DEVELOPMENT APPROACH OF THE HERON MEDIUM ALTITUDE LONG ENDURANCE UAV

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1. ABSTRACT

This paper outlines the development approach and the design cycle of the new generation advanced technology UAV the **HERON**. The basic requirements for the **HERON** UAV were driven from an intensive civil and military market research study.

This research indicated that there is a firm requirement for a platform capable of performing long endurance missions of more than 24 hours, at a medium altitude of 25-30 kft, with the ability to carry different payloads of large sensors and antenna. Consequently, a design cycle was initiated, incorporating technology, and configuration research, in order to determine the most suitable and flexible configuration, and to meet the various mission requirements .

The technologies which were incorporated into the design were:

- Advanced aerodynamics, incorporating a high aspect ratio, NLF, high-lift wing with two-element sections.
- An all-composite light-weight structure, with Integral wing fuel tank (wet-wing).
- Retractable landing gear with wheel brakes
- A civil certified 4 stroke / 4 cylinder water-cooled engine, with variable pitch propeller
- Integrated avionics, flight control and communication systems based on the **HUNTER** JT UAV technology.

Several configurations were evaluated during the preliminary stage, the main tradeoffs included:

- Engine location
- High or low wing
- Conventional or twin boom configuration
- Landing gear concept and location

The twin-boom, rear engine (pusher) configuration, was selected because it offered high mission flexibility in terms of payload installation (center of gravity and clean field of view for the sensors), and future potential growth. Following the above definition for the **HERON** UAV ,a short term program was initiated by an integrated multi-disciplinary team (task-force).

The first flight of the **HERON** took place within 10 months of program launch.

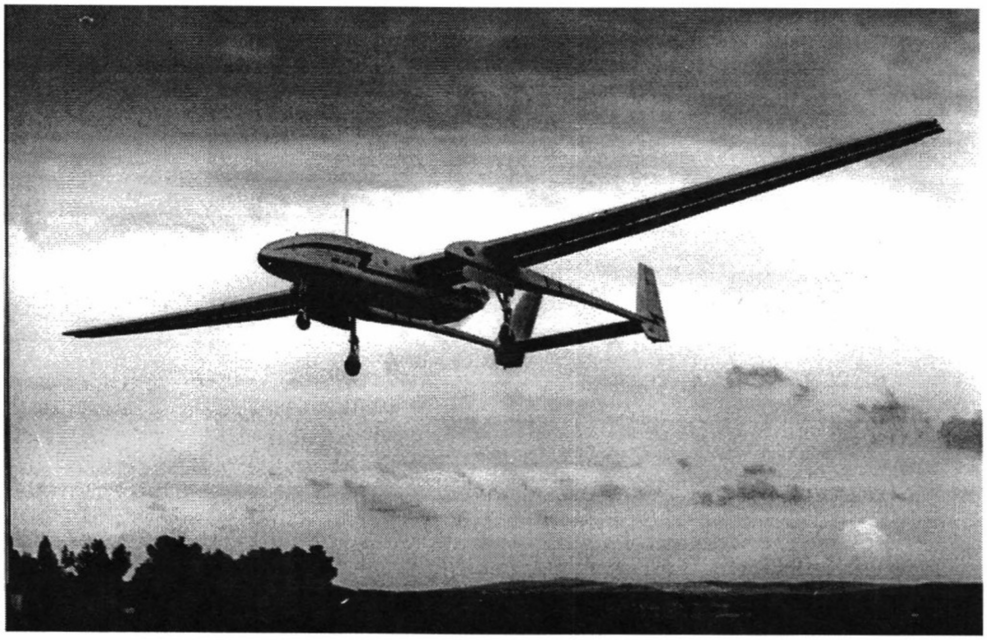


FIGURE-1 : FIRST FLIGHT OF HERON UAV

2. INTRODUCTION

The extensive and successful use of UAVs in military missions in the last decade, laid the groundwork for expanding the use of UAVs for more diversified tactical and strategic missions, as well as for civil missions.
The military missions include:

- Real time image intelligence (**IMINT**)
- Electronic intelligence
- Electronic warfare
- Airborne early warning

Israel Aircraft Industries (**IAI**) has been involved in the development of **UAVs** since 1973 beginning with the **SCOUT** UAV, which was developed for the Israeli Defense Forces (IDF), the **PIONEER** UAV for the US-NAVY, providing excellent results during the Desert Storm operation, the **HUNTER** JT UAV for the US-ARMY forces, the **SEARCHER** UAV for the IDF, and other variants for other customers .
A total of 50,000 flying hours have been logged by **IAI**-UAVs , in tactical surveillance missions.
The **IAI**-UAVs family evolution is presented in Figures 2.1, 2.2 , showing: production year, take-off and payload weights versus altitude and endurance performance.

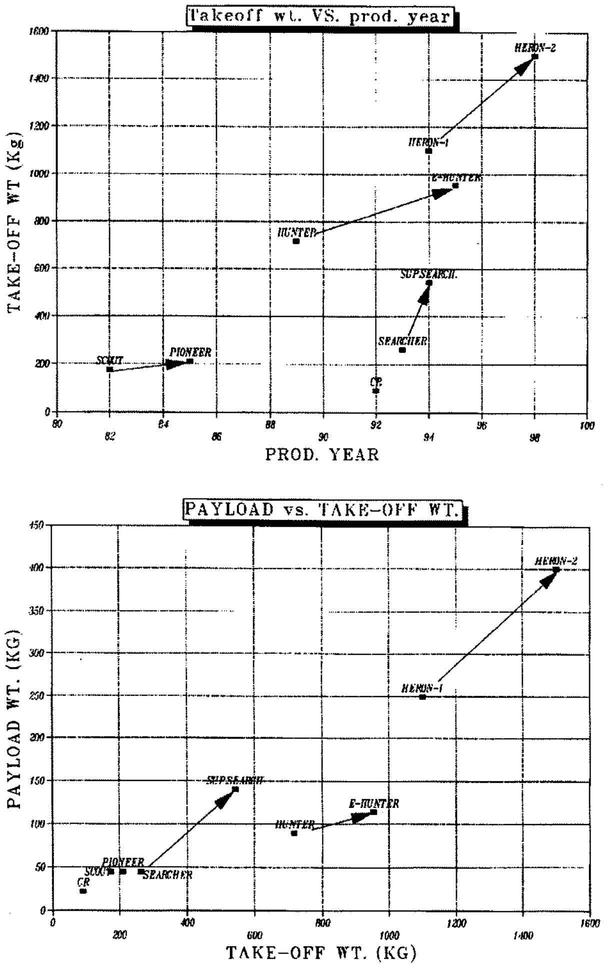


FIGURE-2.1: IAI UAV FAMILY EVOLUTION

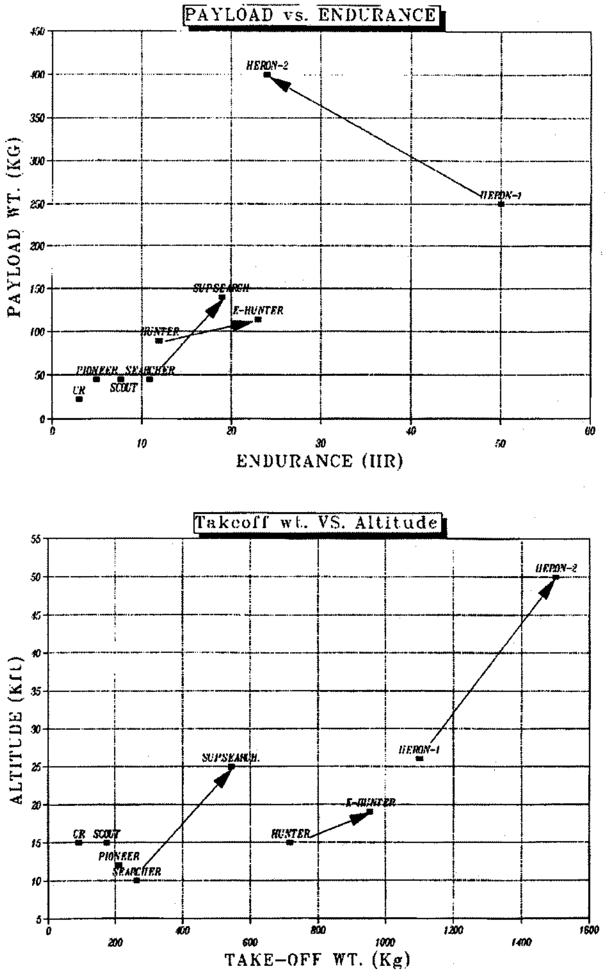


FIGURE-2.2: IAI UAV FAMILY EVOLUTION

3. THE DESIGN APPROACH

The definition of the **HERON** UAV system was based on a trade-off design cycle process.
The design process included:

- Definition of the missions requirements
- Outlining the technologies to be used in the system design
- Study of configuration options
- Predicting the performance and classifying the characteristics of the chosen solution.

This process was necessary in order to provide an affordable and cost effective UAV system which would meet most of the mission requirements.
Such a process cycle is described in Figure 3.
Outlines of the elements of the design cycle are presented in the following sections.

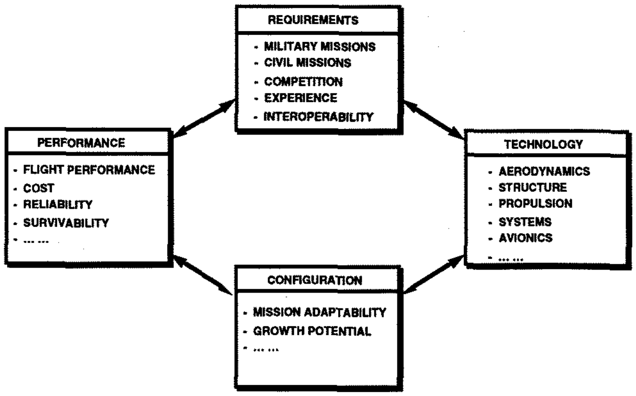


FIGURE- 3: FEASIBILITY & DEFINITION DESIGN CYCLE

3.1 REQUIREMENTS

An intensive military and civil market research was initiated one year prior to program launch.
A market research study was undertaken in order to define three primary aspects:

- Definition of the most appropriate potential missions to perform with the UAV, the majority of which are stand-off support missions, performed with civil or military manned aircraft which have been modified to perform those missions.
- Definition of the suitable payloads to perform those missions. Most of these payloads are off-the-shelf utilizing modern technology. Nevertheless, they require slight modifications for installation on a UAV.
- Definition of the mission profile and performance requirements for those missions.

3.1.1 POTENTIAL MISSIONS

The potential military applications to perform with a UAV were categorized as follows:

- Electronic and communication intelligence missions
- **Communication Relay** missions - for other UAVs , aircraft's, and ground forces
- **Maritime Surveillance** and target acquisition missions
- Wide area all weather reconnaissance
- Electronic warfare
- Airborne early warning

The potential civil applications were defined as follows:

- **Communication Relay** ("low cost" satellite)
  - Cellular phone
  - Direct broadcast television
- **Environmental surveillance**
  - Maritime pollution
  - Pipeline inspection & monitoring
  - Disaster damage assessment
- **Forest Service**
  Area surveillance of forest for fire detection
- **Border Patrol**
  - Border patrols, survey & control
  - Counter narcotics & illegal alien surveillance
- **Weather Services**
  - Storm observation
  - Tornado "chaser"
- **Traffic control** and police surveillance

3.1.2 PAYLOAD CHARACTERISTICS

The appropriate payloads for the selected missions where defined in collaboration with the payloads manufacturers. Most of the payloads where off-the-shelf systems using advanced light weight technologies and were intended to replace, old technology systems installed on missionized manned aircraft. Those new payload systems required several adaptations for installation on a UAV, primarily in the data processing and the down link communication subsystem.

A summary of the physical characteristics of those payloads are:

- **100-250 kg** weight
- **500-800 liter** internal volume
- Large antenna and sensor external installation capability, with **360 deg**. clean field of view
- **5-10 kw** electrical power extraction capability

3.1.3 MISSIONS PERFORMANCE AND REQUIREMENT

Most of the potential missions are stand-off low speed at a medium altitude and require on station long endurance. The performance requirements can be summarized as follows:

- On station endurance time of more than **24 hours**
- Medium altitude mission flight between **15 to 30 kft**
- High mission reliability:
  - Mean time between critical failure **(MTBCF)** of more than **100 hr**
  - Mean time between loss **(MTBL)** of more than **3000 hr**
- Low operational cost

3.1.4 **HERON** DESIGN SPECIFICATIONS

The design specifications for the **HERON** were defined as follows:

- Max. payload weight - **250 kg**
- Payload volume - **800 liter**
- Performance:
  - Service ceiling **30 kft**
  - Endurance **48 hrs** with **100 kg** payload at **15 kft** altitude
  - Short take-off and landing distances - less than **500 m**
  - Stall speed of **50 kts**
  - Max. speed of **100 kts**
- **MTBL** and **MTBCF** - **5000** and **250 hrs** respectively

3.2 TECHNOLOGIES

An analysis of the potential technologies to implement on the design, were initiated in order to cope with the design specifications. The technologies which have been applied to the design were in the following domains:

- **Aerodynamics**
  - High Aspect Ratio, high-lift, Natural Laminar Flow (NLF) wing, advanced two-element sections **SA-21** (1)(2)
  - High values of endurance factor at high lift coefficients required for long endurance flight.
  - High max. lift and high values of drag with large flap deflections (up to 60°) for enhancement of glide performance on landing (1)
  - High wing thickness ratio for structural rigidity and increased volume for internal fuel.

The slotted airfoil **SA-21** (Figure-13) was a basis for the development of the **HERON** wing.

- **Structure**
  - Light weight using all composite materials of sandwich construction graphic facing with polystyrene or honey-comb core, reinforced with unidirectional spars.
  - Manual wet lay-up with vacuum bag compaction, through a curing process.
  - Integral fuel tank inside the composite sandwich structure of the wing and the fuselage, using a sealing process which was specially developed for this purpose.

- **Propulsion**
  - Mature, off-the shelf reliable engine, with civil certification.
  - Turbocharged engine for good performance at medium altitudes.
  - Variable pitch propeller, for good performance at all flight envelope (take-off, endurance, and high speed).
  - Water cooled engine .

The **ROTAX-914** engine, was chosen for the configuration.

- **Systems**
  - Retractable landing gear (L.G.).
  - Main L.G. brakes, and electrical power nose landing gear steering.
  - Hydraulic pack system dedicated to landing gear retraction and extraction and for the wheel brakes.

- **Avionics**
  - An avionics system based on the **HUNTER JT UAV** system, integrated with the communication, the flight control, and the electrical systems.
  - All the UAV avionics system, installed on a detachable tray- for good maintainability.

3.3 CONFIGURATION

A configuration trade-off study was performed in order to define and choose the most appropriate solution for the design of the **HERON**.

After a preliminary concept definition of the different configurations, a process of evaluation and categorization were performed, according to the following criteria:

- **Payload installation:**
  - Simplicity and flexibility to install various payloads
  - Center of gravity (C.G.) location and travel
- **Modularity & potential growth:**
  - Simplified manufacturing
  - Flexibility to changes
  - Modular production brakes
- **Structure weight**
- **Performance:**
  - Wetted area (aerodynamic drag & lift to drag ratio)
  - Lift to drag ratio (L/D)
- **Development risks:**
  - Simple aerodynamic configuration
  - IAI experience

Several of the main configurations that were studied are:

config. A: An AFT. fuselage pusher engine installation, with conventional V-tail (Figure- 4).

This configuration has two primary disadvantages, the first is the difficulty to balance the air-vehicle because of the relatively high weight of the engine, and the second is the large unused volume and wetted area of the aft. fuselage (high weight and drag penalty).

config. B: An AFT. fuselage pusher engine, with long propeller shaft installed in a single boom (Figure- 5).

The primary disadvantage of this configuration, is the development risk of the shaft.

config. C: A twin - boom AFT. fuselage pusher engine, with conventional H-tail (Figure- 6).

config. D: An AFT. fuselage pusher engine ("tower" config.), with single lower boom (Figure- 7)
Several disadvantages are related to this configuration, primarily the propeller diameter limitation, and the high vector of the thrust, which causes changes in pitching moment, during thrust variations.

config. E: A forward fuselage tractor engine installation (Figure- 8)

The primary disadvantage of this configuration is the slipstream and the wake of the propeller, causing high fuselage drag, and disturbances to the external payload sensors.

A qualitative comparison summary between the various configurations according to the above selection criteria, is presented in Table -A.
Based on the comparison results, the twin-boom pusher engine configuration (**Config.C**) was selected.

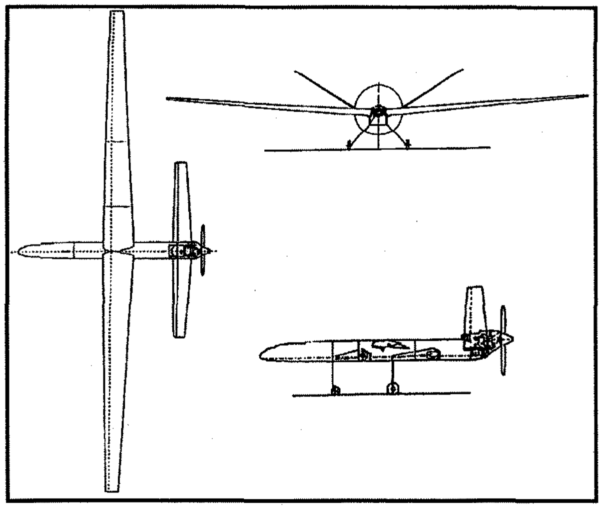


FIGURE- 4 : CONFIG. A - AFT. FUSELAGE ENGINE LOCATION-PUSHER

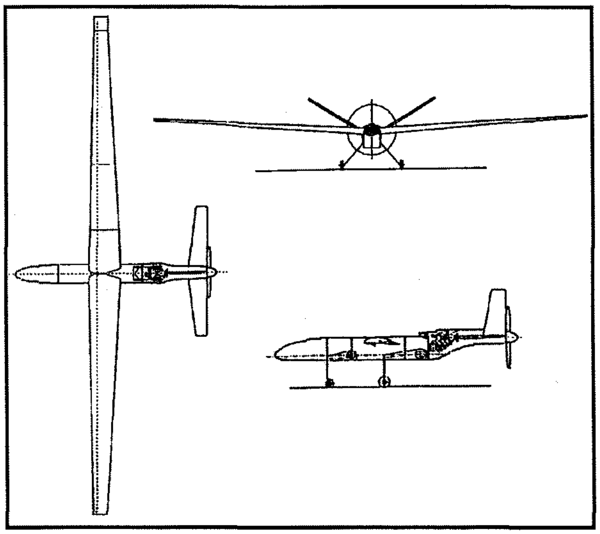


FIGURE- 5 : CONFIG. B - AFT FUSELAGE ENGINE LOCATION PROP. SHAFT-PUSHER

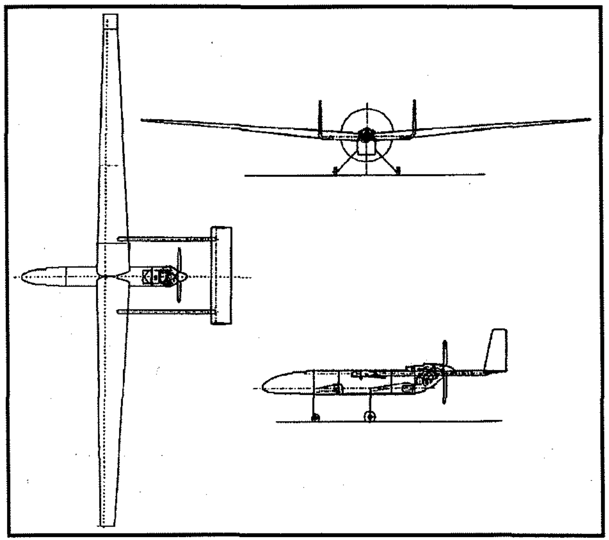


FIGURE- 6 : CONFIG.C - TWIN BOOM AFT. FUSELAGE ENGINE LOCATION PUSHER

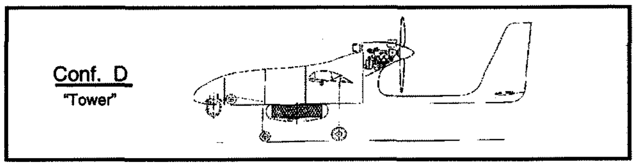


FIGURE- 7 : CONFIG. D - AFT. FUSELAGE "TOWER" ENGINE LOCATION - PUSHER

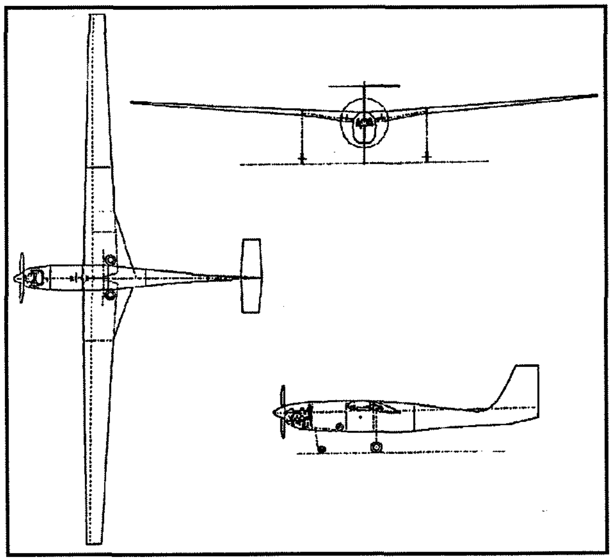


FIGURE- 8 : CONFIG. E - FWD. FUSELAGE ENGINE LOCATION-TRACTOR

TABLE-A: CONFIGURATION OPTIONS COMPARISON

	CONF. A	CONF. B	CONF. C	CONF. D	CONF. E
	AFT ENGINE	AFT ENGINE SHAFT	TWIN BOOM	"TOWER"	FRONT ENGINE
PAYLOAD INSTALLATION					
- FLEXIBILITY	-	-	+	+	-
- C.G.	-	+	+	+	+
MODULARITY					
- MANUFACTURING	+	+	+	-	+
- GROWTH POTENTIAL	-	+	+	-	-
WEIGHT	-	-	+	+	-
PERFORMANCE					
- WETTED AREA	-	+	+	+	+
- (L/D)	-	+	+	+	-
DEVELOPMENT RISKS	+	-	+	-	+

A second trade-off study was initiated, based on the chosen configuration, in order to choose the landing gear location and retraction concept. The following location options were evaluated: fuselage location, wing location, and boom location.
Table - B, compare the various locations, as a function of the selection criteria.

A tri-cycle landing gear concept which retracts into the booms, was chosen, primarily because it offers a clean fuselage belly, thus permitting the simple installation of external payload sensors.

Furthermore, the configuration concept of twin boom with main landing gear attached to them, offers a maximum modularity by separating the fuselage from the aerodynamic lifting surfaces,and the main landing gear, thus converting the fuselage to a "pod" installed on the air vehicle (A/V).

The chosen concept permits growth potential of all the systems installed in the fuselage, such as: engine, avionics, payload weight and volume, fuselage fuel tank, and other subsystems, without changing the basic aerodynamic and stability of the A/V (the fuselage "pod", can be attached to the wing in the required C.G. location, without effecting the stability margin of the A/V).

Based on the chosen configuration, and landing gear location, a detail design process was initiated, for the **HERON** UAV.

TABLE- B: LANDING GEAR LOCATION OPTIONS

	FUSEL.	WING	BOOMS
- INTERNAL FUSEL. VOLUME	-	+	+
- DRAG	+	+	-
- STRUCTURAL CONTINUITY	-	-	+
- MECHANICAL COMPLEXITY	-	+	+
- WING FUEL VOLUME	+	-	+
- INTERFERENCE WITH FLAP	+	-	+
- CLEAN FUSEL. BELLY	-	+	+

3.4 HERON CHARACTERISTICS

A three view and the general characteristics, of the final configuration of the **HERON** UAV, is presented in Figure-9, and Table C and D, respectively.

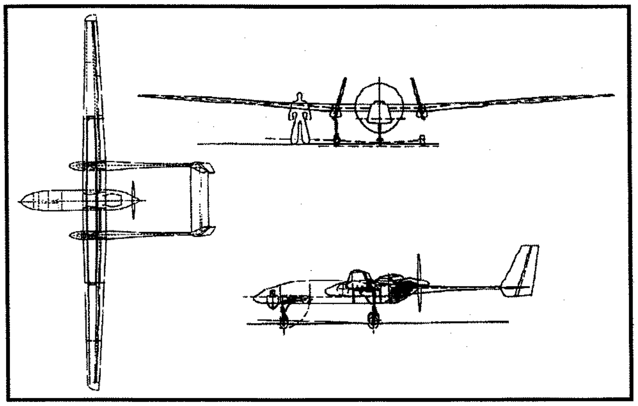


FIGURE-9: HERON GEOMETRICAL DEFINITION

TABLE- C: HERON GEOMETRY

TOTAL LENGTH	[m]	8.58
WING SPAN	[m]	16.6
TOTAL HEIGHT	[m]	2.3
WING AREA	$[m^2]$	13
ASPECT RATIO (AR)		21
FUSELAGE DIMENSIONS		
- LENGTH	[m]	4.88
- HEIGHT	[m]	0.7
- WIDTH	[m]	0.54/0.86
WING LOADING (W/S)	$[kg/m^2]$	82.7

TABLE- D: HERON SPECIFICATIONS - WEIGHTS & PROPULSION

NOMINAL TAKE OFF WEIGHT	[kg]	1100
MAX. USEFUL LOAD (FUEL & P/L)	[kg]	500
MAX. FUEL WEIGHT	[kg]	400
MAX. PAYLOAD WEIGHT	[kg]	250
BASIC EMPTY WEIGHT (BEW)	[kg]	600
PROPULSION		ROTAX 914
POWER @ S.L.S	[hp]	100/115
POWER LOADING (W/P)	[kg/hp]	10.8
PROPELLER DIAMETER	[m]	1.7
PROPELLER NO. OF BLADES		2

3.4.1 PAYLOAD INSTALLATION FEATURES

The key features of the **HERON**, concerning payloads installation, and integration, are as follows:

- Large internal payload volume, divided into two bays (fwd. nose bay, and main central bay). fuselage volume distribution and bays arrangement, are presented in Figure -10.
- A "Clean" fuselage belly, with large ground clearance (60 cm), for external payload sensors installation. The potential installations possibilities are presented in Figure -11.
- Retractable landing-gear, combined with high wing location, providing full, unobstructed 360 deg. field of view.
- Large center of gravity location margin, for various payload installations.
- High electrical power extraction capability for payloads.
- Low performance sensitivity due to external payload installation and power extraction.
- Superior maintenance and accessibility, to payloads and A/V systems. **HERON** accessibility scheme is presented in Figure- 12.

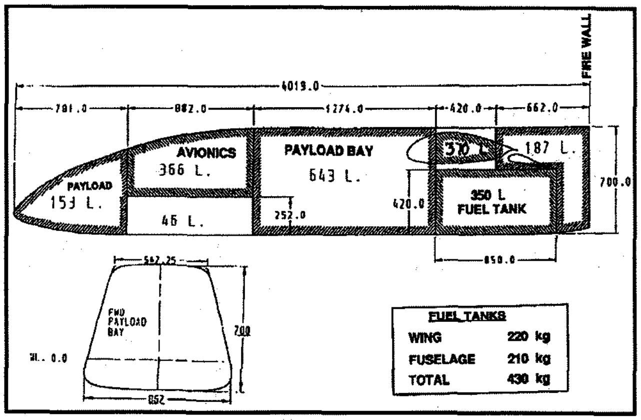


FIGURE-10: FUSELAGE VOLUME DISTRIBUTION AND BAYS ARRANGEMENT

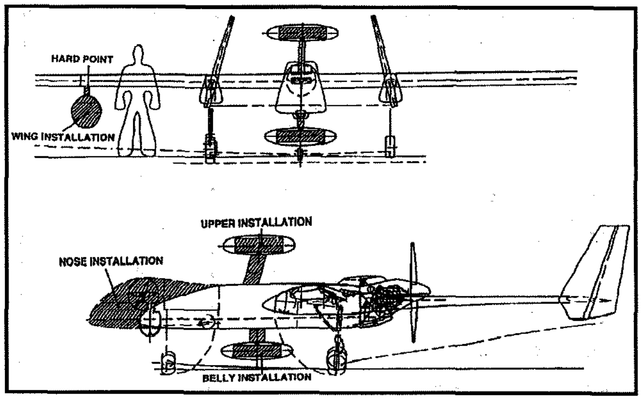


FIGURE-11: POTENTIAL EXTERNAL INSTALLATION OPTIONS

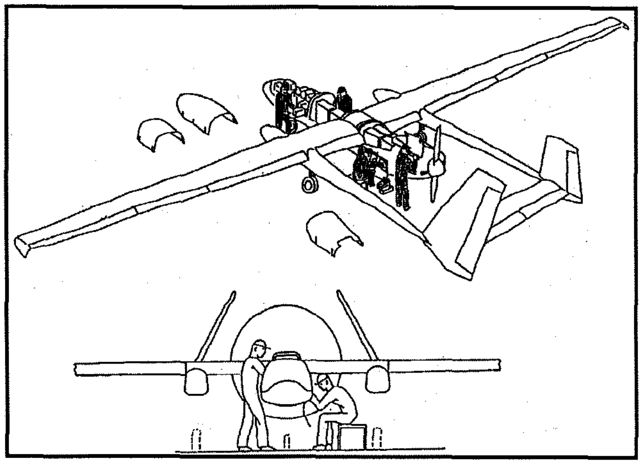


FIGURE-12: HERON ACCESSIBILITY CONCEPT

3.4.2 AERODYNAMICS AND FLIGHT CONTROL
The primary advanced element of the **HERON** aerodynamic configuration is the wing.
The high aspect ratio wing of (AR=21, and a 16.6 m span), is based on a unique slotted airfoil (constructed from two elements). The SA-21 airfoil (presented in Figure-13), was designed for high lift coefficients and high lift to drag ratio (endurance factor), at all flap deflections. The large travel of the flap, from -15 deg. to 60 deg., is used as a variable camber feature during the flight, and is controlled by the autonomous flight control system, with the following flight set-up:

- (-15 deg) flap setting for high speed cruise
- (0 deg) flap setting for optimum endurance
- (30 deg) flap setting for take-off
- (60 deg) flap setting for glide and landing

The **HERON** flight control system uses full redundancy of all the elements, including the control surfaces and electrical actuators as follows: four ailerons surfaces (two per wing side), four flaps surfaces (two per wing side), two elevators and rudders surfaces.

FIGURE- 13: SA-21 TWO ELEMENT, HIGH LIFT, NLF AIRFOIL

3.4.3 AIRFRAME AND STRUCTURAL CONCEPT
The **HERON** structure is made from all composite sandwich panels, the skin panels are made from carbon-fabric impregnated with epoxy resin and a core of either NOMEX honeycomb or ROHACELL foam. The panels are stiffened by embedded unidirectional carbon fibers, working as "beam" caps.

The fuselage structure is manufactured in a "boat" shape with a large base and trapezoidal cross section.
The lower part of the trapezoidal fuselage functions as the structural part, and the upper part is constructed from three large detachable covers, designed for easy access and maintenance of the A/V and payload systems.

The wing / booms structure is divided into three parts:

- The central wing part, used also as an integral fuel tank ("wet- wing")
- The two (2) outboard wing parts (LH & RH), constructed from full depth foam covered with graphite skins.
- The twin booms are attached to the central wing part, and serve as bays for the two main landing gear, and as a carry structure for the tails.

All the twelve (12) control surfaces - eight installed on the wing, and four on the tails-are made from full depth foam covered with carbon fabric skins.
Figure- 14, describes in a "blow- up " view, the structural parts, and the production brake of the **HERON**.
More details about the structural design and production are described in paragraph- 4.

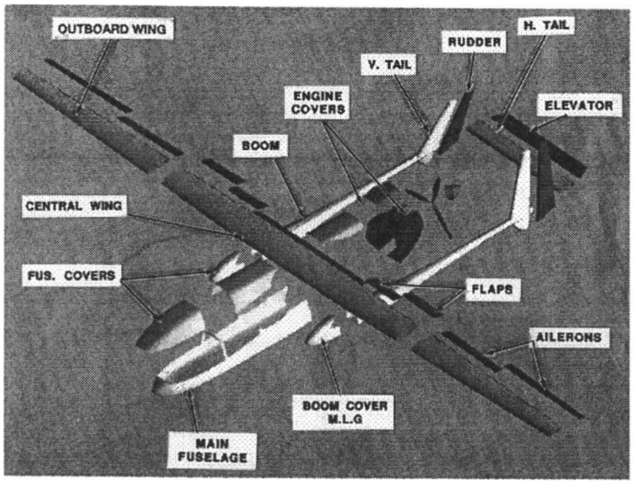


FIGURE- 14: STRUCTURE PRODUCTION BRAKE

3.4.4 SYSTEM INSTALLATION

All the main systems of the A/V are installed in two main bays of the fuselage. The avionics bay located above the nose landing gear, and the aft. service bay, located between the fuselage fuel tank and the engine fire- wall. The avionics, electrical, and the communication LRU's, are installed on a removable rack.
Figure- 15, presents the installation layout inside the fuselage.

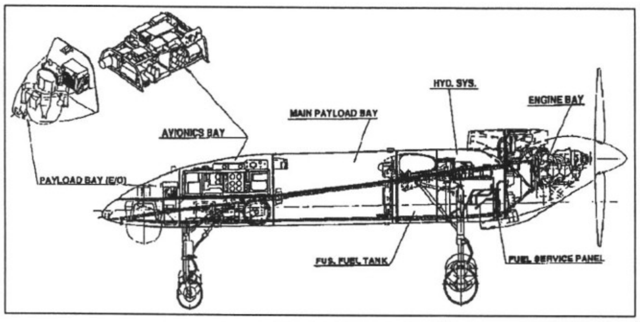


FIGURE- 15: FUSELAGE INSTALLATION LAYOUT

3.4.5 PROPULSION SYSTEM

The propulsion system is based on the mature, civil certified, ROTAX- 912 reciprocating engine, upgraded by installing a GARRETT single stage turbocharger, called **ROTAX- 914**.
The turbocharger enables keeping sea- level power up to 15 kft.
The engine is shock mounted on a frame supported on the A/V firewall.
The main characteristic of the propulsion system are:

- 4 stroke, 4 cylinders, liquid cooled
- Double ignition system
- Electrical starter
- Power:
  - Max. take-off & climb - **115 HP** (5 minutes)
  - Max. continuous - **100 HP** (up to 15,000 ft)
  - Two blades variable pitch propeller with **1.7 m** diameter (The pitch of the propeller is matched automatically to the flight regimes by the flight control system).
- Three heat exchangers (water- glycol, oil, and turbocharged air heat exchangers)

Figure- 16 present the installation of the propulsion system on the firewall.

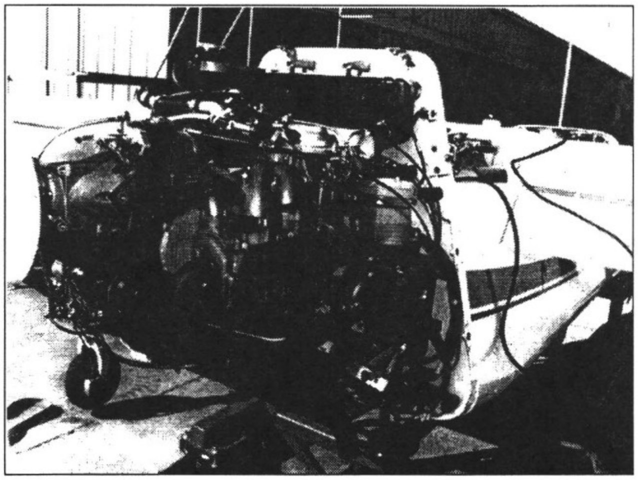


FIGURE- 16: PROPULSION SYSTEM INSTALLATION

3.4.6 LANDING GEAR SYSTEM

The landing gear system is a tricycle retractable configuration with single wheel on each gear.
The gears are actuated by a small hydraulic package system with pneumatic backup. The main gears are equipped with a single disc brake, actuated by the hydraulic system. Each gear bay is closed by a door, which operates mechanically by the gear motion.
The landing gear design was based on the following concepts:

- Simple machined parts
- Off-the shelf components (shock absorber, actuators, brakes, etc.)
- Minimum parts (same parts for LH & RH main gear)
- High reliability and simple maintainability

4. STRUCTURAL DESIGN AND PRODUCTION

The structure design, material, and production of the **HERON** represents a breakthrough in UAVs, at **IAI**. Two primary targets were defined for achievement during the design and production process: the first was to develop an extremely light weight structure, the second was to obtain a low cost, short term production process.

4.1 LIGHT WEIGHT STRUCTURE

The light structure weight was obtained by the following principles:

- Extensive use of delicate, all- composite sandwich skins, reinforced by unidirectional graphite fiber spars. The central wing, fuselage and booms are structure, are made of Rohacell or honey-comb sandwich with very thin graphite fabric facing - see Figure 17.

- Highly loaded internal elements such as: fuselage frames, attachment of main, and nose landing gear, highly loaded webs in the wing etc., are made of graphite fabric facings with a stronger core.
- The two integral fuel tanks, one in the central wing and another in the fuselage, are built integrally with the composite structure, without any separate internal bladder.
- Hard points and attachments are built into the composite, minimizing the use of metallic fittings (wing to fuselage, inner wing to outer wing connection, boom to wing attachments and engine mounts).
- Sizing, and tailoring the structure according to a careful stress analysis, and experimental verifications. (3)

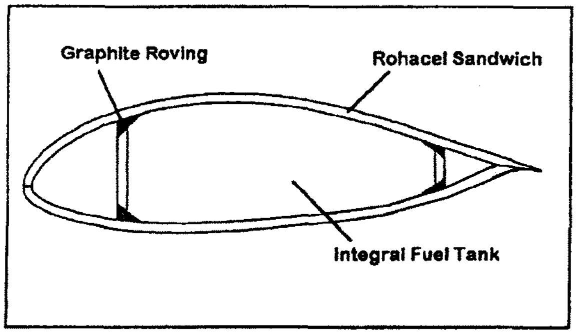
4.2 EXPERIMENTAL

Material coupon and structural element tests were performed in parallel to, and interactively with, the structural development. The wing torsion box (Figure-18), was substantiated by a series of element test (Figure-19), and finally a wing full-scale test (Figure- 20). The fuselage was substantiated by an element test, and by a full scale test (Figure-21) (3)

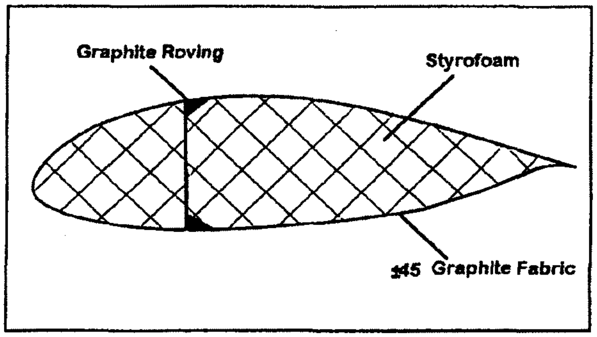
4.3 LOW COST, RAPID PROTOTYPING

The low cost, and rapid prototyping principles were:

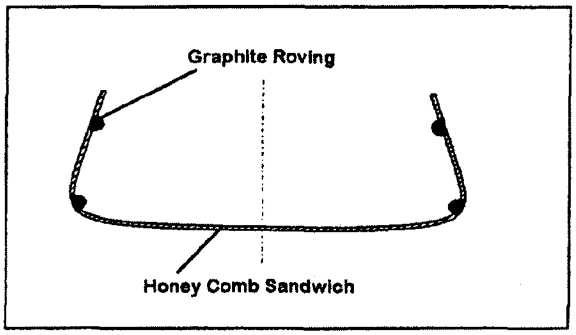
- Dedicated team of design and production workers. Designers worked hands-on in production giving immediate response to changes necessitated by production problems.
- Soft masters using polystyrene foam, which were cut and sanded to shape, and covered with glass fabric producing high quality surface finish
- Molds and necessary tools made by a wet lay-up system using glass fabric and/or NC machining of rigid foams.
- Production based on using mainly manual wet lay-up and vacuum bag compaction if required.
- Outer wing, control surfaces and tail section made from full depth polystyrene core cut to airfoil shape by hot wire cutting system, surfaced by plies of graphite fabric or glass, using manual wet lay-up methods.
- Simplify and minimize the use of metallic parts by using adhesive bonding assembly instead of fasteners.
- Minimize the use of fixtures and jigs for assemblies and for location of hard points (Figure- 22).
- Beams tools, were manufactured by duplicating the wing master geometry. (3)



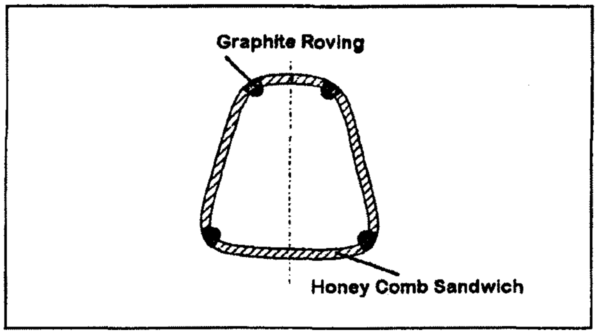
Central Wing Torsion Box



Outer Wing Torsion Box



Fusalage Section



Boom Section

FIGURE- 17: WING, BOOMS, AND FUSELAGE TYPICAL SECTION

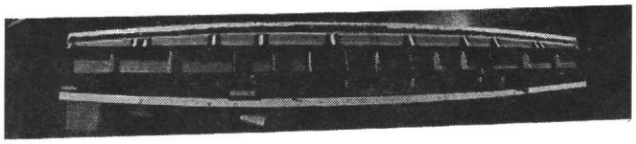


FIGURE- 18: CENTRAL WING TORSION BOX STRUCTURE (BEFORE UPPER SKIN ASSEMBLY)

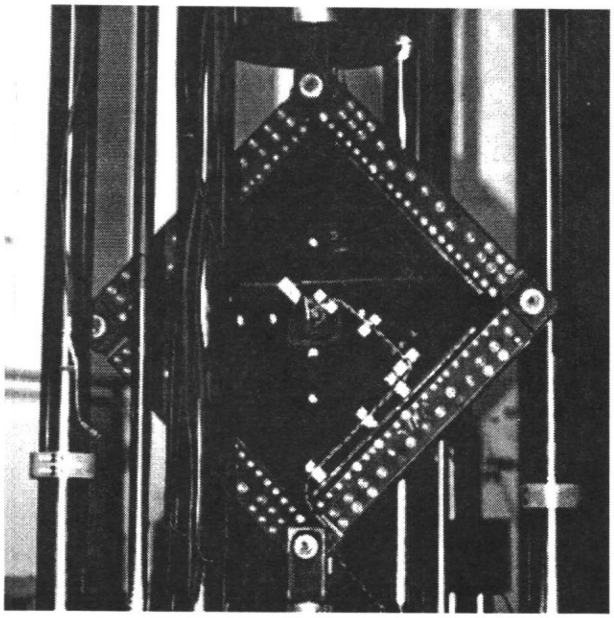


FIGURE- 19: WING SKIN TEST ELEMENT

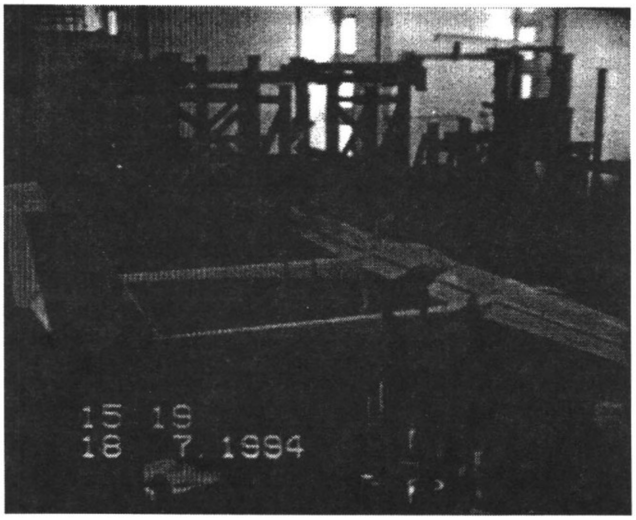


FIGURE- 20: WING FULL- SCALE TEST

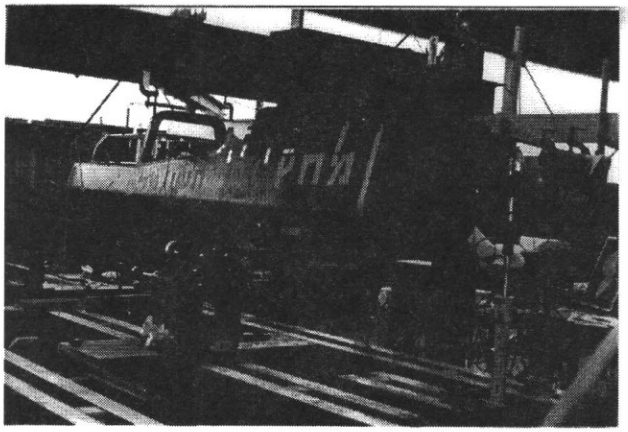


FIGURE- 21: FUSELAGE FULL- SCALE TEST

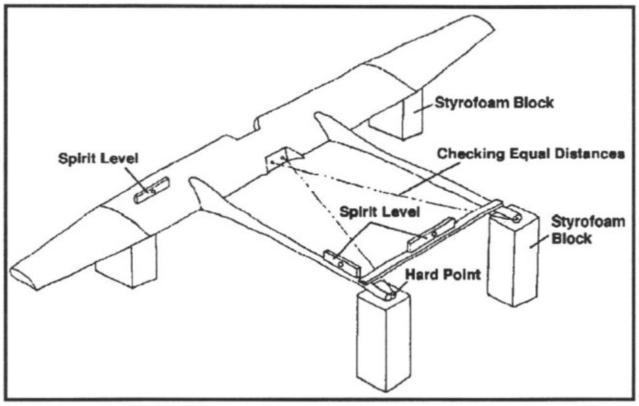


FIGURE- 22: ASSEMBLY WITHOUT JIGS

5. HERON FLIGHT TESTS AND PERFORMANCES

The flight performance of the **HERON** has already been evaluated in more than 150 hrs. and 25 flights. On the **5 March 1995** the **HERON** broke the world record, for 1000 kg. class UAV's, by flying **51 hrs. and 20 min.**, in adverse weather conditions, thereby proving the robustness of the system.

The flight tests indicates that the actual performance of the **HERON** are even better than predicted, in all the flight envelope.

The main flight test performance results are:

- Flight ceiling - **35,000 ft**
- Endurance - **51.3 hrs** with 200 kg payload
- Take- off run - **300 m**
- Landing distance - **200 m**
- Stall speed - less than **50 kts** @ T.O.W
- Max. speed - **120 kts**
- Excellent flying qualities

Figure- 23 summarizes typical flight test results, in comparison with the predicted performance.

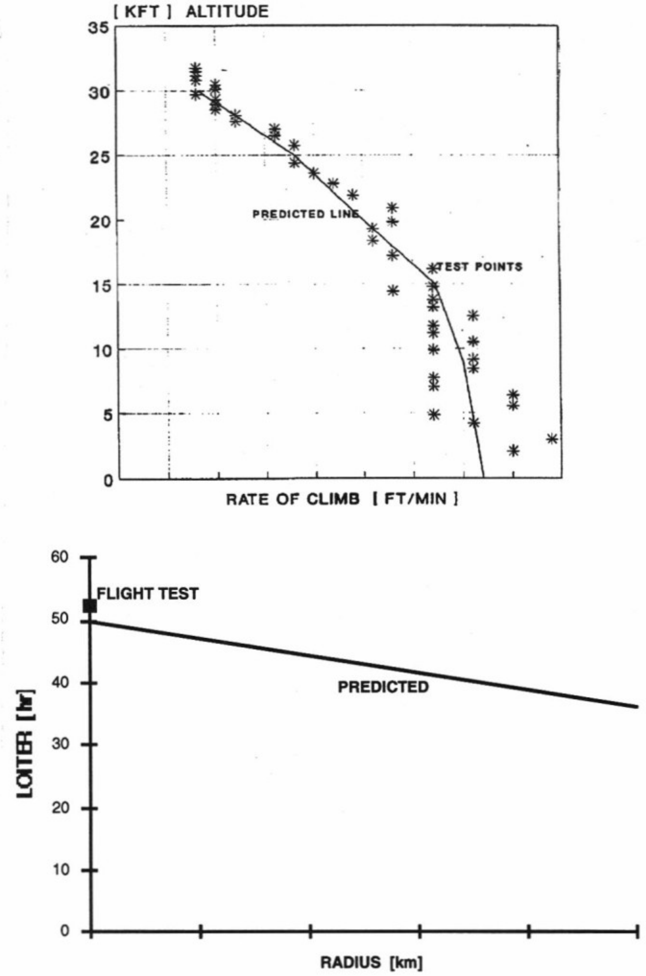


FIGURE- 23: FLIGHT TEST RESULTS VERSUS PREDICTED PERFORMANCE

6. HERON DERIVATIVES

The definition of the basic **HERON** took into account potential future growth and derivatives, by using the flexible twin boom modular configuration. The two derivative configurations are:

The **E- HUNTER** configuration, incorporating the **HERON**, wing, booms, tails, and main landing gear, with the **HUNTER** JT UAV fuselage. The E-HUNTER system was developed by TRW/ IAI team, for payloads demonstrations, and for a long endurance version kit, for the **HUNTER** JT UAV with the following capabilities:

- Useful load	- 670 lb (300 kg) (payload + fuel)
- Endurance	- 25 hrs @ 100 NM
- Flight ceiling	- 20,000 ft

The first flight of the **E- HUNTER** (Figure-24) took place in late 1995.

The **HERON-2** configuration (Figure- 25), which is a high altitude version (50,000 ft) of the **HERON**, incorporating turboprop engine, wing span extension, and higher take- off weight.

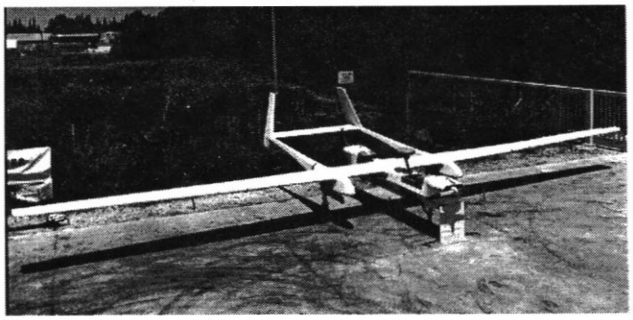


FIGURE- 24: E-HUNTER PROTOTYPE

FIGURE- 25: HERON-2 CONFIGURATION.

7. SUMMARY

This paper presents the highlights of the new IAI **HERON** UAV design approach.
The **HERON** was developed in a very short and low cost cycle, using an efficient development process of concurrent engineering and a collocated small team.
The altitude performance together with long endurance and large payloads carriage capability of the **HERON**, opens a wide spectrum of new operational potential for complex missions-up to now performed by manned vehicles.
HERON UAV covers all tactical endurance requirements, more than 24 hr loitering with 450 lb payload at a range of 500 NM.
The **HERON** is interoperable with the already existing basic avionics & systems, ground facilities, and logistics of the IAI UAV family.

References.

1. D. Koss, M. Shepshelovich, “Design and Experimental Evaluation of a Two-Element, High Lift / Low Drag, Long-Endurance Airfoil”, 35th Israel Annual Conference on Aerospace Sciences, February 95.
2. D. Koss, M. Shepshelovich, M. Steinbuch, “Design and Experimental Evaluation of High Lift, Mild-Stall Airfoil”,12th AIAA Applied Aerodynamics Conference, AIAA 94-1867.
3. V. Weissberg, M. Interator, A. Schwartzberg, A. Gueta, G. Menikes, A. Steinberg, N. Hachman, S. Gali, “High Altitude Long Endurance RPV”, 40th International SAMPE Symposium, May 8-11, 1995