invited you to join that program?

Wing Cdr. Raveendran:
My last posting was Sulur from Tezpur. I got posted to Sulur. I was the senior most Wing Cdr there in the station, and I was in charge of the HS-748 Avro Check 2 service. It's a pretty major kind of a thing. But then I missed my rank. Also, I didn't sort of make it to Gp. Cpt rank. I was seriously considering quitting. Okay. Leaving. That's the time I got an offer. Also, there was some airline coming up in Pune, and they said, okay, we are looking for somebody like you. You maintain our aeroplane. Fly as much as you want. I thought nothing but seriously, because my licence was current at that point. I had a commercial licence by then. And Dr. Ramchand actually sort of supported my flying kind of thing anyway. Okay. So then I got this call from Air Marshal Philip Rajkumar. He was in Delhi at that time. So you said, I'm starting something, called the National Flight Centre to flight test this thing. I want you to join me as lead flight test engineer. So I said, yes, sir. And then I landed up. I never regretted that decision.

3:30
Ganapathy:
Right. Besides both of you being from Epner, you must have also served together, right? I'm

sure

Wing Cdr. Raveendran:
Yeah. When I came back, he was in ASTE (Aircraft and systems testing establishment), and I served under him in Test Pilots school.

Ganapathy:
What stage was the project at when you joined NFTC ?

03:45
Wing Cdr. Raveendran:
In 1995 I joined. By then there was already a small team in place, and we used to see so many days to the first flight. But there is some kind of a pressure and very aggressive kind of a schedule the initial team. They were sort of working very closely with the control law team. Okay. There were pilots from the Air Force, two pilots from the Air Force, and two pilots from the HAL and some scientists from ADA attached. Actually, we had three functional entities. And let me see, there is a flight test operation, there's the flight test engineering and then flight instrumentation. So initial days are a flight operation sandwiched by flight test engineers and flight test Pilots. Okay. In the initial days, the instrumentation both onboard as well as the telemetry ground segments were handled by HAL. But progressively we took it over and then it was under me as a group director. Okay. The initial set of test crew, they spend a considerable amount of time interfacing with the control law team headed by that time Mr. Sreenath Kumar. So under him the entire control law team was working and the flight test pilots and flight engineers. At that time they were interfacing the control law team, giving them basically that the thing was a fine tune handling quality. And this was done on various simulation platforms. We had the engineer in the loop simulator, then RTS, it's called a real time simulator, which was in ADE. And later they even validated these things on IFS. IFS is In Flight Simulation which is a Vista platform, Vista is an F-16 modified. That means the front pilot can fly the aeroplane which you want to fly. That means like Control Law, you could Port it on that and the front guy flies it. In case something happens, the rear guy can take over and land it as an F-16.

6:28
Ganapathy:
Wow. Just boggles my mind when I think about that. These are all done in the US, isn't it?

Wing Cdr. Raveendran:
Yeah. And Tejas has a record of the maximum number of test pilots flying the aeroplane during the development stage. Okay. And I think I have spoken to most of them. They said it was the best aeroplane we have ever flown. The flying quality was the real USP of that aeroplane. So that best testimony to the excellent quality of professional input which has gone into the development of the Control Law

07:11
Ganapathy:
And especially since a lot of them came from the Mirage-2000, which itself is very highly regarded for its handling qualities, isn't it?

Wing Cdr. Raveendran:
Actually, the NFTC has the benefit of people from various backgrounds, so various backgrounds, various types of different nationalities and all that. So we could get the best input from everyone and integrate everybody who has given their bit and that's how it has come out as one of the best aeroplanes, which Air Chief (RKS Bhaduria) says is the best aircraft in the class. He was very closely involved also at that stage. The kind of inputs he has given at various stages is amazing.

8:02
Ganapathy:
Now, a lot of the things that you developed, instrumentation, telemetry, you built these yourself from scratch instead of just buying stuff off the shelf, is that right?

Wing Cdr. Raveendran:
Absolutely. Initially we had some kind of a system to start with. Okay. Like our tracking antenna was supplied by ISRO then we had a PCLD Com system, they call it for handling the data. So all that we upgraded over a period of time.. So see the kind of preparatory work which you are done initial days was first task was we used to sit with the designers, design group to get their flights requirements, these flights requirements, we convert it into test points and that test points gets into a test point database and also we used to take the parameter requirements from them, and that goes as an input into instrumentation requirements. And then we were preparing draft flight schedules for engine, ground run, low speed taxi test and high speed test. High speed taxi test. Okay, then for the preparation of telemetry SOP we need a standard operating procedure for the whole telemetry. So we have to make a document. And we also made a communication protocol document. Communication means who will talk to whom? Who has got the priority? Only the test director will talk to the test pilot. Okay. None of the monitoring guys can talk to him directly. If there is a problem, he only alerts me. And then if there is a serious enough problem, then I take over his page. And then at the end, if there is a safety issue involved and something building up, then we have to recover very quickly. That kind of action is taken. Okay. Then design and implementation system wise, monitoring screens. That was another task which you're taking. And finally the training and clearance of monitoring personnel. We didn't have the luxury of the flight risk engineers sufficient number to man all the screens. So we were using the designers for that. They know everything about that. But then they are not used to this high pressure environment of flight testing. We had to give them special training, and then we had to clear them specifically because they should not panic when something

happens and all that.

10:47
Ganapathy:
Okay. Now for the audience who don't understand what this means, it's a bit like space shuttle control in Houston where there are many screens, many people. Each one is monitoring their own system. Absolutely. So just describe that a little bit for us.

Wing Cdr. Raveendran:
Yeah. See, the test director is sitting on an elevated platform and he's supported by all these system monitoring personnel, each one very closely monitoring his or her system.

Ganapathy:
And by system, just what do you mean?

Wing Cdr. Raveendran:
System means an aeroplane has got different systems, like aerodynamics. It's not a physical system, but yes, aerodynamics. All the parameters coming out of, like, air speed, altitude, these kinds of things. Other one, like engines, propulsion, propulsion systems. That's one system. Then you have an electrical system. There are electrical power sources on the aeroplane, like generators. So electrical is another system. Fuel, hydraulics. Then ECS is an environmental control system, then an armament system. Then your avionics, communication system. Each one is a system to be sort of closely monitored.

12:16
Ganapathy:
So there's one dedicated person per screen. They're just monitoring. Absolutely hundreds of parameters about that system ?

Wing Cdr. Raveendran:
Absolutely.

Ganapathy:
And this data is coming via telemetry, right?

Wing Cdr. Raveendran:
It's coming via telemetry to the ground station. There it is processed and then pumped up to the telemetry monitoring group. Then there are a number of things because I was there on this program for a good 20 years. So quite a lot of things I could do. He also got this lead time because we had these aggressive schedules predicted so that Lag was sort of we could utilise it for doing various things. Like we updated our flight test techniques. This is very interesting work, which you have done in the initial days. We developed a GPS based method of air data calibration and flow angle sensor. Flow angle sensor means angle of attack and side slip. Okay. Calibration using an onboard system.This was never done before, so we developed this in a joint project between NFTC and ASTE. It is done on a Jaguar. So within one acceleration, you could get the calibration for covering the entire

speed range, which was not done before. So this was a real solid upgradation of our flight technique as far as the air data calibration was concerned. Okay. So, like the other one is upgrading the telemetry monitoring room telemetry tracking antenna, which I mentioned to you, the antenna itself. Okay. Then we developed state of the art mobile telemetry. That means like a scale down version of what you see in the normal telemetry you design and then package the whole thing on a mobile, like on a Leyland truck. And there you can do the same thing. You can drive this particular thing to an outstation location. We had to go to our station location for environmental trials and weapon trials and all that. So this mobile telemetry to be driven to that location. And then we also establish fibre optic connectivity and the satellite connectivity of the data from there. And at some stage, it was like aircraft could be flying, maybe say, Jamnagar or whatever, but you could sit and monitor everything in Bangalore.

Ganapathy:
Oh, wow.

14:43
Wing Cdr. Raveendran:
All the entire data is coming through fibre optics or satellite. Okay, so these kinds of things we could do, and that is why we developed the best telemetry available in the country. Then we also established what is called SBTF in Goa. It stands for Shore based Test Facility for the N-LCA (Naval LCA)

15:15
Ganapathy:
You designed that whole thing yourself?.

Wing Cdr. Raveendran:
SBTF is basically a very specialist kind of a replication of what we had as far as the flight test monitoring was concerned. Apart from that, we had Ramp take off and the arrested recovery, those were not done by me per se, but only the data from there we could capture. It was all done by some dedicated, some contracts with some maybe Russians were involved in that. But when it comes to taking the data from there for analysis purposes, that particular bit was introduced by us. Okay. Yeah. Then we also developed something called I-TRAC. When the aeroplane is flying in the sector, the Lat Long and the height of the aeroplane is available through telemetry. It comes to the monitoring station. So we had a scan map on this small aeroplane that will show the position of the thing. So I still remember an interesting thing. When these people are approaching the boundary or the sector boundaries, I used to tell them to turn around and all that so ATC these days there is one Mr. Iyer. Iyer used to monitor this. He was very curious one day he asked me do you have a radar? I said yeah I have a radar but not the type you have and also he came to see this so when he saw that he said after that he went back very satisfied that okay LCA is in very safe hands. Then one more thing we developed a GPS based radio sound what is radio sound for some special test we need very accurate operator data earlier days the separate data used to come from the what

do you call IMD (Indian Meteorological Department) okay and they had a very antiquated kind of testing they used to radio sound they used to release it and all that and they used to try to track it with radar and all that it is a very messy thing and it never used to be available so we developed what is called we put a small GPS sensor in that in the radio sound and put sensor and all to capture the pressure, temperature and release it and with a small transmitter so essentially it gives you positions so you're not dependent on and this particular GPS it's a won an award Aeronautical Society award for Indigenous and Mr. David he's the one who has done it I given the scheme so we both share that Society award

18:22
Ganapathy:
You've shared with me the video of the first flight I think at this point maybe it's a good idea for us to just listen to the audio of the first flight and for YouTube viewers they can also view the video of the first flight

https://www.youtube.com/watch?v=U_7HGD61wLQ

But you were in the control station.

19:45
Wing Cdr. Raveendran:
Yeah, I was with the test director to tell me preparations leading up to the first flight the day of the first flight.

Ganapathy:
What did it feel like and when you gave that clear takeoff signal what was going through your mind? What are some of the feelings?

Wing Cdr. Raveendran:
We had a lot of time to prepare because time was and it was thoroughly prepared we didn't leave anything to chance that way leading up to first flight we had a number of reviews like safety review system safety review then we had what is called FFRR (first flight readiness review) okay anybody can ask any question to anybody and since I can get a very satisfactory answer we don't proceed whatever we could possibly think of we have sort of raised these issues and then we documented and then try to find solution to any eventuality that kind of thing so we had a thorough preparation. Then before going for first flight we had what is called a what if session that means what if this happens that kind of thing anyone can ask you what if this happens this is to be done this happens or this to be done and also the first flight profile was flown by a number of times it was flown in RTS (Real Time Simulator) system. And we checked out. And after the first flight, even the fuel recordings which we got from the simulations were absolutely matching the first flight. To that extent, it was rehearsed and it was absolutely truthful, kind of a reproduction of. Okay, then I told you about the communication protocol that was set up. SOP we had put in place. Then we had a very well laid out procedure for going forward. For each flight, we prepare a schedule. Flight test engineer prepares a schedule. It's signed by the test pilot also, and then coordinated by the certification.

21:45
Ganapathy:
What is the schedule like?

Wing Cdr. Raveendran:
Schedule means it will contain all the test points. Okay. Starting from checks and startup checks, and then everything. Everything is there in that.

Ganapathy:
How many pages?

Wing Cdr. Raveendran:
No, actually, it's about one or two pages only, but details are available elsewhere. But you make the schedule and then it is briefed. The schedule is briefed from the day of the flight. Briefing is done by the test director. Okay. And test pilots cover the safety aspects also in that. And along with that. What do you call the chase? There are some tests that will have Chase aeroplane chase pilots also in attendance. Okay. So that is how then we move to test director moves to telemetry and test pilots goes to the aircraft. Then the flight test process takes place. Each test point is specified. Then it is monitored in the telemetry, and then you give him the clearance, like, for example, there are some tests like flutter test, et cetera. I'll come to that later

23:01
Ganapathy:
Yeah, I know. I want to understand what a flutter test is.

Wing Cdr. Raveendran:
Then immediately after the flight, we do what is called a hot debrief. Okay? Everyone moved to the briefing hall, and each individual was taken. He gives his first impression of that. That's called hot debrief. Then we disperse. Then earlier, it used to take a day. So then data is prepared and analysed by the designers. And then we have what is called data debrief. That's a very detailed briefing session. In the data debrief only we decide whether we can go ahead with the next flight or not, or are there any serious issues to be addressed? And whatever observations from the flights, it gets converted into what is called RFA. RFA stands for ‘requests for action’. That means if there is an observation pertaining to one particular system, it gets recorded in an RFA and it is passed on to that system group and they have to give a solution to it. Then NFTC can only close at RFA. Once we are satisfied that particular issue has been taken care of, then we close at RFA. So this RFA thing came as a very good aid for the certification guys also. So the stage came. They used to ask the designers how many NFTC RFA’s are pending? Then we will clear your writing. So we put some very good systems in place. So it is working well.

24:41
Ganapathy:
Okay. So coming back to the first flight, he (the pilot Wing Cdr. Rajeev Kothyal) walked to the aircraft, started up. What was going through your mind? Were you excited?

Wing Cdr. Raveendran:
Not really. Once you sit there, because we have been through this process, except that he has not taken off. You understand what I'm thinking? Yeah, once you're sitting there, but then you get into that routine. I won't ever say routine because I am dead against using the word routine for flight. It is like any other operation. So there is no other time to think of anything else. And then you go down to the thing. Yes. You must be aware Air Marshal Rajkumar has written because unfortunately, we lost a telemetry link. Yeah. That reason was very funny. What has happened was there are some stealthily. Somebody was using their frequency and the moment the aeroplane took off, the Antenna swung to that and we lost the link.

25:46
Ganapathy:
So, yeah, for the audience who don't understand, telemetry antenna tracks the aircraft. And because somebody else has a software technology Park, I think that's the same frequency. So your antenna turned towards them. And obviously this first flight must have caused a lot of nervousness, but you gave them the thumbs up to continue because.

Wing Cdr. Raveendran:
Yeah. Air Marshal P Rajkumar was sitting there also next to me, then Nambiar was flying the Mirage. So he closed in and then started monitoring very closely from external kinds of whatever you can, and then provided this thing. And then we decided because the whole fight was about 18 minutes. And then again when we were coming back for landing, we got the telemetry link back. That was a bit of a let down.

26:44
Ganapathy:
So tell me about flutter testing. What is flutter testing?

Wing Cdr. Raveendran:
Flutter? Yeah. Okay. You see flutter, it's an aeroelastic phenomenon of structural response to inertial, elastic and aerodynamic forces in flight. Okay. What happens is aeroplane structure has got everything has got a mode like, say, if you knock on your table or something, make

some noise, that means it's vibrating at some natural frequency. Likewise, aeroplanes as a structure have various modes. And these modes we can understand. We can get the details of the modes by what is called a GVT (ground vibration test). Okay. So structural modes are known and the structure has got certain frequency, certain modes and frequencies. And it's got structural damping. Also, each sector has got damping. And these structural vibration characteristics are a function of stiffness, mass, inertia, and all that. Okay. And now once it's airborne, what happens is now aerodynamic force comes in. Now there is aerodynamic damping coming in. Okay. Now, there are two ways this damping can happen. Either this damping can aid structural damping or it can get out of phase with it, in which case it will go diverging. Okay. So it is one of the riskiest and at times very dangerous. So it is part of an envelope expansion test. Envelope when you say it is an aeroplane has got a flight envelope. Flight envelope is in terms of height, altitude, it can go, speed, it can cover, mach number, it can cover, angle of attack, it can cover. Okay, I like that. So that envelope. So the loads, et cetera, depend on envelope, like higher the speed, higher the load and all that. So the idea is to see that your aeroplane is free of flutter in the envelope which is clearing. So you start with a lot of these ground test analysis, et cetera. Okay. Then do a simulation and then you have an idea whether your flutter envelope is outside the envelope you want to clear, but then you will have to validate it through a flight test, won't it? So this flight test is very gingerly. We approach this flight testing See, the thing is, this fly by wire systems, if you excite the flutter, the older planes, we used to have some bongers (rubber hamer) to excite. Okay. There are various methods of exciting, very cumbersome. But this fibre machine has an advantage. You have the close loop control system and through that you can inject the excitation signal. Okay. So that is also you have a series of excitation signals programmed and then loaded on the aeroplane. And that particular condition is set up in terms of altitude, Mach number, et cetera. We give clearance for him to select that particular signal and then inject through that, the moment you inject through that, it lasts very short, very small time. And then we have set up something like a quick look kind of a thing in the available data on the telemetry, you have a look at the frequency and damping parameter as a function of the Mach number. And if there is an even minute variation from the predicted result, we don't proceed. Because what happens is flutter. An Airplane can break up in no time because you just get on YouTube and say flutter accidents. You'll see a number of them. I still remember when I was doing flights, sorry, the course in France, one day I was sitting on the tarmac and I found one aeroplane called Super Étendard. So this aeroplane, when I was on final approach, then I found there is something funny about aircraft. Then I found that the vertical fin was missing. This guy was doing a flutter test and he was diving with Mach number constant and he lost track. I mean, he forgot to look at the airspeed, air speed crossed the limits and then in no time, the vertical fin got into a flutter. It just blew away. Luckily, he was able to land that kind of thing. There are plenty of you can see. So there is a famous saying by Theodore Juan Carmen about flutter. He says some fear flutters because they don't understand. And there are some others here because they understand. They understand. So what we look for is in an aeroplane, what we see is ultimately what we are trying to see is that your cleared envelope is not within the flutter envelope. So it is a very painstaking process, very gingerly done without any kind of bravado. That is what flutters.

32:07
So another dangerous exercise is what is called store separation. When you release a store,

any store released, if it has got a Pitchup tendency, there's a very strong chance of it coming back and hitting.

32:21
Ganapathy :
That right. And just for the audience, if you can explain what is store, you mean drop tanks, weapons, bombs, missiles, anything, right.

Wing Cdr. Raveendran:
Anything which is slapped on an airplane, be it bomb, Rockets or drop tanks, additional tanks, whatever you slap on. Okay. Which alters the aerodynamic configuration and the characteristics. And also when it releases, there is a chance of it going and going and hitting the A/C. So here again, we do a lot of simulation before we do a store release test.

33:01
Ganapathy:
Any interesting emergencies that you can tell us about ?

Wing Cdr. Raveendran:
Yeah, there were occasions which led to my balding ! A couple of things I remember were that we had a double hydraulic utility system. There are two main pumps. And then we have what is called the EMDP (engine mounted driven pump.) Then we have hydraulically driven pumps. There are four sources like that. Okay. Then this main system itself is segregated into FCS lines and utility lines. Okay. Because the FCS line is very critical. If that leaks off, then you're going to lose flight control. Once what happened was one utility system failed. Once in the utility system, there is a leak or something. The content is hydraulic fluid content from the reservoir. It just starts depleting, it goes down. And at a set level, there is an isolation valve involved which cuts off the utility system, preventing further leak. So that means the utility system is not available. Okay. Utility system drives the undercarriage, brakes, nose wheel steering, that kind of. Okay, so utility system 1 fails, light comes on and immediately if you don't take the gear down and if the other one fails then you are in trouble. So immediately I shouted out gear down. So he put the gear down and then the other one also failed. If there was a little delay then there would have been no way to save the A/C because you can't take the gear down. What has led to that was again, there was a leak. This is a high pressure system. This is like a water jet cutting machine. So there were special instructions to the pilot. If there is a leak, don't put your finger there because you'll lose the figure because it's like a knife. It will cut you. So this leak from one system, it cut the other system. So that's how it happened.

35:32
Ganapathy :
Then you had an incident where there was a plastic cover that exploded at Mach 1.4.

Wing Cdr. Raveendran:
Yeah. Near the ladder, for the pilot to get up. There is a small I don't remember what is inside. There is a plastic disc okay. In flight what happened was I was a colleague in telemetry and I heard him coughing like that. Then when he came and he said I smelled something. So I went there and went to the aeroplane and then found that this particular disc was missing. What happened was by design, this disco is supposed to have a hole in the centre because then the pressure gets equalised. So now this particular thing did not have that hole. And then whatever pressure was trapped inside behind that, it started expanding and the aircraft was climbing. It just popped out and that thing went into the intake. And then that is what happened. Then earlier I thought that there is no. It was not in the drawing. Actually, it was in the drawing, but it was a lapse somewhere. There was no hold there. So when you put the hold there, it is. That is another incident. And there are a couple of other incidents which I remember. One was very interesting. We used to very regularly monitor what is called rundown time of the engine. Right. You shut down the engine and then you start the stopwatch. And the rundown time is an indication of the condition of the rotating assembly. If there is any friction, rundown time will decrease once because I found there is a sudden decrease in rundown time. And these engine trades engine groups, when I checked up everything and all that, they said, no, nothing wrong from our side. And now it's within limits. So we'll fly. I said nothing. So I just put my foot down. And then they started because the engine had an accessory mounted gearbox coupled to the engine. Any load coming on that can put a load and then it can reduce the rundown time. So then they started looking at each of the accessories. They found one of the HMDGs. (Hydraulically motor driven generator) had seized. It was supposed to be a standby power for the FCS channels in case the main fails. And earlier, prior to this incident, we were not monitoring HMDG. What do you call the health monitoring was not done. Right. Okay. So then they were replaced. I think everything became all right. And then they changed the electrical page (in the telemetry) to monitor This particular incident. Okay, so like this, there are a couple of incidents. It's very interesting where I put my foot down and it had beneficial effects down the line. I'm very happy.

39:09
Ganapathy:
So sir if we can just take a step back. You've been associated with this project for 20 years. You saw it even before the first taxi trials. I think all the way to close to its final operational clearance. You've seen all the challenges. You've run an incredibly successful test program with absolutely no accidents or any such thing. What are some big picture lessons that you've drawn for our aviation capability and how do you think we should continue to build on this? Any major lessons you learned from this, how we could do it better the next time.

Wing Cdr. Raveendran:
Okay. Before that I want to sort of just touch upon one thing. It's just the pinnacle of my test career.. When I was about to leave, I retired at the age of 60. Then I was on extension, on extension. I got a chance to fly a trainer and all that. Okay. What happened was just when we were approaching IOC (initial operation clearance), the control law team, they wanted to incorporate what is called ALSR or (automatic low speed recovery software). Okay. So they wanted reliable redundant client gradient, aerodynamic gradient information. So they were using the one coming from IN (Inertial navigation) system because we had only one IN system, international navigation system and they were arriving at this particular thing in an indirect manner. And also for a control system you need a redundant source. So they were stuck for that. Then I certainly sort of came to my mind. This is what was my project in Epner (France). So I sort of proposed this particular thing. You use this and they jumped at it and that (system) is flying now. That was incredibly satisfying for me. And now they're not using this particular algorithm. But I was told by the control law team guys that this algorithm which I developed and which was incorporated in the IOC, that is still in the aeroplane as a backup, was really satisfying.

41:45
Also because of this, because of this particular solution which I gave the IOC came in time with less cost. Otherwise they had to put in another IN system or something. It costs a huge amount of money and time. So that is really fine then. Yeah. Coming to your listing, there are some challenges which I sort of faced. One main challenge is that test crews get dirty jobs. I'll say difficult jobs because we have a problem finding jobs. You have to find the fault with the system. All right. So the designers tend to develop some kind of an emotional attachment to their system because it's their baby. Okay. And when you point out some defects, they don't like it, they don't accept it. Okay. So this to convince them like I tell them and my experience is that there are some system designing teams which took the flight test input very seriously in the right spirit. Those systems matured very well. So during my interaction with the designers I should say system failure is not personal failure. System failure or defective deficiencies are expected during the development stage. Okay. And if you have some kind of a problem coming up during flight test time, you should consider yourself extremely lucky because the flight test is done under highly controlled conditions by the extremely qualified and experienced guys. Okay. And you imagine the thing happening in the squadron which then you can do the aeroplane. So that was one of the issues which I try to emphasise during my interaction with the designers and then we will have to tell them that we are all here. We have the same objective to give a safe A/C to the user and then now LCA project has been of such magnitude and depth I think we have the capability to develop state of the art aeroplanes

44:11
Ganapathy :
I think we should keep developing such aircraft so that we do not lose such capability.

Wing Cdr. Raveendran:
Yes. Absolutely We should not give a gap and lose the ground covered already.

44:17
Ganapathy :
Wonderful. So you've spent so much time. I want to thank you for your service. I want to thank you for the time you've taken today to answer all my questions so patiently and so clearly. I really appreciate it.

Wing Cdr. Raveendran:
Thank you.