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The Gallivant Kaveri Project: Hits & Misses

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Abstract

The significance of airpower cannot be over-emphasised in the military stature of a nation. While the world is flaunting sixth generation fighter aircrafts, India is struggling with its depleting fleet and ageing fighters. In its quest of self-reliance, India is trying to develop own advanced fighter, thus facing the impasse of not having own jet engine. The ambitious 'Kaveri Project', launched in 1980s to develop indigenous jet engine, has not been able to deliver the desired results. This paper attempts to analyse the decades long journey of the 'Kaveri Project', its successes and failures in the way.

Keywords: Kaveri Project, Jet Engine, Ghatak, AMCA

On 26 December 2024, militaries across the world were surprised to see the maiden flights of two sixth generation fighters by China assumed to be named as Chengdu J-36 and Shenyang J-50— no official confirmation has been given yet by the Chinese government; however, the fighters are said to be having superior stealth, speed, manoeuvrability, AI capability and three engines (Kumar, 2025). This move was in sharp contrast with the concerns expressed by the Indian Chief of Air Staff on the dwindling numbers of fighters in IAF earlier in October 2024 (Pubby, 2024). While IAF is trying multiple pronged approach to grapple with the situation, one of the main reasons lie in the inability to develop indigenous fighters in entirety primarily due to lack of own jet engine. In this article, we have made an endeavour to look at India's ambitious project to develop own jet engine "Kaveri"—its journey of 35 years, success and failures in its stride.

Need for Indigenous Jet Engine

The global context of conflict and the era of Cold War significantly influenced the advancement in fighter jet technology. In the 1980s, at the height of third generation fighter jet production, India initiated the 'Kaveri engine project'. In 1983, India launched the Light Combat Aircraft (LCA) project, aiming to develop a new, lightweight combat aircraft in order to substitute the aging fleet of MiG-21s, which had been a cornerstone of the Indian Air Force (IAF) from 1963 onwards. At one point, the IAF had an operational fleet of approx. 874 MiG-21 aircrafts. The

"Long Term Re-Equipment Plan 1981" highlighted that by the early 1990s, significant portion of the IAF's MiG-21 fleet would approach retirement age, thus creating a projected 40% deficit in the required number of fighter aircraft (Philip, Tejas flying record world's best, criticism unfortunate, says IAF veteran who flew LCA at 78, 2021).

The DRDO established the Aeronautical Development Agency (ADA) in 1984 to manage and supervise the Light Combat Aircraft program. Hindustan Aeronautics Limited (HAL) was chosen as the main contractor while the ADA took responsibility for designing and developing the LCA. The LCA project, driven by the government's 'self-sufficiency initiative', sought to incorporate three sophisticated technologies viz. an electronic flight control system (Fly-by-wire), an advanced pulse-Doppler radar with multiple modes, and a turbofan engine featuring afterburner capability (Reddy, 2002).

In 1986, the DRDO received approval to begin a program aimed at developing indigenous engine for the LCA. For the LCA's prototype version, planners selected the F404-GE-F2J3, an afterburning turbofan engine manufactured by General Electric. However, if the parallel program to develop an indigenous engine proved successful, then the production versions of the aircraft will be powered by this domestic engine.

The DRDO tasked its Gas Turbine Research Establishment (GTRE) with leading the engine's development. GTRE possessed prior experience in jet engine development, having created the GTX37-14U afterburning turbojet. This engine was successfully tested in 1977. A turbofan version— GTX37-14UB, was later developed (Gunston, 2006). GTRE, then shifted its focus back to turbojet technology, creating the significantly redesigned (though ultimately unsuccessful design) named GTX-35.

For the LCA program, GTRE embarked on another turbofan design— the GTX-35VS "Kaveri". Full-scale development received approval in April 1989. The project, initially estimated to take 93 months and costed ₹382.21 crore, was anticipated for completion by December 1996 (Developments of Kaveri Fighter Engine, 2015).

Where does "Kaveri" Stand After 35 Years?

As per 2021 government statement in Rajya Sabha, the Kaveri engine, despite reaching advanced Technology Readiness Levels in key areas, will not power the HAL Tejas FOC (Final Operational Clearance) variant. This decision stems from the FOC variant's need for greater thrust, which the Kaveri's current design cannot deliver. Knowledge gained from the Kaveri project could potentially benefit future engine development for the HAL AMCA— a program where international companies may partner to create a new powerplant (Design, Development, Manufacture and Induction of Light Combat Aircraft, 2021).

In October 2022, additional high-altitude testing of the Kaveri engine was conducted at Russia's Gromov Flight Research Institute, following earlier tests where it produced 46 kN of thrust without afterburner and 70.5 kN with afterburner engaged. These figures fall short of the project's original requirement of 81 kN and the 85+ kN needed to power the LCA Tejas (Narayanan, P. and Deepak, J. 2023).

In February 2023, the Kaveri engine underwent 75 hours of high-altitude testing at the Baranov Central Institute of Aviation Motor Development in Russia. During this period, the engine was subjected to simulated conditions equivalent to 13,000 meters (43,000 feet), achieving a dry thrust of 48.5 kN (Narayanan, P. and Deepak, J. 2023).

Self-reliance, including the development of an indigenous engine, was a key objective of the LCA program from its inception. However, due to difficulties in developing the Kaveri engine, the General Electric F404-GE-F2J3 afterburning turbofan was chosen as a temporary replacement. Subsequently, beginning in 2004, upgraded engines of General Electric F404-GE-IN20, have been incorporated into the Limited Series Production, Naval prototype and Mark 1 variants (GE Awarded $105 Million Development Contract from India, 2004). This same engine will be utilised to power the Mark 1A as well. The Tejas Mark 2, a heavier version, will utilise the General Electric F414-INS6 engine. As a result, the Tejas LCA program no longer relies on the Kaveri engine (Siddiqui, 2023).

Some Hits Among the Misses

In September 2024, Bharat Heavy Electricals Limited (BHEL) and the Gas Turbine Research Establishment (GTRE) announced a collaborative effort to develop Marine Gas Turbines (MGTs) and heavy-duty industrial gas turbines. For naval applications, gas turbines offer key tactical advantages, including rapid acceleration, high speed, and minimal preparation time, hence making them highly desirable for ship propulsion systems (ET Energy World, 2023).

Project Ghatak, a stealthy UCAV initiative, was launched by the ADA in collaboration with the IAF. The project aims to create a flying-wing design, which offers inherent stealth capabilities and the potential for increased fuel and payload capacity compared to traditional UCAVs. However, this configuration presents challenges due to its more intricate flight control surfaces and systems. The Ghatak UCAV is expected to be lighter than a conventional fighter jet and is projected to incorporate a "dry engine" variant of the GTRE GTX-35VS Kaveri turbofan, capable of generating 52 kN of thrust. In 2016, initial funding of ₹2.31 billion was allocated for the Ghatak's design and development of crucial technologies, applicable to both the Ghatak and the HAL AMCA program (Ahlawat, 2024). The Indian Navy has shown interest in the initiative, aiming to acquire deck-based UCAVs for its upcoming Landing Platform Docks (LPD) and aircraft carriers (Pandit, 2015).

Why Kaveri Could Not Achieve Optimal Results

The initial design of this project predates GTRE's access to adequate computational fluid dynamics (CFD) resources and a robust collection of prior wind-tunnel data.

- Creating a contemporary low-bypass turbofan (LBTF) jet engine presents a significant hurdle for a nation with limited prior investment in jet engine development, apart from efforts to enhance existing foreign engines and construct indigenous technology demonstrators.
- The ₹2133 crores spent on the Kaveri project to date represent a mere pittance relative to the global costs associated with developing a low-bypass turbofan (LBTF) engine (The Hindu, 2020).

- Glitches in the Kaveri Design.
- The Kaveri engine's intake might require modifications to minimise the risk of stall-induced self-excited vibrations (flutter) affecting the duct fan blades.
- The current Kaveri prototypes face notable combustion oscillations in their augmenters or afterburners, which also negatively affects specific fuel consumption during reheat operations.
- The first stage of the Kaveri’s low-pressure compressor is currently encountering concerning levels of rotor blade vibrations.

Where Does the World Stand?

Jet engine manufacturing is a highly specialised field, with only few nations possessing the capability. The global market is primarily controlled by the US, France, Russia and China. Germany, Japan, Italy and Ukraine have some capacity, often through collaborative efforts. Other countries such as Brazil, South Korea and Turkey, are pursuing their own jet engine technologies, often with significant reliance on foreign designs. In the US, General Electric (GE) Aviation is the dominant force, powering a large portion of both civilian and military aircraft and boasting a market capitalisation of roughly USD 220 billion. Pratt and Whitney is the second-largest US jet engine producer. Williams International, also based in the US, specialises in smaller gas turbine engines for cruise missiles and small jets (Leyes & Fleming, 1948). Rolls-Royce, based in the UK, is a major global turbofan manufacturer, with a market capitalisation of about USD 6.5 billion. Safran, a key player in aerospace, has achieved notable engine manufacturing milestones for both commercial and military use, solidifying France's position among leading jet engine manufacturers. Russia's Aviadvigatel, successor to the Soviet Soloviev Design Bureau, along with NPO Saturn and Klimov, are the country's main jet engine producers (Fehrm, B., 2016). Jet engine research and development typically requires investments exceeding USD 10 billion (₹86,000 crore). The Kaveri project's budget of approximately ₹2,300 crore is a tiny fraction of this typical investment, hence placing it at a significant disadvantage. Additionally, with only DRDO and HAL involved, there has been lack of incentive for private sector R&D in this area (Shet, 2024).

The Way Ahead

Technology gives power. US domination of the world in the field of technology is a result of systematic funding and time bound project-oriented research. As per the Congressional Research Service report to US Congress in November 2024, (Nicastro, Luke, A., 2024) the US Government funds military research in eight different fields i.e. basic, applied, advanced technology development, advanced component development and prototypes, system development, and demonstration, management support, operational system development, software and digital technology pilot programmes. Every year the funding for list of specific projects is announced with timelines and periodic allocation of funds are reserved accordingly. Research projects are exclusive of broad departmental allocations and not subject to annual expenditure restrictions or partial surrender of funds at the end of each financial year.

India spends a minuscule 0.65% of the GDP in the research sector, compared to the US at 2.83% and China at 2.14% of their GDP. We need to deepen our pockets for R&D if we want to be self-reliant in military manufacturing (project based funding holds the key). Such R&D can have not only military but also tremendous civil application as well like the General Electronics of US powering most of the civil aviation.

In addition to funding, participation of the private sector needs to be encouraged to conduct R&D especially in the field of jet engines. India does not lack the human resource and talent for research as evident from participation of Indians in most of the leading R&D projects in the west. Indigenous firms need to be incorporated with assured business at home and export potential products so that they can hire the best in the domain.

The Kaveri project has not been able to meet the expectations due to technical shortcomings primarily in the fields of high fuel consumption, thrust-to-weight ratio and engine reliability. These inadequacies can be met with better metallurgy and testing facilities. Creating a conducive ecosystem with private industry is an inescapable need of the hour. Collaboration with foreign companies for transfer of technology needs to be given further impetus. The MoU between GE and HAL has witnessed very limited success. Earlier agreement with French company "Safran" for co-developing an aerospace engine in India did not fructify as the latter refused to share its critical aviation technology. There is a need to revamp such efforts with strategic leverage (Palve, 2023).

Ambitions can turn into reality only if supported with appropriate funding, a well thought out strategy and action plan. In a turbulent world, where lines between friends and foe are getting blurred, the only way to recoup our depleting numbers of military platforms, aging hardware and ensure supply chain in a time of crisis is to reduce and diversify our dependency on foreign firms and develop own capabilities. While discussion comparing the American F-35 and Russian SU-57 has gathered momentum, our own Advanced Medium Combat Aircraft (AMCA) {a fifth-generation multirole combat aircraft project} has become more critical than ever before. Kaveri can be the answer for the AMCA question. While China flaunts its sixth-generation fighters to the world, we cannot afford to remain in dilemma for long. Kaveri is a classic case study which should give us a wakeup call from our policy and decision paralysis. Slow paced and ill funded research projects with unrealistic expectations will not take us anywhere but expensive emergency imports and reduced numbers. It's time we have own jet engines— that's the only way ahead. The Kaveri story has its lessons for future and massive opportunity for the nation.

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