# ONLINE INTERACTIVE SESSION WITH DR. T.G PAI

We, the students of Aryaan Study Circle got opportunity to interact with Dr. T. G. Pai, a renowned personality in the world of Aerospace Engineering on Wednesday, January 13, 2021.

This interaction started with the introduction of Dr. T.G. Pai. Our Director Mr. Venkatesh Prabhudesai introduced us to this well-known personality.

Dr. T G Pai has acquired basic Engineering degree from Manipal Institute of Technology and further did his Master of Engineering from Indian Institute of Science (IISc) Bangalore and Ph. D from Indian Institute of Technology - Kanpur under guidance of Prof. M S Ramchandra. Dr. T. G Pai was the classmate of the famous personalities, Dr. M S Krishnamurthy and Dr. Kota Harinarayana who happened to be mentors for our Director Mr. Venkatesh Prabhudesai.

Dr. T.G Pai has vast experience of 23 years in Aircraft designing and development at Hindustan Aeronautics Limited (HAL) - Bangalore, Deutsches Zentrum für Luft- und Raumfahrt (DLR)- a German Aerospace Center and Aeronautical Development Agency (ADA) – Bangalore.

Aerodynamics, Flight Mechanics and Aircraft design remains his areas of interest. He was the Project Director of one of the Indian prestigious project Light Combat Aircraft (LCA) 'TEJAS'. He has worked in the areas of Aerodynamic configuration freezing, Aerodynamic data generation using CFD and wind tunnel tests for aircraft loads, flight simulation and aircraft Integration. For Airforce version of 'Tejas' initiated the studies on LCA, Navy version including shore board facility at INS Hansa. At NTU-Singapore he worked on design of Solar UAV over three years with 42 student's project. Dr. Pai also worked on specialized test facility for Air Intake technique at IIT Kanpur and Bangalore. He worked on early design of LCA (2001) with aerospace Research and Development fraternities in India viz. DRDO, CSIR, IITs and IIScs. He banked the Post Doctor fellowship award from famous Alexander Lord Foundation. Dr. Pai, with his passion of learning, is currently associated with Manipal Institute of Technology since past 3 years as Adjunct Professor.

Professor Pai, started with mentioning that Aerospace is a superlative of technology anywhere in the world. It is very diverse, with a multitude of commercial, industrial, and military applications. It is a wide

area not limited to materials, structures, aerodynamics, or propulsion. Aerospace is very wide canvas as it has a wide application. Aerospace organizations research, design, manufacture, operate, or maintain aircraft or spacecraft. Flight testing is one of the important fields validating the design of an aircraft or a spacecraft.

The outline of Interaction was on accomplishment around the world and some recent aviation and aerospace news in India, the learning from nature – the story of Migratory Birds' Epic Journey, Recent worlds records of four special Aircraft Flights, Commercial Flight with Head and Tail wind, Polar v/s Atlantic route – a San Francisco Flight.

- ✓ Recent aviation and Aerospace news in India Dr. Pai had given examples of A-SAT Missile _ Mission Shakti. In April 2019, India tested an anti-satellite weapon during an operation code named Mission Shakti developed by DRDO. It takes three minutes to destroy Satellite at 300 Km altitude in LEO. This was India's successful demonstration of the A-SAT capability to signify its ability to intercept an intercontinental ballistic missile. The ASAT test utilized a modified anti-ballistic missile interceptor code-named Prithvi Defense Vehicle Mark-II which was developed under Project XSV-1. The test made India the fourth country after the US, Russia and China to have tested an ASAT weapon.

- ✓ Chandrayaan II – was ISROs' one of the prestigious and the complex projects (August 2019) with a significant technological leap. This mission brought together an Orbiter, Lander, and Rover with the goal of exploring south pole of the Moon. This unique mission was conducted to study not just one area of the Moon but all the areas combining the exosphere, the surface as well as the sub-surface of the moon in a single mission.

In his interaction Dr. Pai mentioned about great learning from nature with example of Migratory birds.

- ✓ Scientists have determined that the V-shaped formation these birds use while migrating serves two important purposes: First, it conserves their energy. Each bird flies slightly above the bird in front of him, resulting in a reduction of wind resistance. The second benefit to the V formation is that it is easy to keep track of every bird in the group. This learning of V-formation while flying

from migratory birds is being used to improve the fuel efficiency of aircraft and are used on military flight missions. Formation flight was estimated to increase range covered by 60%.

- ✓ Another example he pulled, is about Bar-tailed Godwit, another migrating bird migrates from Alaska to New Zealand. These migrating birds make the longest non-stop endurance flights in the animal kingdom. An Alaskan bar-tailed godwit holds the world record for migratory flight by a land bird – 11,430 km non-stop, in three segments with longest one 8800 km over 9 days.

  The long migration of the Bar-tailed Godwit, around the Pacific Ocean is the most complex and seasonally structured. Faced with marked variation in wind regimes and storm conditions across oceanic migration corridors, the birds make critical decisions about when and where to fly during nonstop flights of a week's duration or longer. Based on the wind profitability (Tailwinds) and thus reduce energetic costs of migration. It is analyzed that their flight performance is relative to wind conditions during three major migration legs between destinations. It is also identified that flight efficiency is dependent significantly on altitude and hypothesize that Bar-tailed Godwits exhibit adaptive flexibility by varying flight altitude to optimize flight efficiency.

Further, during his interaction, he had mentioned some recent world Records of four special Aircraft Flights

- ✓ Global Flyer (2005)

  The GlobalFlyer was specifically designed to make an uninterrupted (non-refueled) circumnavigation of the globe with a single pilot. Unusual for a modern civil aircraft, the GlobalFlyer has only a single jet engine. Physically, the GlobalFlyer has twin tail booms mounted outboard of a shorter central fuselage nacelle. The pressurized cockpit is in the front of the fuselage and provides 7 feet (2.1 m) of space in which the pilot sits. The single turbofan engine is mounted in an unusual position above the fuselage at a point several feet behind the cockpit, seen also on the Heinkel He 162 and Cirrus Vision SF50. The outboard booms contain large fuel tanks and end in tail surfaces, which are not cross connected. The globalFlyer is a single seat, turbofan powered airplane designed by Scaled to fly around the world nonstop, unrefueled with solo pilot. It acheved this milestone for the first time on March 3, 2005 after 67 hours and one minute of flying tme. With that Pilot Steve Fossett set the record for fastest time around the world unrefueled.

- ✓ Solar UAV – Zephyr (2010)

  Unmanned solar powered aircraft offer a unique set of advanced capabilities and have set general aviation records for longest continuous flight and greatest sustained altitude. However, the application of solar powered flight to small scale solar powered unmanned aerial vehicles (UAVs) has seen sparse research activity and is only partially explored. The use of solar power as an energy resource allows small scale UAVs to carry heavier, more powerful sensor payloads, and can extend flight times to over 24 hours, thereby achieving multi-day flight.

  Zephyr is the world's leading solar-electric stratospheric Unmanned Aerial System (UAS), with a wingspan of 22.5 m and take-off mass of 50kg. Zephyr relies on solar energy, with secondary batteries charged in daylight to power overnight flight. Manually launched by 5 people running.

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|---|---|
| Model | Zephyr 7 |
| Crew | None |
| Payload | 2.5 kg (5.5 lb) |
| Solar Technology | Amorphous Silicon |
| Span | 22.50 m (73 ft 10 in) |
| MTOW | 53 kg (117 lb) |
| Motors | 2× Newcastle University custom permanent-magnet synchronous motor |
| Power | 0.45 kW (0.60 hp) each |
| Cruise | 30 kn (56 km/h) |
| Ceiling | 21,562 m (70,741 ft) |
| Endurance | 14 days |

- ✓ Solar Impulse 2 (2015-16)

  Solar Impulse started off with Bertrand Piccard's vision of building an airplane capable of flying night and day without using any fuel, propelled solely by solar energy. The aim of the project was to develop a symbol which would attractively promote a pioneering and innovative spirit, particularly in the field of renewable energy and clean technologies. During the day, the solar cells recharge the Solar Impulse 2's lithium batteries, allowing the plane to fly at night. That said, the plane does depend on appropriate weather to ensure there's enough sunlight for the solar cells to absorb.

  The wingspan of *Solar Impulse 2* is 71.9 m (236 ft), slightly less than that of an Airbus A380, the world's largest passenger airliner, but compared with the 500-ton A380, the carbon-fibre Solar

Impulse weighs only about 2.3 tonnes (5,100 lb), little more than an average SUV. It features a non-pressurized cockpit 3.8 cubic meters (130 cu ft) in size and advanced avionics, including limited functionality of an autopilot that allows the pilot to sleep for up to 20 minutes at a time, enabling multi-day transcontinental and trans-oceanic flights. Supplemental oxygen and various other environmental support systems allow the pilot to cruise up to an altitude of 12,000 meters (39,000 ft).

Key milestones of the project:

- 1999: Bertrand Piccard's vision
- 2003: EPFL Feasibility study led by André Borschberg
- 2004-2009: start-up financing, design, and construction of Solar Impulse 1
- 2010: first ever solar-powered day and night flight (André Borshberg)
- 2011: special guest at Paris-le-Bourget International Air Show
- 2012: first intercontinental solar flight across the Mediterranean to Morocco
- 2013: Across America Mission from San Francisco to New York City
- 2014: Solar Impulse 2 maiden flight
- 9 March 2015: departure for the first Round- Flight from Abu Dhabi (André Borschberg)
- 26 July 2016: completion of the first Round- Flight from Abu Dhabi (Bertrand Piccard)

✓ AN-225 : World Biggest Aircraft (1989)

The Antonov An-225 Mriya is a strategic airlift cargo aircraft that was designed by the Antonov Design Bureau in the Ukrainian SSR within the Soviet Union during the 1980s. It is powered by six turbofan engines and is the heaviest aircraft ever built, with a maximum takeoff weight of 640 tonnes (710 short tons; 630 long tons). It also has the largest wingspan of any aircraft in operational service. The single example built has the Ukrainian civil registration UR-82060.

The Antonov AN-225 was initially developed as an enlargement of the Antonov AN-124 to transport *Buran*-class orbiters. The only AN-225 airplane was completed in 1988. After successfully fulfilling its Soviet military missions, it was mothballed for eight years. It was then refurbished and reintroduced, and is in commercial operation with Antonov Airlines, carrying oversized payloads. The airlifter holds the absolute world record for an airlifted single-item payload of 189,980 kg and an airlifted total payload of 253,820 kg.

The Antonov An-225 was designed to airlift the Energia rocket's boosters and the *Buran*-class orbiters for the Soviet space program. The An-225's original mission and objectives are almost identical to that of the United States' Shuttle Carrier Aircraft.

AN-225 carrying *Buran* (1.01) in 1989

**General characteristics of AN-225**

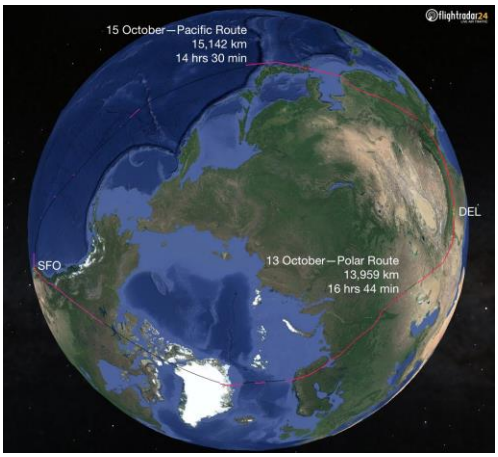
- Length: 84 m (275 ft 7 in)
- Wingspan: 88.4 m (290 ft 0 in)
- Height: 18.1 m (59 ft 5 in)
- Wing area: 905 $m^2$ (9,740 sq ft)
- Empty weight: 285,000 kg (628,317 lb)
- Max takeoff weight: 640,000 kg (1,410,958 lb)
- Fuel capacity: more than 300,000 kg (661,000 lb)
- Powerplant: 6 × Progress D-18T turbofans, 229.5 kN (51,600 lbf) thrust each
- Maximum speed: 850 km/h (530 mph, 460 kn)
- Cruise speed: 800 km/h (500 mph, 430 kn)
- Range: 15,400 km (9,600 mi, 8,300 nmi) with maximum fuel;

AN-225's main landing gear

Turbofan engines on the AN-225

- ✓ Air India Taking advantage of Tail winds

  Dr Pai further explained us, on Air India taking advantage of tail winds on its flying route San Francisco to New Delhi. On 15 October, Air India adjusted the routing of its flight to increase the distance of the flight by over 1000 kilometers. In doing so, however, the airline saved 2 hours and 15 minutes of flying time. This is all done taking advantage of favorable wind conditions i.e. Tail wind. While the distance flown will increase by over 1000 kilometers, depending on the speed of the wind, the flight time is between one and three hours shorter. Taking advantage of the tailwind offered by the jet stream on this route also help the airline cut the amount of fuel it uses during the flight




Professor Pai further mentioned about Aeronautical and Aerospace Organizations in India under the Government sector which have contributed in the growth of country in aviation and aerospace engineering.

In the question -answer session, Professor Dr. Pai has answered all question exhaustively,

- Headwind and tailwind, are they not predictable, how can you plan a flight like that. Dr Pai explained that the flight timings are given for specific season and specific route. Seasonal wind conditions are stable for specific period that helps in route planning.
- On the question asked by a student regarding “Why was configuration of tailless delta wing configuration was chosen for the LCA which is generation 4.5 over the canard delta wing configuration which is used in most modern aircrafts of 5$^{th}$ generation like Eurofighter typhoon, Saab JAS Gripen or Dassault Rafale”, Dr. Pai answered that the selection is based on the early stage of feasibility studies and also the size of aircraft, the totality of system (not only the

aerodynamics). As delta was meeting the requirement with the weight of system they wanted to have and the performance. Every option has its own advantages and penalty.

- Another student asked can India develop an aircraft as big as AN-225 (Mriya), to this question Dr. Pai answered that is not question of capability but the requirement or opportunity. The size of the aircraft, size of the hanger and the kind of use of the aircraft determines or drives the development scenario.
- To the final question asked on selecting the career path for genuinely interested student to choose aeronautics as a career, should they do mechanical from IIT and then specialize in aerospace so that they get opportunities in case they don't get a job in aerospace or should they take mechanical which is a versatile branch and then specialize in aerospace engineering, Dr Pai answered that, today there is enough scope in India as there are many projects pipeline which are coming up and things are becoming better. Also, Aeronautics being a versatile branch and system of systems, the students can be fit in many areas eg. Software Engineers, Structure Engineers, Control Engineers and CFD analysts.

This interactive session gave us an insight into the future of aeronautical industry. On behalf of the students of Aryaan Study Circle, I would like to thank Dr. T. G Pai for spending his invaluable experience with us, as well as Sir Vyankatesh Prabhudesai for giving us the opportunity to interact with one of the eminent personalities.

Written By,

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Student, XI. (Regular)