1:00
Ganapathy :
Hello and welcome to the Blue Skies Podcast. I'm PR Ganapathy, your host.
It is my great pleasure to welcome back to the program a previous guest. Air Cmde, Harish Nayani. As you remember, Air Cmde Nayani is a qualified test pilot and a fighter pilot. We had spoken to him earlier on the induction of the Mig 21 Bison aircraft, but today we're going to speak to him as part of our series on the LCA Tejas because Commodore Nayani had a significant role to play in the test flying off the LCA. So welcome back to the program, sir. Thank you so much for speaking to us again, particularly about the Tejas

Air Cmde Nayani :
Thank you very much, Gana privilege to be back again on your program. ‘

Ganapathy :
Lovely, sir. So nice to have you back. So, sir, just love to back up a little. Where were you when you were first informed or told that you were going to be involved with the LCA? And what was the environment like? What was your thinking? What were your expectations at that time?

Air Cmde Nayani :
Yes. So as you would recall, I was commanding Three Squadron, the first Bison Squadron. I took over the quarter towards the end of 2002 and had a very memorable tenure of a little more than two years. So towards the end of my career, as it always happens, I was contemplating on where I would probably be posted and what plans did the higher formations and the Air Force have for me. And it was at that stage that I was told by none other than the chief of the air staff himself that I would probably be going back to NFTC because my services were required there. And then, of course, since it had come from such a high position, I really had no doubt. And that really excited me a great deal because right from the time I graduated as a test pilot, it was my dream to be involved in a prototype flight test program. And I think the fact that it was now coming to fruition was something that really excited me a great deal.

2:59
Ganapathy :
Very nice.
Yeah. I think you're all experimental test pilots, but I think very few of you get to put the E to work and do actual experimental test flying, and I think the Tejas program provided you all with that opportunity.

3:14
Air Cmde Nayani :
Very true. Yes, we do a lot of experimental work at ASTE pertaining to systems and subsystems, but to do an experimental fighters program on an entire aircraft is a different kettle

of fish altogether.
3:30
Ganapathy :
Lovely,So what stage was the program at when you reported to NFTC and joined the flight test team there?

3:36
Air Cmde Nayani :
Yes. So the program was at the stage when PV One had just flown. We were still on the 4G Control Law, and we were flying on fixed gains. To give your listeners a little bit of an idea as to what fixed gains means, the LCA, as most of you know, has a fly by wire control system wherein the pilot moves the control stick. But he has no idea as to what the control surfaces are doing. All that is decided by the flybywire computers. And an optimal control surface deflection is thereafter imparted to maneuver the plane in a manner that the pilot so desires. So in the initial stages of our flight test program, as a matter of abundant caution, we were flying with a fixed gain control system where the system wasn't actually fine tuned to behave in an optimal manner depending on where you were on the envelope, insofar as the altitude, airspeed and mach number were concerned. So that was a very conservative method of progressing forward. And in hindsight, I think it was the right method because we gained a lot of confidence in the, you know, how rapid the flight control system was. And after that, when needed. We opened up to variable gains. That was where the program was at that point in time.

4:53
Ganapathy :
Right Right. For you as a pilot, what is the difference that you experience? Is there a difference in feel? Is there a difference in handling in a fixed gain system versus a variable gain system?

5:10
Air Cmde Nayani :
Yes, this certainly is because, for instance, let's say in a fixed gain system, I'm at a speed of maybe 850 km/hour. And when I pull back on the stick, I expect the aircraft to maneuver in a certain manner and give me the G that I'm demanding. Once again, for your listeners, the control stick in the fly by wire aircraft is either a G demand or a pitch rate demand. In other words, if I deflect the control column by, say, 3 cm, the aircraft will always give me, say, 5G, irrespective of what the speed is. Unlike in a manually controlled aircraft, where my stick to deflection has to be tailored to my air data, what my aircraft systems are sensing and the G that I demand. So in a fixed gain system, at the higher end of the speed envelope, the aircraft tends to be a little more sluggish. Whereas when you open up the gains and it's fine tuned to operate in a manner that's optimal for that particular point on the envelope, you get a better control response from the aircraft.

6:08
Ganapathy :

Okay. It almost sounds like one has to unlearn some of you know if you're coming from a conventional controls aircraft or fly by wire. Is that the case that you have to learn a slightly different way of flying?

Air Cmde Nayani:
Yes, it does feel different initially, but then it's much more easy because the aircraft is doing most of what the pilot would have to do and you can concentrate on other tasks. Initially, yes, it does feel a little bit different. But you settled onto it very quickly

6:40
Ganapathy:
And there was no trainer at that time. So the first time you flew the prototype, you flew by yourself. So what was that first flight like and what was the preparation up to it? Yeah.

6:55
Air Cmde Nayani :
So what was decided was that since the LCA flies quite similar to the Mirage 2000, every pilot who was posted to the NFTC went to Gwalior AFB. We did a short capsule on the Mirage 2000 (a couple of Sorties) because that again is a flyby wire, albeit an analog system. But insofar as the pilot is concerned, you really can't makeout, whether it's analog or digital. But that really prepared us well for the first flight on the LCA. But more importantly, we had what was called the real time simulator located at the ADE (Aeronautical Development Establishment), which was basically a development simulator which was used to check out the flight control laws and then put it on the aircraft. But it flew so well and the head of display symbology was so realistic that it actually proved to be an excellent training aid for us. So all of us do a great deal on the RTS, which prepared us for the first flight on the actual item.

7:56
Ganapathy :
Was that a very basic simulator in the sense it is not full motion with a full visual display, but at least all the instruments would react correctly.

8:06
Air Cmde Nayani :
Yes, it was a fixed base simulator. It had the head up display symbology which was representative of the actual aircraft, but most of the cockpit systems and all were very rudimentary, but it flew very much like the aircraft. And just to tell you, even when we set about practicing for our aerobatic displays and all that, it was real time simulator that really helped us fine tune our profile and get the display going.

8:30
Ganapathy :

Wonderful. So tell us about your first flight. Put us in the cockpit with you. What was that experience like?

8:36
Air Cmde Nayani :
Yes. So again, how it was actually done was that the pilot would first do a ground run wherein you would start up the aircraft, run up the engine, run through all the flight control tests, et cetera. By the way, the built-in test for the flyby control system on the LCA when I joined the program was to the tune of eight to ten minutes, again, as a measure of abundant caution because it was a very intrusive test. It went through every single mode of the fly by wire control system, which in itself was a great experience. And then after the ground run, you would shut down and get debriefed on various aspects. That was followed up by a taxi run where you just taxi route to the runway, opened up the throttle to only dry power, roll down the runway and thereafter cleared off and came back to the dispersal. After that was when we would actually launch off on the first solo.

Ganapathy :
Okay.

9:31
Air Cmde Nayani :
So my initial impressions about the aircraft was firstly, there was an apprehension that in such a small aircraft, in such a small cockpit, it would be pretty uncomfortable. But that really wasn't the case. The aircraft is very ergonomically designed. Almost all the controls are where you actually want them to be. And the ejection seat is not probably in the class of a F-16 where it's raked back by 30 degrees. Over here, it's in the region of over 20 degrees or a shade more than that, which again was very comfortable. And what was very impressive was the view from the sides and from over the nose, which was excellent. And all in all, the cockpit did feel extremely comfortable.

Ganapathy:
Okay.

Air Cmde Nayani :
But I think what really was an eye opener was the moment you pulled the stick for take off as you began to rotate was the handling qualities of the aircraft. I can only call them exemplary. The aircraft flew extremely well, again very similar to how a Mirage 2000 flew, but most of us, I'd say all the pilots who flew the LCA feel that she handled the shade better than the Mirage 2000.

10:42
Ganapathy:

Wow, and this was an early prototype, and even then you were perceiving this Mark difference. It's very nice to hear.

10:52
Air Cmde Nayani :
Yes.

Ganapathy:
And so your first flight is typically a simple profile.

Air Cmde Nayani :
It was a simple profile where you got airborne, climbed up into the sector, climbed up to about 15,000ft, did a couple of turns, and of course, that time we had a G limit of just 4G and also a lot of restrictions on the roll rate and other parameters. So basically it was a very benign kind of a flight profile, after which you came back, did an overshoot where you came down for an approach in landing, but went around and then came back and did a full soft.

11:28
Ganapathy:
Okay, nice, wonderful. And then you got regularly rostered into the flying program.

Air Cmde Nayani :
Oh, yes, we would draw up a flight test program and follow it.

Ganapathy:
So I'm curious, how many test pilots were there and how did you develop the eh.. break up, the responsibilities? Were there specific systems that one test pilot was testing and therefore would do all the progressive tests on that system or was it all mixed up where everybody was doing everything so that you'd get an even balance of work? How was the flight test program organized? How is it organized? Typically

12:05
Air Cmde Nayani :
Yeah. So how NFTC was organized when I joined, we had a complement of five test pilots. NFTC was led by then Air Commodore RK Sharma, who later became an Air Marshal. Below him, we had again the ex chief an excellent professional, then Group Captain RKS Bhaduria. I Slotted in next, and after me was again now an air Marshal, then wing commander Vikram Singh. And then we had wing commander Tyagi. So that was the complement of test pilots with us at that point in time, and we had a team of extremely capable flight test engineers led by Wing Commander Ravindran. And then we had Wing Commander Prabhu and Wing Commander Das. So how it would work was that between the chief test pilot and the PD that's

the principal director, the forthcoming flight tests would be worked out in consultation with the designers and the engineers at HAL. And at that point in time, since most of the work was devoted to envelope expansion, flutter testing, and such kind of tests, there wasn't any distribution, pilot wise, as to who would look after what it was an equitable distribution where most of us were given a chance to fly an equal number of sorties through the months, although the PD himself wouldn't fly that much because he had other tasks at hand.

13:33
Ganapathy :
How much test flying was going on. And the reason for my question is you just came off as Sqn command tenure, where you were probably flying day in and day out, particularly since it was a new aircraft training up the rest of the team, and then you come to an experimental test program where there's a lot of engineering work between flights and so on and so forth. Were you getting a lot of flying?

14:01
Air Cmde Nayani :
I would call it a lot compared to what I was doing in the field. But then that is to be expected, because after all, this is a prototype flight test program. You need to tread with caution. Every single milestone has to be analyzed in depth. So how it would happen was immediately following a sortie, we would have what is called a hot debrief. So we would sit in the briefing room, cum debriefing room, all of us pilots, all of us flight test engineers, and more importantly, a big team of designers from ADA, as well as engineers from HAL. So the pilot will then give a hot debrief based on his perceptions of what went right, what went wrong in the sortie. And again, to just give your listeners a flavor, every single flight in those days. And well after that was monitored in the telemetry room. So the telemetry room, if you walked into it, you would probably feel that you were in a control room for missile testing or something like that. Every single parameter, believe me, every single parameter, however minute, was monitored real time by the engineers and the test director sitting there. So after the hot debrief, we would all disperse, and the next day we would have what is called a detailed data brief, where numbers, graphs, parameters would be projected, and any deviations from what was expected by the designers would be flagged, discussed, and analyzed to a very great detail. And if it was something that required a fix, that would be fixed before the next flight. So as you would imagine, the flying effort per se wasn't what a pilot would like it to be in terms of the quantum of flying. But then that's how it had to be done, and that's how we did it, right?

15:55
Ganapathy:
Yeah. Is there a concern that your currency, your skills are getting rusty because you're not flying enough, or are you all at a level of proficiency and professionalism, but that doesn't really make much of a difference?

Air Cmde Nayani :
Yeah. The latter part of what you mentioned is right to a large extent. And to answer the first part of that question that you posed. Yes. The RTS (real time simulator) again came to the rescue. So anytime we were free and had things to do in terms of checking out the flight control system software updates, we would be off to the RTS, spend about an hour or two there and Hone up light skills as well in that process. And in addition, those of us who are qualified on certain types of aircraft at ASTE would often go and fly probably the Mig-21 or the Jaguar there. So flight still wasn't really an issue at that point in time.

16:45
Ganapathy :
Wasn't an issue. Okay. And you were involved with the first flight of the PV-3, if I remember correctly. And so tell us about that. Were the new modifications introduced in that? What was that first flight like?

17:02
Air Cmde Nayani :
Yes. So PV-3 was a lot closer to the IOC, that's the initial operation clearance version of the aircraft as far as the cockpit and some of the flight control system issues were concerned. The aircraft had a third MFD (multi-functional display) which was placed in front of the cockpit, in front of the control stick right in between the pilot's knees. It had what an open architecture computer architecture is called for, the Avionics. It had a new upfront control panel which was just below the head of display which gave the pilot a lot of flexibility, a great deal of flexibility and also certain modifications to the air conditioning system and other utility systems on the A/C.

Ganapathy:
Very nice.

Air Cmde Nayani :
So to tell you how we went for the first flight, I did mention the real time simulator in parallel ,we had another very useful device called the Ironbird, right? Yeah. So the Ironbird, as the name itself implies, was a device where all the hydraulics, the utility systems of the aircraft, the landing extension retraction could be done in the lab which was located at the Aeronautical Development Agency and we would run a whole lot of tests on the Ironbird till the point where we were satisfied that this particular system is now rugged enough and it's unlikely to fail in the air. So PV-3, of course, every single aircraft's first flight was preceded by umpteen number of tests on the Ironbird & the RTS, after which is when we went to the aircraft. And what then Air Commodore had also instituted was what if session. So we would sit with the designers and the engineers and discuss as to what if this went wrong? What if that went wrong? What if the flight control system misbehaves? What if he sprung a hydraulic leak and it was done so very thoroughly that when I went up for that first flight, I was absolutely convinced that nothing could

go wrong. But if anything did go wrong, we had the wherewithal to deal with that problem and bring the aircraft back.

19:20
Ganapathy :
Very Nice. Ok.!
So can you describe the first flight to us ?

Air Cmde Nayani :
Again, at that point in time, we followed the SOP of not retracting the landing year after getting airborne as a measure of abundant caution. So I got airborne, kept the landing gear down and within the limits of the speed that was permitted in that configuration, did a couple of basic maneuvers, and then came back and landed. In the event, it was a flawless flight. And I really enjoyed myself because the displays behaved absolutely meticulously without a problem at all. The flight control system in that particular version, again, behaved beautifully, and was a real joy to fly.

20:10 Music begins
20:22 Music ends

Ganapathy:
And so this is a segue to my next question, which is that you were involved a lot with the development of the multifunction displays in the Tejas. That does sound like a really complex work is figuring out what needs to be presented, at what time, how the pilot interacts with it. So tell us about that process. What is the thinking that went into it? How did you develop these, test them, refine them?

20:55
Air Cmde Nayani :
So on this, I must compliment the team at ADA, the Avionics team led by Mrs. Padmavati, who rose to become a very senior scientist at that point in the program. So a lot of documents would be prepared beforehand as to what were the display formats in various pilot selection modes that could be displayed, what was required, what was not required, and how to make it better. Again, this involved a great deal of discussions with the designers either at ADA or at NSTC, and once again at ADA.

Ganapathy
Who was specifying these requirements and what was the research that went into comparing other aircraft and how they presented information and then writing our requirements. What is

that process?

Air Cmde Nayani :
Yes, we would have brainstorming sessions within NFTC to begin with, the five or six of us a little later on. (Air Marshall now) N.Tiwari also joined in with a lot of experience on the Mirage 2000 and me with my experience on the Bison as well as the Sukhoi 30. So we would all sit together and decide on what was the best format for each mode that was available, and a lot of inputs were also given by Cmde Maolankar, who was then also in the program. And our discussion would carry on literally for hours and hours. And then we would finally zero down on the format that we wanted. We would then discuss this with the designers Mrs Padmavati and her team, who would then put it onto the integration rig at ADA, so that's when the pilot machine or the man machine interface would be checked out very, very thoroughly, and once we were satisfied with a particular format, it was frozen and then put it onto the aircraft.

22:53
Ganapathy :
Unrelated, but also somewhat related. I used to be head of product management for my financial information startup, and I had a usability expert, a user interface design expert working for me, and in a previous life she had actually designed interfaces for F 16.

Air Cmde Nayani :Wow.

Ganapathy:
So what information is presented, what icons are used, what colors are used, that sort of thing. So it was just amazing to see the amount of testing that she described went into it. They used to study how people play video games and then design their interfaces so that it's intuitive to those people.

Air Cmde Nayani : Very cool.

Ganapathy:
So would you bring in somebody completely from outside the system and show them a display and see whether they could perform certain tasks and whether they could understand the information that was some of that sort of usability testing done?

23:58
Air Cmde Nayani :

It wasn't done precisely because of the fact that the moment a pilot undergoes his test pilot training at ASTE, one of the first things that he is told is that you are the interface between the designer and the young flying officer out there in the field. So you need to think like the flying officer, while your understanding has to be at the level of a designer. So from that point of view, we would always relate everything to what a pilot in the field, a junior pilot with limited experience would require, what are the kinds of problems that he would be faced with and then tailor the system accordingly? I think the aim is the same more or less because.

Ganapathy:
Okay, understood. It makes a lot of sense. Great. We change gears a little bit. So you've spoken about the aerobatics routine being practiced in the simulator and you did the aerobatics routine for Aero India in 2007. If I remember correctly, what stage was the aircraft at in terms of its envelope and what was that routine like? How did you go about practicing it? What was the experience like to actually fly finally in front of the crowd?

25:01
Air Cmde Nayani :
Yes. So this was the first time that the flight control team led by then Dr. Shamshetty and very assisted by Dr. Girish Deodhare, who's now the PGT at ADA, discussed the whole thing with us to a great detail. And a 6G control law was slowly opened up. And even more importantly, this was the first time that the PGD that Air Cmde Sharma at that point in time said that we will now carry out a vertical profile as well.

Ganapathy: Okay.

Air Cmde Nayani :
Till that point, we hadn't carried out a loop. We were limited to barrel rolls, rolls, high G turns. So we did a couple of loops which were very closely monitored in terms of how much height would you gain on the first half of the loop? What would be the speed on the back? How much height would you lose while it's coming down? Again, this was preceded by practices on the RTS, and it was then decided that, yes, for Aero India 2007, the LCA would carry out a complete profile, including vertical maneuvers such as the loop and the roll off the top as such. So it was my responsibility. By then, I had become the chief test pilot and I had to formulate an aerobatic display profile. So I did go through certain profiles that were followed by Indian display pilots as well as the Gripen display program, the Rafael display program and I formulated a profile had it approved by the by the PD, practice on the RTS and then myself and then group Captain AP Singh who had joined us were nominated as a display pilot and unluckily for AP Singh he was to fly the TD-2 which still had a four and a half G control law. So his profile was a little more benign to what I was doing on PV-2, sorry. PV-3. PV- 3, yes the profile as such was pretty impressive and we received a lot of compliments from both present at the air show, both foreign as well as Indian pilots, flight test engineers and the crowd in general.

Ganapathy:
I know it's been a long time but do you remember what the profile was like:

27:25
Air Cmde Nayani :
Laughs. Every single maneuver, every single moment. Can you describe it to us? To begin with we fueled up the aircraft to just about 1200 kg to keep the weight light and also to make sure that the landing weight was at a figure where we could also demonstrate a short landing if required. So we would taxi out to the takeoff point, run up the aircraft to full military power, that is maximum dry power, release the brakes and go into maximum after burner immediately after getting airborne as the wheels were coming up you would throw in a turn to the left, a very steep climbing turn to the left displaying the platform of the aircraft to the crowd behind.

Ganapathy:
Lovely

Air Cmde Nayani :
And then reverse the turn to the right. That means you initially turn left, climbing up, pushing up by about 35-40 deg. Thereafter turn right, get down to about 100 meters and then fly along the runway from right to left. In this flyby we would do quick 360 degree rolls, one to the left, one to the right and once again do a right climbing turn displaying the delta-planform to the crowd coming in from the opposite side and do an inverted flyby just about 100 meters above the ground. My goodness. Then from the inverted flyby we would revert to normal, straight level flight, turn away from the crowd and display a minimum radius turn. If I remember correctly we would do this at about 500 km/hour indicated speed pulling the maximum possible G with the stick fully back. This was with maximum afterburner and as you would imagine with its high thrust to weight ratio the aircraft would actually accelerate slightly during this time. Well, to demonstrate the aircraft's agility immediately after the turn we'd get into a vertical loop, a proper vertical loop and then complete the loop turn around once again towards the other side of the runway because we couldn't cross what is called a foul line; it could come anywhere close to the crowd. And thereafter we will do a Max G turn, turn downwind, and thereafter carry out a curved approach where we would come into our final turn just as we were abeam the edge of the runway. That's the landing threshold, and then come in and land and use the tailchute (break parachute), demonstrate the landing capability of the aircraft, and then taxi back.

Ganapathy:
WoW, Wonderful

30:03
Air Cmde Nayani :That's about six minutes or so.

Ganapathy:
Amazing. I'll see if I can find a YouTube link and maybe post it off that display. But really, I could visualize it perfectly as you described it to me just now. So thank you so much for that. Okay. I was reading about this thing that you were involved with called the transonic drag rise problem. So it's Greek to me. So I just love for you to explain what transaction drag rise is and how do you go about testing it and what is the problem and how did we fix it?

30:43
Air Cmde Nayani :
Yes. So one of the things that struck me when I first went to the program, or even before that, I was following the program very closely. It was evident from the initial pictures, photographs of the LCA that the fixed geometry intake on the LCA was not really tailored for a sustained flight at high supersonic speeds. Indeed, even aircraft like the Mig 21, the Mig 23, the Mig 29, and the Mirage 2000 have some form of variable geometry in the air intake to optimize it for supersonic flight. So without this form of variable geometry, the aircraft would probably not be able to sustain a speed higher than typically ~1.4-1.6 Mach. And this is exactly the same limitation that even aircraft like the F 16 and the F 18, both of which have fixed geometry intakes suffer from. Although on the Superhornet the F-18 EF, they have addressed this issue, and they have some form of variable geometry. And I think the supersonic performance on that aircraft is better.
On the LCA. What I would like to state was that she pretty briskly accelerates through the transonic barrier, but after Mark 1.2, the acceleration is sluggish for the very same reasons that I talked about because of the geometry intake. And in addition, the installed thrust losses also figured, leading to a situation where we were forced to accept the supersonic performance that was available given the constraints. And it was decided that since that part of the envelope, the supersonic envelope above mach ~1.4-1.5 is rarely used in combat, we could actually proceed ahead and continue with the rest of our flight testing. I'm sure that with the incorporation of the GE-414 engine, which hopefully should come up on the LCA Mk2, this particular problem should get sorted out to a large extent.

32:53
Ganapathy :
Okay. Right. So for the lay public, can you explain what happens at that point which causes this inability to go beyond and why does variable geometry solve that problem?

Air Cmde Nayani :
Yes. So what happens is the moment an aircraft goes supersonic, there is a shock wave that is produced at the air intake lip, or in case you have a cone, like in the Mig 21, at the tip of the cone. Now, this shock wave has to be tailored so that it impinges just on the lip and the airflow within the air intake becomes subsonic. Right. It may seem a little difficult for a layman or a lay person to understand that while the aircraft is flying supersonic, how can the airflow inside the

intake be subsonic, right? Yeah, but that's precisely how it works. The air intake, when it is tailored for proper supersonic performance, optimizes the pressure recovery within the air intake by keeping the airflow subsonic by the time it reaches the face of the compressor. Now, if you do this, then the engine is operating a lot more efficiently and you'll have much better supersonic performance.

Ganapathy:
Understood. Great super. Anything else that you were involved with the LCA that I haven't asked you about?

Air Cmde Nayani :
The first R 73 firing?

Ganapathy:
Oh, my goodness. Tell us about that.

34:20
Air Cmde Nayani :
Yes. Now, the LCA was envisaged with configuration where she would always carry two R 73 missiles, because that at that point in time was the best missile that we had. Of course, when the aircraft was initially designed, she was designed around two R60 missiles, a much smaller missile, but that went out of work and was phased out long before the program actually started gaining momentum. And we had to switch from the R 60 to the R 73 missile.

Ganapathy:
And so for the audience who don't know what an R 73 is, can you just briefly tell us about that?

35:01
Air Cmde Nayani :
Yes. The R 73 is a Russian missile, which is also called an AAACM, all aspect air combat missile. When I say all aspect, what happens is when we have the first generation of missiles, the Sidewinder-AIM9, I think the AIM 9B was the first version. In parallel, the Russians had what is called the K 13, which our initial Mig 21 came with. Now, these missiles can only be fired if the target aircraft is in front of you and moving away from you. In other words, the metal has to be exposed to the heat generated by the exhaust or the hot jet pipe of the target aircraft. And the infrared spectrum was also tuned to those particular wavelengths. This was a very severe disadvantage in air combat, as was realized during the Vietnam conflict and others as well, where you had to really maneuver aircraft, your own aircraft, to get behind the enemy, wait for your missile infrared lock tone, and then shoot the missile. So it was decided that the missile had to be modified to hold on to the hot tube of the exhaust gasses as well. So this gave rise to

the first generation of what was called close combat missiles (CCM's) in the Indian Air Force we got the Matra Magic One, which was integrated on the Mig 21 BIS and the Jaguar, which could fire at an enemy aircraft or an adversary which was even 90 degrees pointing away because the seeker was now fine tuned to home onto that particular spectrum of the infrared energy. So then seeker head technology was improved to such an extent that you could now fire at an aircraft which is now head on to you. Absolutely head on, provided his after burner was on. Okay. So what the metal would do was it would lock on to the exhaust fume of the aircraft, which was visible to it behind the fuselage. And then, of course, the control laws were modified so that the missile could head towards the aircraft and the warhead would explode by means of proximity fuse designed to create maximum damage to the target aircraft. So the R 73 belonged to this class of missiles, all aspect air combat missiles. It had a nitrogen bottle which would cool the Seeker head, because the seeker head now needed to be cooled. And all in all, an excellent missile. It's done very creditably for itself in various exercises. So the LCA was now integrated with the R 73. Mig 21 Bison also integrates with the R 73.

Ganapathy :
I think, if I remember correctly, Wing Cdr. Abhinandan Varthaman used the R 73 to shoot down the F16 is what I hear.

Air Cmde Nayani :
Absolutely. The Bison, as well as Mig 29's, were upgraded with R 73. And so was quite early.

38:06
Ganapathy :
Okay, great. So tell us about the test program for the R 73 on the LCA.

Air Cmde Nayani :
So when the time came for us to plan these flight tests, certainly very important considerations emerged. One was when you test a fly by wire aircraft, you begin with what are called ground vibration tests on the ground, followed by structural coupling tests. What happens is, as the aircraft flies through the air, there are certain vibrations that the airframe picks up. Now, these vibrations, if they are wrongly detected by the flight control computers, could give inputs, undesirable inputs, and make the aircraft maneuver. When the pilot doesn't want to maneuver, the worst case scenario could even lead to certain conditions of loss of control. That is one issue. The second is related to flutter. Again, for the sake of your listeners who may not be aware, flutter is a phenomenon in the air wherein, due to the interaction between aerodynamic forces, the elastic forces of the aircraft structure and certain vibrations are set in. If the interaction results in a situation where these are self induced and can carry on to an extent where they can cause problems, you need to address these. In the worst case, you could also have structural failure where the wing could actually break up and lead to catastrophic damage. So all these tests are done on the ground so that you can preclude any of them occurring. And if there is a problem, we had a fantastic team. Once again, like I told you, led by Dr Shamshetty and Girish who would install what are called notch filters in the flight control software to

disregard this particular spectrum and thereafter you continue as normal. That is, the flight control computers would handle this particular problem. Now, all these tests were done with the missile suspended on the launcher. Now if you did fire the missile and you didn't have the missile, you just had only the launcher. All this had to be repeated, correct, if you know what I mean. So this was done as a starting point. The second issue was the effect of the exhaust plume of the R 73 on firstly the air intake of the aircraft, on stable operation of the engine and on the composite structure. And just to let you know, the R 73 exhaust plume iis considered rather for want of a better term, dirty because it contains a great deal of phosphorus and this could give rise to disruptions of the air flow and the air intake leading to problems with the engine operation. And in a worst case situation, the engine flaming out that is failing completely. And the other problem we envisage was if this exhaust plume at a very high temperature impacted or made contact with the aircraft structure, all composite wing structure of the aircraft, would there be any damage?

41:10
Ganapathy:
Right.

Air Cmde Nayani :
So this has to be studied. And once again it was what I call ‘jugaad’, which the Indians are so very good at. So what was done was an R-73 missile was stripped off its warhead and the electronics and the guidance and it was just a rocket motor which was strapped onto a test bed at Hyderabad with DRDL. They had the facility to test this and I remember Wg Cdr. Rawindran and myself and a whole lot of us from HAL and ADA and he went across to Hyderabad and did this step. So we were cocooned inside the control room which was completely shielded from any blast or anything that could occur and the R 73 missile was fired up. The plume was very closely captured using cameras in all kinds of spectrums: infrared, visual for offline analysis. The thrust of the motor was measured and the whole thing finished in about 6 seconds. From the countdown we got the rocket motor burning and within 6 seconds it was all over. And what was so amazing was to give you an idea, the thrust as measured at that test bed was 6200 kg. That's the thrust of a Mig 21 Type 77 engine in full after burning.

Ganapathy:
My goodness, isn't that amazing? And just a little missile, no wonder it accelerates so fast. Now, does the R 73 drop and then the motor fires or it fires off the rail

42:46
Air Cmde Nayani :
It's a rail launch. Okay, yeah, almost all of the radar guided missiles are rail launched or what

the Russians call a catapult launch. So this missile fires off from the rail and then proceeds towards the target. So once we had analyzed all this data, we decided that, yes, it's now safe to proceed. The disruptions of the air flow were unlikely to affect the air intake and the engine would continue to operate. Stably the composite structure wouldn't be subjected to the hottest part of the plume is what was the best model. And we went ahead and did the firing at Goa. So we fed it to Goa myself and then Commander Maolankar as a standby pilot. The aircraft was prepared. It was PV 1 at that stage, and we needed a photo chase. So we had requested the Indian Navy, who were kind enough to give a Sea Harrier trainer, which filmed the entire operation. So we did a couple of dummy profiles where I would get airborne with the Harrier, get used to the profile when exactly I would fire the missiles, what radio calls I would give so that nothing would be lost out and the camera chase would capture everything very correctly. Finally went up and fired the missile. Of course, I did have experience of firing missiles from Mig 21 Bison, Mig 21 BIS I, and also the Mig 29. So my countdown down, of course, started once the camera chase had confirmed his readiness and I fired the missile. It was one big whoosh. And before I knew it, the test was over. And I see, of course, the missile fume moving away from me, after which the fuse was activated and the missile exploded. That, of course, I could not see because it's far away from me, over the sea. Right. And this is the carriage and release. Basically, this was carriage and release because the rest of the guidance systems and all that are all well proven. Right. Yes, this was an unguided launch. And thereafter, I think,Tyagi and the others took on the guided portion of the launch test from us.

45:26
Ganapathy:
So I've been asking all the test pilots I've spoken to who've been involved with the LCA test program. You've been a Squadron combat pilot. What is your sense of the aircraft that we have now that's in the squadrons? What would you reckon your chances in combat against the sorts of adversaries we face in the subcontinent? What's your assessment of the platform that we've created?

45:59
Air Cmde Nayani :
Okay, to begin with, I think what's most important for a fighter pilot in a combat scenario is to have the best possible situational awareness. And this is one area where I think the LCA reigns supreme, or I would say she's probably up there amongst the best in the world. The way the sensors are engineered, the way the displays are presented to the pilot and what all he has at his command are something that I think our pilots would be extremely happy with. So if you build up your situational awareness and you can tailor it to a situation where you have the opportunity of a first launch, your chances of winning combat engagement are that much better, so that from that point of view, the LCA is absolutely amazing.
Next, coming to weapons, I would like to develop on what exactly has now been integrated onto the LCA. But once again, they are world class and they give up pilots a tremendous edge over

the adversary, whoever he may be. Right. But in the same breath, I'd like to say that, yes, the adversary also has comparable or probably a shade better missiles in certain parts of the envelope. But all said and done, we are very evenly matched insofar as weapons are concerned.

Then the next point is the RCS, as well as a visual signature. The LCA today is the smallest fighter aircraft flying period, and an air combat small is beautiful, both in the beyond visual range arena, because the smaller you are, of course, there are various other aspects, but it's natural that your radar signature would be that much smaller. And when you come in close in the visual arena, small is what every pilot probably wants. So not only is the aircraft very small, the F 404 engines are virtually smokeless, so the aircraft is extremely difficult to spot in air combat scenarios. So from this point of view, once again, I think our pilots would be extremely happy with the aircraft. And then, of course, when it comes to actual maneuvering, the aircraft is pretty good. Not as good as what was envisaged initially when she was on the design boards. But all said and done, she can hold her own against even an aircraft of the category of an F 16 or probably even outdo a JF 17, which I think is excellent capability.

48:29
Air Cmde Nayani :
More importantly, the flight controls are absolutely marvelous and she flies very well at low speeds. So if a pilot does happen to get into a low speed situation in air combat, the aircraft has a huge Delta wing with very low wing Loading. Loading is a simple term. The total weight of the aircraft is divided by the wing area, and the lower the wing Loading, the better is the maneuverability at low speeds, and it has a great advantage even at high speeds. Okay, once again, is pretty good. Again, not as good as what was envisaged, but I would say fairly decent. So all said and done, it's an excellent little platform, and I'm glad our pilots have now gotten to fly this aircraft after so many years, and I'm sure they'll do extremely well.

49:18
Ganapathy:
Okay. Amazing. Have you had a chance to interact with some of the operational pilots in this cordon who have been flying it and get their feedback?

Air Cmde Nayani :
Yes, I did interact with Group Captain Rangachari, who commanded the first sqn, and then pilots who come to Yelahanka for the Aero India show they are absolutely delighted with the aircraft. I do understand that there are some teething problems to do with the initial induction technical issues, but all in all, they're extremely happy.

49:48
Ganapathy:
Thank you so much. It's been a wonderful conversation to learn about your involvement with the test program of the LCA and to learn about the aircraft and more. So I can't thank you enough for your service. I can't thank you enough for the time you spent with me today.

Air Cmde Nayani :
Thank you very much. Thank you. It's always been a pleasure interacting with you.