

November 2024

The Center for **High-Speed Flight**

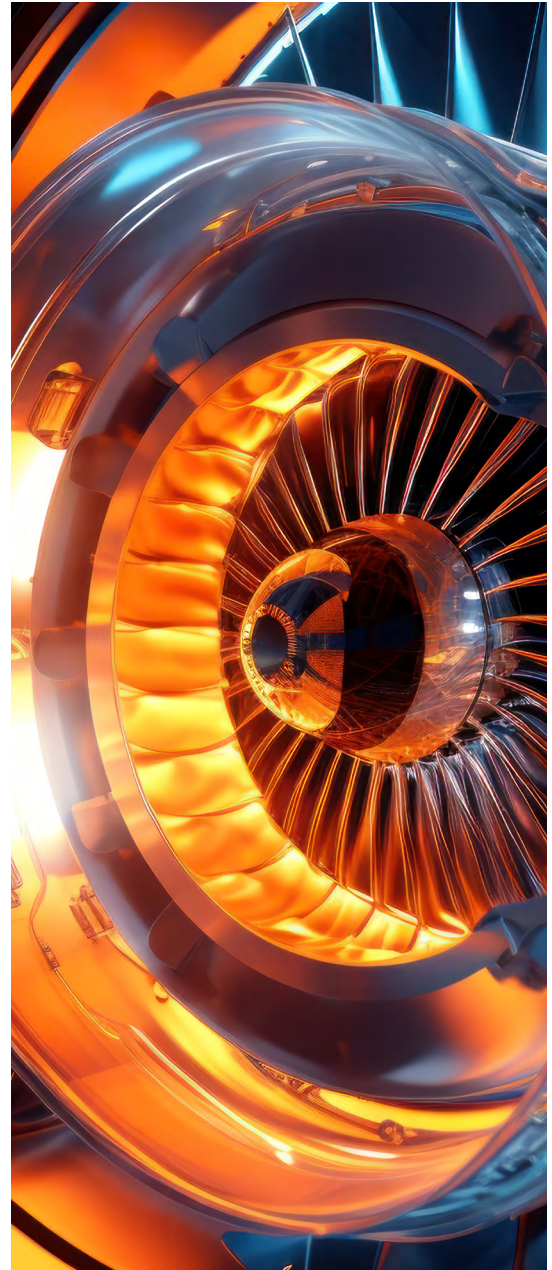
in the Morton and Beverley Rechler Family Foundation Research Building

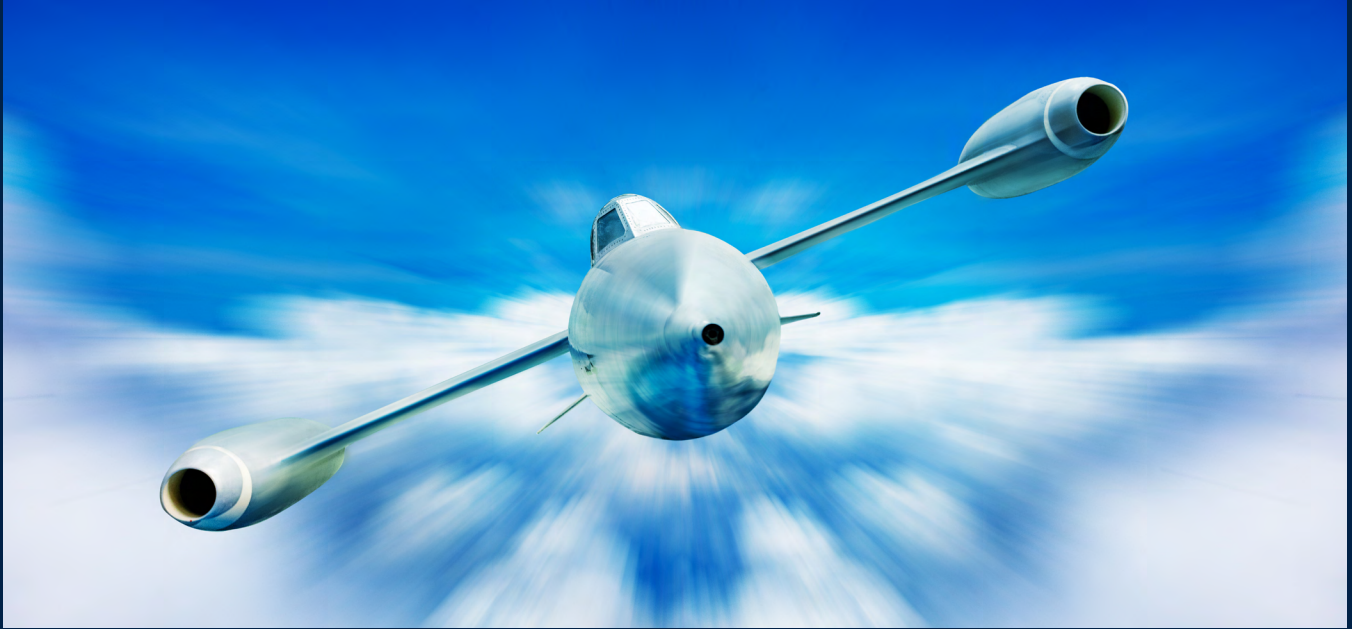
The Importance of High-Speed Flight Research

One of the most exciting research areas in aerospace engineering is hypersonics — the study and design of vehicles capable of traveling faster than five times the speed of sound (Mach 5).

Although this field has been actively researched since the 1950s, it is currently undergoing a renaissance due to important advances in cutting-edge technology and growing strategic interest. Several countries — including the U.S., China, Russia, India, Japan, Australia, France, and the U.K. — are investing in the development of hypersonics. While the high velocities associated with hypersonic flight have been achieved by various spacecraft and missiles, there are many challenges linked to the design of advanced hypersonic aircraft.

Israel is already at the forefront of aerospace technologies, and one of a handful of countries with an independent capacity to launch satellites and place them into orbit. Technion graduates in industry and government are leading Israeli aerospace innovation while collaborating closely with researchers at our Faculty of Aerospace Engineering, the only academic faculty of its kind in Israel. In concert with industry, Technion is now poised to tackle stubborn challenges to hypersonic flight head on. ■





Unparalleled Flight Conditions

Multiple forces act on hypersonic aircraft, dynamically fluctuating with little warning and variable effects. The properties of air, and the resulting airflow dynamics, undergo sudden radical change as the vehicle accelerates, transitioning from subsonic to supersonic, to hypersonic speeds. At increased speeds the air becomes compressed and pressure piles up ahead of each part of the aircraft, until shock waves form and interfere with the airflow; the lifting effectiveness of the wing and tail surfaces lessens, drag forces become more pronounced, and airplane stability is compromised. Friction caused by the airflow along surfaces generates heat extreme enough to melt standard aircraft structures, while simultaneously affecting surrounding air molecules in a way that changes

the magnitude of forces exerted on the vehicle. Consequently, hypersonics necessitates a revolution in every aspect of aircraft design; compared to conventional aircraft, a vehicle flying at hypersonic velocity requires a completely different propulsion system, aerodynamic design, materials, structure, and controls.

In short, high-speed flight approaching Mach 5 at altitudes as high as the outer edge of the earth's atmosphere will depend on researchers' ability to anticipate the totality of aerodynamic, thermodynamic, and chemical phenomena and to account for them in the design of propulsion technologies and hypersonic airframes, their physical geometries, and the materials used. ■



The Technion Center for **High-Speed Flight**

Given the level of unknowns and the costs of failure, flight testing full-scale hypersonic prototypes is a prohibitively risky proposition. The lack of flight testing has often been an Achilles Heel impeding the development of hypersonics, as has the tendency to take on multisystem phenomena one system at a time – rather than synergistically moving forward on multiple fronts of research and development.

Headed by two-time Israel Defense Prize recipient Brigadier General (Res.) Amnon Harari, the Technion's new Center for High-Speed Flight (TeCHFlight) is steadily building all the components necessary for rapid, simultaneous advancement on all fronts of hypersonics R&D.

TeCHFlight's multidisciplinary teams of researchers and graduate students from different Technion faculties work in tandem with Israel's aerospace industries. Many of the scientists and engineers on these teams are uniquely qualified – having real-world experience in aerodynamics and high-speed flight, as pilots or technical engineers in Israel's air force and the IMOD. Using advanced Computational Fluid Dynamics (CFD) software and developing novel high-temperature materials, these teams are bridging knowledge gaps and drawing us closer to the next generation of hypersonic aircraft.

The center's future accommodations at the Morton and Beverley Rechler Family Foundation Research Building and at other locations on the campus, will offer new, state-of-the-art ground-testing facilities, including: a high-grade Aerodynamics Laboratory; a Hypersonic Compression Shock Tunnel Laboratory; an Advanced Optical Diagnostics Laboratory, and more. Similarly, the Technion's new High Performance Computing capabilities will guarantee significantly greater CFD and other simulations capacity.

With its unique advantages, TeCHFlight is uniformly progressing in six areas of expertise:

- **Flight Performance** – maximizing flight performance by optimizing the configurations of the airframe and other vehicle components, and innovating new guidance, navigation, and control (GNC) methods.
- **Hypersonic Aerodynamics** – studying aerodynamic forces, and their interactions, at different altitudes and speeds (including effects of changes in the molecular structure of the surrounding air and its effects on the vehicle).
- **Structures and Materials** – researching the elasticity of structures under extreme aerothermal conditions, developing materials, and 3D printing of structures that can withstand the extreme conditions of hypersonics.
- **Propulsion and Combustion** – studying and modeling the physics of “air breathing” scramjet engines (characterized by the compression of supersonic airstreams drawn into the engine inlet by the forward motion of the vehicle, and combusted using injected fuel ignited by a flame). Issues include fuel composition, injection strategies, flames and ignition development, and more.
- **Thermal Management** – focusing on heat transfer in the flow field along the surface of the vehicle, characteristics of heat loss using ablative materials, and novel schemes for active thermal management.
- **Measurement Methods** – innovating and implementing new measurement methods to enhance the quality of research in the other five areas of expertise. ■



The Morton and Beverley Rechler Family Foundation Research Building

Housing two technically advanced laboratories, the Morton and Beverley Rechler Family Foundation Research Building will become an integral facility at the Technion, incorporating study of high-speed flight systems.

Research into cutting-edge hypersonic flight technology will keep the Technion at the forefront of this critical area, and ensure that Israel is well-positioned to implement these advances in flight technology in ways that can defend the State of Israel for decades to come. The Technion will announce the construction timeline for this building in the near future. Hypersonic research will be led within the building by members of the Faculty of Aerospace Engineering, but will also involve researchers from other Technion faculties including Mechanical Engineering, Materials Science and Engineering, Chemical Engineering, and Physics. Currently, a number of Technion researchers are working independently on hypersonic-related projects, but coordination, collaboration, and upgraded facilities are needed to bring the University's hypersonic research to the next level. To achieve the required scientific and technological advances in hypersonic systems, the building will host research facilities not found elsewhere in Israel.

The Morton and Beverley Rechler Family Foundation Research Building will become an attractive platform for international academic cooperation, and an effective vehicle for Israeli governmental organizations focused on aerospace R&D. ■



Laboratories within the Center

Two laboratories located in the Morton and Beverley Rechler Family Foundation Research Building are currently available for naming:

■ The Arc-tunnel Laboratory

The first laboratory scheduled for completion will incorporate a heated wind tunnel that is already in operation at the Technion. This wind tunnel utilizes a high-powered electrical arc source to heat air to temperatures of more than 9,000°F with the goal of testing materials for use in hypersonic flights. The wind tunnel will be upgraded with three goals in mind: handling an increase in air velocity up to Mach 6, increasing the size of the wind tunnel's cross-section in order to test larger structures, and introducing different types of fuels for enabling combustion research.

■ The Hypersonic Wind Tunnel Laboratory

The second laboratory will house a new wind tunnel which will better fit research on air-breathing propulsion for hypersonic flight at Mach numbers of 5 to 8, such as supersonic combustion ramjets, and enable testing models of full engines (inlet-combustor-nozzle). This tunnel will provide three times higher air pressure and Reynolds number compared with the arc tunnel, which are parameters which are crucial for propulsion systems. The air will be heated using electrical resistance heaters up to temperature of 2,000°F and pressure of up to 1000 psi. This tunnel will complement the upgraded arc-tunnel in the range of air flow conditions and also will be very useful for studying hypersonic aerodynamics. ■

A satellite is shown in space, with its solar panels extended. The Earth's atmosphere and clouds are visible in the background. The satellite has various instruments and antennas.

Funding Opportunities

- A gift of **\$2.6M** will name and equip the **Arc-tunnel Laboratory**.
- A gift of **\$8.6M** will name and equip the **Hypersonic Wind Tunnel Laboratory**.
- Donations of **\$10,000 and above** are welcome to support **the Center for High-Speed Flight**.

TeCHFlight budget requirements for the coming decade are projected to exceed \$55M. Much funding will come from government grants, industry partners, and other sources, yet the Technion anticipates the need to raise 30% of the total budget from philanthropic donors. Support will be used for capital and research infrastructure (e.g., adaptation of test equipment and instrumentation; equipment upgrades; and safety). ■

Budgets

Arc-Tunnel Laboratory	
Item	Amount (CAD)
Construction	1,551,000
Equipment	1,259,412
Infrastructure Costs	989,538
Technion Canada Administrative Expenses	618, 596
Total Project Cost	4,418,546

The Hypersonic Wind Tunnel Laboratory	
Item	Amount (CAD)
Construction	1,551,000
Equipment	6,346,974
Infrastructure Costs	4,262,289
Technion Canada Administrative Expenses	1,979,577
Total Project Cost	14,139,840

Donor Recognition

The highest form of donor recognition bestowed by the Technion is inclusion in the President's Circle.

This extraordinary honor is awarded by the University to its most devoted friends upon reaching the milestone of the equivalent of **\$10 million** USD in support. Donors who provide the equivalent of **\$1 million** USD in support and above are bestowed the title of Technion Guardian and are honored by physical and digital plaques situated in a most prominent central campus location.

Capital gifts at all levels are recognized by a physical plaque of distinction.

Gifts between the equivalent of \$25,000 and \$1 million USD will be recognized in the form of digital plaques situated in the foyer of Churchill Auditorium, whose dome is one of the most noted features of the Technion, and on a master plaque located within the Morton and Beverly Rechler Family Foundation Research Building.

Gifts starting at the equivalent of **\$100K USD** will be listed in the President's Report, the official annual report of the Technion. Gifts are listed in one printed version of the Report; recognition appears when gifts reach 50% completion.

Additionally, donors will receive an annual report of activities carried out within the Center for High-Speed Flight. ■





Thank You

The Technion reserves special gratitude for those who support its research initiatives. These gifts, which help expand the frontiers of knowledge in specific academic disciplines, represent the very best of the spirit of discovery for which the Technion is globally renowned. Support for research ensures that the Technion is at the forefront of academic institutions, attracting new cadres of highly accomplished faculty and promising students. The gift you have bestowed for the Center for High-Speed Flight allows researchers in this area to usher in the next wave of discoveries that will benefit the Technion and the world now that the University has commenced its second century of operation.



TECHNION

Israel Institute of Technology

Situated in Haifa, the Technion-Israel Institute of Technology, founded in 1912, stands as Israel's oldest university, offering a wide array of degrees in science, engineering, and interdisciplinary fields to its diverse student body of over 15,000. Known for its groundbreaking research in areas such as energy, nanotechnology, and life sciences, the Technion hosts 18 academic faculties and over 60 research centers, playing a pivotal role in shaping both academic discourse and the socio-economic landscape of Israel.

With a rich history spanning a century, the Technion maintains its position as a globally recognized institution, consistently ranking among the top academic establishments worldwide. Its sprawling campus overlooking the Mediterranean serves as a hub for applied research, attracting renowned faculty members and fostering a culture of innovation and collaboration. Among its 565 faculty members are leaders in their fields, boasting numerous international honors and prizes, including three Nobel Prizes, and contributing significantly to the advancement of knowledge through their research endeavors.