DELFT UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF AEROSPACE ENGINEERING

Memorandum M-525

REPORT OF THE 1984 STUDY TOUR TO ISRAEL

by

The Society of Aerospace Students
of
Delft University of Technology
"LEONARDO DA VINCI"

DELFT - THE NETHERLANDS

December 1984

LEONARDO DA VINCI

INTRODUCTION

PREFACE

The Society of Aerospace Students "Leonardo da Vinci" is the association of students of the Department of Aerospace Engineering of the Delft University of Technology. Since 1945, the year in which the Society was founded, activities have been organized complementary to the Department's study program.
The total membership of the Society is well over four hundred.

Apart from activities to support and improve the study program, the Society organizes lectures, films, symposia and study tours to the Dutch aerospace industries. Thus a broad view on the aerospace activities in these countries and an impression of the possible future working area is gained.

Because of the strong international character of the aerospace industry, the Society has also developed the good habit of organizing study tours abroad. In the past few years tours were organized to:

- The U.K. (1979)
- The U.S.A. (1981)
- Scandinavia (1982)
- Canada and the U.S.A. (1983)

In 1980 the Society celebrated its 7th 'Lustrum'. The festivities included an international air-display at Rotterdam Airport, a symposium titled 'The Challenge of Space' and an exhibition on helicopters.

This year, inspired by a visit of Prof. J. Singer, President of the Technion-Israel Institute of Technology, to our Department, the Society decided to organize a study tour to Israel.

Thanks to the tremendous cooperation offered by the Technion and the Dutch Technion Society, it was possible to draw up an interesting program, covering a wide variety of Israeli aerospace activities.

This report on the study tour was written with assistance of the participants and concludes with some final remarks, summarizing some general impressions gained during the entire tour.

INTRODUCTION

CONTENTS

INTRODUCTION

COMMITTEE OF RECOMMENDATION

- Mr. A.M. Van Bemmelen
  Dutch Senator
  Vice-Chairman of the Board of the Dutch Technion Society

- Ir. J.A. van der Bliek
  Director of the Foundation National Aerospace Laboratory (N.L.R.)

- Ir. J. Cornelis
  Vice-President Engineering of Fokker

- Prof.dr.ir. O.H. Gerlach
  Chairman of the Foundation National Aerospace Laboratory (N.L.R.)

- Lt.-Gen. ret. M.G. Geschiere (Royal Netherlands Airforce)
  Chairman of the Netherlands Agency for Aerospace Programs (N.I.V.R.)

- Prof.ir. J.A. van Ghesel Grothe
  Dean of the Department of Aerospace Engineering of the
  Delft University of Technology
  Member of the Presidium of the Dutch Technion Society

- Drs. C. de Hart
  Chairman of the Executive Board of the
  Delft University of Technology
  Member of the Dutch Technion Society

- J. Nechushtan
  Ambassador of Israel in the Netherlands

- Drs. S. Orlandini
  President-Director of K.L.M. Royal Dutch Airlines

- Mr. H. Raben
  Director-General of the Dutch Civil Aviation Authority (R.L.D.)

- Prof. J. Singer
  President of the Technion-Israel Institute of Technology

- F. Swarttouw
  Chairman of the Board of Management of Fokker

- Prof. M. Trella
  Technical Director of the European Space Research and
  Technology Centre (ESTEC)

INTRODUCTION

- Prof.ir. B.P.Th. Veltman
  Rector Magnificus of the Delft University of Technology

- Mr. R.E. Waterman
  Member of the Provincial Council of South-Holland
  Chairman of the Board of the Dutch Technion Society

- Lt.-Gen. ret. A.J.W. Wijting (Royal Netherlands Airforce)
  Chairman of the Royal Dutch Association for Aviation (KNVvL)

- Lt.-Gen. ret. A.B. Wolff (Royal Netherlands Airforce)

- Prof.dr. G. Zoutendijk
  Dutch Senator
  Chairman of the Presidium of the Dutch Technion Society.

INTRODUCTION

ACKNOWLEDGEMENTS

The Society wishes to thank the following companies, foundations and individual for their financial support, that made the 1984 study tour to Israel possible:

- K.L.M. Royal Dutch Airlines
- Foundation Nationaal Luchtvaartfonds - Van den Berg van Heemstede
- Foundation Prof.dr.ir. H.J. van der Maasfonds
- Fokker B.V.
- Foundation Ir. Timmers Verhoeven Fonds
- Bank Mees & Hope N.V.
- Foundation Kraus-Uithof Fonds
- Algemene Bank Nederland N.V.
- Nederlandse Luchtvaart Pool N.V.
- N.V. Indivers
- Schreiner Aviation Group
- Philips Gloeilampenfabriek N.V.
- Nationaal Vliegtuigbeheer N.V.
- Koninklijk Instituut voor Ingenieurs
- Van Doorne's Bedrijfswagenfabriek DAF B.V.
- N.V. Royal Delft Ware Manufactory "De Porceleyne Fles"
- Technische Handelsmaatschappij Hollinda B.V.
- Miniature Precision Bearings M.P.B. Europe B.V.
- Nederlandse Instrumenten Compagnie Nedinsco B.V.
- Mr. R.E. Waterman

The Society offers its special thanks to the various people of the Technion-Israel Institute of Technology:

- Prof. J. Singer
  President

INTRODUCTION

- Prof. Y. Eckstein
  Vice-President for Development
- Prof. A. Kogan
  Dean of the Department of Aeronautical Engineering
- Prof. I. Elishakoff
  Associate Professor
- Mr. B. Phillips
  Head of the Public Relations Department
- Mr. E.E. Tenne
  European Representative
- Mrs. M. Weinbrand
  Public Relations Department

of the Dutch Technion Society:

- Mr. R.E. Waterman
  Chairman of the Board
- Mr. A.M. van Bemmelen
  Vice-Chairman of the Board

of the Department of Aerospace Engineering of the Delft University of Technology:

- Prof.ir. J.A. Van Ghesel Grothe
  Dean of the Department
- Mr. C.W. van Schaik
  Financial Administration
- The lady-secretaries, especially Helma Oosterbaan.

Participants in front of an El Al Boeing 767

INTRODUCTION

LIST OF PARTICIPANTS

1. Marcel de Jong (Board)
2. René van Paassen (Board)
3. Jos van den Akker (Board)
4. Patrick Liesker (Board)
5. Wilfried Boel
6. Klaas Borst
7. Ebo Bos
8. Bart-Jan Brandt
9. Simon Brouwer
10. Henk Bulte
11. Marc van Buren
12. Johan Buter
13. Eddy van Duivenbode
14. Ab Hoolhorst
15. Jack Huisman
16. Henk van Huizen
17. Jan-Willem Jacobs
18. René de Jager
19. Joost Krebbekx
20. Frans Louwers
21. Hans Paalvast
22. Robin Prins
23. Reinoud van der Reijden
24. Frido Smulders
25. Robert Stäb
26. Marc Tolsma
27. Marcel van Varik
28. Tom van Velze

29. Prof.ir. J.A. van Ghesel Grothe (University Staff)
30. Mrs. T. van Ghesel Grothe-Visser
31. Ir. T.J. van Baten (University Staff)
32. Mrs. Y. Vaandrager
33. Ir. H. Binkhorst (University Staff)

INTRODUCTION

COSTS BREAKDOWN

- Flight tickets: Amsterdam - Tel Aviv	
Tel Aviv - Amsterdam	ƒ 19.992,00
- Lodging	ƒ 6.937,91
Living	ƒ 11.254,80
Touringcar + guide + driver	ƒ 10.603,07
- Insurance	ƒ 810,76
- Report	ƒ 1.200,00
- Representation, administration	
miscellaneous	ƒ 1.880,00 +
	ƒ 52.678,54

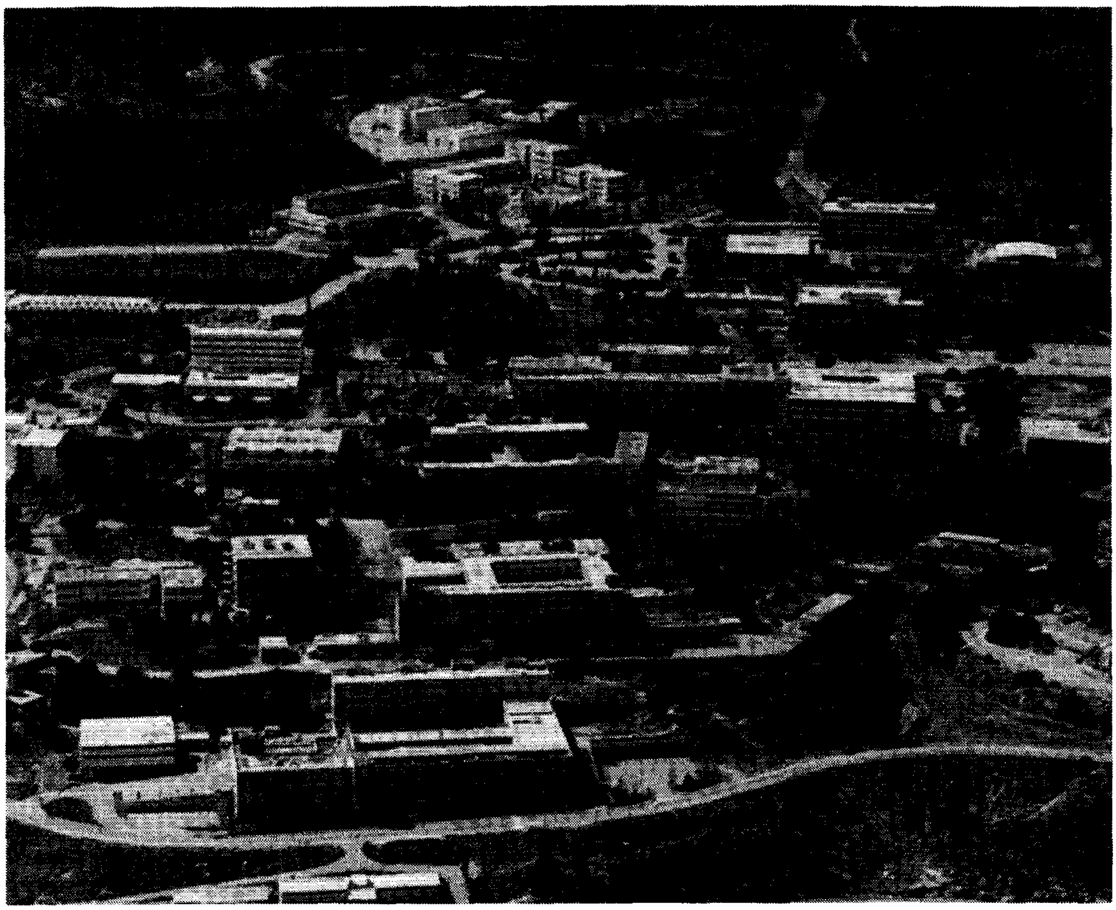
Period: July 3rd/July 18th 1984.
28 students; University Staff members and their wives not included.
Rate: $ 1.00 = ƒ 3.162


ROSH HA NIQRA
KABRI
ACCO
YA'AD
CAPERNAUM
SEA OF GALILEE
KINNERET
HAIFA
MEDITERRANEAN SEA
ISRAEL
TEL AVIV
LOD
REHOVOT
YAVNE
JERICHO
JERUSALEM
BET SHEMESH
DEAD SEA
EIN GEDI
MASSADA

INTRODUCTION

PROGRAM

Tue July 3rd	Departure from Schiphol, Airport Amsterdam
Wed July 4th	Arrival at Ben Goerion Airport, Tel Aviv Transfer to the Technion-Israel Institute of Technology, Canada-Village dormitories, Haifa Sight-seeing Haifa
Thu July 5th	Opening Seminar at the Department of Aeronautical Engineering Reception
Fri July 6th	Cabiran Non Ferrous Precision Castings, Kibbutz Cabri
Sat July 7th	Sight-seeing Galilee
Sun July 8th	Elbit Computers, Haifa Elscint, Haifa
Mon July 9th	El-Op Electro Optics, Rehovot Weizmann Institute of Science, Rehovot Ormat Turbines, Yavne
Tue July 10th	El Al Israel Airlines, B.G. Airport Bet Shemesh Engines, Bet Shemesh Transfer to Jerusalem College of Technology, dormitories
Wed July 11th	Israel Aircraft Industries, B.G. Airport
Thu July 12th	Mata Helicopters, Jerusalem
Fri July 13th	Transfer to Youth Hostel, Ein Gedi
Sat July 14th	Trip to Massada Back to Jerusalem College of Technology
Sun July 15th	Knesset, Jerusalem
Mon July 16th	Sight-seeing Jerusalem
Tue July 17th	Transfer to Tel Aviv Diaspora Museum, Tel Aviv Board pays a visit to the Ambassador of The Netherlands in Israel, Mr. M. van Berkel
Wed July 18th	Departure from B.G. Airport Arrival at Schiphol.



Technion City

TECHNION
ISRAEL INSTITUTE OF TECHNOLOGY

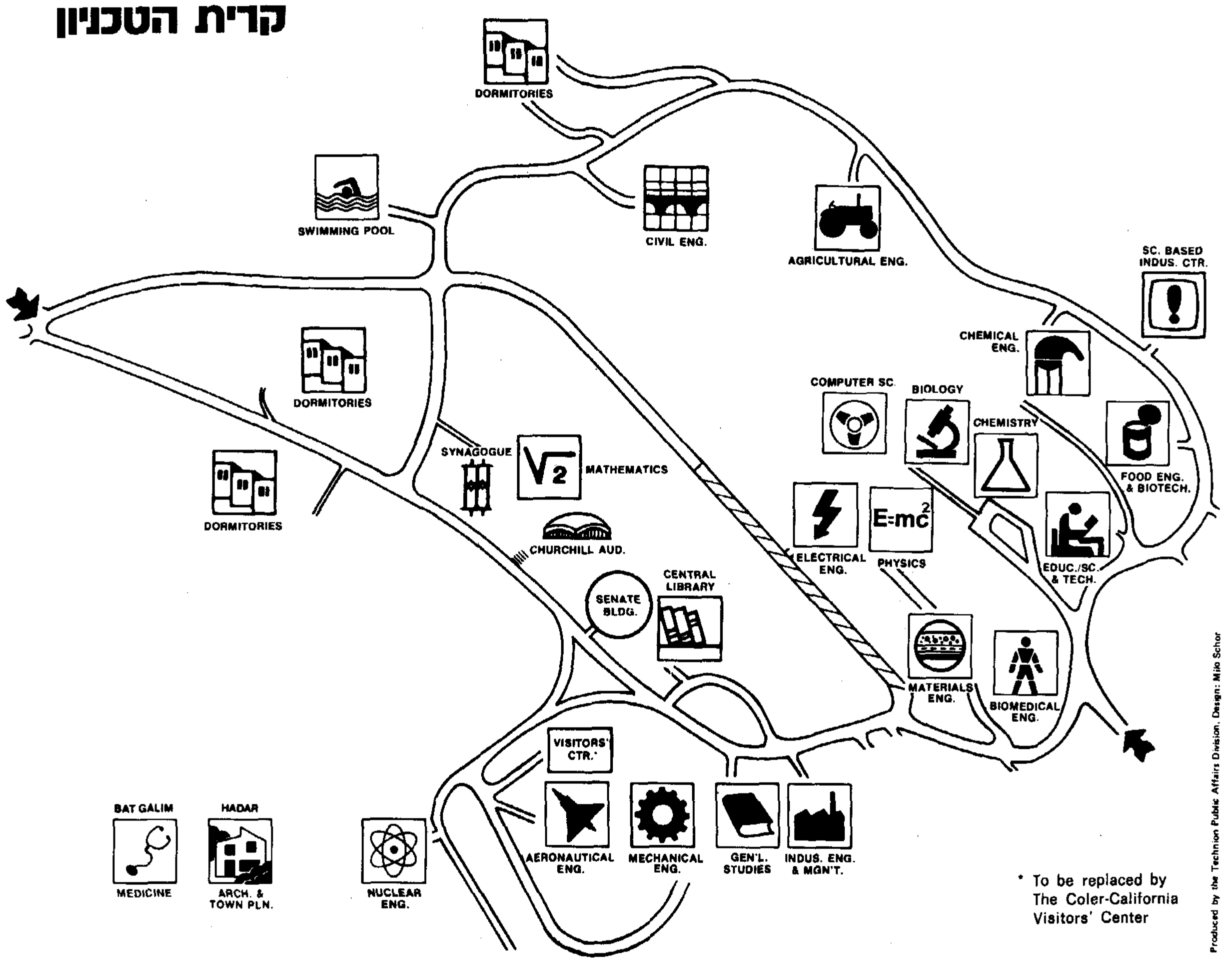
TECHNION 1924-1984

TECHNION-ISRAEL INSTITUTE OF TECHNOLOGY

The Technion-Israel Institute of Technology is Israel's technological showcase. More than three quarters of the country's high-technology engineers and scientists are educated here, and the research and development projects spawned in Technion laboratories have astonished top-rate scientists around the world. It can be ranked among the world's most prestigious technological institutes and it has been of vital importance to the engineering and sciencti-fical growth of the State of Israel.
The Technion is Israel's oldest academic institution. Known then as the Technikum it was established by the Hilfsverein der Deutschen Juden, a German-Jewish society that also administered a network of vocational and secondary schools in Palestine - the most organized educational system in the country. It was opened in 1907 but, due to several language and financial problems and the outbreak of World War I, it never really outlived its growing pains and went bankrupt in 1915. It was revitalized in 1923 and classes began in December 1924.
Sixty years later the Technion is comfortably located on a separate campus comprising about 100 buildings, housing educational facilities, research laboratories and dormitories. Construction of this campus, now known as 'Technion City', started in the early 60s and gradually the extensive 300 acre area on the upper slopes of Mount Carmel in Haifa was filled up. Now, all faculties have occupied their new-built quarters with the exception of the Faculty of Architecture and Town Planning, which is still located in the old Technion site in central Haifa, and the Faculty of Medicine, which has an own campus at Bat Galim, just off the coast in Haifa. But the end of Technion's growth is not yet in sight, if it ever will be. Recently, priority in the construction has been given to student hostels, and so our group could enjoy staying in luxurious, one-year-old dormitories while in Haifa. We were told they were the best in Technion City.
The building program also includes additional facilities for students sports and social activities, creating an integrated student community as can be seen in American universities, with obvious academic, intellectual and social advantages. It is therefore only hopeful that a greater enrolment of female students at the Technion will also be established.
As already mentioned, the Technion is a technological university. It has 20 faculties and departments covering all major fields of engineering, science, architecture and even medicine. The overall amount of students adds up to about 8,000; 2,000 graduates and 6,000 undergraduates. The academic staff numbers over 1,000. In order to increase the number of first- year enrolments, the Technion has made contacts with several highschools in Israel. Pupils with potential in science and engineering are picked out and, with extra lessons and special classes on 'General Technological Enrichment', motivated towards a technological career, starting of coarse at the Technion.
Five years ago the Technion instituted a major change in its degree program, offering a three-year Bachelor of Arts degree in the science subjects, in addition to the regular four-year Bachelor of Science degree. The change was motivated by a desire to attract more students to these subjects in view of the fact that the other universities were offering a three-year degree. Now the Technion is reconsidering the change and restoring the original higher standards. For this is one of the main objectives of the Techion: to keep up high quality standards of education, rather than to increase quantity. To ensure this, the faculties and departments are submitted to the critical scrutiny of the outside authorities.

The Department of Aeronautical Engineering was founded in 1954. It expanded rapidly, especially after 1968, owing to expansion of the aeronautical industries in Israel and the consequent increasing demand for aeronautical engineers. At present, about 300 undergraduate and 120 graduate students are enrolled in it. The curriculum takes 4 years and is designed to give the students the necessary theoretical and experimental background. After 2 years of fundamental science and engineering courses, the students are introduced to aeronautical engineering subjects. During the last undergraduate year the students are given the option of specialization. After graduation they can carry on for a Master's or Doctor's degree, or find a job in industry. All this time, laboratories equipped with up-to-date facilities are available.
One of the keys to success of the Technion are its extensive ties with industry. Many research projects are carried out in cooperation with, and sponsored by Israeli and foreign industry.
A good example of this cooperation is Gutwirth Center, a small industrial park on the Technion campus. It is based on the philosophy that new industry needs the conditions and atmosphere conducive to growth. The small science-based industries are given a maximum of 3 years to draw upon the facilities and know-how of the Technion as they try to establish themselves. The rent they have to pay is used by the Technion for scholarships and grants to students and researchers. This way the academic resources of the Technion are comfortably blended with the praticalities of a functioning business. And as the Technion's role in the development of Israel has always been oriented towards the practical, it is no surprise that the Israeli industry is enjoying these services in the fields of sponsored research and for testing more and more.
Setting high goals and paying for them are two different problems. Both are essential for the Technion. It is obvious that an institute of higher education like the Technion is a money consumer almost incomparable to anything else, and in fact Israel can't afford it. This year the Technion, a private institute, functions on a \$75 million annual budget, of which about \$50 million comes from the Israeli government. Another \$6.8 million comes from tuition fees (a student pays between \$600 and \$700 each year; quite expensive by Israeli standards), while \$7.5 million comes from Technion societies, established in Israel and 16 countries abroad, including The Netherlands. (There is a \$5.6 million

TECHNION CITY
קרית הטכניון



* To be replaced by The Coler-California Visitors' Center

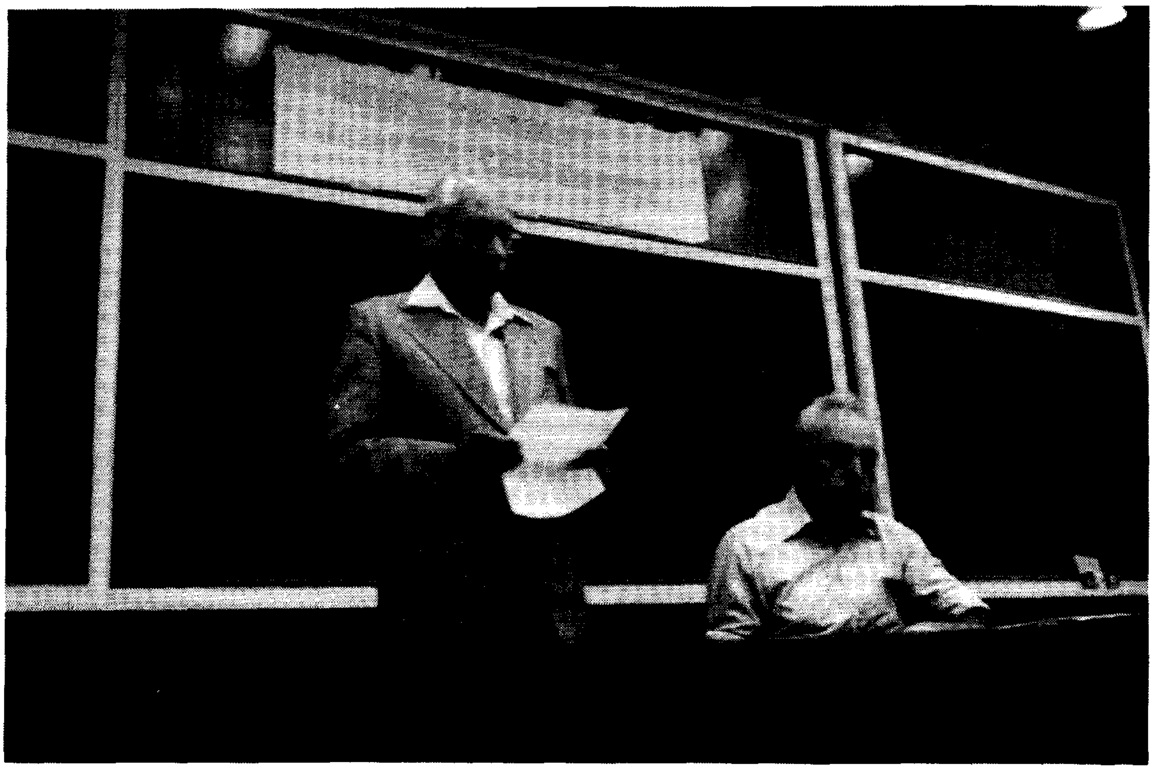
Produced by the Technion Public Affairs Division. Design: Milo Schor deficit built-in in this year's budget.) These societies raise funds - most of the buildings in Technion City carry the names op people that financed them - and these funds are of increasing importance as the Technion feels the effects of national austerity measures. The problem of cutting the costs and at the same time increasing the productivity may be one of the most difficult problems the Technion has ever met, but the institute, with its international reputation of inventiveness, will undoubtedly find a way to cope with it.

Delft University of Technology
Department of Aerospace Engineering
Delft, The Netherlands

Technion-Israel Institute of Technology
Department of Aeronautical Engineering
Haifa, Israel

JOINT ONE-DAY CONFERENCE ON AERONAUTICAL AND AEROSPACE RESEARCH AND EDUCATION

Building of Aeronautical Engineering
Auditorium, Room 235
July 5, 1984



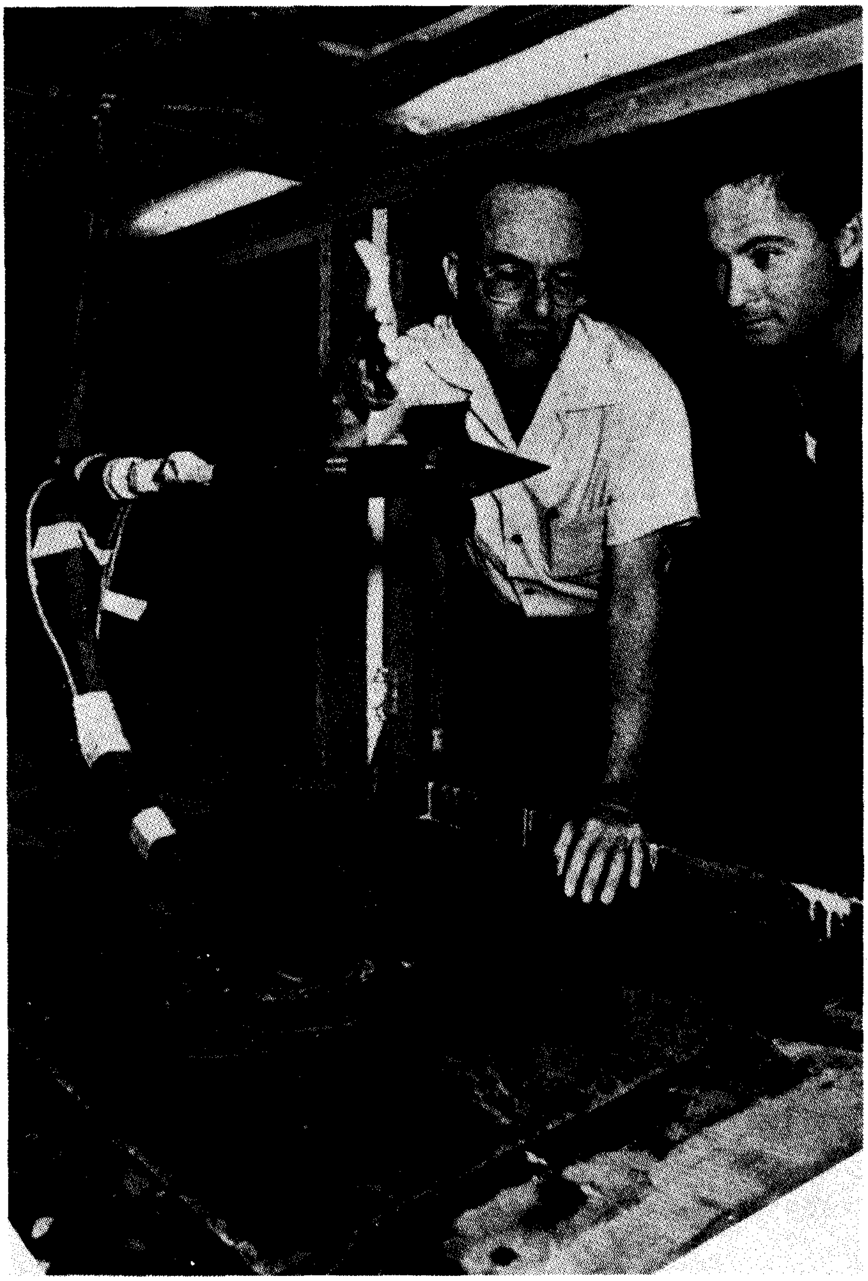
Opening by Mr A. Uriel (left) and Prof J. Kogan

TECHNION

OPENING SEMINAR AT THE DEPARTMENT OF AERONAUTICAL ENGINEERING

Program

8.00-8.10	Opening Prof. J. Kogan, Dean Department Aeronautical Engineering, Technion Mr. A. Uriel, Consul of The Netherlands in Haifa
8.10-8.40	History of the Department of Aeronautical Engineering of the Techion Prof. J. Kogan
8.40-9.10	Delft University of Technology and the Department of Aerospace Engineering Prof.ir. J.A. van Ghesel Grothe, Dean of the Department of Aerospace Engineering, Delft
9.10-9.35	Research and Education in Fluid Dynamics Dr. A. Seginer, Technion
9.35-10.00	Research and Education in Flight Control Prof. S. Merhav, Technion
10.00-10.15	Coffee Break
10.15-10.45	Research in Low Speed Aerodynamics Ir. H. Binkhorst, Delft
10.45-11.45	Visit to Wind Tunnel and Aerodynamics Lab. Dr. A. Seginer and Dr. D. Levin, Technion Visit to Flight Control Lab. Prof. S. Merhav and Dr. A. Grunwald, Technion
11.45-12.30	Visit to Turbo- and Jet-Engines Lab. Prof. B. Gal-Or and Dr. A. Rasputnis, Techion Research and Education in Engines Prof. B. Gal-Or, Technion
12.30-13.30	Lunch
13.30-13.50	Research and Education in Combustion and Propulsion Dr. Y. Tambour, Technion
13.50-14.05	Preliminary Design for Third Year Students J. Jacobs and J. Krebbekx, Delft
14.05-14.20	Plans voor CAD Dr. A. Segal, Technion
14.20-14.40	Computer Graphics Dr. Y. Harit, Technion
14.40-15.05	Visit to Combustion and Propulsion Lab. Dr. Y. Tambour, Dr. J. Goldman and G. Gadiot, Technion
15.05-15.20	Coffee Break
15.20-15.40	Movie on the Department of Aeronautical Engineering, Technion
15.40-16.00	Research and Education in Helicopters Dr. A. Rosen, Technion
16.00-16.15	Combined Wind Tunnel Experiment and Flight Test for Fourth Year Students K. Borst and M. Tolsma, Delft
16.15-16.30	Strength Calculations of Aircraft H. Bulte, Delft
16.30-16.50	A Survey of Research in Advanced Structures Ir. T.J. van Baten, Delft
16.50-17.15	Research and Education in Structures Prof. A. Libai, Technion
17.15-17.45	Visit to Structures Lab. Prof. A. Libai and Dr. T. Weller, Technion
17.45-18.05	Demonstration of Supersonic Flow around the Two-Dimensional Profile F. Anidjar, Technion Robot Arm E. Segal, Technion



Prof A. Seginer (left) with a missile model
in the subsonic windtunnel

TECHNION

RESEARCH AND EDUCATION IN FLUID DYNAMICS

Dr. A. Seginer - Technion

The four-year curriculum at the Aeronautical Engineering Department starts with a broad base education. In the field of aerodynamics the course, divided into eight semesters, contains the following colleges:

Semester	College
I	Instructions to aeronautical engineering
II	Thermodynamics I
III	Thermodynamics II
IV	Fluid dynamics I
V	Fluid dynamics II
	Viscous flow + heat transformation
	Flight mechanics I
VI	Flight mechanics II
IV-VII	Engineering at laboratories

At the end, one can choose an elective, for example:
- applied aerodynamics (wings + aircraft)
- preliminary design (aerodyn.)
- molecular thermodynamics
- helicopter dynamics
- aero-elasticity
- num. methods in fluid dynamics
- optical methods in aeronautics.

Nowadays much research is done into the behaviour of airflow around airfoils at high angles of attack. This research is of particular interest with regard to the manoeuvring of high-speed aircraft.

Special topics for research are:
- vortex shedding (wing, fuselage)
- vortex lift
- vortex breakdown
- breakdown-flow
- supercritical flow (mixed)

For experimental research the Department has three wind tunnels:
- a subsonic tunnel for testing of, for instance, propeller-driven aircraft and take-off and landing characteristics of all sorts of aircraft;
- a transsonic tunnel with a range of 0.4 to 1.5 Mach;
- and finally a supersonic tunnel which reaches 1.5 Mach to even 4.5 Mach. This tunnel is of the blow-down type which needs only half an hour to generate enough pressure for testing. Nevertheless the operating costs are low. This is also due to the self-activity of the researchers. For example, they have made their own balance-system for only one-third of the usual price.

In these wind tunnels a lot of important measurements on the Kfir-fighter have taken place. This is due to the progressive policy of the laboratory, so they were ready for testing when Israel Aircraft Industries decided to develop the Kfir.
Beside these wind tunnels, the wind tunnel laboratory will this year begin operation of a hypersonic wind tunnel. This is related to increased activity in space technology; Israel's next frontier. The country's first hypersonic tunnel will be used for research into Space Shuttle aerodynamics. It is designed for speeds above Mach 5.0. Because it functions at very high temperatures (about 3300°C), the hypersonic tunnel will be able to test the internal flow of rocket engines with the object of developing thermal protection materials later. Construction started in 1978 and so far it has cost $2 million, a figure likely to increase.
It can be said that the Technion's Aeronautical Engineering Department has provided the basic research in aerodynamics for Israel.

RESEARCH AND EDUCATION IN FLIGHT CONTROL

Prof. S. Merhav - Technion

Prof. Merhav has his educational background in electronics. After working in the army on guidance control, he joined the Department of Aeronautical Engineering in 1971.

In recent years aircraft technology has undergone a revolutionary process with respect to automation and instrumentation. In modern aircraft costs of avionics and instrumentation can amount up to 50% of total costs. The Technion has research and educational programs on these topics.

Compulsory courses are:
- Introduction to automatic control
- Dynamic systems
- Probability theory
- Aeronautical instrumentation

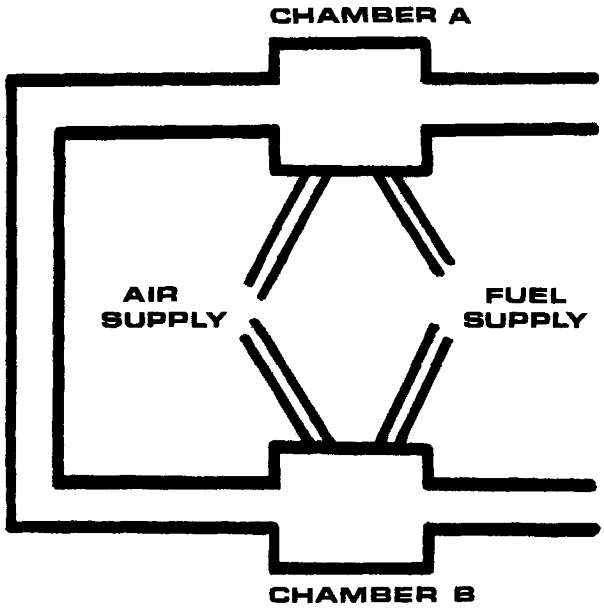
Elective courses deal with subjects such as automatic control, navigational systems and guidance systems. There are also graduate courses on optimal control, differential games for use in air combat situations and digital control systems.

The total staff involved in avionics and instrumentation comprises twenty people, among whom Prof. I. Ben Itzhach (navigational estimation), Prof. J. Shinar (guidance systems and differential games) and Prof. S. Merhav, specialized in man-machine systems, estimation, identification and navigational systems. Of the latter topic especially the possibilities of low cost navigational systems for small aircraft are investigated. The reduction in costs is hoped to be reached by not using gyros in these systems. Navigational systems based on terrain recognition are also being investigated. Work on man-machine systems is directed towards supression of biodynamic interference on the performance of pilots under gusty conditions. Research in this field has already produced results in the form of a program, aiding a pilot in the Technion's 3-D simulator to control a simple two-dimensional unstable system.

RESEARCH IN LOW-SPEED AERODYNAMICS

Ir. H. Binkhorst - TH Delft

At the Department of Aerospace Engineering of Delft University of Technology several aerodynamics-orien-



Schematic lay-out of the double pulse combustor

ted subject groups exist. There are groups on general fluid mechanics, high- and low-speed aerodynamics, stability and control, design and performance. In this lecture the emphasis was on the low-speed aerodynamics group. A survey is given of the facilities of the low-speed wind tunnel laboratory including a 1.80 m x 1.25 m closed-circuit wind tunnel, two specialized boundary-layer wind tunnels and several small wind tunnels.
Available are among others a six-component balance system, an automatic multimanometer, computer controlled traversing system, a two-component laser-Doppler system and an HP-1000 laboratory-computer system.
A closer look was taken at two of the main research projects. First the work on developing the LSL airfoil analysis and a design computer program is discussed and the project described in which the ASW-19 sailplane airfoil was improved as verification of the calculating method. Second the research on sharp-edged deltawings, with the objective to develop, in cooperation with the National Aerospace Laboratory, a free-vortex sheet, high-order panel method to predict the aerodynamic characteristics of these configurations, is discussed. The experimental research on this project is carried out in Delft using laser-light screen methods to visualize the flow and 5-hole probe and laser-Doppler techniques to measure quantitatively the flow characteristics.

RESEARCH AND EDUCATION IN ENGINES AND VISIT TO THE TURBO- AND JET-ENGINES LAB.

Prof. B. Gal-Or - Technion

This laboratory is the youngest of the five labs at the Department of Aeronautical Engineering. It was established 12 years ago, and there are about 19 staff members conducting research.
First we were shown an old Allison T53 turboshaft engine, driving a Rolls Royce compressor to supply the lab with high pressure air, used for various test benches.
At the first floor there were several cutaways of jet-engines like the Pratt & Whitney F100 and the General Electric J79. These cutaways are used for instruction purposes.
Research is conducted in:

- combustion chambers
- alternative fuels : coal derived fuels, shale oil
- large dust filters : particularly with regard to the harsh conditions in which helicopters have to operate in the Negev
- 2-D vectoring nozzles: which promises to bring a revolution in the future jet fighter performance, i.e. shorter take-off run, greatly improved agility and thrust reversing.

Research at the lab is sponsored by both GE and P&W, supplying cash and equipment. There is also support from Allison, the Air Force and Germany.
Currently the lab is also working on the development of the new PW 1120 jet engine, which will power the new Lavi fighter.

RESEARCH AND EDUCATION IN COMBUSTION AND PROPULSION AND VISIT TO COMBUSTION AND PROPULSION LAB.

Dr. Y. Tambour - Technion

In the combustion lab research was done on several subjects such as coaxial turbulent liquid fuel combustion, coal combustion and pulse combustion. Something quite different was the project in which artificial clouds were produced by a system consisting of a combustion chamber and a single stage compressor. The meaning of these clouds was to prevent the freezing of crops in clear nights.
In the propulsion lab a pulse combustor with two combustion chambers in parallel was tested. After igniting the fuel-air mixture in chamber A, a pressure and temperature wave moves to chamber B. This wave ignites the mixture in chamber B and a new pressure wave moves to chamber A and ignites the mixture there (see figure). As long as fuel and air are supplied to the combustion chambers the process will go on.
The big advantage of this engine is the absence of moving parts, and in the future this pulse combustion might drive Israeli RPVs (Remotely Piloted Vehicles).
Another engine that was a subject of research was the so-called "Hybrid Engine". In this engine a solid is used as fuel and preheated air as oxidator. The preheating is done to simulate the real situation in flight in which the air is heated by aerodynamic compression. By measuring all important parameters the flow is known. These experimental data are compared with theoretical results and in the long run one hopes to get a better understanding of appearing combustion phenomena, such as unstable combustion.

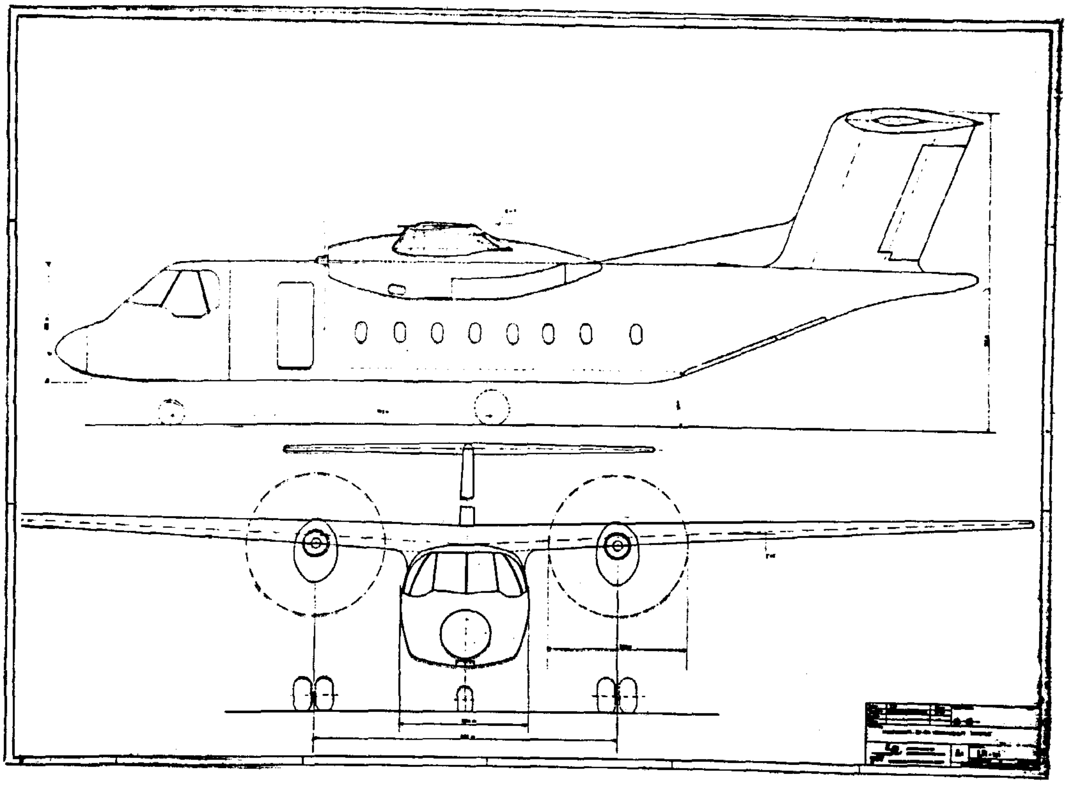
PRELIMINARY DESIGN EXERCISE FOR THIRD YEAR STUDENTS

J. Krebbekx and J. Jacobs TH-Delft

This exercise is done during the third year at the Department of Aerospace Engineering. The main purpose is to enable the student to synthesize the knowledge obtained seperately in courses on aerodynamics, aircraft structures, stability and control etc. For the design the textbook "Synthesis of subsonic airplane design", written by Professor E. Torenbeek, was used. The book is used for the design of conventional subsonic airplanes.
The exercise is subdivided in:

- T01

First of all the student gets a list of specifications. After a proper investigation of the function of the aircraft and translation of the most important requirements in a suitable positioning of the major parts, he can draw some possible configurations. Then he puts the best parts together, or chooses the best one. The first section of the detailed design, will be the fuselage design, which depends on many things. The next step will be to choose engine type and wing size by estimations and reversed performance calculations. Then the eventual



Preliminary design of a twin-turboprop aircraft

propeller is considered.
Many parameters are calculated or choosen. So after checking the requirements, the wing parameters are choosen or calculated.
The most important part is the weight and balance of the aircraft. The weight of the plane is divided in several groups. Each group has its center of gravity. All these groups have to give one center of gravity, which should lay in between the limitations imposed by loading and balance. The entire initial design phase is just one step in a large iteration process.

- TO2

This part of the exercise is subdivided in four parts:

a. the structural arrangements of the wing, the tail surfaces and the fuselage
b. the wing-fuselage connection
c. the suspension and the driving of the flaps or the ailerons
d. an elective subject, for example the attachment of the main undercarriage leg or the engine.

- TO3

The last part of the exercise comprises more detailed calculations of some performance, aerodynamic behaviour and stability of the aircraft.

PLANS FOR CAD

Dr. A Segal - Technion

Due to the fast developments of computer graphics different applications of computer graphics became more and more popular, e.g. the use of computer graphics in arts, on displays in aircraft flight decks and for design (Computer Aided Design, CAD).
The industry was first to use CAD. Lateron the need for people with some education in CAD was growing.
In Israel the Technion was the first institute to start with CAD-education. Because CAD hardware is very expensive, in the beginning Technion didn't have enough financial means for its own installation. Therefore Technion-students went to Tel Aviv, where they could make use of a large IBM-computer for CAD. Nowadays the Technion has its own CAD-installation.
In the old study programs there was one course in computer science dealing with programming and numerical analysis. Nowadays due to the CAD developments there are two courses: 1. Numerical Analysis and 2. Programming and Introduction Computer Systems.
At the moment two different CAD software packets are used:

1. CADAM: (Computer Augmented Design And Manufacturing) for 2-dimensional drawings of a design; this program is developed by Lockheed;
2. CATIA (Computer Graphics Aided 3-dimensional Interactive Application), developed by Dassault.

Already second year students get courses in CADAM.
One of the main activities in the field of CAD is extending CAD programs with programs for predicting flight performances, stability, operation costs and for stress analysis of preliminary designs.

Dr. Segal also told about a unic design project done by Technion students. The purpose of the project is to design, manufacture and test a rocket. The project started 9
years ago, but was not completed. Fortunately 4 years ago the project was restarted. During the project the use of CAD was very important. So far, the project has given good results and is found to be very successful.

COMPUTER GRAPHICS

Dr. Y. Harit - Technion

Dr. Harit started with a brief survey of the developments in the still young science of computer graphics in general and at the Technion in particular. Computer graphics is a topic of rapidly growing importance in the computer field. It has always been one of the visually most spectaculair branches of computer technology, producing images whose appearance and motion make them quite unlike any other form of computer output. Computer graphics is also an extremely effective medium for communication between man and computer; the human eye can absorb the information content of a displayed diagram or perspective view much faster than it can scan a table of numbers.
All of this has been known for some years, but the high cost of computer graphics technology has prevented its widespread use. Now costs are dropping rapidly and interactive computer graphics is becoming available to more and more people.
The development of computer graphics has been accelerated by the development of modern and advanced types of Cathode Ray Tubes (CRT) and very fast computers. The main reason for the effectiveness of interactive computer graphics is the speed with which the user of the computer can assimilate the displayed information. For example, the engineer designing an integrated circuit can see on the screen features that would never be apparent in an ordinary numerical computer printout.
With the ability to interact with the computer, the engineer can quickly correct a design error and see a revised picture of the circuit. Thus interactive graphics improve the bandwidth of communication between the user and the computer in both directions.
Also at the Technion, the importance of studying and developing computer graphics soon became greater and greater. Lectures in various subjects of computer graphics have been added to the study program in order to enable the student to become familiar with computer graphics. In these lectures a fundamental approach to computer graphics is being made in stead of only giving standard and machine related programs and telling how to use them. The fundamental approach deals with questions like: what is the geometrical relationship between two lines of an object?; what happens with the mathematical equation of a line, when it is translated in the X-, Y- or Z-direction or rotated around one of these axis?; what kind of coordinates can be used and what is the relationship between world coordinates and screen coordinates?; and how are the answers of these questions to be used in a useful algorithm?

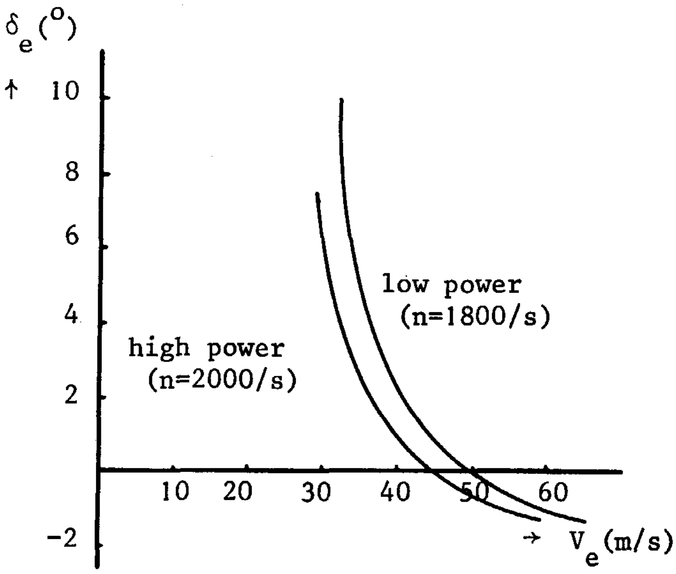


Figure 1 :
Elevator-trim-curve

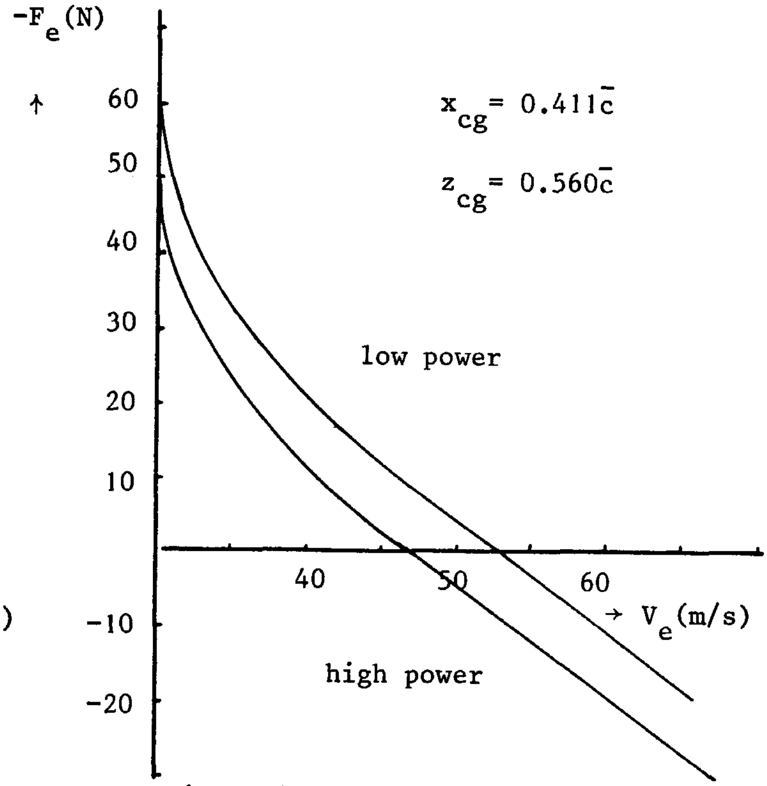


Figure 2:
Stickforce-curve

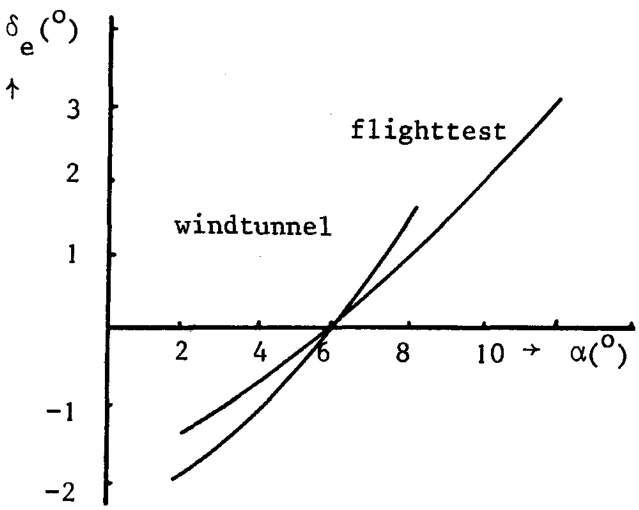


Figure 3 :
Comparison of the results

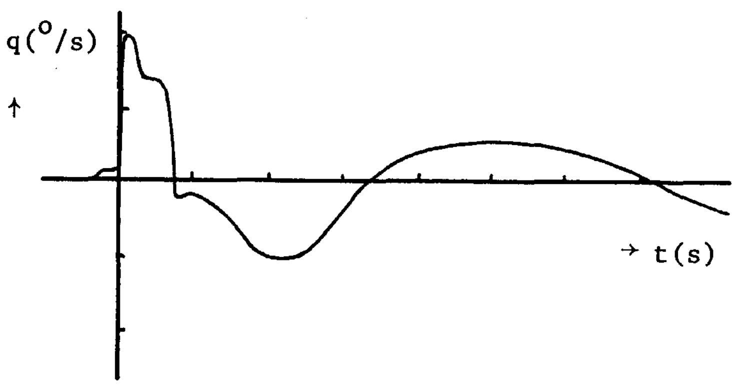


Figure 4 :
Roll-rate about the Y-axis

With this fundamental approach less problems will occur when another standard program or another machine is used.

RESEARCH AND EDUCATION IN HELICOPTERS

Dr. A. Rosen - Technion

This is a new academic technical field for Israel and the Technion. Dr. A. Rosen devided his lecture in two main parts: education and research.
Education consists of three courses being:

1. dynamics and aerodynamics of helicopters
2. stability and control of helicopters
3. wind turbines and energy production (the theory is similar to the rotary-wing theory, but there are differences too).

In the future a fourth course in structural design and aeroelasticity will be added.
The main research topics are:

1. Mechanics of flight:
   a. performance and trim: the theory, a computer-prediction, compared with the experiments, gave rather good results
   b. stability and control: this concerns manoeuvres and the response of the helicopter to the pilot's commands.
2. Aerodynamics: extra problems arise while for a helicopter in steady flight the rotor blades need not to move under steady circumstances.
   They use two kinds of models:
   a. prescribed-wake models
   b. free-wake models
   Free-wake models give better approximations of the flow-pattern at the cost of more computation-time.
3. Aeroelastic response/dynamics: a general and accurate model (the blade having three axes of rotation) is used.
   Also curved blades are a field of interest.
4. Handling qualities: in theory as well as in a simulator one describes the hovering above small moving ship-decks.
5. Wind turbines, being quite an important potential energy-source for Israel.
   Two types are investigated:
   a. "Darrieus" Wind Turbine (vertical axis); this type gives special aerodynamic problems
   b. "Savonius" Wind Turbine (horizontal axis); biggest advantage is the simplicity of construction.

COMBINED WIND TUNNEL EXPERIMENT AND FLIGHT TEST FOR FOURTH YEAR STUDENTS

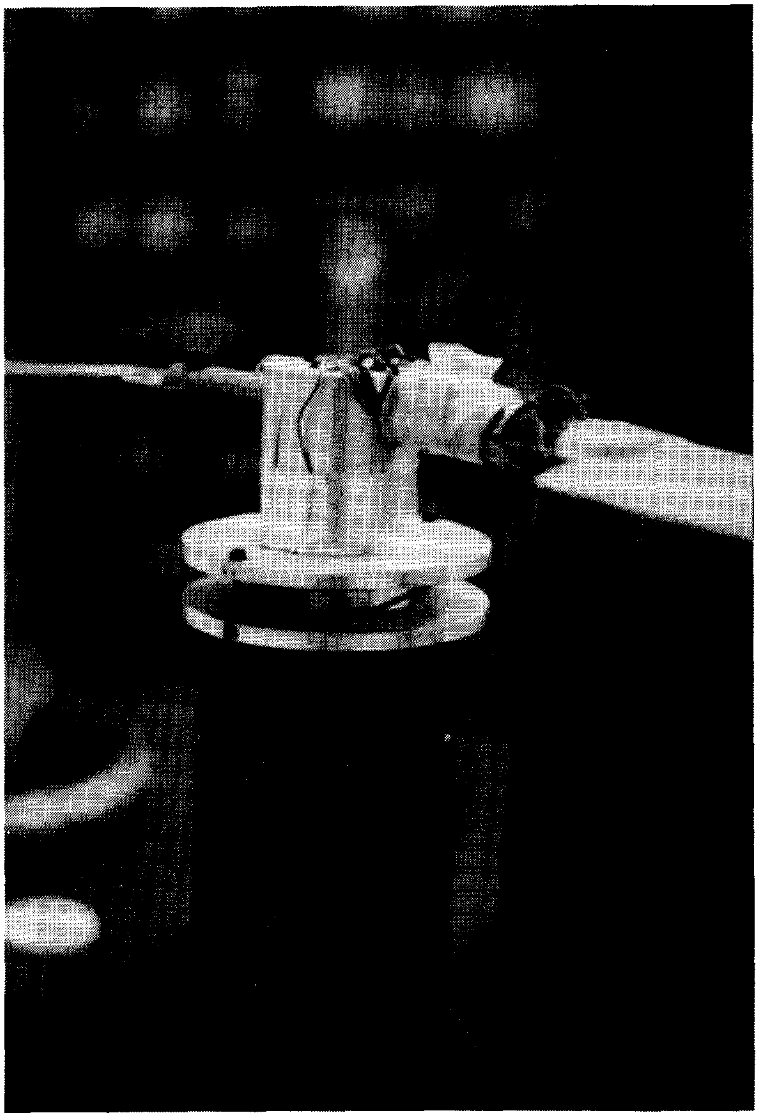
K. Borst and M. Tolsma - TH Delft

In the fourth year students have a combined wind tunnel experiment and flighttest. The purpose of this exercise is to compare the results of some experiments with each other. To do so we determine for both the elevationtrim-curve for equivalent aircraft configurations.
The flighttest is performed with the DHC-2 "Beaver", the laboratory aircraft of the Department of Aerospace Engineering. In the wind tunnel is worked with a 1:11 scale model of this type of aircraft. In both cases the measurements have taken place in steady and symmetrical flightconditions.
The wind tunnelmodel has no air intake, antennae etc. The watercooled electrical engine rotates with 30.000 rpm, in order to obtain the same progression-coefficient as in real flight.
The coefficients C_N and C_M are measured as a function of the angle of attack and the elevator deflection. These values are obtained from a servodriven weightbalance system and presented in tables by the computer. The next step is to put these values into graphics. The resulting elevator-trim-curve can now easily be drawn.
During the flighttest pressure altitude, indicated airspeed, rpm of the engine, angle of attack, static air temperature, differential pressure between total pressure behind the propeller and total pressure on the wing, air intake pressure, elevatortrim, stick-forces and the time (to calculate the actual weight) are measured.
With this information not only the elevatortrim-curve (fig. 1) but also the stickforce-curve (fig. 2) can be drawn.
The measurements take place during climb with high powersetting and during descent with low powersetting. This way the effect of the slipstream of the propeller on the curves can be shown.
The data obtained need to be compensated for instrument-errors and also adapted to a standard value of the aircraft weight.
For the calculations the moment of inertia of the aircraft is needed, which can be determined with a balance system in the hangar.
Now the graphics can be drawn (fig. 3). As the elevationtrimcurve of the wind tunnel is compared with that of the flighttest, one can conclude that the results show no large differences for angles of attack between 2^o and 8^o.
The second part of the flighttest is a demonstration of some dynamic motions. We use a plotter to make time-histories of characteristic variables.
First we look at the slow oscillating motion. In theory there is an assumption that the time-gradients of the angle of attack and the roll-rate around the Y-axis are zero.
Looking at the picture (fig. 4) one can see that for the time-gradient of the latter this assumption will not hold.
The next flying motion is the Dutch Roll. It shows that after the Dutch Roll has damped out the aircraft has a roll-rate around the X-axis and roll-rate around the Z-axis unequal to zero. So this motion will result in a diverting downward movement.
We may conclude that the theory's assumption of the roll angle and roll-rate around the X-axis being zero is not right for this type of aircraft.
Finally in the flightsimulator we fly the movements ourselves.

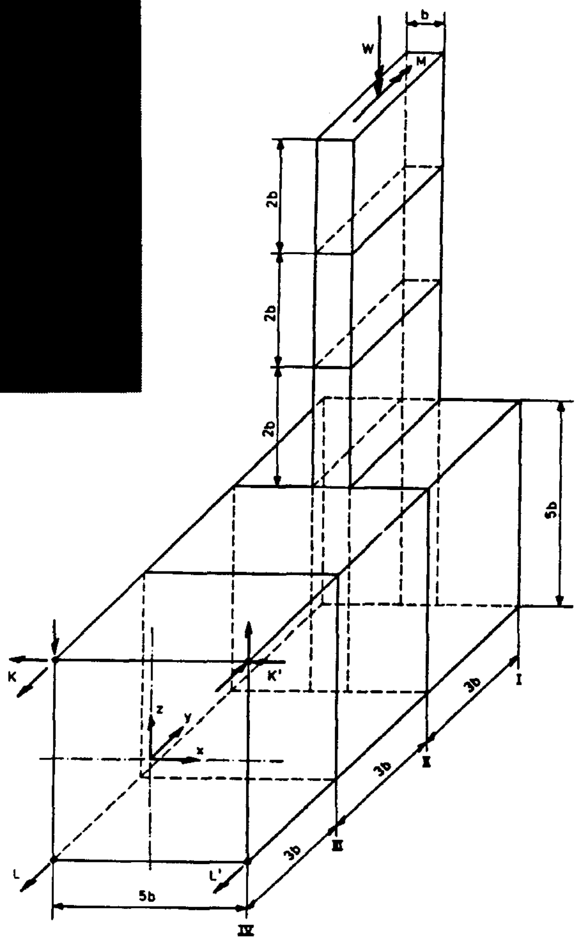
STRENGTH CALCULATIONS OF AIRCRAFT

H. Bulte - TH Delft

Students, who are specializing in aircraft structures, are doing two computer exercises in the fourth year, one of which is the "strength cal-

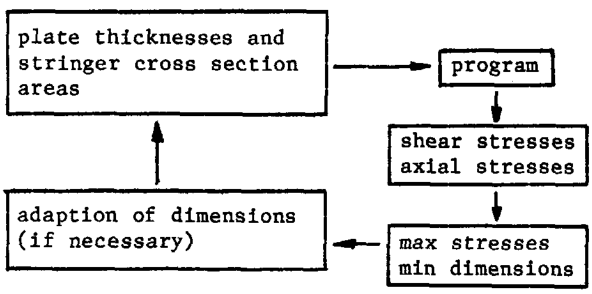


Rotor-head research



Schematic 3-D fuselage rear section

culations of aircraft" exercise.
This exercise concerns a 2-dimensional and a 3-dimensional structure. The goal of the exercise is finding the optimal dimensions of the elements of the structure. This means that each element should reach a stress-level as high as possible, but not above a certain maximum, so it gets its optimal weight. At the same time however, the dimensions of each element should not be less than a specified minimum. The computer program that is used for this exercise is not written by the student himself, but is an already existing program. This program can be used for every structure that can be idealized into a structure that consists of plate elements and stringer elements.
Let's take a look at a particular 3-dimensional structure (fig. 5).
This is a typical fuselage rear section. The loads on the structure are 2 moments, resulting from a rudder deflection. Now there are 28 plate elements and 80 stringer elements in the structure. The load is prescribed.
We want to know the thickness of each plate and the cross section area of each stringer element. In the idealization that is made, the plate elements only carry shear flows, while stringer elements only carry axial forces. To find the 28 plate thicknesses and 80 cross section areas, the following work scheme is used:



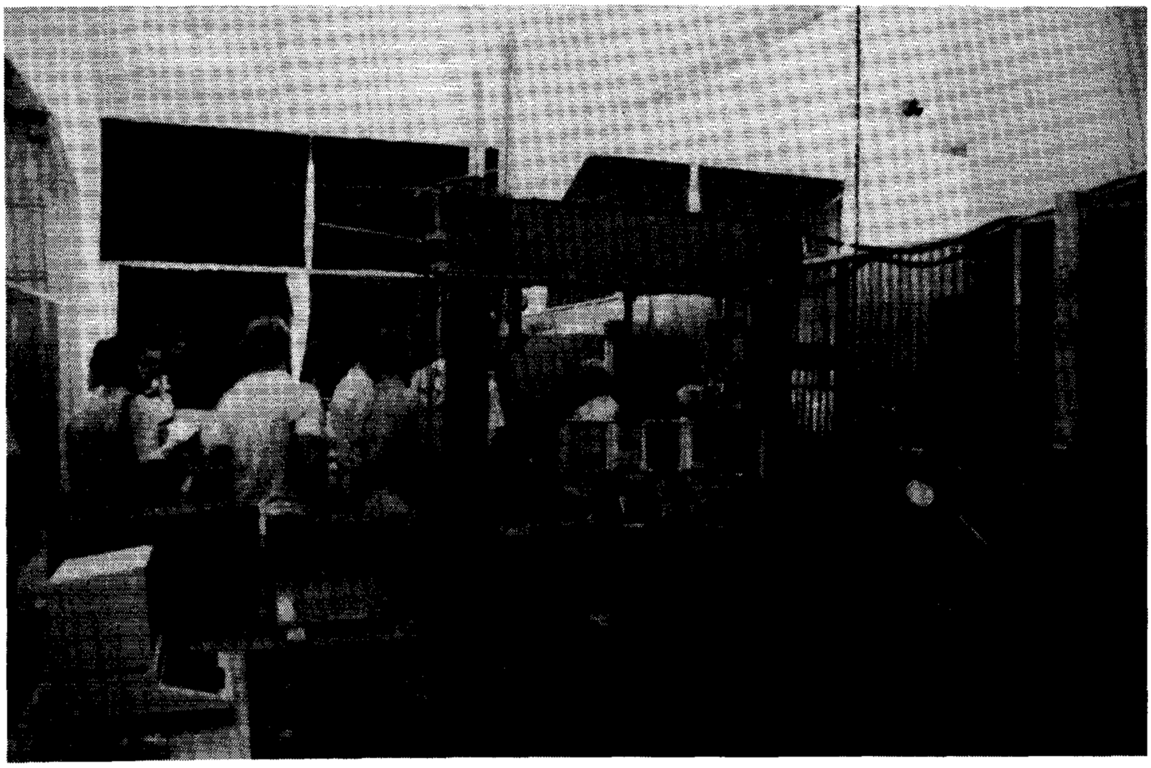
For the first run, the minimal dimensions for each element are taken and the shear stress in each plate element as well as normal (= axial) stress in each stringer element is calculated by the computer. When the stress in an element is above the maximum, the thickness is increased if it is a plate element or the cross section is enlarged if it is a stringer element. With the new dimensions, a second run is made and the stresses are checked again. This is repeated until the stress in each element is as close to the maximum as possible, while at the same time its dimensions are not below the minimum.
For element 1, for example, the shear flow after the first run is 0.89 p/b, while its minimum thickness is t, so that its shear stress is 0.89 p/bt, which is not above the maximum of 1.6 p/bt. This element needs no change. Element 18 however has a shear flow of 2.06 p/b and a shear stress of 2.06 p/bt; this plate needs to be thickened.
After a couple of runs, the shear flow of element 1 is 0.91 p/b and its shear stress is 0.91 p/bt. Element 18 has a shear flow of 2.17 p/b, a thickness of 1.5 t and a shear stress of 1.45 p/bt.
Element 1 cannot be made thinner, while the stress of element 18 is already close to the maximum 1.6 p/bt.
There are a few dozen of such problems; each student solves two. In fact, all this looks easier than it really is; not only element dimensions have to be put into the computer, but additionally the flexibility of each element and a few complex load systems have to be calculated. The calculation method is learned in other courses, as well as the programming. The program that is used here, has been made by employees of the Department of Aerospace Engineering.

RESEARCH IN ADVANCED STRUCTURES

Ir. T.J. van Baten - TH Delft

A short survey was presented on two research projects in the field of structures and materials.
The first project concerned the research on the new composite material ARALL developed at Delft University of Technology. The material has been developed in view of the expected high strength with respect to fatigue loading. Indeed it was proven to fulfil these expectations completely. Besides it appeared to have good properties like high static strength, easy machinability, high resistance against lightning strikes, etc.
As standard plate material it consists of two aluminium alloy sheets enclosing a layer of aramid fibres embedded in an adhesive compound. It is produced in a press or autoclave under high pressure and temperature. In order to avoid tensile initial stresses in the sheets, due to the differences in thermal expansion of sheets and fibres, the fibres have to be prestressed during curing or the material has to be prestrained afterwards.
Research is going on to increase the fracture toughness and to describe the material properties in full detail. By redesigning, building and testing an outerwing lowerskin panel of the Fokker F-27 aeroplane, design experience is acquired with the new material. A weight saving of 20 to 30% is expected by using this new class of materials, which are subject of great interest shown by the international aircraft industry. The material meanwhile has been taken in production, on an experimental basis, by Alcoa in the U.S.A.

The second project concerned research on CAD/CAM structural optimum design, which was started in 1983. The available hardware comprises a Prime 750 + workstations. The design system being developed will be based on the geometric modeller called Medusa and on the interactive finite element analysis program called Gitts, both programs running on the Prime hardware. In addition special purpose and optimization programs are being developed while a design database management environment will be defined to serve optimal datatransfer and storage. User control of the design process is to be taken care of by an executive control program in which the multilevel optimal design procedure is implemented.
This multilevel approach allows for stepwise development and use of the several functional units of the system. A global description was presented of the several levels distinguishing global and detail



Visit to structures laboratory

optimization drawing production and report writing.
Parallel to the development of the system a case study will be defined to verify the system on an application. It concerns the structural design of the wing of a medium range civil aircraft.

RESEARCH AND EDUCATION IN STRUCTURES AND VISIT TO THE STRUCTURES LAB
Prof. A. Libai and Dr. T Weller - Technion

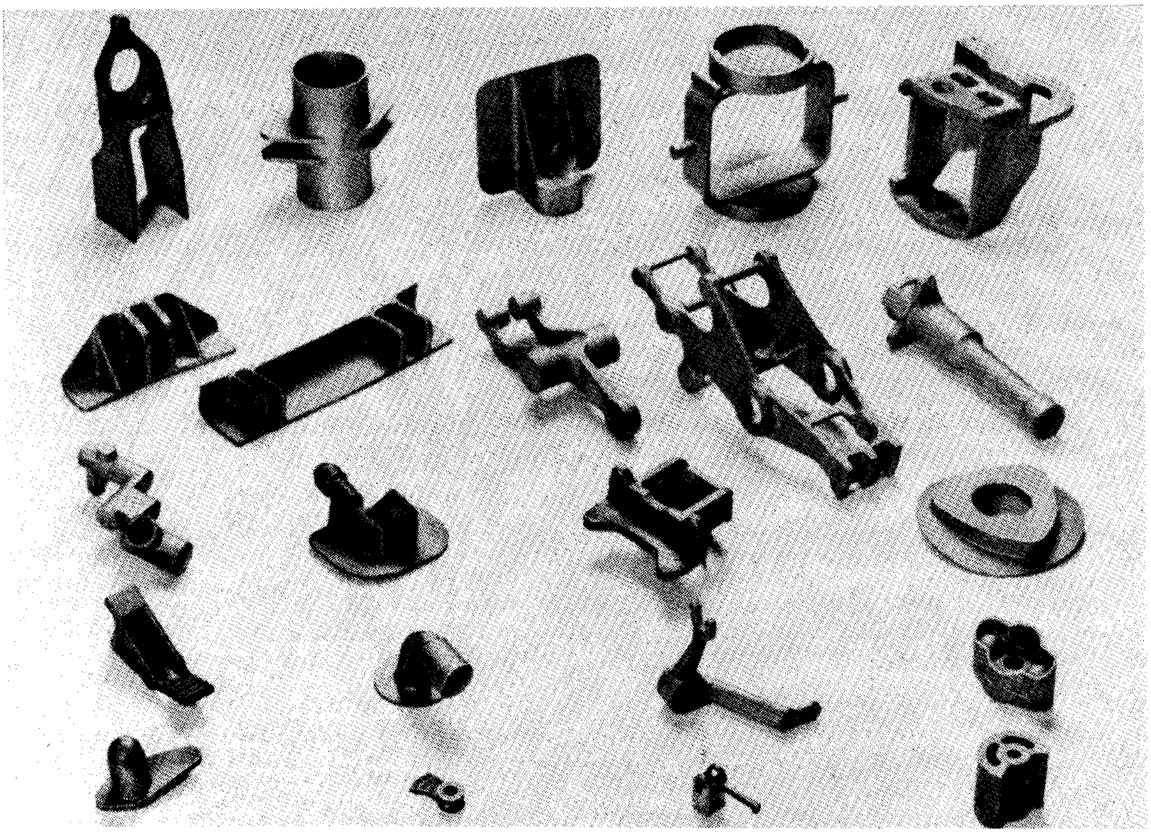
The following courses are required for all aeronautical students:
- Mechanics of Solids I
- Mechanics of Solids II
- Theory of Vibrations
- Foundations of Theory of Aeron. Structures
- Strength Analysis of Flight Vehicles
- Stability and Strength of Thin Walled Structures
- Structures Laboratory

Furthermore, a seminar in aeronautical structures and a design project may be done as elective subjects.
Those who are specializing in structures are taking courses like Aircraft Fatigue Problems, Aircraft Structural Design, Composite Plates and Shells, Advanced Topics in Aeronautical Structures, Aeroelasticity etc.

The structures laboratory was founded in 1955. The floor is made of concrete to enable it to carry heavy machines and great forces.
Two spar structures which were tested on fatigue were shown. These structures were loaded with shear stresses beyond their buckling load, because the webs were already buckling out of their plane. One of these spar webs was made of a laminar material, and one could see that one layer was already delaminating, because of the fluctuating shear load. However, this did not affect the maximum load the spar was able to carry at that time. Purpose of these tests was to get to know the effect of several types of stiffeners, the effect of holes and of production imperfections.
Furthermore, the Department of Aeronautical Engineering has developed a procedure to make very thin stiffened cilindrical shells. Plate thickness is only 0.2 to 0.3 mm. Actually, a tube is being integrally milled into this structure. These structures are tested on production imperfections, boundary conditions and load excentricities. They are extremely light, have a length and diameter of about 40 cm and cost about $ 800 to produce.
Among others, turbine blades and helicopter blades were also tested on strength and bending.

DEMONSTRATION OF THE CAD-SYSTEM
F. Anidjar and E Segal - Technion

At the end of the day we were demonstrated the only recently installed Tektronix display unit connected to the mainframe CAD computer.
In brief a student showed us some of the possibilities of the system: he visualised the supersonic flow pattern around a two-dimensional profile, as well as the design of a robot arm.
So far only one terminal had been installed, and the students and university staff members were still exploring the system and expanding its software package.



Casting products for the aeronautical industry

CABIRAN

NON-FERROUS PRECISION CASTINGS

CABIRAN NON FERROUS PRECISION CASTINGS

Cabiran is a foundry owned and run by Kibbutz Cabri, West Galilee. The plant is specialized in casting aluminium alloys of small and medium size, both for civil and military applications, including the aircraft industry. Although the Israeli industry is a very important client of the foundry, many of the products are exported, especially to the USA. The ± 15 employees are subjected to circulation of tasks, except for those working at the Engineering Department.

The casting technique used is the so-called 'lost wax' method. This method has been chosen because it leads to high precision products.

First a die of the desired product is made. This die can have a maximum weight of up to 800 kg. The material used is aluminium; steel is too expensive. Under high pressure the wax is pressed into the die at a temperature of 60°C. After the wax has solidified at 20°C the model can be put together with more models forming a 'tree'. Next step is either coating of the model with a ceramic shell or putting it in a gypsbox. Although the coating takes more time and money, it is often preferred because no shrinking occurs and solidification of the casting is easier to be controled, which leads to better mechanical qualities. The coating is carried out by covering the waxmodel with several layers of sand after immersing it in some fluids with different substances. After the coating has dried the wax is removed by steam under high pressure (7 atm.). This has to be done very quickly, because otherwise the wax will expand and destroy the ceramic coating. The removed wax is recycled and is, for example, used again for feedings for other models. As already mentioned also gyps is used instead of ceramics. In this case the waxmodel is put in a box which is filled up with gyps under vacuum conditions. The gyps is dried and the wax is removed by steam. In order to remove the remaining water and wax and to harden the gyps, a thermal treatment is carried out: 24 hours at 450-500 °C. The ceramic shell is kept at a temperature of 750-800°C for only one hour.

The aluminium for the casting is imported from the USA in standard blocks. The percentage of iron (0.07%) is of the utmost importance. The smaller this percentage, the better the elasticity of the material. After the blocks have been melted, nitrogen gass is lead through the melt to remove the hydrogen that causes big holes and brittleness in the casting. The melted aluminium is cast into the ceramic shell or the gypsbox under vacuum conditions.

Next, the casting gets a treatment, such as the removal of the shell/gypsbox and feedings and the cleaning of the product with a high pressure watergun. Because no casting is exactly straight, all castings get a thermal treatment: 12 hours at 536°C. The material becomes more plastic and is easier to correct by means of a plastic hammer. When the casting the desired shape it gets a final thermal treatment, which improves the mechanical qualities.

Before leaving the factory, the products are checked: by X-ray for inner structure faults and by the penetrating method to find little cracks at the surface of the casting. A set of little drawbars has accompanied each set of castings during the complete process. These are tested to check the mechanical qualitites of the product. If desired the customer also gets some of these drawbars to test them himself.

Kibbutz Cabri

The kibbutz is in origin an agricultural settlement with a collective way of production and living, founded by young socialist-zionist pioneers, aiming for total equality. The 'Kibbutz-movement' got going early this century (first kibbutz Deganja 1910). Nowadays one can find more than 200 kibbutzim spread all over the country. In spite of the many immigration waves after 1910 and the social-cultural changes they brought with them, the 'principle of equality' still holds.

Two typical aspects for the kibbutz-life are:

1. "Kirch, Kind und Küche". The equality ideal is found e.g. in equalizing the tasks of man and woman. The latter gets rid of the 'fate of mothership', by being put on heavy works normally done by men. Husbands on the other hand do some housekeeping, children education, etc. This is facilitated by collectivating the cooking and the education. In the early years this was not only pure ideology, but necessity as well, because of the hard circumstances.

Another aspect of living in a community, which a kibbutz is, is that within the kibbutz one can unfurl oneself, with respect to the norms and the objectives of the kibbutz.

2. "Collectivity". A kibbutz is one big industry and one big householding; all the families contribute to it and take the benefit. The production only satisfies their own needs of living; therefore all goods and services are immediately directed to the members of the community, without the intervention of money. One works as hard as he or she can, but earns as much as he or she needs. Money income by members that work outside the kibbutz is collective property. Apart from some small goods, there are no private possesions.

When the settlers grew in numbers greater than work could be provided in farming, technological advances were made. During the past decade, the kibbutzim underwent a rapid process of industrialization. It began with cottage industries, workshops rather than factories.

Soon the kibbutzim were systematically entering the industrial field, organizing, uniting in ventures, surveying markets, sending members to study new technologies and applying local research assiduously obtained during the years of tilling the soil.

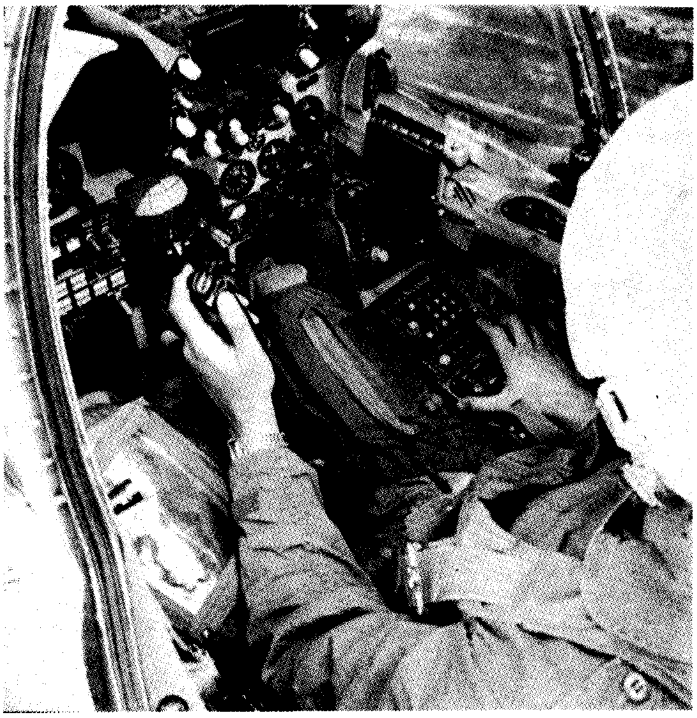
Today the kibbutzim are an important factor in Israeli industry and in high-technology research. The same small proportion of the population providing almost half of agricultural produce is responsible for more than 6% of Israel's manufacturing exports. There are industrial enterprises (350 including the tourist industry) in 170 kibbutzim which employ 11,500 Israelis (13,000 including those employed in guest houses).

Cabri is a good example of an average kibbutz: 400 ha. area, 450 members + 350 children.

their main source of income is still in agriculture:

avocados (100 ha), bananas (60 ha), beef-cattle (2000 head) and poultry. Other sorts of income are found in clothing-industry, the foundry and members that work outside the kibbutz. Work at the kibbutz circulates between the members. The executive committee changes every four years. Decisions are made democratically. In principle, work at the kibbutz is only done by members, but in emergency cases, e.g. reaping time, people from outside are engaged. Working hours are from 6.00 until 15.30.
Because the profits of the plant go to the community, the investments also have to come from there. Money for the foundry can only be obtained if the expenditures can be justified.
And only this way it works: sharing and working together.

MOSHAV YA'AD
In the afternoon we also visited moshav Ya'ad.
Roughly speaking, a moshav is, as a kibbutz, a typical Israeli community, but has a less self-sufficient and socialistic character.
Ya'ad is established by Technion computer science graduates, members of the first graduating class, in 1972. They shared two common desires: to live in northern Israel, away from the cramped, polluted cities; and to work at the vocation for which they had been trained.
They were granted land by the Jewish Agency in the Segev development area, about 40 km north of Haifa. The Segev region was full of hilly terrain and lacked both arable land and water supply; it needed a new kind of 'crop', the industrial centre planned was well suited for the region.
When eight families moved into temporary quarters about 10 km from Ya'ad, in December 1974, the completion of the settlement was still three years away. But even while waiting, in 1975, they started a computer operation.
A year later an architect joined the group. By 1977 an electronics company, Li'ad, was taking shape, and soon everyone moved to the new modern buildings that became their home.
A software company, specializing in management informations systems, word processing and data retrieving systems for mini- and microcomputers, was set up. The company's 15 employees and their PDPII computer pre-empted a large portion of space in the moshav's two-storey, central workshop building. They were a busy group with clients throughout Israel and the beginnings of an export trade to the United States and Great Britain. They have managed to reverse what is the usual process for Israel.
The software company and the other enterprises in Ya'ad are the main business. A few years ago, the moshav built a hot house for the export of flowers, but that's a sideline. Their agricultural expert, a Technion graduate in engineering, preferred to do something different.
Of the eight people who comprise the staff of Li'ad Electronics, six are Technion graduates. The expertise of the firm's personnel helped them develop an electronic poultry sorting system controlling quantity and conveying the fowl by weight to numerous packaging units. A different weighing system for batching of materials for the plastic, rubber and chemical industries was also developed by those young businessmen. In the future, they will turn their computer electronics knowledge to the sorting of fruit by weight, size and color.
Li'ad has designed special control systems at their client's request and even an alarm and warning unit that can measure the speed of up to 18 motors.



Elbit's Weapon Delivery and Navigation System (WDNS)
installed in the Kfir-C2

Elbit's Tank Fire Control System (TFCS)
installed in the Merkava tank

Elbit COMPUTERS

ELBIT COMPUTERS

Elbit Computers Ltd. is Israel's leading company in the design, manufacture and marketing of computer-based systems and products for military and civil application. Elbit stands for Electronic Bitachon which means electronic defence. Elbit is the main supplier of computer-based products and systems to Israel's armed forces.

Elbit Computers was established in 1966. Elbit was founded as a joint venture of the Israeli Ministry of Defence and Elron Electronics Industries Ltd. (which itself was estabilished in 1961) with a nucleus of highly trained engineers from the Technion-Israel Institute of Technology in Haifa. In 1977 Elbit became a public company with about a third of its shares issued to the public on the Tel-aviv stock exchange. At present 69% of Elbit stock is owned by Elron, with the remainder being held by the public and employees. In turn, Elbit controls the following subsidaries:

- Elmar Medical systems (100%), engaged in the development and production of a computer-based hemodialysis system.
- Eltan (45%), active in the design, manufacture, installation and maintenance of telephone and other communication systems.
- Eltek (67%), which manufactures printed circuit boards, sold to both Elbit and other electronics companies in Israel and abroad. Apart from the ones in Israel there are Elbit facilities in the USA, the UK, France, West-Germany, Switzerland, Singapore and Brazil.

Elbit has four main facilities in Israel:
its headquarters, situated at the Advanced Technology Center (where nearly all research and development activities are concentrated) in Haifa, the Engineering and Mechanical Workshop, also in the Haifa bay area, a new manufacturing plant in Carmiel (a developing area in the lower Galilee), and another in Nes-Ziona, designing a wide array of antennae for communication, radar and electronic warfare use.

Elbit has 1750 employees, over 650 are involved in R&D. As a result of Israel's defence needs, military applications comprise a major part of Elbit's business, representing about two-thirds of consolidated sales. Elbit manufactures systems and products for air, naval, and ground forces, the range comprising the following main items:

- for air forces: air-to-ground and air-to-air weapon delivery and navigation systems (WDNS); automatic test and simulation sets for the WDNS; a Ground-Controlled Interception Simulator (GCI-SIM); weapon delivery simulators; antennas; displays and Electronic Warfare (EW) systems
- for navies: tactical training centers; anti-submarine warfare trainers; EW equipment and simulators; antennas, displays and stand alone communication units
- for armies: tank fire control systems; tank gunery simulators and several training equipment.

In addition, Elbit and its subsidaries develop and manufacture most of the peripheral and auxiliary equipment for the systems mentioned, such as display consoles and panels, control terminal units, management systems, etc.

There is also a major emphasis on export, with about 40% of the production being sold abroad. the company has received a $14 million order to manufacture computer-assisted hemodialysis equipment for Diatronics Inc., a US company that operates dialysis centers. In fact, the system was developed by Elbit's own engineers in a R&D effort which lasted three years.

Elbit is a supplier for international companies like Data Control, E-Systems, General Dynamics, Honeywell, Hughes, Itek, Lear Siegler, Nixdorf ans Westinghouse.

Nearly all the equipment offered by Elbit has been designed to meet the specific and stringent requirements of the Israeli Defence Forces, and many of them are battle proven. In many cases the equipment sold abroad has been modified for the customer after close consultation. In fact, Elbit stresses its basic philosophy to develop "tailor made" products and its capability to provide not only hardware but also advice, support, and even basis studies aimed at identifying user requirements.

On the "civilian side", Elbit's commercial products division began to produce minicomputers as far back as 1967. Elbit entered the world market on a serious basis in 1970 as a result of its partnership with Control Data Corporation of the US.

Thousands of systems, including central processing units, memories, controllers and terminals have been sold since then. Elbit's latest entry into the minicomputer field is the ANAT series, introduced in 1980. It is a family of IBM 370 plugcompatible computer, whose modes of operation include batch processing, on-line transaction processing and time sharing.

Nixdorf Computers AG of West Germany has an exclusive license to manufacture and to market the ANAT series in several European countries.

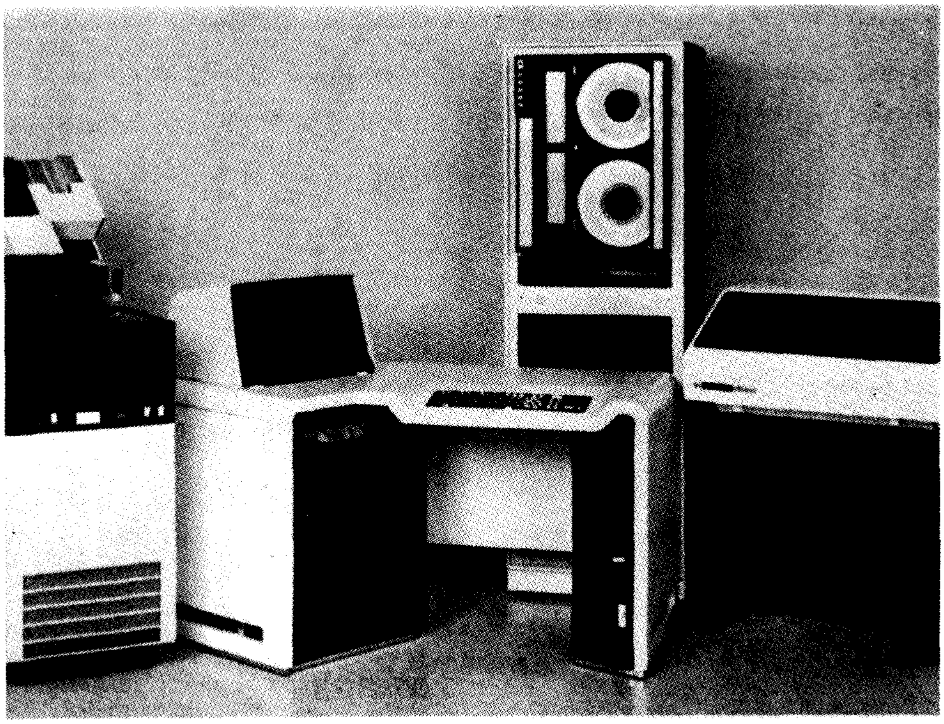
Things are going well for Elbit. Turnover, incomes and profits are growing every year.

Maj.-Gen. (Res) Benjamin Peled, President of Elbit

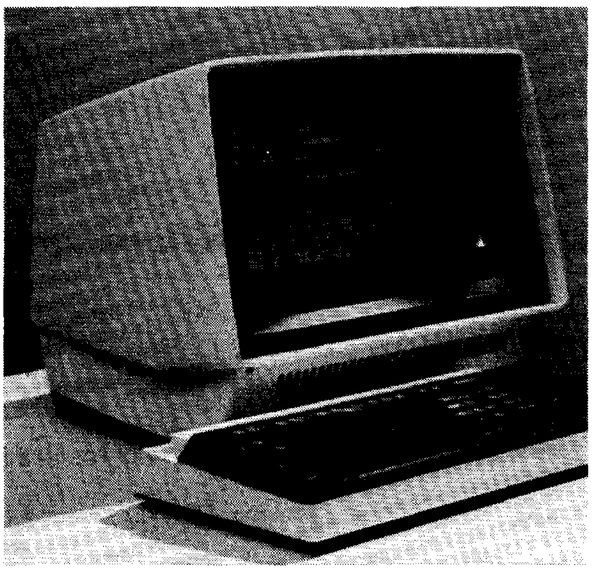
Financial Highlights
(per $ in millions)

	1982/83	Increase over 81/82 (in %)
Net sales	85.4	18
Net income	5.0	460
Shareholders equity	26.5	
Earnings per share	0.62	400

Sales	
Non-Israel sales	30.5
Israel sales	54.9
Total	85.4
Military sector	59.7
Commercial sector	25.7
Total	85.4
Backlog of orders	155.0



The Elbit 'Anat' family of Super-Mini computers



Elbit's advanced 8-bit Desk-top Office Information System

Computers and graduate of the Technion's Aeronautical Department, summarizes : "I would say that Elbit will be a company firmly established in three main areas: the first includes fire control and navigation with some "fire and forget" weapon systems; the second is Command Control and Communication (C^3) Systems for both military and civil applications; and the third embraces a commercial line of computerized products, including maybe some intelligent machines. We are now starting to look at what we call artificial intelligence".

Avionics Systems

For a wide variety of combat aircraft, Elbit has produced generations of Weapon Delivery and Navigation Systems (WDNS), airborne displays, and other avionics systems, with full ground support.

In 1971, Elbit manufactured its first WDNS, under license, for the A-4 Skyhawk. The company later adapted it to the Kfir, and integrated an air-to-air 'hot line' gunnery mode and an ability to handle additional weapons. Further improvements were made in navigation, accuracy, and short alignment.

In 1977, in partnership, Elbit updated the Israel F-4E and RF-4E by participating in systems specifications, development, manufacturing, and flight tests of a second-generation WDNS.

A third generation, System 82, fully developed by Elbit, integrates a sophisiticated Fire Control Computer, Multi-Functional Display, smart weapon handling, and Programmable Stores Management System, which replaces numerous switches and selectors for improved human engineering and decreased pilot workload.

The WDNS is supported by a full range of computer-controlled ground equipment for testing, simulation, and performance analysis. Depot-level maintenance, training spares, and software modifications have been supplied to the Israeli Air Force for over a decade.

To accomodate market demand for a simplified system, Elbit has developed the Low Cost Weapon Delivery System (LCWDS), with a digital computer and Head-Up Display, for advanced trainers, interceptors, and light attack-aircraft.

Success in avionics has led Elbit to design and pro duce a family of Digital Data Communication System for both ground and airborne use.

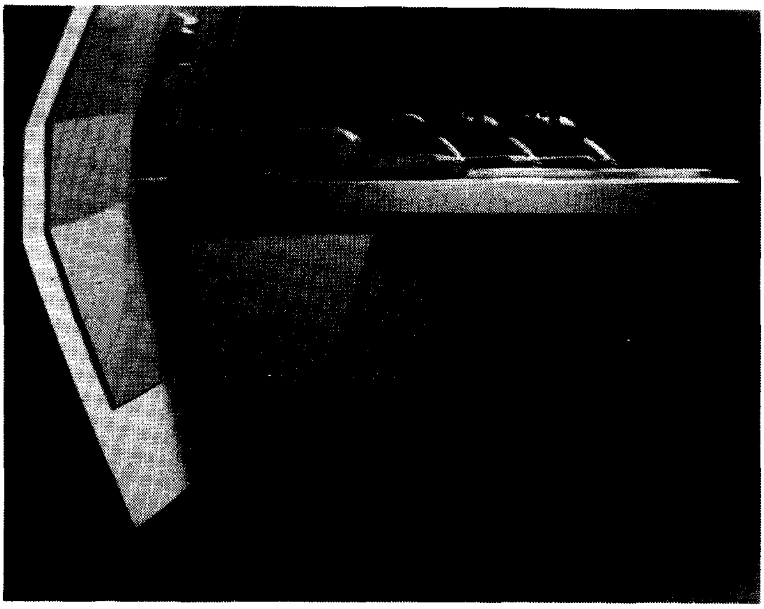
All Israeli Skyhawks, Phantoms and Kfirs are now equipped with Elbit systems. Elbit also has a contract from General Dynamics to supply a stores management computer for the F-16. The company has a major role in the design and development of the avionics systems of Israel's new combat aircraft, the Lavi.

Elbit is a qualified avionics subcontractor and vendor to major American aerospace companies, and its own systems are marketed worldwide.

Fire Control System

Elbit's Tank Fire Control System (TFCS) is a system built around a Ballistic Processing Unit which consists of: Operation Units, Control and Feedback Servo Loops and Sensors. The Operation Units are composed of Gunner's, Commander's and Loader's Units. The Control Loop transfers information to both the hydraulic gun elevation driver, the ballistic driver, as well as deflection data to the moving re ticle.

The Feedback Loop computes data on super elevation and deflection and will correct errors accordingly. Sensors include: laser range finder, turret cant angle sensor, target angular velocity sensor, cross wind velocity sensor, charge temperature sensor, barrel bend (MRS), and atmospheric pressure sensor. The TFCS is operational in the Merkava-tank and best suited for retrofit of battle tanks such as the Centurion, M-47, M-48 and M-60. The system may be operated manually in case of power failure.



Elscint's CAT-scanner

elscint

ELSCINT

Elscint, a subsidiary, as Elbit, of the Elron Company, manufactures all kinds of medical diagnostic imaging systems. Their product range extends from relatively straight-forward X-ray systems to the imaging system of the future: Nuclear Magnetic Resonance, NMR, which is currently under development with Elscint.

The Elscint company was founded as recently as 1969 and is an example of the cooperation between the Technion-Israel Institute of Technology and the Israeli industry, in Israel's endeavoury towards high-tech industries.
The bondage with the Technion is reflected in the name of the company since Elscint stands for Electronic Scientific Intelligence. Futhermore the original workforce was composed primarily out of scientists formerly associated with the Technion and graduates of the same institute.

Today Elscint has a workforce of more than 3000 employees, and the company is growing at the astonishing rate of nearly 50% per year. Of course, such a growing rate cannot be supported by the Israeli homemarket alone.
To support the export market Elscint has founded several service companies throughout Europe and the US. Beside those service facilities Elscint also has some production facilities abroad.
Elscint has more than doubled its US sales and service staffs through the $10 million purchase of the marketing organization of Xonics, an American maker of medical electronics equipment.
The acquisition gives Elscint a US sales force of 180, up from 80, and a service staff of 350, up from 150. Aiming for $250 million in sales in the 1984/5 fiscal year, a rise of more than 50% over the $160 million projected for the current 1983/4 year, Elscint makes more than 95% of its sales abroad with 65% of sales going to North America. Xonics, which had a cash flow problem, had sales of $119 million last year. Elscint also obtained a right of first refusal on the possible purchase of Xonics' production facilities.

Another pillar under Elscint's growing rate is its huge investment in R & D. Nearly 50% of its revenues and a dito percentage of its manpower are put into new products and the development of new products-to-be. Those incredible figures are another proof of the high-tech character of Elscint.

As mentioned earlier the products of Elscint are medical diagnostic imaging systems.
The products are divided into 6 main product categories:

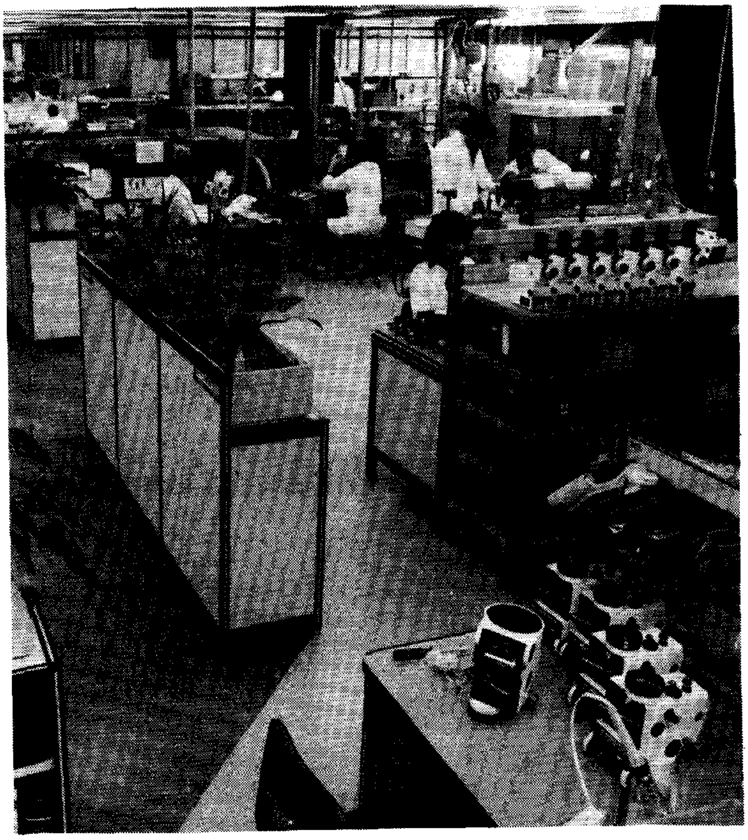
1. Conventional Radiology (X-ray)
2. Phluorgraphy
3. Ultrasound (Echoscopy)
4. Nuclear Medical Equipment
5. Computer Axial Tomography (CAT-scanner)
6. Nuclear Magnetic Resonance (NMR)

CAT-scanner

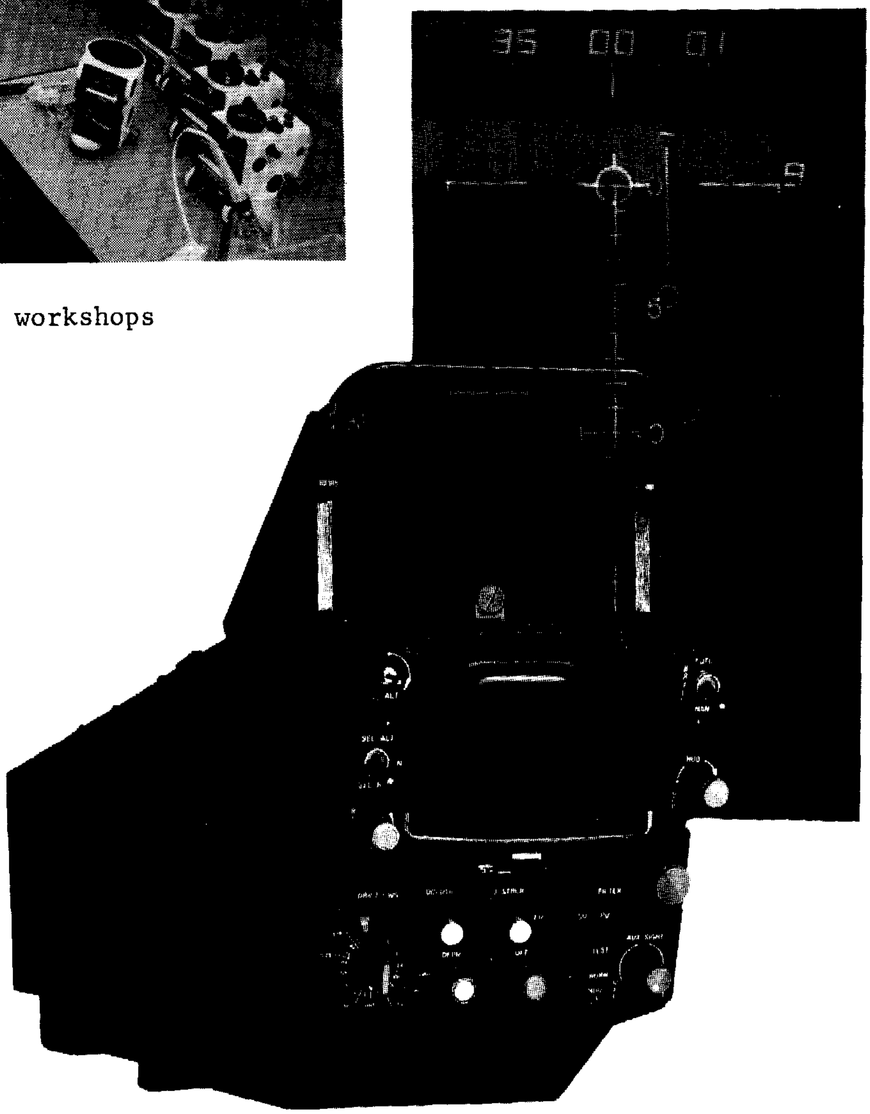
Elscint's prime product, from the high-tech point of view, is the so-called CAT-scanner. This is an apparatus with which you are able to scan a patient "slice-by-slice" by means of X-rays.
If a certain tumor is detected and, for example, radiation therapy is employed to shrink the tumor, the volume of that tumor can be measured in minuscular cubes and the radiation therapy be followed, quantifying the shrinkage by percentage points.
The patient is placed on a table which translates along its longitudinal axis, making it possible to scan every desired cross-section of the patient's body. Furthermore, the X-ray tube can be rotated around the same axis in order to view a "slice" from different angles, giving a fairer image of that particular cross-section. Then there is another rotation possibility around the axis perpendicular to the longitudinal axis, in the plain of the table. This possibility enables to take "slanting-slices" i.e. cross-sections not perpendicular to the longitudinal axis.
The X-ray image is digitized and processed by computer to give real-time visualization. The computer, which is able to record thousands of X-ray images, reconstructs, in any 2 of the 3 dimensions, the images of complete organs and bones.
This system combines a high scanning speed with high spatial resolution (< 1 mm) and this is not a common quality, its a quality which makes the CAT-scanner highly competitive.

NMR

From the other categories mentioned above NMR deserves some more attention. Elscint has recently opened a plant to research and produce equipment in this field. NMR is based on the observation of the effect of extremely strong magnets on different elements. Elscint has a level of in-house expertise and technology to be able to manufacture such magnets by itself as opposed to the lot of Elscint's competitors. The equipment can detect the slightest alteration in the chemical composition of tissues. NMR enables to study not only structures, but also the function of all the body's organs in a non-invasive way, in the living subject, the human being. It is completely non-molesting, unlike the CAT-scanner, which is ionizing. It will enable to see the functions of the brain, to discern oxygen consumption and how it behaves in moods.
Indeed another proof of Elscint's strength and a justification of Elscint's optimistical view of the future.



View of one of El Op's workshops



El Op's Kfir Head Up Display (HUD)

ELECTROOPTICS INDUSTRIES

Image of Quality

EL OP ELECTRO-OPTICS INDUSTRIES

Electro-optics, or El Op, is a company that makes optical equipment for defence purposes. This means that they produce complete systems for passive night vision, laser range finding, avionic instrumentations and others.
The prime market of El Op is the Israeli Defence Force, but they supply to the American and Australian armies as well. El Op had ties with the Dutch "N.V. Optische Industrie Oude Delft", and was partly owned by Oude Delft until the mid seventies, when Oude Delft lost its interest in El Op and sold its shares. The benefit for El Op was a good amount of know how on organization, administration and technology in optical industry.
El Op is now owned jointly by Tadiran and the Federmann Group.

The History

El Op was founded in 1937 by Prof. Emil Goldberg, who came from Zeiss and found out there was no optical industry in Israel. He therefore started a laboratory on applied optics which was mainly serving military equipment. After this start the policy of the company was to acquire all needed knowledge "by themselves" and not to lean on imported knowledge. However it seems that this is not taken that strict anymore because El Op bought e.g. the Leopard I tank firecontrol system.

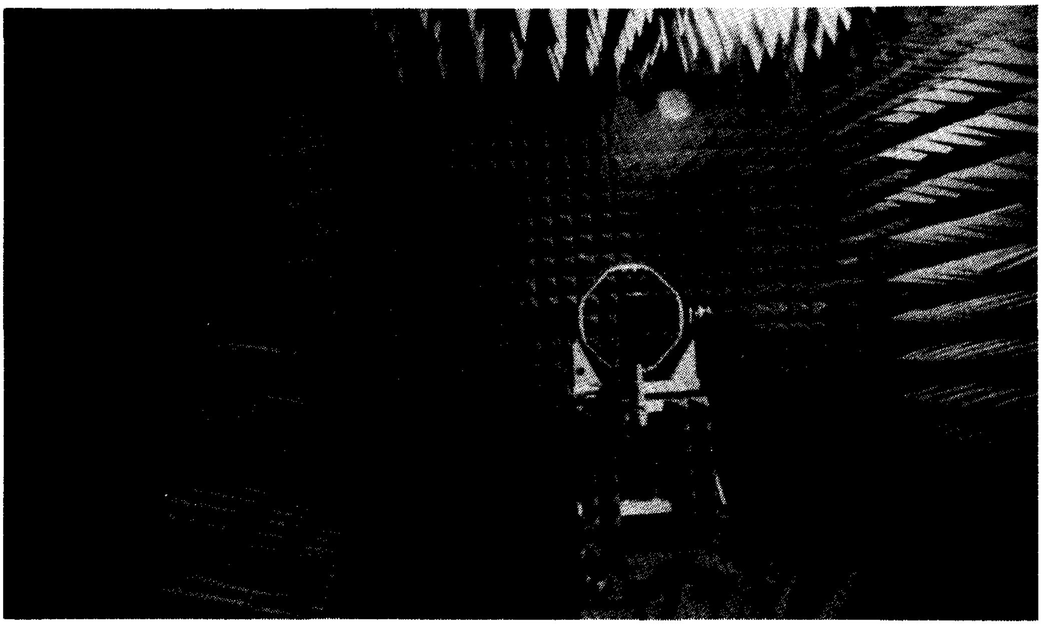
The factory

Walking through the factory the first striking thing is the tidyness of the place and the absence of anoying noise. Last year the company has won a price for being the tidiest firm in Israel.
A visit to the mechanical engineering department shows that the firm uses, to be able to regroup their engineering teams for different projects a system of movable walls, so that the "rooms" on one floor are always at the right size. At the moment a new CAD system was being introduced. The computerprograms for the system are being developed in cooperation with the French firm Euclid.
The next department we visited was the prototype department. There we learned that, beside prototypes, also small series of very difficult objects are made. This means that for these small series it is not necessary to make entire production systems and therefore that the product will not be too expensive.

Of all departments at the factory, the optical department is the most astonishing. Here, both old and very modern machinery is used to make lenses and glass panels. Most of these optical components are made in dustfree rooms. Dustfree means here that the air contains less than 2000 dust particles per m^3.
The raw material is imported from Germany and the USA. Most of the expensive materials is bought in preliminary shape, so not too much has to be grinded off.
When a lense has got its shape, it is polished for some time. This can take about 30 seconds for a spectacle lens, up to about 8 hours for a laser window. This is because the latter should have a flat surface with an accuracy of less than 1/20 wavelength on a span of 10 cm. This gives extra problems for the biggest windows made: 300 x 200 cm.
The next stage is that some lenses have to be coated. For this, there are four modern vacuum chambers in which at low pressure and high temperature in 2 up to 10 hours coatings are laid up. These coatings are made and developed by El Op. It is possible to apply 20 to 25 different coatings mainly to diminish reflection on the surface when laserbeams are put through.

The products

The products that El Op can make are nearly all possible optical instruments, but mostly they produce entire systems for defence purposes such as their MATADOR. This is a Tank Fire Control System that consists of a laser equipped rangefinder, a passive night vision elbow, an improved gunners' periscope and a computer that gives correction for crosswind and takes into account other influences like munitiontype etc. and then gives elevation and side correction.
Other products of El Op are Head Up Displays for military aircraft and a Gunsight Aircraft Camera, which records air-to-air and air-to-ground combat. This camera offers a very good training facility.
El Op will build the Head Up Display for the Lavi, a wide angle system, under a licence from Hughes.
The products of El Op are of an international quality, but their main advantage is the fact that they produce at a price-level that is lower than anywhere else in the western world. Nor should one forget that their products are battle proven.



Anechoic room at the Weizmann Institute of Science

WEIZMANN

1934-1984 · THE WEIZMANN INSTITUTE OF SCIENCE · FIFTY YEARS OF RESEARCH

THE WEIZMANN INSTITUTE OF SCIENCE

'I feel sure that science will bring to this land both peace and a renewal of its youth, creating here the springs of a new spiritual and material life, and here I speak of science for its own sake and of applied science'.

Chaim Weizmann, 1946

Chaim Weizmann (1874-1952) was born in Czarist Russia. He was one of the chief architects of the State of Israel and its first President. Apart from his political movements, he was also a distinguished organic chemist and microbiologist, known for his use of fermentation to produce acetone and butyl alcohol. It was his concept of a scientific research center, serving the needs of Palestine's infant agricultural industry as well as forming part of the world community of science, that led to the foundation of the Daniel Sieff Research Institute in 1934. Starting in the middle of a dessert with a few buildings this became after subsequent expansion in 1949 the multidisciplinary Weizmann Institute of Science, a green spot in the neighbourhood of Rehovot.
The Institute is devoted to research and teaching in the natural sciences without commercial purposes. Institute policy is set by a Board of Governors and its Executive Council. The Institute's Chief Executive Officer is its President, aided by a Presidential Advisory Committee and a Scientific Council, which has many of the functions of a university senate. The Institute consists of 21 research units grouped in five faculties: Biology, Biophysics-Biochemistry, Chemistry, Mathematics and Physics. The campus community numbers some 1800 researchers, engineers, technicians, scientists and students (M.Sc. and Ph.D.) and about 700 people forming administrative and service personnel.

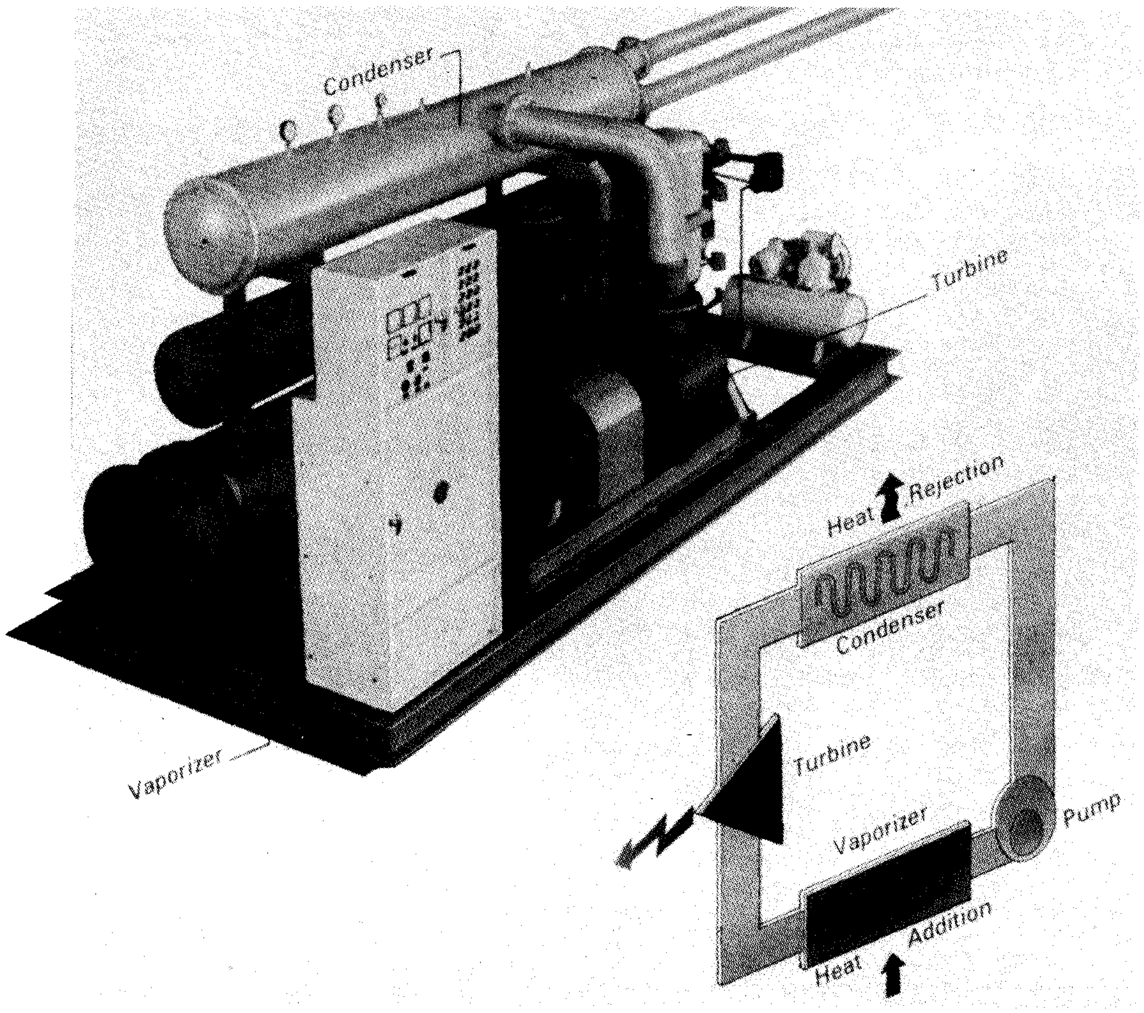
Institute scientists do joint research projects with overseas private and governmental organizations and participate in major international scientific conferences. Investigations are carried out into topics like cancer, immunology, aging, third world ills, bio-engineering, neurosciences, agricultural development astrophysics and the energy crisis.

In the field of applied physics Institute scientists are pursuing basic studies into magnetism, lasers and holography as well as the design of innovative motors, microwave antennas (applicable to aircraft and spacecraft) and imageprocessing technologies. An automated non-destructive evaluation system based on holography has been developed compatible with industrial needs. This approach enables detection of minute flaws in a variety of metallic and plastic parts, such as aircraft wings and other large complex structures.
At the Institute three large computers were build: WEIZAC in 1954, GOLEM A in 1964 and GOLEM B in 1974. A host of major scientific problems were analyzed with the aid of these machines. Recent years have seen striking progress in the area of software, for example the development of new kinds of logic to analyze computer programs, the construction of ingenious schemes for the coding of computer data and messages, and the invention of powerful computer techniques for solving the complex equations that govern flow of fluids and the distribution of strain in solids. The mathematicians have also helped to design methods of desalination and have shown how to control highly complex aircraft and factories that are subject to uncertain environments.

Laboratory of solid state physics

At this laboratory one of the projects concernes the development of a new kind of antenna for high frequencies in the range of 1-40 GHz.
First they try to put up a theory of parabolic antennae and use this by making a new, flat antenna. This flat antenna can easily be made on a plate and exists of little blocks of metal (so-called printed antennae). A further application can be an antenna upon the skin of an aircraft. It is easily understood that such an antenna will be very light.
Finally we visited the testing room, where they did all the measurements. It was a non-echoing room with a special micro wave transmitter and the testing-antenna.

The excursion was concluded with a visit to Weizmann's grave, nearby the house where he used to live.



Ormat's Energy Convertor with basic working principle

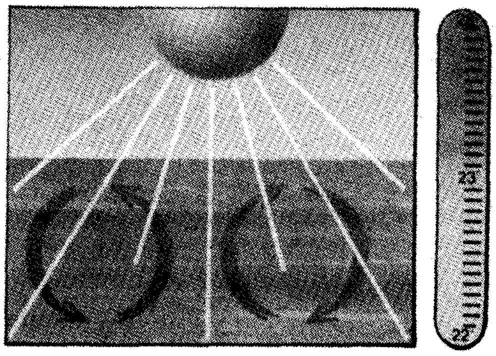


Figure 1 :
Temperature distribution in an ordinary pond

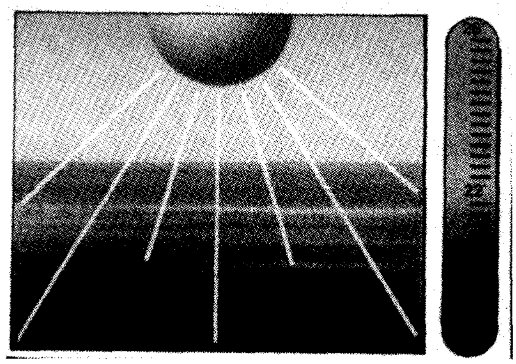


Figure 2 :
Temperature distribution in a solar pond

ORMAT TURBINES

ORMAT TURBINES

In the early fifties, David Ben Gurion was the driving force behind the idea to harness the sun's energy and he stimulated research. But after he retired, solar energy research lost its guiding light. However, Lucien Bronicki, the founder of Ormat Turbines, continued and made the company to what it is now.

Formed in 1965, Ormat Turbines started with the development, manufacture and marketing of Rankine cycle, organic motive fluid turbine-driven systems for the generation of electrical power.

Nowadays, more than 3.000 Ormat Turbogenerators using conventional and non-conventional fuels are in operation around the world in often remote unattended applications.

Since 1973 the company has been engaged in the development of new products and systems directed towards the use of alternative energy sources. An example of this is Ormat's involvement, through its affiliated company Solmat, under the Government National Interest Research Program, in the development of the 5 MW Solar Pond Power Plant near Beit Ha'Arava at the northern most tip of the Dead Sea.

Furthermore, Ormat has engaged in applied research programs in other areas, such as the Stirling Engine and Photo-Chemical Solar Cells.

The company's 40,000 square meter complex at Yavne includes production shops, assembly areas, testing laboratories, engineering and administrative offices, a vocational training school and an extensive research and development facility. Ormat Turbines operates to international quality standards and is an approved supplier to the aircraft industry.

At present Ormat employs more than 350 people, of which 50% are involved in manufacturing operations, while 20% of the total working force has an academic degree.

Products

The systems manufactured by Ormat Turbines can be divided into four main areas:

- energy converters to produce electricity from waste heat.
- energy converters to produce electricity from solar ponds
- self-contained engine-driven electrical power systems for remote unattended locations
- aircraft generators and engine-driven generating sets.

Waste heat

Virtually all process-industries (e.g. petrochemicals, pulp and paper, glass, cement, primary metals, chemicals, food) expel vast quantities of low grade heat. Usually this is wasted, but Ormat produces Organic Rankine Cycle Turbogenerators to recover this waste heat and convert it to electrical power. Because of these low temperatures these generators have an efficiency as low as 5%!

Solar ponds

The idea of the solar pond came from nature. In the outmost south of Israel, near Eilat, a natural "Sun Pool" exists, with a bottom temperature of 70°C.

In an ordinary pond (fig. 1) water has a uniform density. Through convection currents there is always an exchange of heat between the lower and upper layers of water.

A solar pond, however, is non-convecting (fig. 2). This is achieved by increasing the salt concentration from top to bottom. The bottom layer of brine is relatively heavy and remains there, in spite of its rise in temperature to near the boiling point caused by sun rays heating the bottom of the pond. Floating nets in the upper water layers protect it from windmixing forces.

The Ormat Solar Pond Power Plant is a combination of the Solmat Solar Pond and the Ormat Energy Converter. The latter is an Organic Rankine Cycle Turbogenerator, specifically developed and optimized to operate on low temperature heat sources.

Hot brine is pumped from the bottom of the pond to the evaporator (fig. 3) to heat and evaporate the motive organic fluid, and back again to the bottom of the pond. The pressurized organic vapors flow into the turbogenerator unit and drive a turbine wheel, directly coupled to an electric generator. After that the vapor is condensed by water from the upper water layers of the pond and returned to the evaporator.

Each square kilometer of solar pond can thus produce an annual 40,000 tons of fuel oil equivalent i.e. 24 million kWh.

Since 1979 a 150 kW pilot plant is operating near En Boqeq at the Dead Sea, as well as a 5 MW unit at Beit Ha'Arava, the first in a planned series of solar pond station to be erected in the area over the next 10 to 20 years. The first export order came from the Southern Californian Edison Company in the USA, which ordered the largest solar pond in the world, at a cost of about $15 million. To be constructed in California's San Bernadino County, the solar pond will grow from 12 MW in the first stage of the project to 48 MW at a later stage. It will provide the peak power demands for 30,000 of the clients. The American company has signed a 30-year contract to purchase the electricity from the Ormat subsidiary that will operate it. The new plant will work on the model of the second solar facility, the Beit Ha'Arava plant.

Electrical power for remote unattended locations

For this purpose Ormat manufactures self-contained systems which are virtually maintenance-free and utilize locally available fuels, such as alcohol, natural gas, LPG, kerosene or diesel fuel. The unit is hermetically sealed-for-life in stainless steel, with only one rotating part for high reliability.

There are over 3,000 units operating in over 40 countries, mostly in Third World countries, to provide electrical power to remote villages. The electricity is used for illumination, waterpumping and filtering, refrigeration of medicines and communication.

One marked application of these systems is in connection with the Alaskan pipeline, where it is used to illuminate unmanned airfields. When an airplane is approaching the airfield, the electrical power unit is switched on from the aircraft by remote control. The runway lights now illuminate the airfield and the aircraft can land. Upon leaving, the

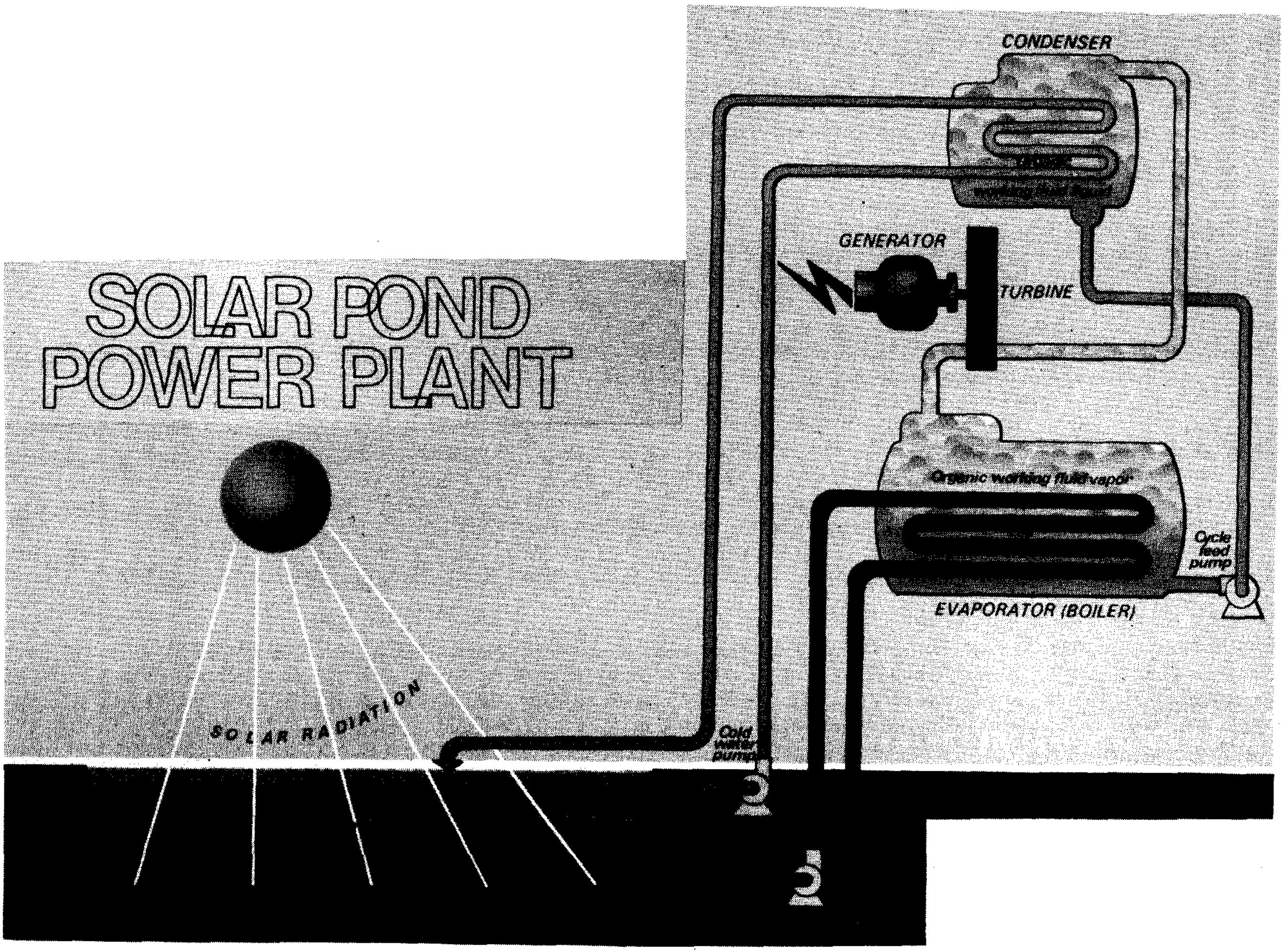
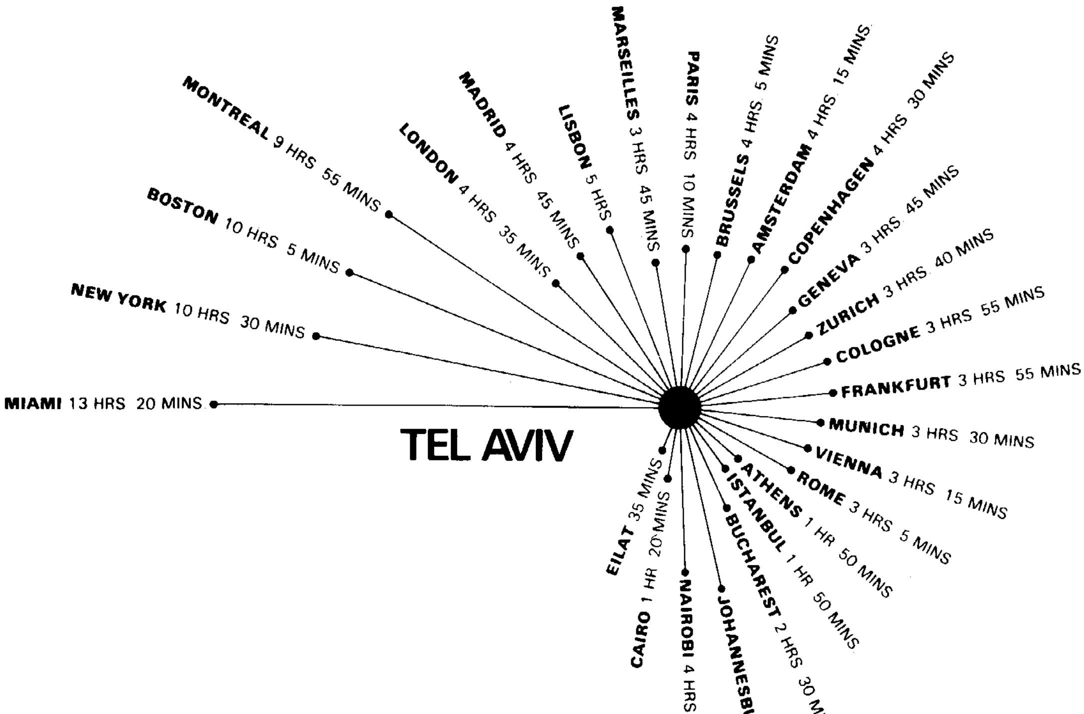


Figure 3 : Basic working principle of a Solar Pond Power Plant

same procedure is gone through the other way round, and the unit is switched off after the aircraft has taken off.

Aircraft generators and engine-driven sets

Ormat supplies oil cooled aircraft A.C. generators to the aircraft industry, as well as self-contained engine-driven generating sets for civil and military applications.
The generator is low-maintenance, brushless, with commutator and no slip-rings.



destinations and average flying time

Close inspection of one of El Al's Boeing 767s

EL AL ISRAEL AIRLINES

El Al, the national airline of Israel, located at Ben Goerion Airport, Lod, was incorporated on November 15th, 1948. Its charter objectives then remain the same today: 'to secure and maintain a regular airlink at all times and under all conditions within a framework of maximum profitability'. The principal shareholder at the moment is the Government of Israel.
El Al recorded net profits for 18 years until 1979 when world economic crises, massive rises in operating, labor and fuel costs affected its operation.
After suffering losses since 1979, El Al initiated a major reorganization program in 1980, incorporating operational changes, the sale of fuel inefficient aircraft, reduction of personnel and closure of nonprofitable lines and offices.
A second major reorganization program was initiated in January 1983, when a new management team was appointed. Further operational cutbacks were implemented and losses have been substantially reduced. Passenger load factors are among the highest in the airline industry, reaching 90% across the Atlantic. Today El Al's negative financial position is attributed to the high cost of debt burden, stemming from the previous years, operating losses. A return to profitability is projected in 1985. The acquisition of four Boeing 767 aircraft, a economical, advanced technology and wide body aircraft, will permit further operational cost reductions as the company retires its Boeing 707 fleet.
El Al is not subsidized and its existing aircraft, eight 707, two 737, eight 747 and four 767 are self-financed

El Al development

Year	Pax flown	Pax load factor	Total Revenue (mill. US$)
1973/1974	756,888	66.2	166.2
1974/1975	743,109	67.7	193.3
1975/1976	767,745	65.1	195.0
1976/1977	944,000	67.0	256.0
1977/1978	1.089,852	69.0	307.2
1978/1979	1.126,621	70.1	331.2
1979/1980	1.251,959	69.7	414.0
1980/1981	1.179,350	69.1	436.0
1981/1982	1.254,703	71.4	443.9
1982/1983	956,630	74.4	416.0

El Al was shut down four months (September 1982 - January 1983) due to a major labor dispute. The company was reorganized under new management and resumed limited operations until a full flight schedule was reinstalled in mid March 1983. El Al's route network of 26 cities includes services between Tel Aviv and New York, Miami, Montreal, most European capitals, Johannesburg, Nairobi and Bucharest.

El Al maintains offices in another 26 cities.
This airline is a crucial factor in Israel's economy, as of October 1983, 3600 employees are employed in El Al.

Historical flights

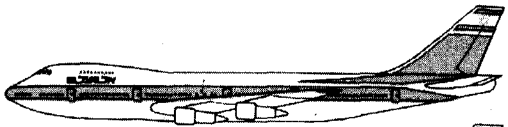
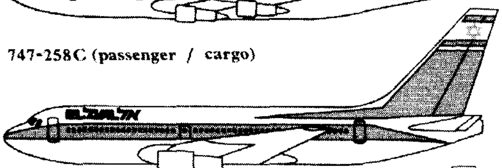
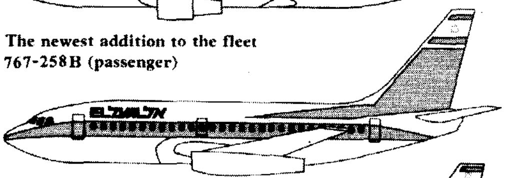
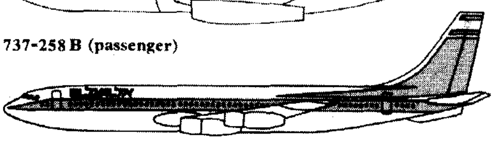
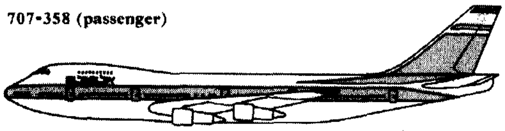
September	1948	- Inaugural flight Geneva/Tel Aviv with Israel's first president, Dr. Chaim Weizmann
July	1949	- First Commercial scheduled flight
December	1957	- Blue Ribbon Speed Record, New York/London, 8hr., 35 min.
June	1961	- First non-stop Flight New York/Tel Aviv, Boeing 707, setting record for world's longest commercial flight, 5760 statute miles (9 hr. 33 min)
April	1980	- Inaugural flight - Tel Aviv/Cairo
July	1983	- First Boeing 767 flight

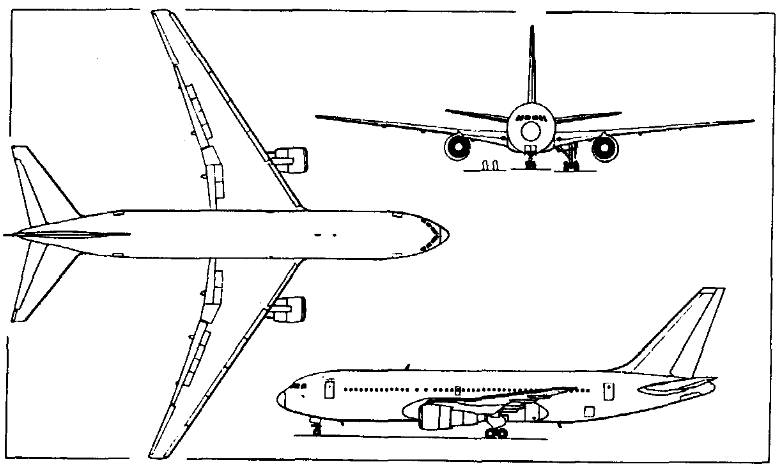
Beside passengers transport, El Al also transports cargo: El Al Cargo Division. El Al's Cargo System maintains a network of air routes to 29 cities on four continents. El Al operates two 747 Freighter aircraft in addition to the freight capabilities of its passenger aircraft. El Al operates El Al Express, a door to door parcel service for shipments of 25 kilos (maximum) between Tel Aviv and Europe. A door to door Containerized Service was inaugurated in 1980 utilizing an overland trucking Feeder and Distribution Service linking Amsterdam to other European cities.
El Al personnel perform all aircraft maintenance and repair, and its maintenance division is fully licensed by the Civil Aviation Administration of most countries. Up to date machine shops and advanced engine build-up workshops enable complete overhaul of 707, 737, 747 and 767 aircraft in modern hangar facilities.
In 1979, 'Sharon', El Al Cargo's computerized tracking and space control system for its airborne cargo equipment was introduced. In October 1980, El Al joined the BAGTRAC worldwide computerized baggage tracking system.
El Al maintains its own training programs covering technical and administrative fields, such as: flight crew training, management training and mechanics training. Flight crew training utilizes a full scale section Boeing 747 mockup, 747 Cockpit Instrument Trainer and 707 Flight Simulator.
During our stay at El Al we visited the maintenance division, reservation systems, the System Control Centre, and a lecture on the new Boeing 767 was delivered.
The reservation system 'Carmel' used by El Al was bought from British Airways and was made applicable for El Al. Carmel (Computerized Airline Reservations and Message El Al) is linked with the USA, the UK and all El Al offices; Carmel provides instant general information for all El Al and 2500 connecting flights of 90 world airlines. Fly-drive programs and hotel reservations are also available through Carmel.

Boeing 767

El Al operates the medium-range version of the B-767, equipped with two Pratt & Whitney JT9D-7R4D engines, each rated at 212.6 kN (47,800 lb st).
- Dimensions External
  Wing span 47.57 m

AIRCRAFT FLEET

		Seating Capacity		Freight	Total
	First	Business	Economy	Payload (Tons)	
 747-258 B (passenger)	10	16/20 24/35	413/428 434/440	20-30	4
 747-258C (passenger / cargo)	–	0/16/24	183/289/320	35-45-70-114	2
 The newest addition to the fleet 767-258B (passenger)	–	18	206	10-15	4
 737-258 B (passenger)	–	0/12	93/111	1-2	2
 707-358 (passenger)	–	0/12/16	147/157/163/210	4-7	4
 747-258 F/Z (cargo)	–	–	–	130,000 99,000	1 1
		Total Aircraft			18



Boeing 767-200

EL AL

Wing area gross	283.3 m^2
Length overall	48.51 m
Length of fuselage	47.24 m
Height overall	15.85 m
- Dimensions Internal	
Cabin length, excl. flight deck	33.93 m
Cabin max. width	4.72 m
Cabin max. height	2.87 m
Cabin floor area	154.9 m^2
- Weights	
Manufacturers weight empty	74,094 kg
Operating weight empty	80,550 kg
Max T-O weight	142,880 kg
Max zero-fuel weight	113,400 kg
Max landing weight	123,375 kg
- Performance (estimated at max T-O weight)	
Cruising speed	M = 0,8
Initial cruise altitude	11,550 m
T-O field length	1,981 m
Design range	6,727 km

The lecture on the new B-767 was given by Mr. Ami Polonsky. The B-707s El Al is flying with since 1960 made approximately 64,000 hrs. and are now replaced by the B-767 for the following reasons: the 707 is too noisy, has a high fuel consumption and is not an efficient aircraft anymore.

The replaced 707s are dismantled by El Al and parts of it are used for the 707 freighters, publicity purposes or training programs.

At the moment, the B-767 is the most efficient aircraft. The costs to fly a 707 as compared to a 767 are equal , while they transport 160 and 224 passengers (maximum) respectively.

On average, operation costs decreased by 10% and the costs for maintenance were also lowered considerably.

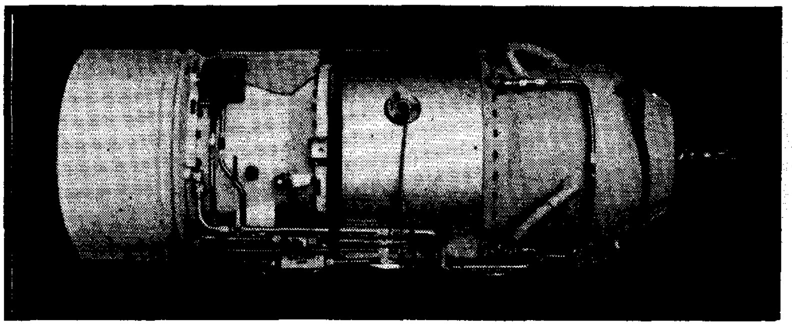
Decrease in weight was achieved by using composite materials like Kevlar and Carbon. For example the main spar in the tail is completely made of Carbonfibre. By a better plane profile reduction in fuel consumption was effected.

To fly a B-767 only two pilots are required instead of three, this also makes the 767 attractive for an airline.

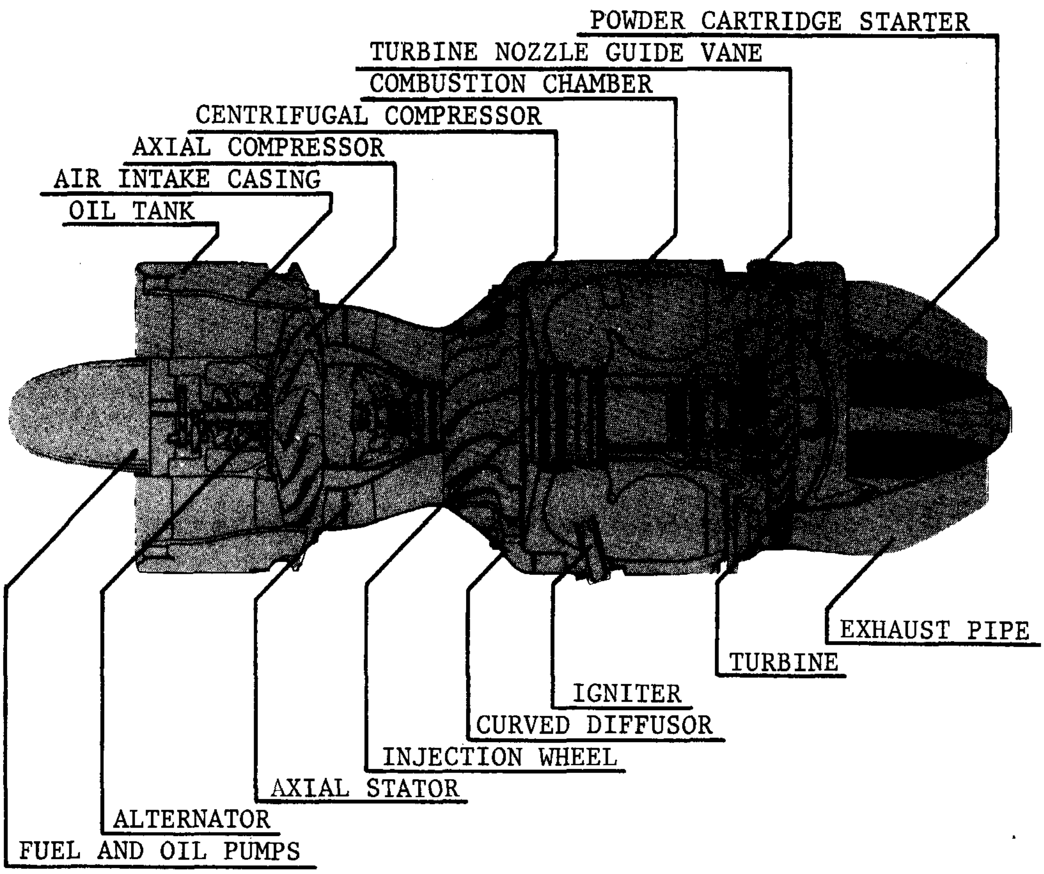
During tests by El Al it appeared to be possible to make a normal landing with both engines shut off. The emergency turbines, driven by wind, automatically switched on, so hydraulic pressure was available all the time.

El Al is flying the B-767 for a year now and they could nothing but sound the praises of it.

sorek4



Expendable Turbojet Engine



BET SHEMESH ENGINES

BET SHEMESH ENGINES

Bet Shemesh Engines Ltd. was established in 1968 by Joseph R. Szydlowski. The company is owned by the Israeli government (majority holding of 51%), by Turboméca S.A. and by Joseph R. Szydlowski. The latter was President and Director-General of Turboméca, the French engine manufacturing company, which also brought in the know-how for manufacturing the Marboré-6 turbojet engine, used to propel the Israeli Air Force Fouga Magister training planes. This was what Bet Shemesh Engines started with, and for that purpose they opened the first section of 12.000 m^2 aero engine factory (1969). This manufacturing plant was based on the Turboméca factory at Tarnos.
Since those early days there have been a number of spin-off developments from the original engines, which have become an increasingly important factor in company sales. One of them is the 800 kW M2TL industrial gass turbine engine, used to power electric generators, compressors and other machinery. The company has now developed a more powerful version, M5TL, with 1,5 times the capacity of the smaller model.
Bet Shemesh also manufactures the Sorek family of engines, including the Sorek 4, the light and compact expandable turbojet engine used for powering target drones. They are working on a more powerful version, the Sorek 6. They also manufacture parts of the Marboré II, Artouste II and III, Turmo II and Astazou II.
In 1975 the company began to produce a large part of the J-79 engine for the locally manufactured Kfir fighter. The engine was developed by General Electric. It was this contract that opened a new stage in the company's history.
During the years 1975-1976 the number of employees increased from less than 500 to about 1300, and the plant area doubled.
New technologies were introduced, enabling Bet Shemesh to manufacture an entire range of investment castings and aviation gear boxes for engines and other precision equipment beyond the company's own range of primary or assembled products.
About 10% of the company budget goes into R&D. The R&D department is at work on a number of projects, including the Sorek 6, a digital control system for turbines, and a hollow blade for the operation of gas turbines at high temperature.
In 1981 Bet Shemesh was awarded the contract for manufacturing the engine for the Lavi jetfighter, the aircraft that will serve as the backbone of the Israeli Air Force in the 1990s.
Apart from assembling this PW 1120 Pratt & Whitney jet engine, Bet Shemesh will manufacture many of the parts, developed and licensed by Pratt & Whitney.
The first 30 production engines will be delivered from P&W's Hartford, Connecticut complex. The next block of 100 engines will be produced jointly by P&W and the Israeli firm.
According to 'Interavia' the company has been having problems, the company is believed to make heavy losses. The senior management and board of directors resigned last year en-mass as a protest, it is believed, at Government failure to inject funds which had been promised earlier.

The visit

When we arrived Mr. Catz, Marketing Director, gave us a short welcome speech. After that we went for a tour around the plant. The first thing we saw was the almost completed assembly hall, where the Lavi engine will be put together in the near future. Then we went on to the Bet Shemesh testfacilities, where the J-79, F-100 and smaller engines are tested after completion or overhaul; very impressive. The assembly line of the J-79 engine was shown to us next. In the same building there was also an overhaul: facility for the Turboméca Astazou engines.
The final thing we saw was the Bet Shemesh investment casting facility. Here aerospace products are being manufactured such as turbine-blades, airframe structural parts and guidance parts.

The Investment Casting

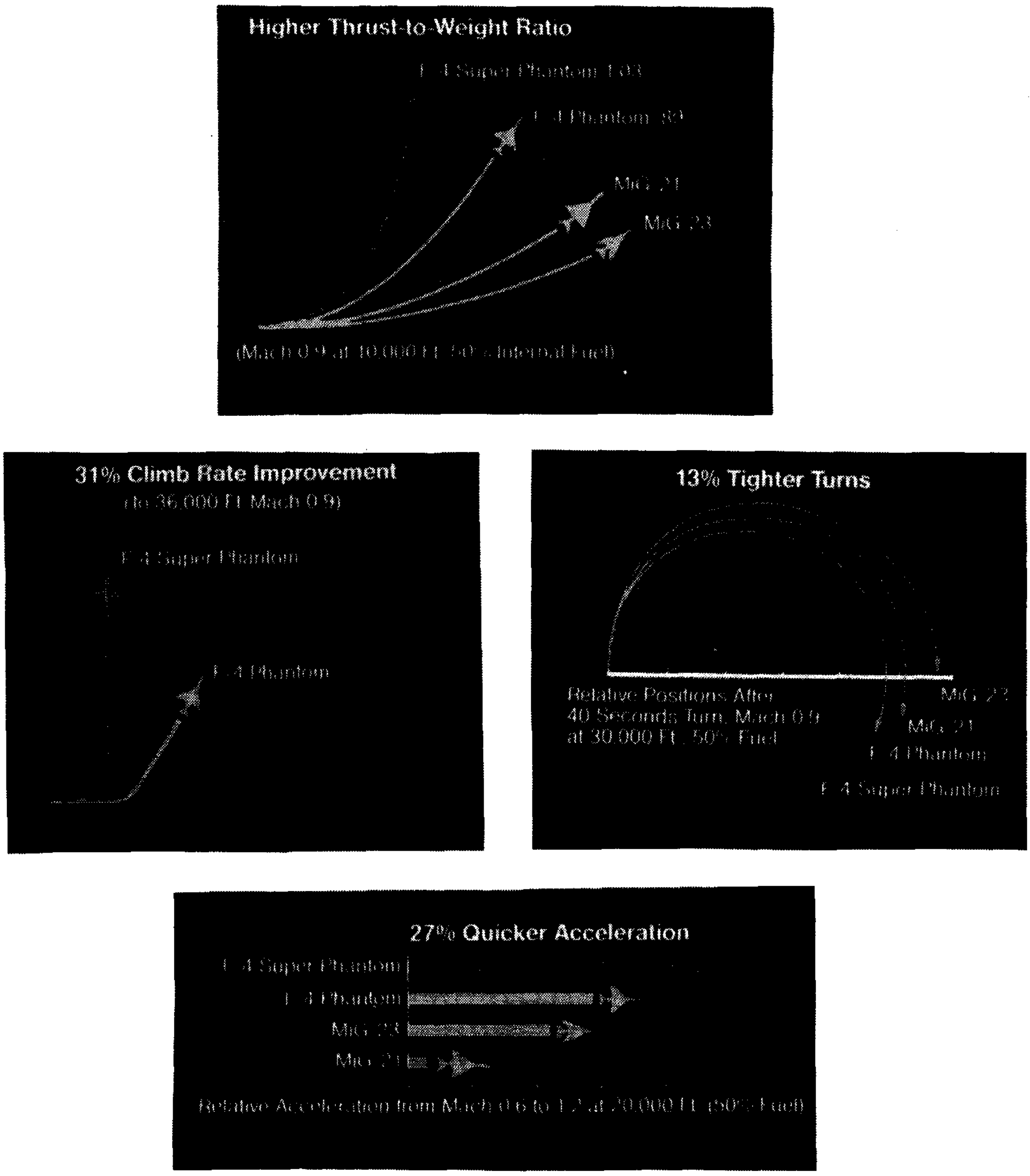
At the Bet Shemesh Investment Casting the Howmet-Misco patented Monoshell process for vacuum melted castings is utilized in addition to the own developed Silica Shell process for air melted castings. A wide range of alloys, steels, stainless, cobalt and nickle base, are available upon request.
The foundry supplies to the aerospace industry:
- aircraft engine components
- airframe structural parts
- gas turbine blades, vanes and integral wheels
- missile guidance parts;

and to the general industry it supplies parts for:
- computers and accounting machines
- agricultural machines
- steam turbines
- surgical instruments.

The normal tolerance corresponds to qualities J14 or J15 (ISO) or approximately ± 0.127 mm per 25 mm. Closer (premium) tolerances can be obtained following final adjustment of the tooling.
Minimum angular tolerance is ± 30'. Minimum fillet and corner tolerance is ± 0.4 mm.
Castings produced 'as-cast' require little or no surfaces finishing. Standard 'as-cast' of approximately Ra 2.2 µm is routine although surface finished up to Ra 0.8 µm or better are available.
All castings are produced according to standard specs (Mil-c-6021) and customer's requirements.

The Sorek 4

The Sorek 4 uses a two-stage compressor, an annular combustion chamber and a single-stage axial turbine. It is reliable in all operating conditions, even after extended storage.
The engine is started by a pyrotechnic cartridge or compressed air. It reaches full power within 10 seconds of ignition. In the starting mode, fuel flow to the engine is programmed as a function of engine speed. The speed governor controls the fuel flow to maintain engine speed within ± 0.4% of the set reference speed.
A correction signal as a function of Exhaust Gas Temperature (EGT) is incorporated in the control system and prevents exceeding the EGT values in starting and run modes.



Super Phantom performance improvements

BET SHEMESH

Engine Characteristics:

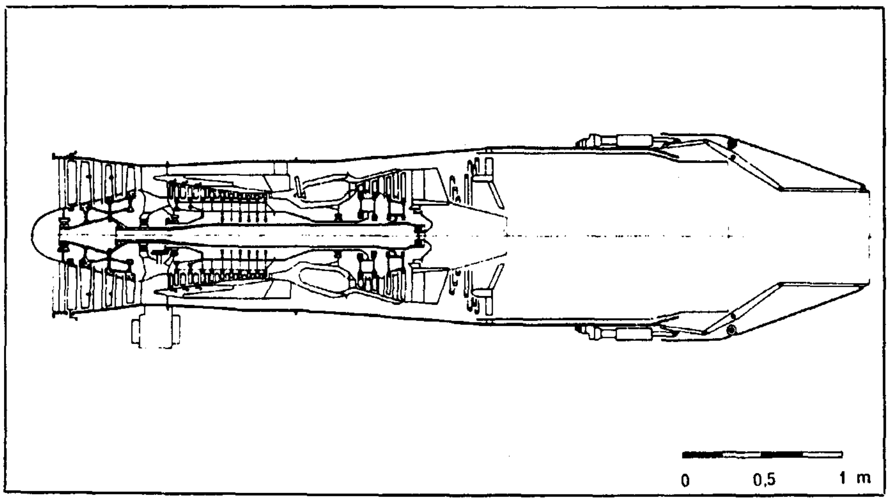
- Static thrust	3,670 N (809 lb)
- Air mass flow	5.5 kg/sec
- Overall length	1104 mm
- Overall diameter	330 mm
- Pressure ratio	5.8:1
- Total weight	60 kg
- Max. operating speed	M = 0.9
- Fuel	All standard aviation fuels

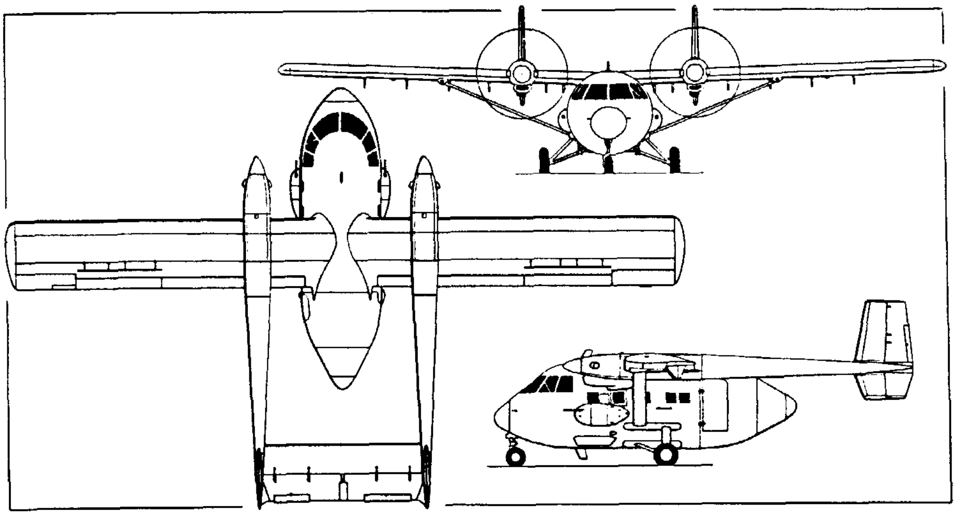
Super Phantom

As we go to press, the Israeli Air Force is seriously considering upgrading its 130 F-4 Phantom IIs by re-engining them with Pratt & Whitney PW 1120 engines, the same engine that will power the Lavi.

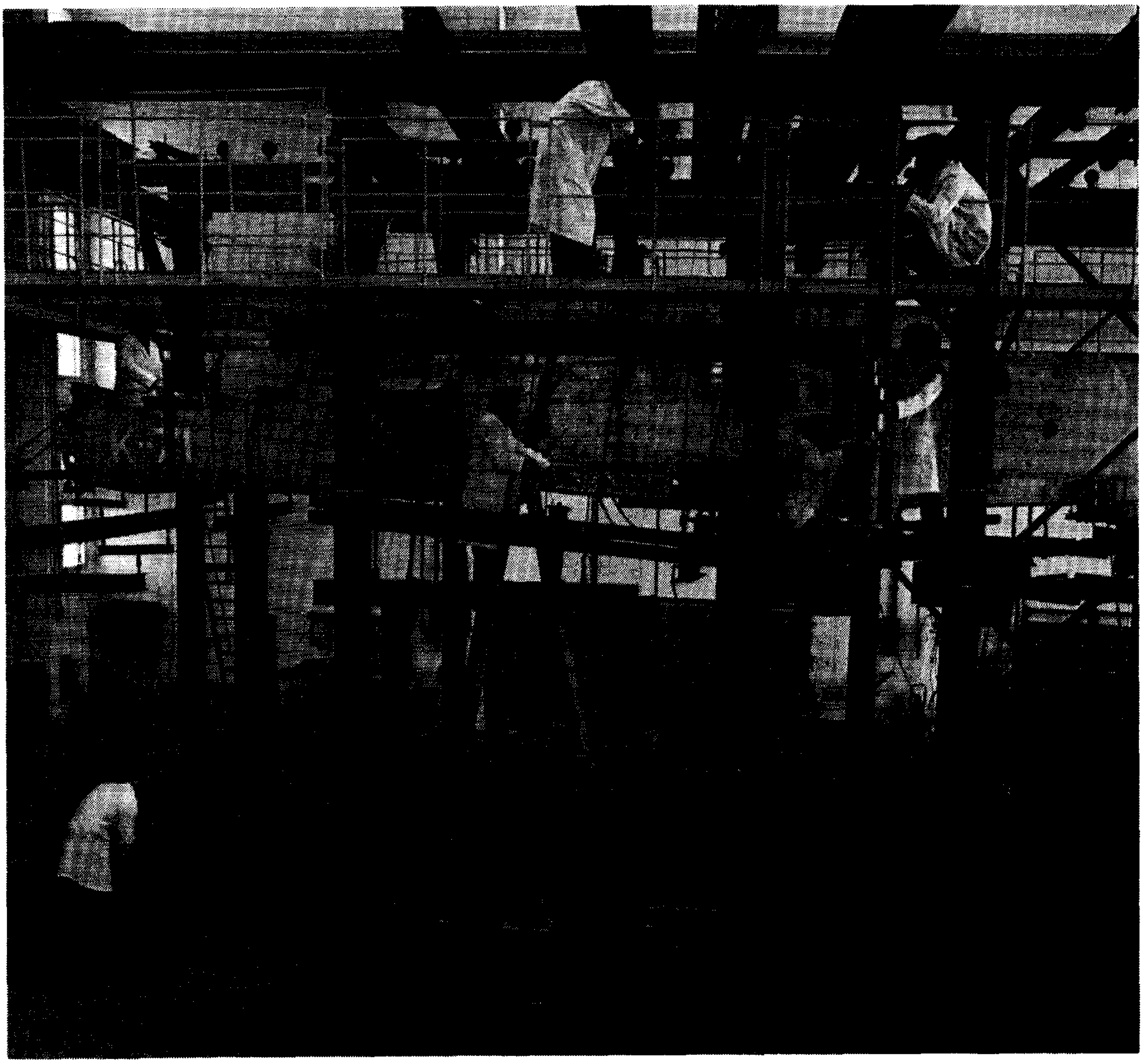
Compared to the current General Electric J79, the PW 1120 offers 2,700 kg (6,000 lb) more thrust, 900 kg (2,000 lb) less weight and is virtually smokeless.
As can be seen in the figures on the opposite side, this gives the "Super Phantom", a quicker acceleration, greater manoeuvrability, longer range and more payload capability.
Boeing, in cooperation with P&W, is offering this retrofit, which will extend the life of Phantoms with sufficient airframe life left by 10-15 years, keeping it operational beyond the year 2000.
Israel is to have one F-4 converted as a demonstrator aircraft, and it should fly by the end of 1985 with one PW 1120 and one J 79 for comparative tests.

PRATT AND WITHNEY F 100





IAI 201 Arava



Structural testing of a Kfir fuselage

ISRAEL AIRCRAFT INDUSTRIES

ISRAEL AIRCRAFT INDUSTRIES
"We fly tomorrow what we dream of today"

History
Israel's reach towards the skies was initiated by a handful of men. One was David Ben-Goerion, who, even before the State got into existence, saw the need for Jewish wings over the Middle East. The second was Ben-Goerion's youthful assistant, Shimon Peres, who supported the proposition that Israel had to tame its skies. The third was the Connecticut-born flight engineer, Al Schwimmer.
They argued that aviation in Israel was imperative for the safety and the economy of the country. In 1953, on the sand dunes adjacent to Lod Airport, Bedek Aviation was born, a tiny overhaul facility. A major milestone was reached, when the Government approved a plan to assemble a jet trainer in Israel: the Fouga CM. 170 Magister. By 1957, there were 800 employees, almost none of them experienced, huge efforts were made to update equipment and knowledge. By the end of 1961 the planes started rolling off. But IAI wanted to develop an original aircraft design. In 1967 the Arava design was launched. Many problems had to be faced; e.g. the crash of one of the prototypes due to flutter problems and the withdrawal from the project of the French. After FAA certification in 1972, interest for the STOL plane grew steadily.
Parallel IAI started producing the Jet Commander, a design of Rockwell-Standard. An improved IAI version, the Commodore Jet, was certificated. This aircraft later evolved to the Westwind 1124, certificated in 1976. More than 400 of these have been sold since.

In 1963 the Israeli Air Force acquired its first modern warplane, the Dassault Mirage IIIC. In 1965 Israel had ordered for 50 new Mirage V aircraft. However, due to Israel's victory against Egypt, Syria and Jordan in 1967, Charles de Gaulle ordered a partial embargo to Israel.
Schwimmer was asked if he could build the Israeli equivalent of the Mirage V and he replied that he could en would. Despite the political situation, a formal agreement was signed with Dassault and Snecma, whereby the Israelis would purchase the expertise for licensed manufacture of the plane and the ATAR-9 engine. Already during the transfer of know-how, Schwimmer and Peres decided that the Mirage V would grow out to the new and much better Kfir, powered by the American General Electric J 79.
In 1971 the Swiss jet engineer Alfred Frauenknecht was accused of stealing ATAR-9 engine plans and turning them over to Israel. He was sentenced to 4½ years at hard labour. Israel had no comment.
In 1974, the first Kfir made its maidenflight. With its saw-toothed leading edge, canard shaped extra wings and new nose assembly it was far removed from French technology.
(Literature: Israel High Technology, by Messrs. A. Sherman and P. Hirschhorn, Jerusalem, May 1984.)

Today
Now, in 1984, the company employs over 20.000 workers in plants all over Israel; some 10.000 in Tel Aviv, and the balance on the Golan Heights, in Jeruzalem etc.
The company as it is today, has five divisions:
* Engineering Division
* A/C Manufacturing Division
* Bedek Aviation Division
* Combined Technology Division
* Electronics Division

The first three divisions were visited and will be described in the next sections.

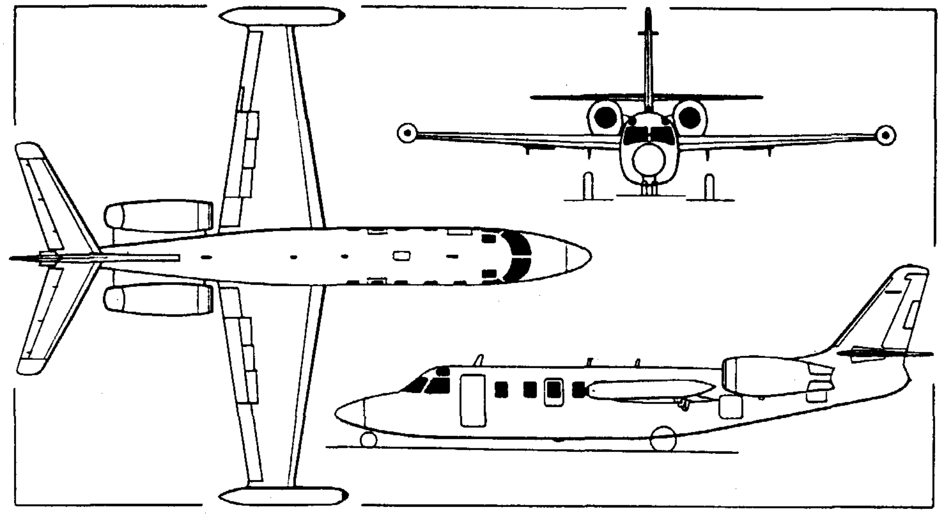
* Engineering division

Ground Test Engineering Department
The Ground Test Engineering (GTE) Department comprises laboratories for static and fatigue structural testing of aircraft components, assemblies and full-scale airframes.
When we visited the Department, the Astra (no. 003) corporate jet was undergoing fatigue testing. The range of fatigue loadings is based upon operations with the Westwind fleet, including flight and ground loads, and cabin pressure cycling. It is very important to simulate flight and cabin pressure loadings at the same time, because of their combined influence in the wing-fuselage area.
Static tests for stress analysis are done with the aid of stress gauges, which yield information fed to a computer, while exact programmed forces are applied to the test article.
The aircraft is loaded equivalent to three times its life time. After the life time of the aircraft, there are inspections for cracks; if there are non, cracks are deliberately made and the development of the cracks is followed during the continuation of the fatigue test.

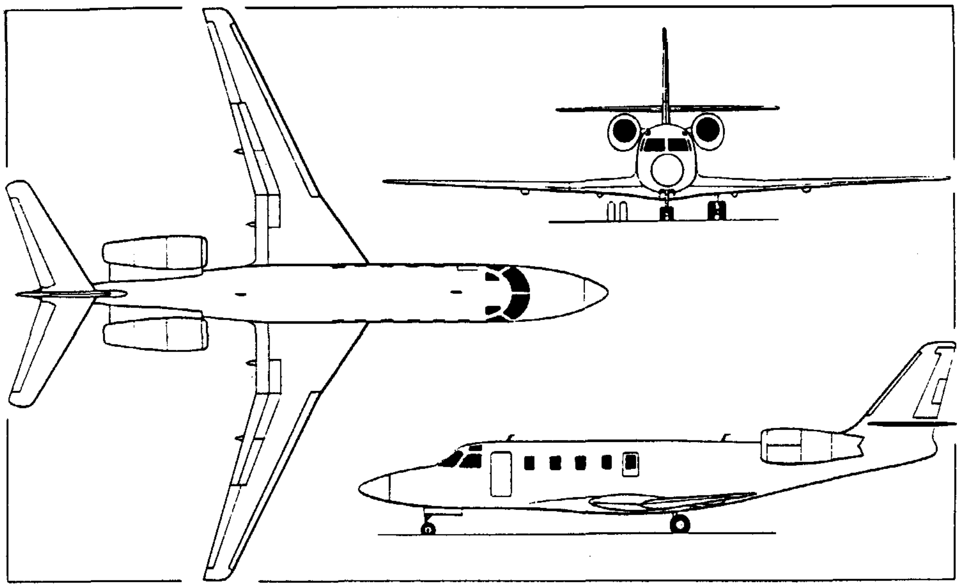
Prototype Development Centre
The Prototype Development Centre is part of the Engineering Division. At the moment, IAI is developing two new aircraft, the Astra and the Lavi.

- The IAI 1125 Astra

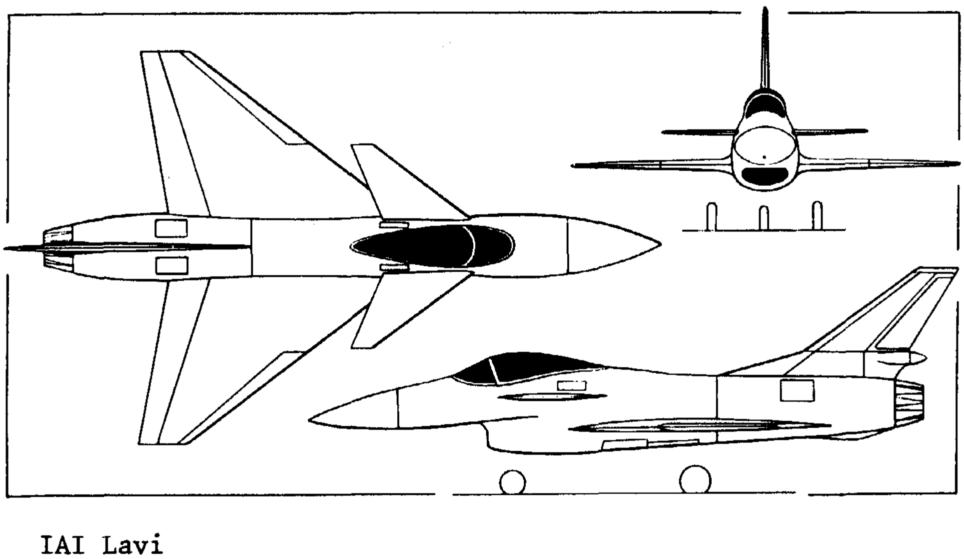
The Astra is a corporate jet. After roll-out in September 1983, the first flight of Astra prototype no. 001 took place on March 19, 1984, four years after the "go-ahead" decision.
Prototype no. 002 was scheduled to make its first flight approximately a week after our visit.
The 1200 to 1400 hr. flight test program will be carried out by prototypes 001, 002 and later 004.
No. 003 is the first production aircraft, used for static and dynamic testing.
Prototype no. 001 is used for aerodynamic testing. For this purpose, a number of short threads are attached to the wing. With the aid of these threads it is possible to see irregularities in the airflow, at large angles of attack. On the wingtip of this aircraft, a small plate is attached. By changing the angle of attack in a certain frequency, flutter can be induced. The movement of the wing is recorded on video.
Prototype no. 002 will be used for system and avionics testing. This aircraft is the first to get the standard avionics, which includes a five-tube (CRT) Collings electronic flight instrument system, pre-



IAI 1124 Westwind



IAI 1125 Astra



IAI Lavi

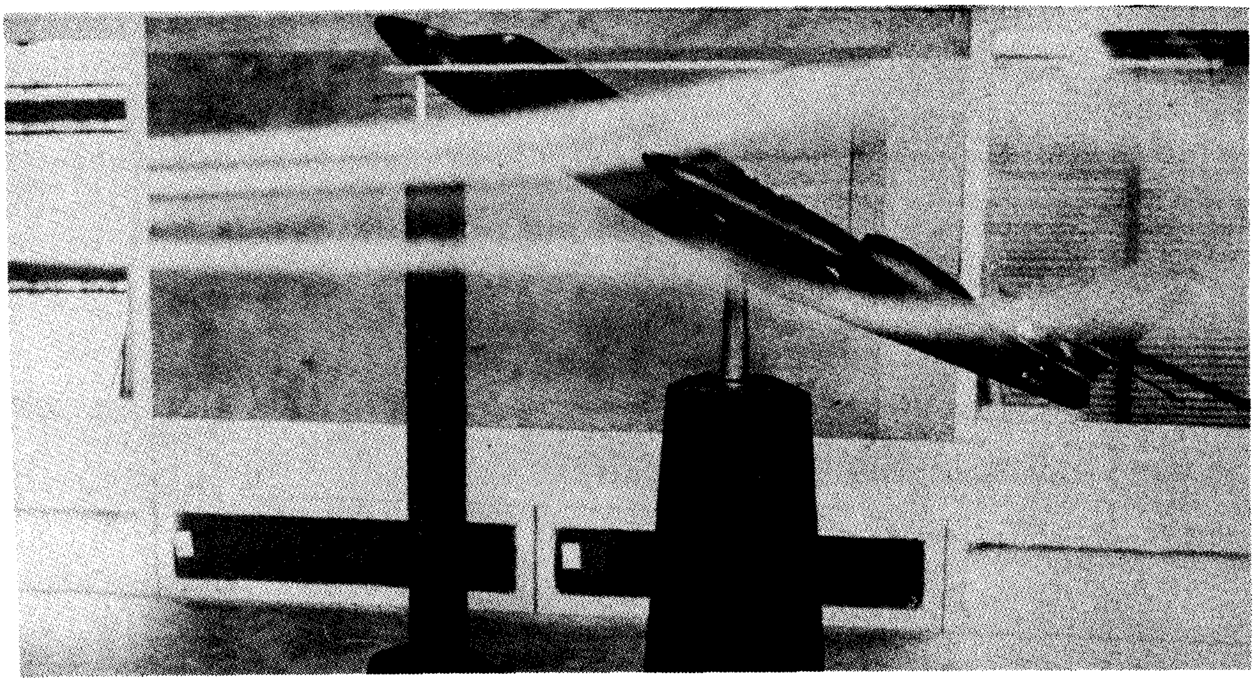
senting navigation, flight and weather information. Certification, to FAR parts 25 and 36, will be completed by August 1985.

The IAI 1125 Astra, originally known as the IAI 1125 Westwind Astra is a further development of the IAI 1124 Westwind series. The most significant difference between these two aircraft is in the wing design.
The Astra has a wing, mounted low on the fuselage, beneath the passenger floor, while the mid-wing of the Westwind passes through the fuselage behind the passenger cabin. The Astra has a double swept wing with a new - IAI designed - airfoil section, called Sigma 2. This is a computer-assisted improvement of the Sigma 1 section (modified NASA 64A-212) used in the Westwind's straight wing. The critical curvature of the wing is formed by shot-peening. This curvature and other aerodynamic features allow the wing to be optimized without the need for winglets. (The Westwind 2 is equipped with winglets.) To achieve the exactness required for the Astra wing, IAI is using computer aided design and manufacturing techniques (CAD/CAM).
Wing devices will be conventional: ailerons for roll control; four wing panels that serve as speed brakes in flight and as lift dumpers in landing; electrically operated Fowler flaps and inboard leading-edge slats.
The new wing helps to provide a more efficient high-subsonic cruising flight over long ranges and so operating costs are reduced: direct operating costs are estimated at $ 500 to $ 600 per hour.
The IAI Astra can carry 5 passengers over a distance of 6,000 km with two removable 189 liter (50 US gallon) longrange fueltanks placed in the baggage-compartment. The longrange fueltanks occupy less than 10 percent of the available baggage compartment space.
Composite materials will be used extensively in non-structural parts of the Astra. The wing-fuselage fairings are made of Kevlar, wingtips and inboard leading-edges of Kevlar and Nomex and ailerons of carbonfibre with Nomex honeycomb core. According to IAI, the total weight of the composite materials is only 86 kg (190 lb). This is about 4% of the aircraft total airframe weight of 22,675 kg.
The passenger cabin is nearly 0.61 m (2ft) longer than that of the Westwind and has a maximum seating capacity of nine. The cockpit will be about 4 cm longer than the Westwind's. The nose is also a little longer. Although the Astra is a larger aircraft, the new jet will have an operating empty weight of 5,747 kg (without long-range fueltanks), which is even a little less than that of its predecessor (5,761 kg). The maximum gross take off weight, 10,691 kg, will be about the same in comparison to the Westwind. The Astra has twin wheels on both main landing gear legs.
At the time of the type's first flight in March, plans for the production of the first batch of 20 aircraft had already been approved. Half of the first production batch had been sold by mid-April, all to Westwind buyers, and the remaining ten had been reserved by potential customers. Price of the Astra (IAI equipped) is estimated at about $ 6 million (July 1983). Israel Aircraft Industries is investing over $ 100 million in research and development in the Astra program and another $ 50 million in new production tooling; only 10 percent of the Westwind tooling is usable. Thus the company says it has to sell 150 Astras before it starts making money on this new aircraft. First deliveries should be available by October 1985. The manufacturer hopes to deliver three aircraft a month.
The Astra is equipped with two 16.23 kN (3,650 lb st) Garrett TFE 731-3B-100G turbofan engines, with Grumman thrust reserves, pod-mounted in Grumman nacelles on each side of the rear fuselage. An automatic power reserve, that automatically boosts the take-off thrust of one engine by 2 or 3%, if there is a loss of normal take-off power in the other engine, will be available as an option. The Astra will be a relatively quiet aircraft and will be able to operate at noise-limited airports such as Washington National.
Wind tunnels used in the lengthy test program include IAI's own low and high speed tunnels, as well as the Technion's, NLR's (The Netherlands), LTD's (Texas, US) and Weybridge's wind tunnels. Icing tests were carried out in Lockheed's icing tunnel in California.

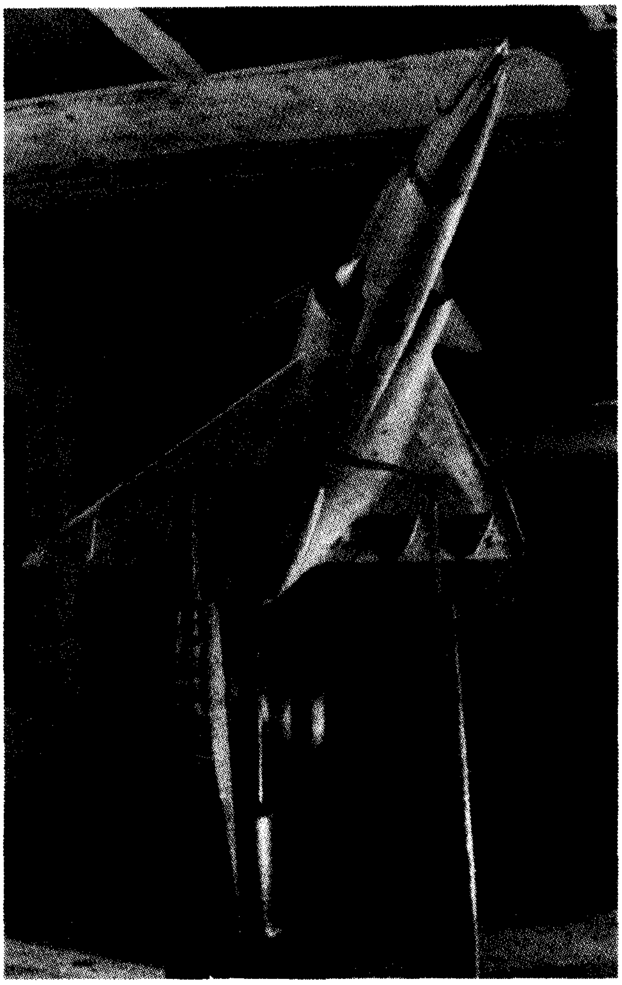
- Dimensions External	
Wing span	16.05 m
Wing area gross	29.4 m^2
Wing aspect ratio	8.76
Length overall	16.94 m
Height overall	5.54 m
- Dimensions Internal	
Length incl. flight deck	6.86 m
Length excl. flight deck	5.23 m
Max width	1.45 m
Max height	1.70 m
- Weights	
Basic operating weight empty	5,747 kg
Max T.O. weight	10,660 kg
Max landing weight	9,389 kg
Max zero-fuel weight	7,257 kg
Max payload	1,510 kg
- Performance (estimated at max T.O. weight, ISA)	
Max cruising speed at 10,670 m	876 km/h
Max rate of climb at S/L	1,085 m/min
one engine shut off	335 m/min
Max certification altitude	13,715 m
T-0 balanced field length	1,630 m
Range 5 pass., max fuel , M=0.72	6,185 km

- The Lavi

After a long political debate, the Israeli government decided to develop its own fighter, the Lavi. The Lavi is to replace the older aircraft types in the Israeli Air Force, like the A-4 Skyhawk, F-4 Phantom and later the Kfir C2/C7. Deliveries of the Lavi are planned to begin in 1990. Series production is intended to be at the initial rate of one per month increasing to 30-36 per year by the mid-1990s. The Israeli Air Force has a requirement for at least 300 aircraft, including 60 combat capable two-seat trainers.
The Lavi is now in its final design stage. It's decided to build five development aircraft, including



1/10 model of the Westwind in a windtunnel with smoke generator



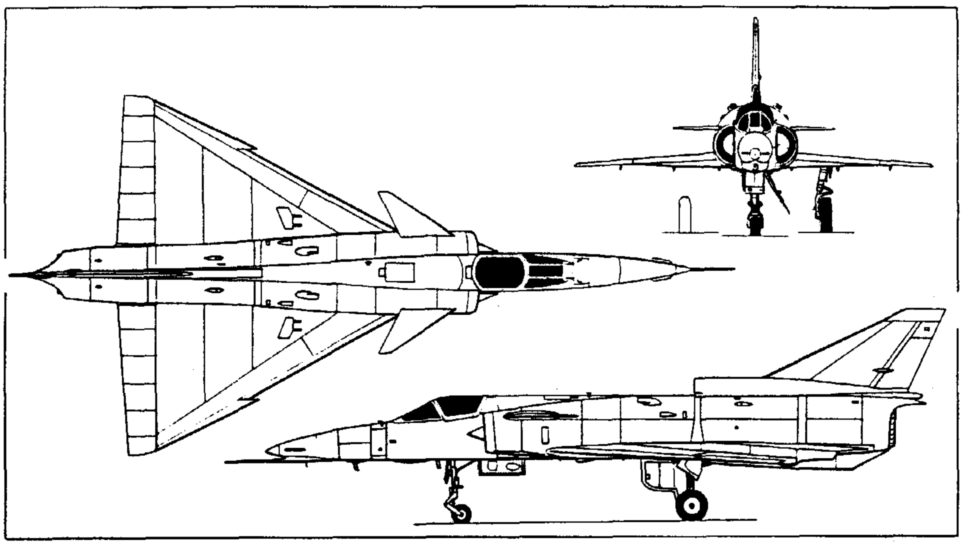
1/6 model of the Kfir-C2 in the windtunnel test section

three two-seaters. First flight is expected in early 1986. In the Prototype Development Centre hangarwork is done on the mock-up of Israel's future combat aircraft. This mock-up is made of wood and metal and used to make sure everything fits before production of the five prototypes starts. It is also used to check the CAD/CAM results on utility, e.g. how long it will take to change an engine.
The IAI Lavi is a close-support, strike and air defence fighter with double delta wings and canard surfaces. Design characteristics include high-speed penetration, high manoeuvrability, first-pass bombing accuracy and battle damage tolerance for safe recovery.
Approximately 20% of the structural weight will be made out of composite materials. This will include many components made of graphite epoxy (carbonfibre), such as wing skins and -substructure, the vertical tail, the all-moving foreplanes, control surfaces and various doors and panels. In most cases, development and initial production of such advanced technology components will take place in the USA (who support the project financially and technically). Grumman will for instance produce the first 20 carbonfibre fins.
The Lavi is powered by one 91.7 kN (20,620 lb st) Pratt & Whitney PW 1120 afterburning turbofan engine. Most parts of this engine will be manufactured under licence by Bet Shemesh Engines Ltd. The Lavi will be equipped with a digital fly-by-wire control system (joint venture with US company Moog).
The Lavi landing gear is a conventional, passive system. An active system means a loss in reliability and higher maintenance costs. The EL/M-2021 radar of Elta, claimed to be equivalent to the AN/APG-66 of the F-16, will form the basis of a new radar developed for the Lavi. System weight will be about 180 kg and a moving flat plane antenna will provide azimuth and elevation scanning.
Elbit is developing the stores management and the mission computer as well as a range of standard modules. A high degree of standardization is being employed on the Lavi. The system will use the Mil Std 1553 data bus and Mil Std 1750 computers.

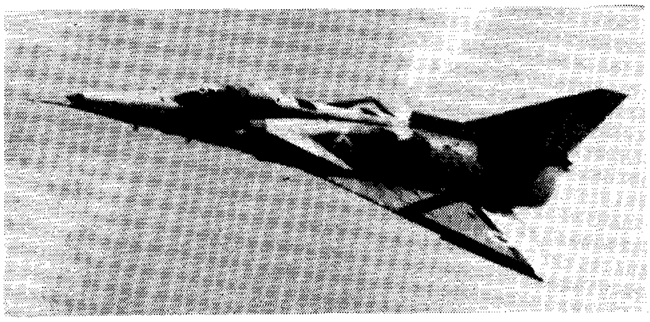
- Dimensions	
Wing span	8.71 m
Wing area gross	32.5 m^2
Length overall	14.39 m
Height overall	5.28 m
- Weight and Loading	
Max fuel internal	2721 kg
Max fuel external	4164 kg
Max ordnance (excl. A/A missiles)	2721 kg
Max external load	7257 kg
- Performance (estimated)	
Thrust/weight ratio	1.1
Max level speed above 11,000 m	M=1.85
Air turning rate at M=0.8 at 4575 m	
sustained	13.2°/s
max	24.3°/s
Combat radius (8 bombs 340 kg each, 2 A/A miss.)	452 km
g limit	+9

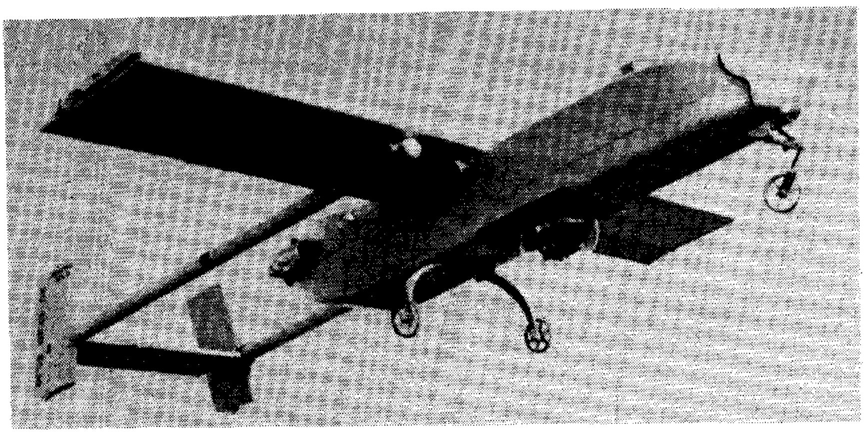
The Wind tunnels
Our last visit was to the Aerodynamic Testing facility which belongs to the Engineering Division, and disposes of a subsonic as well as a transsonic-supersonic wind tunnel. There is also a modelshop capable of building models out of wood, metal, plastics or fibreglass.
First we were shown the low speed wind tunnel which is a closed circuit single return atmospheric tunnel with a test section of 2,60 x 2,65 x 8,38 m., where testing is carried out on civil aircraft and also on some classified military projects in cooperation with the Israeli Air Force, such as different weapon arrangements under the F-16, versions of the Kfir and surely the Lavi. Also other special test programs can be conducted such as inlet distortion measurements, weapon release, aeroelastic testing of airframes and propulsion simulation.
Power is supplied by a 1300 kW D.C. motor, operating a six bladed wooden fan. For up to thirty minutes the engine can deliver up to 1730 kW. The airspeed ranges from 25 till 400 km/h with an accuracy of 0,1 percent, through a variable frequency electrical system.
The airflow circuit is 800 m long, and measurement of forces and moments is done by a six component external balance or an internal balance in cases of high angles of attack. Pressure distribution is measured with pressure transducers and modular pressure scanning switches (scanivalve).
For data-aqcuisition a DEC model VAC 11/780 computer is used.
Adjacent to the low speed wind tunnel is the high speed tunnel capable of reaching M=0.5 till M=5.0. The tunnel - blow down type - has a test section of 1.2 x 1.2 m. Pressure in the air storage tank is 600 psi. Measurements with a duration of 10 to 20 seconds are recorded with 600 samples per second. About 20 to 40 minutes are needed to recharge, during which time some 10% of the electrical power of Tel Aviv is consumed. The wind tunnel itself has been bought by IAI in 1977 for a bargain (about $1 million) from General Dynamics.
The models wich are used in both tunnels can be very expensive. To give an example: the model of the Astra, ± 2 meter span, costs $ 200,000.

- Manufacturing Division
All over the world, F-15 Eagles are provided with the so-called "FAST-packs" (Fuel And Sensor Tactical- pack).
All these longe-range fueltanks are built in Israel, including the ones for the US Air Force.
Entirely indigenous is the assembly-line of the Kfir. This fighter is often called a French lady with American power and Israeli intelligence.
The engine of the Kfir is 85% manufactured in Israel, the rest of the plane even close to 100%. Only the heavy castings cannot (yet) be produced in Israel. The ejection seat of a Martin Baker-type is license produced.
The countries which fly the upgraded Mirages and Kfirs are not always officially known, but even the U.S.A. has shown interest to lease/buy some Kfirs.
One of the first stations of the assembly line is a computerized testbench for the testing of electrical



IAI Kfir-C2





IAI Scout Mini-RPV

and hydraulic systems. At this stage the aircraft is nothing but a fuselage and cockpit.
The next stations on the line are the assembly of the nosewheel carriage, the wing and main undercarriage, and the rear end of the fuselage including the and vertical tailplane.
Halfway the huge hall, there stood a special case, not often dealt with at IAI.
The Kfir in question had pulled 9g, which is in excess of what is allowed. Normally, this aircraft cannot be used as a fighter anymore, because it is "twisted" and the guns are no longer leveled. But a shot is given to bring the aircraft back into service, to save the expenses of manufacturing a new Kfir. To do so, aluminium plates of the skin are at the right places replaced by titanium plates. The results of these replacements can only be given by a testpilot after careful flighttesting.
Next and last stations on the line are the assembly of the tires, the nose and the engine. Next the aircraft are painted and are ready for a last check of the systems and flighttesting.

The Scout Mini-RPV

At the end of the hall we were shown a few IAI Scouts, a very successful weapon during the operation Peace for Galilee in 1982.
The Scout Mini-RPV (Remotely-Piloted Vehicle), a small unmanned aircraft that can fly for several hours over and behind the battlefield, is able to transfer TV pictures and realtime data to a control station. They are deployed in the Israeli Air Force in such multiple roles as:
- border control
- localizing enemy troop concentrations, artillery positions and control of own fire into these targets (advanced observer over the target)
- localizing enemy anti-tank and combat helicopters and warning of friendly armour units
- localizing and participating in the destruction of enemy air defence positions
- in support of the close air support actions of the Air Force. With the use of the RPV the forward aircontroller has the ability to see the target from above and can thus lead the pilots, and also see the results of attacks in real time.
- Reconnaissance in depth over the battlefield. As the RPV's can fly more than 100 km, they are able to close the reconnaissance gap.
- Observation of take-offs and landings of enemy planes at air bases near the frontier.

The mini-drone can be launched using a catapult system fired from a ramp mounted on a truck and it is retrieved using a net. The RPV has a video-link and is guided from a command post. It is linked with
- the tactical leader
- the artillery commander
- the Air Force
- the supreme commander of the campaign.

The Scout has a stabilized TV camera which makes it possible to supervise, from an altitude of 900 m, an area of some 50 km^2. Fitted with a zoom it is possible to identify targets in an area of 40 m^2. On the TV picture one can read the coordinates of the drone's position and, combined with a plotter, one can identify the position of the drone or the target on the map.
This gives the tactical leader the possibility of ord ring his artillery commander or the Air Force to engage targets, without loosing any time. This is especially important when targets are moving - the RPV can easily follow these targets.
It was found that above an altitude of 900 m the RPV cannot be seen or detected by radar.
The costs of a typical unit of 4-6 scouts is some $ 3.2 million with equipment, spare parts, command station, launching and recovery means included.
The Scout has already been exported to a number of customers abroad.

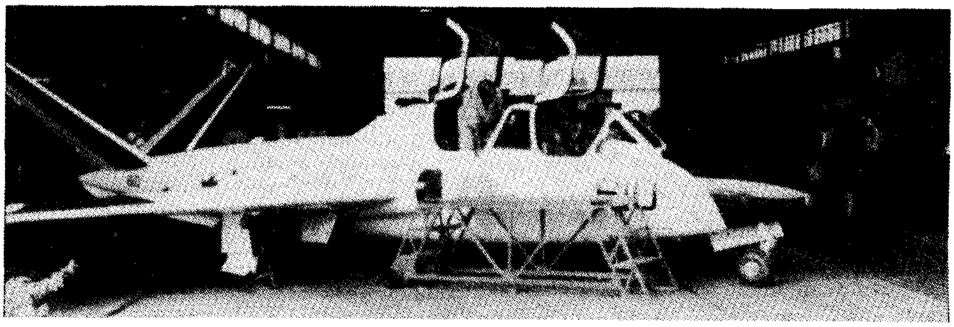
- Data:

Airframe: Cantilever high-wing monoplane. Fuselage is a rectangular-section aluminium nacelle; twin inward-canted fins and rudders, supported by twin tailbooms extending from wings outboard of fuselage. Wings, tailbooms and tail unit are of glassfibre. No landing gear on catapult-launched version, but a non-retractable tricycle gear can be fitted, if required for operation from paved strips. Modular construction, with large access panels.
Power plant: One 13.4 kW two-cylinder air-cooled piston engine, installed in the rear of the fuselage nacelle, driving a specially designed two-blade pusher propeller. Fuel is a 20:1 petrol/oil mixture.
Special equipment: TV camera, with telephoto lens, mounted in belly on a stabilized platform, servocontrolled for vibration damping. Large transparant hemispherical blister under the centre of the fuselage nacelle. The camera can rotate and scan through 60° on each side of the flight path. Configuration permits installation of other mission equipment packages, such as laser designator/rangefinder and thermal imaging camera, to customer's requirements.

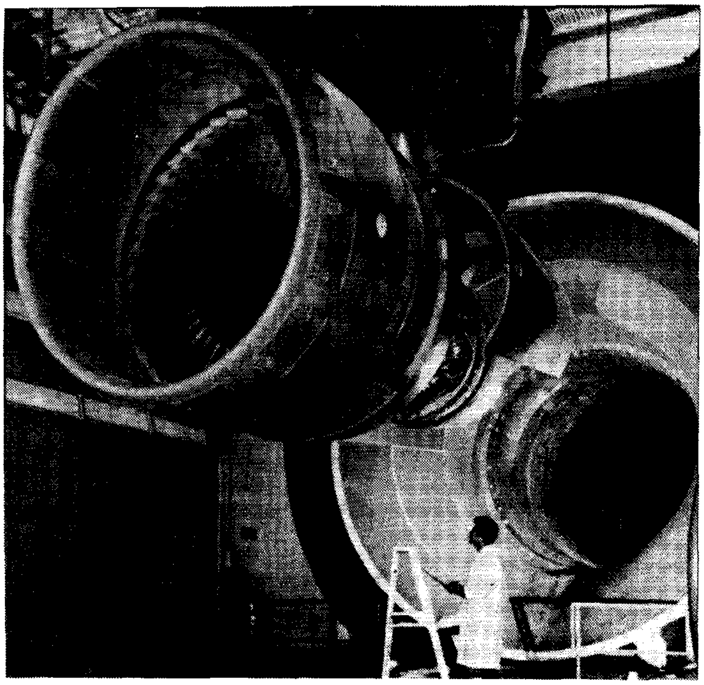
External Dimensions:	Wing span	3.60 m
	Overall length	3.68 m
	Height	0.94 m
Weights:	Mission equipment	22.7 kg
	Fuel	14.5 kg
	Launching weight	118 kg
Performance:	Max level speed	148 km/h
	Speed for max range	102 km/h
	Stalling speed	78 km/h
	Rate of climb at S/L	152 m/min
	Max operating altitude	3050 m
	Control range	100 km
	Flight endurance	more than 4 hours 30 min.

- Further development of the RPV

The RPV still has some weaknesses:
* The link between the RPV and the ground station is not yet fully secure. Using ESM the enemy can also see the TV picture. To combat this, a secure link for the TV camera is now in development.
* At this time one ground station can guide only one RPV in the air. The aim is to be able to guide six to twelve drones at the same time.
* The Israeli RPVs are fair-weather drones. Seen from a European point of view it seems better to monitor enemy area to a depth of 120 km, 200 days a year than to see nothing during 365 days. The development of an all weather and day/night capable drone is on its way and should present no



Fouga Magister remanufacturing at Bedek



Big-fan engine test cell at Bedek

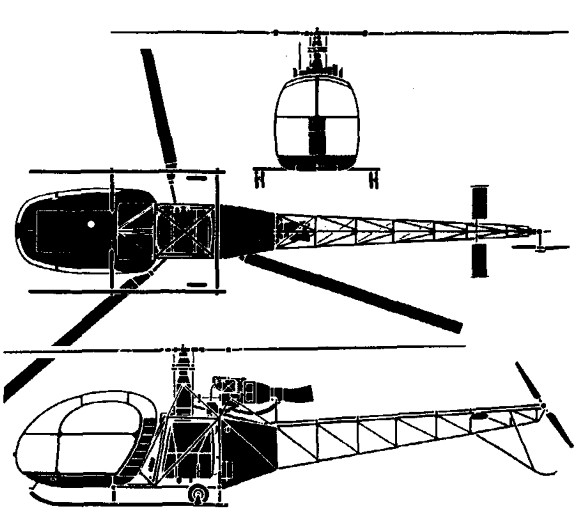
difficulties.
About two years ago, both IAI and Tadiran, the manufacturer of the Mastiff mini-RPV, tendered for the development of a next-generation mini-RPV for the Israeli Defence Forces. Since then, the two companies have formed a joint venture company to manufacture the current equipment and development of the next-generation RPVs.
They are understood to be looking at different payloads, including FLIR, communications relay equipment, laser target designation, and a range of electronic warfare equipment including ECM and decoy packages. Changes to the data link are also possible, together with increased payload an ability to fly at higher altitudes.

- Bedek Aviation Division

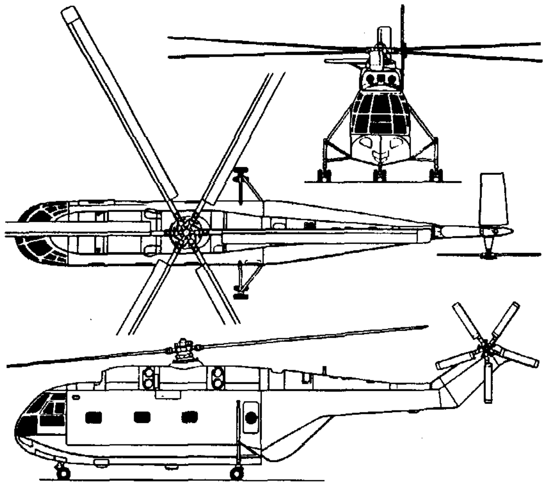
Bedek Aviation Division, the oldest part of IAI, was founded 30 year ago with 180 people.
'Bedek', a biblical word meaning 'restoration', was the original name of IAI. Today, the company employs 4,000 people and generates annual sales of $ 200 million.
This division does all the major overhauls and maintenance on almost every thinkable airplane. Regular customers are Lockheed C-130 Herculeses and Dakotas. While we were visiting Bedek, an Ecuadorian Boeing 707 was undergoing a major overhaul, a job that takes 42 days, in which the paint, the engines and the cockpit systems etc. are stripped.
It is interesting to know that Israel is the only country, beside the United States, that is permitted to convert passenger Boeing 707 aircraft to cargo aircraft.
Customers of the Bedek Division are small airlines which do not have the facilities for maintenance and overhaul. Transavia used to be a customer and even KLM had a few planes maintained here; MOAF, an Israeli charter company has its maintenance for 707's at Bedek. Most of the customers however, are South American carriers. Bedek is, of course, not only engaged in civil aircraft, but also does the major overhauls and heavy maintenance for the Israeli Air Force.
The F-4E Phantom has its slats, wings and centerwings replaced at the Division.
In all probability the J-79 engines of the Phantom will be superseded by Pratt & Whitney's PW 1120 powerplants. Other IDF/AF aircraft, like the Skyhawk, undergo a complete overhaul. The painting of aircraft takes place in the painting shop, the biggest aircraft that can be painted here is a Boeing 737. The painting of a 707 is done in the hangar.
A substantial job for Bedek is the remanufacturing of the about 80 Potez-Air Fouga Magister jettrainers. These trainers, which were built in the sixties under licence by Bedek Aviation, serve at Hatzerim Air Force Base. The Israeli government was looking for a replacement of the twenty year old Fougas, but with the remanufacturing a more economic solution was found (a new one would cost $ 7 million). The modernization mainly comprises the renewal of the French cockpit and electronics by American equipment, a new hydraulic system, a new skin, and a more powerful Marboré engine, supplied by Bet Shemesh.
The total costs per aircraft are $ 1.25 million, and this "new" aircraft, then called Amit, will fly another twenty years, according to IAI.
Foreign customers can, of course, have their old Fouga Magisters renewed by Bedek as well.

- The Engine Overhaul Shop

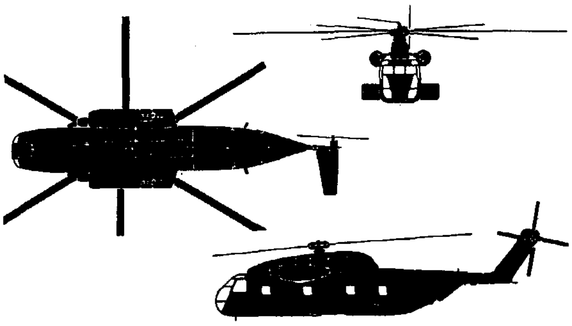
Bedek has, beside the aircraft division, comprehensive maintenance and overhaul facilities for civil and military engines.
This part of Bedek Aviation Division takes care of the cleaning and inspection of the stripped engines and repairs will be done if necessary. Bedek can handle some hundred different types of engines. In the large overhaul shop there were, for example, the Pratt & Whitney J-52 of the Skyhawk, F-100 engines of the F-15 and F-16 aircraft and Lycoming T-53 helicopter engines.
The Kfir, which is derived from the Mirage 5, has not the Atar 9C engine of the Mirage, but like the Phantom a General Electric J-79 engine. This J-79 engine is almost completely manufactured in Israel, only the casing and some accessories of the engine are made in the United States. The Israeli built J-79 powerplant, for that matter, is called J-1-E.
As mentioned before the Phantom is liked to be re-engined with PW-1120 engines and, in the future, will have the same powerplant as the Lavi combat aircraft.
Bedek has the disposal of six test cells for civil and military engines. We visited test cell-G which is big enough for the JT-9D powerplant of the Boeing 747 and 767. Other civil engines tested here are: JT-3D, -4A engines of Boeing 707 and JT-8D of 727 and 737 aircraft.
In this cell also the F-100, J-79 and J-52 military engines are tested. A new testbench is being built for, among others, the PW-1120 engine.



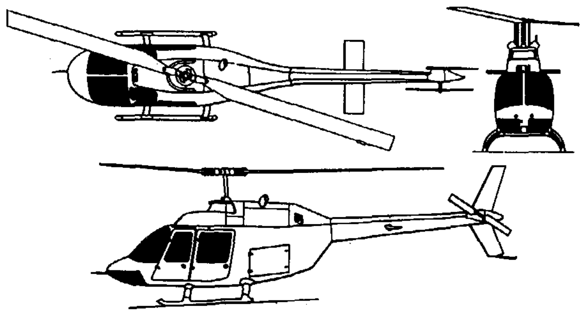
Aerospatiale SA 318 'Alouette II'



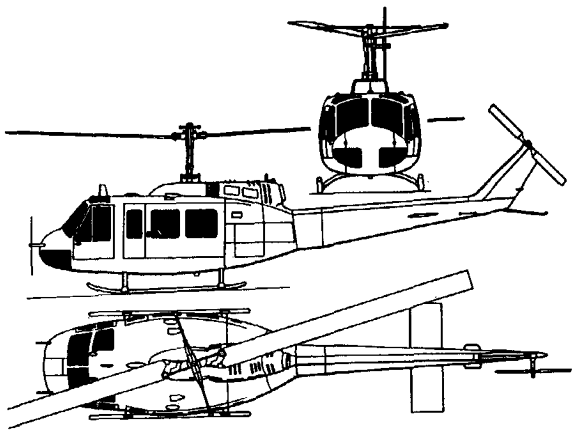
Aerospatiale SA 321 'Super Frelon'



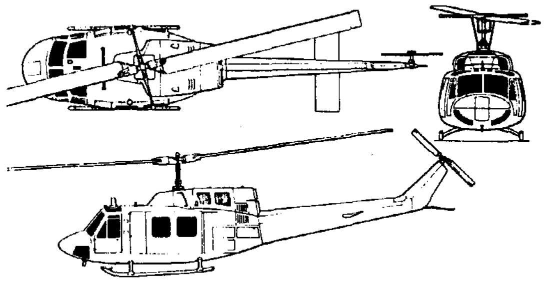
Sikorsky S-65 'Sea Stallion'



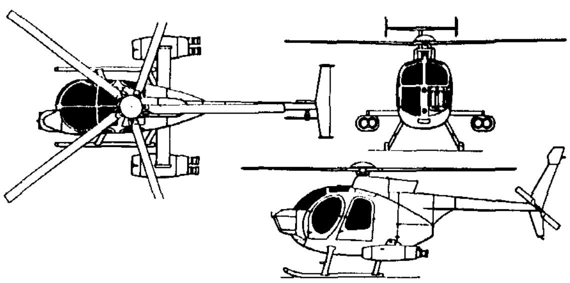
Bell 206 'Jet Ranger'



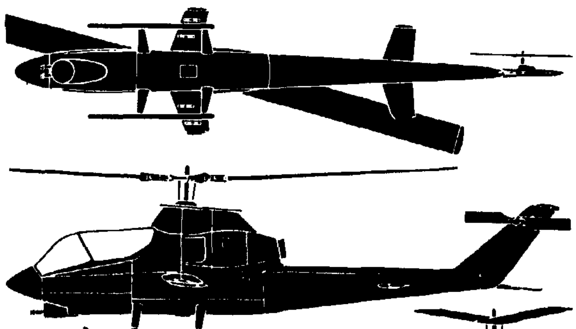
Bell 205 'Huey'



Bell 212 'Twin Two-Twelve'



Hughes 500 MD 'Defender'



Bell 209 'HueyCobra'

MATA - Helicopters

MATA HELICOPTERS
(When will the Israelis build their own helicopter?)

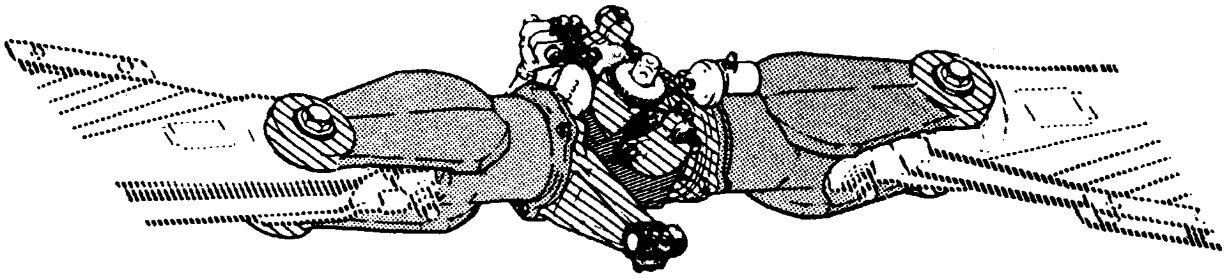
Introduction
Mata stands for Masok Taasiva Avirit, hebrew for "Helicopter Aviation Industries".
The history of Mata is closely linked to that of IAI. 20 To 25 years ago the Israelis started repairing and maintaining aircraft for the Air Force and El Al. "The embryo of engineering capability was formed by the knowledge gained through licence-building, later manufacturing, of the Fouga Magister, a French jet-trainer", says Mr. Kiczales, marketing manager at Mata. "In a hard process lasting more than 10 years, they then learned to design and manufacture their own airplanes up to the Astra, a modern business-jet, and the Lavi, Israel's fighter for the nineties."
Twelve years ago, in 1972, activities in the field of helicopters, such as repairing and maintaining rotorblades, gearboxes and airframes, started. Until 7 years ago about 10 people, among which 2 engineers, worked in a small shop, situated near the IAI complex at Lod, Ben Gurion Airport. Nowadays 350, all Israeli people, including 22 engineers, work in a much larger interim factory (hired) near Jerusalem Airport in Atarot, a former kibbutz (1920-1948), a few kilometers north of the capital. Now Mata also offers helicopter upgrading services and installation of weapons and other special-mission systems.
The firm is a Bell, FAA and Hughes approved service-centre and has an agreement with Sikorsky, which allows it to draw on the US company's blade-repair technology.
Still growing, they plan to move in september 1984 to their own completely new buildings nearby.

Activities today
"The helicopter structure is more complicated than that of a fixed-wing aircraft. Many parts are of primary importance and if anything should go wrong, a helicopter will make a crash-landing like a stone; landing by autorotation is very much restricted by time and the pilot's skill", according to Mr. Kiczales. So special attention is paid to the maintenance of vital components.
As stated earlier, the firm's activities include overhaul of helicopters and repair and maintenance of helicopter-airframes, -blades and -gearboxes/ shafts for the Israel Defence Forces and civil operators all over the world. This means Mata handles the Aérospatiale Alouette II and Super Frelon, Bell's 205, Twin Two-Twelve, 209 Huey Cobra and 206 Jetranger, Sikorsky's S-65 and the Hughes Defender.

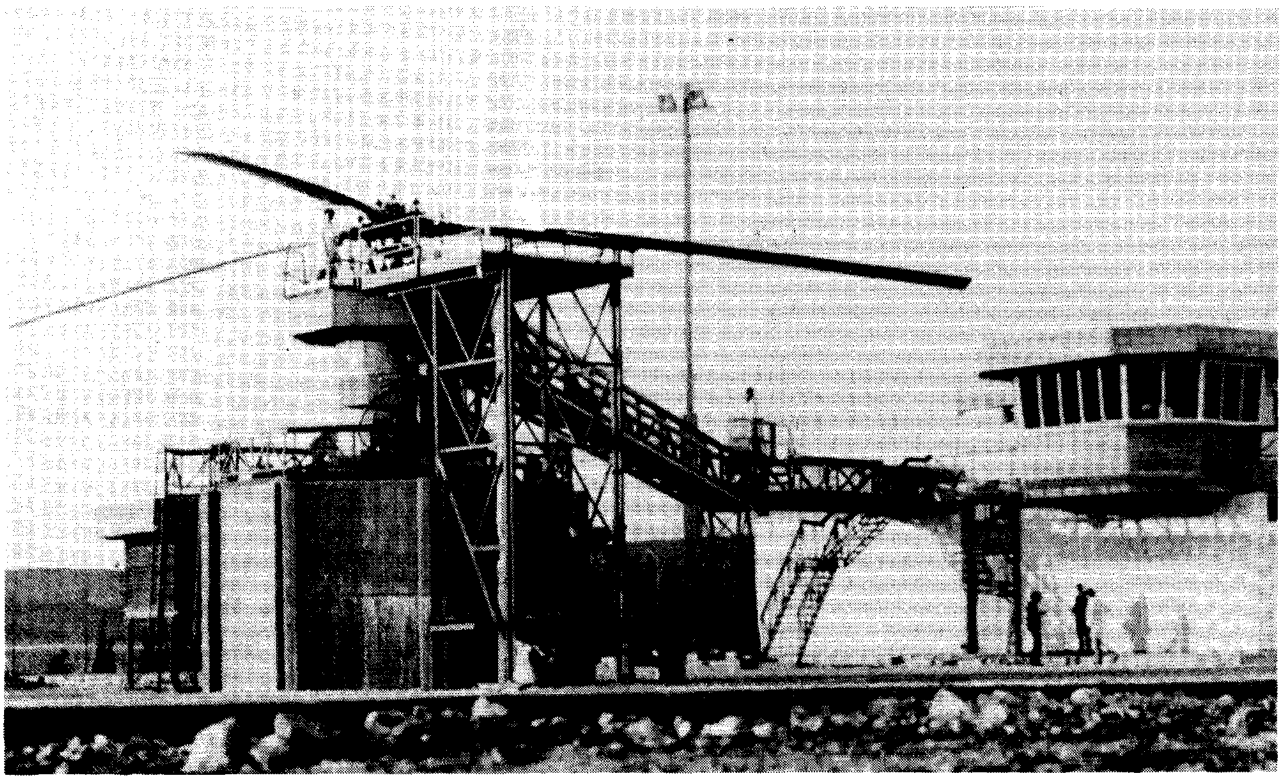
Airframes
Mata inspects helicopters for little cracks, especially in reinforced regions and regions where heavy stresses occur, like junctions and the nod in tail-booms. Together with Bell Helicopters they do rerearch into the causes of breakdown of structures. Though they repair under own responsibility, Bell has to give permission for small improvements.

Blades
In general, a rotorblade consists of a main spar (aluminium, titanium) forming a box-like D-section together with the glass-fibre leading edge, whereas the trailing edge is often made out of a honeycomb panel; the blade skin again is made of glass-fibre (state-of-the-art technology). The occuring stresses are cuased by centrifugal forces, weight, airloading and vibration (fatigue loading 300-400 rpm). A special problem is caused by mechanical erosion of the blades through sand and dust, typical for the battlefield in the Middle-East, where helicopters often have to fly low above the deserts.
If no protection would be used, the leading edge of main- as well as tailrotorblades would become as sharp as razorblades after 15 hours of flight. So, to prevent the rotorblade from losing its aerodynamic shape, they use a polyurethan strip or spray to protect the leading edge. For this purpose they also dispose of a testing facility, working with microparticles to simulate the dust and sand during flight.
Testing for internal separation of the honeycomb, caused by corrosion, is done with a hammer and experienced ears, a rather primitive, though satisfactory method.
The high fatigue-load restricts the lifetime of all vital parts, like the rotorblades: they are guaranteed for 2000 to 2500 hours, depending on the type of helicopter. After that record they are useless, even if they appear to be in a perfect state. Another example is the yoke of the Bell-helicopters: the mainrotorhead has a lifetime of about 10 years, while the metallic/composite straps, carrying the axial tension between rotorblade and hub, officially last for 1200 hours.
Repair creates inbalances, which will cause heavy vibrations in flight. To reach static balance, they attach small counterweights in the tip. Mata disposes of a static balancing system for various angles of attack. They also have to reckon with external i.e. aerodynamic inbalance.
Mata handles both Sikorsky and Bell rotorblades. The Sikorsky blades consist of several so-called pockets, while the Bell rotorblades are made out of one piece. The former have the advantage that a cracked part can be replaced by a new one, which is cheaper and easier than repair, but they have the disadvantage that balancing takes a lot of time. The Bell blades have to be repaired or completely renewed but need less time for balancing.

Gearboxes/Shafts
Gearboxes are needed to reduce the engine output of about 5000 rpm to the rotorspeed of about 300 rpm.
Mata disposes of a complete workshop to maintain gearboxes. They are disassembled and each seperate part undergoes a non-destructive test (NDT). After reassembling the tested or new components the entire gearbox is back at 'zero hours'. Then all gearboxes are tested for about 15 hours under loadconditions, in which the rotor is simulated by a hydraulic brake. During these tests they measure temperatures and vibrations. Afterwards the oil is checked for the amount of small metal parts. The testbench uses a 'close-loop re-energy system'. For this testbench Mata is developing at this moment its own control- and remote sensingroom.



Bell main rotor hub

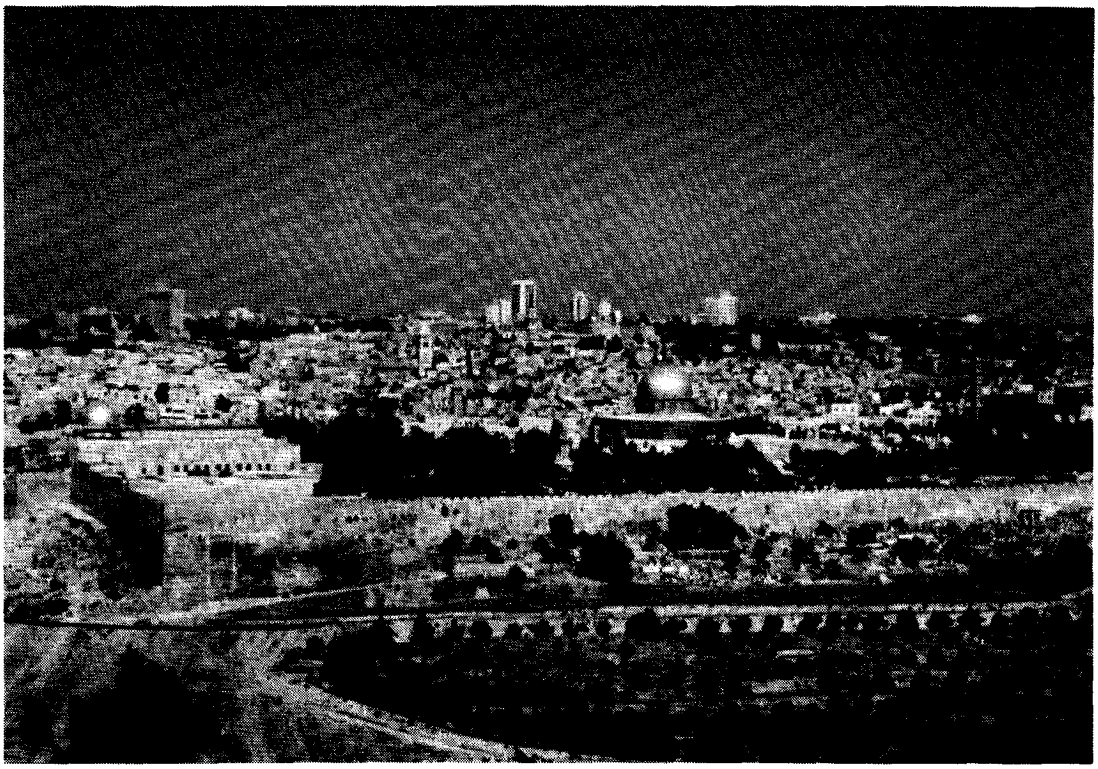


Mata's dynamic balancing tower

Concerning the shafts, Mata does corrosion research with the magnaflux-system (NDT), surface treatment (reprotectioning) and shaftbalancing, with an accuracy of a few hundredths of a millimeter.

To achieve greater accuracy in testing the rotorblades and to examine the dynamic inbalance, Mata bought a dynamic balancing tower, which is operational since 2 years. Before that time they had to test the rotorblades on the helicopter itself. The tower is driven by a 2700 kW electric engine, which operates with a maximum of 500 rpm during 3 minutes. Computer capability is added to indicate all kinds of aerodynamic forces and the precise location of the inbalance.
The tower is equipped with one Sikorsky masterblade attached to a universal 3-blade rotorhead, thus allowing 2 blades to be tested or simultaneously. This whirl-tower also contains an alarmsystem, registering main spar cracks and blade-root-fixing-imperfections.

The future
In september 1984 Mata plans to move to a brand new facility, about 2 km from the old location. In this area they have built a huge hangar, which gives place to 5 to 6 large helicopters. Here they will undertake the major inspection and overhaul of the big heavy-lift helicopters. Also a new ministry-building and some shop-capability is added. The present building will house the mechanical erosion section.
The new facility has to grow to give work to 600 people. Parallel they are slowly developing an increasing engineering capability. As Mr. Kiczales said: "We will learn what a helicopter is and, though it has been and will be a long 'Via Dolorosa', Israel wants to build (or at least participate in) its own helicopter for military purpose."



View of Jerusalem

NON TECH

NONTECH

As a matter of course there was more than a mere technological program.
Israel, however small it may be, is ample provided with beautiful sights, picturesque towns and historic places.
Fortunately, the Technion regarded it as a must to show us as many of these as possible; a bus, driver and guide were at our disposal. This guide was even so enthousiastic about his country, that he did not want us to go to bed when we arrived at the Technion dormitories at 7.00 a.m., but took us to Haifa for an early sight-seeing.
Haifa (± 400,000 inhab.), situated on a mediterranean bay and terraced against the green Mount Carmel, is claimed to be the most beautiful city of Israel. Unfortunately this bay has not been given a glamorous boulevard. More important for the country was a big seaharbour; especially the lowest of the three city-terraces therefore has all the charmes and characteristics of a port city. Higher up Mount Carmel is the shopping district and all kinds of evening life can be found here (the Hadar-district). On the third and highest level mainly residential quarters are located with a beautiful bellevue on city, port and bay.
During this trip we paid visits to the Bahai-temple, with its golden dome; the Carmelite monastery, the principal monastery for this catholic order and finally the Maritime Museum.
Two days later we went to see Rosh Hanikra and Acco. Rosh Hanikra, at the most northern point of the Israeli coast, has steep chalk-cliffs with marvellous caverns. It strongly contrasts with the Dutch-like beaches and dunes 100 metres southward. Acco or Acre, ±20 km north of Haifa, is since the Phoenician era a major harbour. It was an abutment for the crusaders and has a lot of historical buildings, forts and a beautiful mosque.
On the first sabbath a trip through North-East Galilee was made. A facultative boat-tour on the Lake of Galilee, from Tiberias to Capernaum, the Jordan river and the famous, but chaotic city of Nazareth were on the program. Of course, a great number of biblical places and events were brought to our attention.
Salient were the many huge melons that were sold along the roads, and all the Arab families working on their small fields.
Sunday afternoon implied for most of the participants: Haifa-beach. Thursday afternoon, our residence at that time was the Jerusalem College of Technology, the Jerusalem neighbourhood was surveyed. We visited Bethlehem. After viewing the church, dedicated to Jezus' birth, we were free to explore this village. Some of us got acquainted with the local, symbolic Sabra-fruit; on the outside it is tough and thorny, but inside it is really soft and sweet.
Friday we departed for the youth hostel in Ein Gedi at the Dead Sea shore (400 m. below sea level!). When we reached the Dead Sea Valley, we had lunch in the oasis Jericho.
Later that day we took a walk in the nature park just behind the youth hostel. We saw some antelopes as well as a few cascades.
Early next morning we conquered the historical Massada Mountain. Here one can find the ruines of two palaces of King Herod. On this mountain the Jews fought till death during a Roman besiege (73 A.C.). A fantastic view was the reward, when Massada, with the help of lots of fresh water, was climbed. Back in Ein Gedi we floated for an hour in the awfully salt Dead Sea and then returned to Jerusalem.
Sunday morning a visit was paid to the Governmental building, the Knesset. There were no meetings, because Parliament was on summer leave. After a general introduction and conducted tour through the building, a lecture was delivered to our group by one of the members of the House Committee. Israeli politics and Israel's bad economical situation were extensively discussed.
Sunday afternoon and monday were completely dedicated to the exploration of Jerusalem.
Jerusalem is one of the most fascinating cities in the world. The old city of Jerusalem, surrounded by enormous city walls, is devided into four quarters: a Jewish, a Moslem, an Armenian and a Christian quarter. These are composed of a tangle of narrow alleys, coloured by numerous tiny shops and bazars.
Being a major centre of three world religions, the old city contains innumerable historical sites; including the holiest place for the Jews, the Wailing Wall; the third holiest place for the Moslems, the El-Aksa Mosque, with its silver dome; and for the Christians the Holy Grave Church and, just outside the city walls, Golgotha, where Jesus was crusified. As a matter of course, all these were visited. Also the Temple Square and the Dome of the Rock, where Mohammed ascended, were on the program as well as a city wall promenade and a Via Dolorosa promenade.
In the new city Yad VaShem is located, an impressing memorial park for the 6 million Jews killed in World War II.
All buildings in Jerusalem are built of Jerusalem stone, hacked from the rocks surrounding the city.
A beautiful overall view of Jerusalem is seen from the Mount of Olives (see picture).
Also situated in the new city is Ben Yehuda Street. This is one of the very few streets in Jerusalem, where many bars, pavement cafés and big beers are found; quite interesting indeed.
The last day we went off in the direction of Tel Aviv. The diaspora Museum, dealing with the Jewish persecutions and dispersion all over the world, was visited and in the afternoon, after a short visit to old Jaffa, the beach of modern and western Tel Aviv was explored.
Late that night, early next morning actually, we took off for 'frog-country'.

CONCLUDING REMARKS

CONCLUDING REMARKS

Although acknowledging that the two very crowded weeks spent in Israel were not sufficient to get a total overall view, we venture to make some remarks on the impression we obtained.

- To gain high efficiency in research there is a very close relationship between the Technion and the Israeli industry.
  A majority of the graduate students is involved in projects of direct practical application and value.

- The 'density' of academically trained people is very high in Israel.

- The biggest single driving force behind Israel's aerospace industry is the country's need to maintain effective defences in an unstable and largely hostile region.

- In the military sphere the upgraded aircraft is becoming a formidable competitor to the increasingly expensive new ones. Meanwhile, as a result of battlefield experience, maintainability and reliability are stressed.

- Increasing self-sufficiency in the supply of military aircraft and all their systems is considered to be of the utmost importance.

- The young Israeli aerospace and equipment industry today makes products which can compare favourably in price and quality with the best of the world; increasing high-tech export figures are registered.

- In general, R&D closely follows work being done in the US, where this is relevant to tactical warfare. In some areas, however, Israel has a lead, e.g. in the development of RPVs.

- The Lavi project seems to be regarded as a national effort.

- Israel has only recently embarked upon a modest space program, but has some ambitious plans, including the development of a communications satellite in cooperation with Fairchild of the USA.

Looking back, we believe that our study tour to Israel gave us a clear view of the Israeli aerospace industry as well as the Israeli way of life. This made our tour not only very instructive, but also most enjoyable.
We hope that future tours will have the same success.

Delft, November 1984 — Jos van den Akker

Patrick Liesker