HISTORY OF UAV DEVELOPMENT IN IAI & ROAD AHEAD

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Abstract

This paper presents a short overview of main development programs in IAI for Unmanned Air Vehicles (UAVs), which commenced at the end of 1973 and has continued and expanded until the present time. The major UAV systems that have been developed in IAI are addressed, including the Scout, Pioneer, Searcher, Hunter, Heron, Heron TP and Activities in the fields of micro and mini UAVs. Close Range, HALE and VTOL UAVs concepts, are described; as well as life extension and improvement of existing UAVs. Activity in the sphere of UAVS for civilian applications is described.

The main issues, which are the results of the gathered experience are noted, including the main technologies which are the building blocks. The issues of safety, reliability and affordability are raised.

The paper presents the road ahead and describes the on going activities, which create the continuation to new programs in the tactical area including Mini-UAV, Micro-UAV and new generation of tactical UAVs bigger size configurations as Heron-TP in 4000KG class, HA-50 new HALE-UAV and in future fuel cell propelled UAV like HA-315 and cargo UAV.

1. History

The Beginning - Decoy Uavs

The Yom Kippur war, and its high number of aerial causalities, together with the surprise of SA-6 and SA-2 missiles, which limited air operations, provided the initiative for commencing UAV development in IAI. The first IAI UAV was a decoy (UAV-A) designed to be carried and launched from combat aircraft. Its general configuration is shown in Fig. 1.

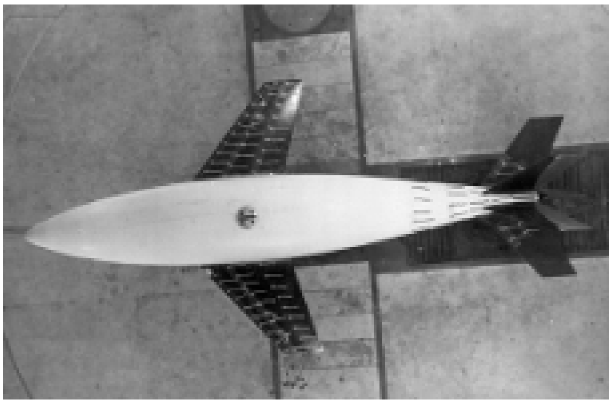

Fig. 1 – UAV-A

The decoy was designed to simulate a real combat aircraft using Lindbergh lens and flying at high speed by gliding with very high wing loading. The UAV was made of fiberglass covering two halves of a heavy lead casting. This incidentally, was the first UAV model to inaugurate operation of the IAI wind tunnel. The very short development time, using a "Skunk works" type development process, was a remarkable achievement. The first flight test was only one month after program launch and about 8 prototypes were manufactured and flight-tested, being launched from aircraft. This program was later terminated for various reasons.

The Main Direction – Tactical Intelligence Missions

1.1 Scout

One of the main lessons of the 1973 war, was the lack of good operational intelligence. At the beginning of 1974, development of a tactical surveillance UAV was launched in IAI. The first UAV was code-named "Scout". Figure 2 shows the Scout UAV in flight.

Fig. 2 – Scout

The initial "Scout" UAV was a 120 lb. aircraft with a span of 3.2 M. This basic configuration was finalized with a 320 lb. take-off weight and a span of 4.0 M. The UAV was introduced with initial operating capability in 1977. It is interesting to note, that the first "Scout" air vehicles were manufactured from aluminum, lacking the experience of composite materials at that time. The first experimental fiberglass fuselage was manufactured at the beginning of 1980 and was used later for the Pioneer program.
The main achievement and proof of capability came during the 1982 "Lebanon war". The very successful operation of the of Scout", integrated with both the army and the air-force, contributed to the overwhelming success in destroying the SAM batteries on the ground, in a very short time at the beginning of the war. The scout is still in service today after 26 years of successful operation.

1.2 Pioneer

The consequences of the successful UAV operation in the 1982 Lebanon war, was expressed in the US Navy's interest in the possibility of adapting the Israeli UAV to America's requirements. The result was the "Pioneer" which is a derivative of the "Scout" UAV. Figure 3 shows the air vehicle in flight.

Fig. 3 - Pioneer

The Pioneer, which was introduced into the American Navy, was produced together with an American based company A.A.I. The Pioneer commenced initial operating capability in the US Navy in 1985; and has since been upgraded with numerous improvements. Pioneer had participated in all the US campaigns in the last 15 years. During the "Desert Storm" campaign in 1991 the Pioneer proved its capabilities with great success. The Pioneer was adapted for Navy operation by implementing point rocket launch, and point recovery by means of a net on board ship. The basic engine is the German "Sachs" engine, which was adapted for UAV operation. The Pioneer system underwent a lengthy process of improvement, and today is in operational service with a life expectancy until 2012. At the present it can achieve endurance of 6 hours with up to 35KG payload. Meanwhile, the possibilities are being examined for improving endurance and payload weight capability.

1.3 Hunter

UAV development in the USA has been organized and lead by the JPO agency which formulated the blueprint for UAV development and deployment. The JPO defined different UAV classes, taking into consideration performance, communications, range, payload, weight and flight envelope. In 1989 an RFP was submitted to the industries for a "Short Range" UAV and several companies responded including IAI. IAI was successful in winning the demonstration phase and proceeded to the following phases of full development and production.

The IAI Hunter UAV was designed to very rigorous requirements, which included rocket launching, and parachute landing. Compared with previous IAI models, it was a larger UAV in the 1500 lb class. The first flight occurred in Sept. 1990. Figure 4 shows the Hunter in Flight during the launch phase.

Fig. 4 – Hunter

Unfortunately the Hunter program was terminated at the end of 1996 following a series of aircraft malfunctions and some crashes. The systems were stored at that time, apart from a single system which was used for payload demonstration and operational training. The source of failures which caused the aircraft malfunction were identified and repaired quite efficiently. Since this improvement, the Hunters from the single system, continue to fly flawlessly accumulating many hours of successful operation.

Many different payloads have been demonstrated including communications data relay, laser designator, Sigint, and others. They were successfully operated in the Bosnia and Kosovo wars, and more recently in Afghanistan and Iraq.

Similarly, improved systems based on the Hunter were sold to France (Hunter-F) providing one system commissioned in 1997, and later to Belgium (Hunter-B) commissioned at the end of 2001. A total of three systems (18 UAVs, 6 ACGS) entered operational use. Today, the proven Hunter configuration achieves a very high mission reliability of 0.985. It can achieve endurance of 12 hours with up to 100KG payload. At the end of 2002 it performed a successful weapon launching demonstration of "BAT" munitions by the US Army and TRW.

1.4 Searcher

The IDF continued to use the "Scout" operationally, and lessons learnt from their experience pointed to the need to improve the performance of this UAV in the fields of bigger payloads, better endurance and higher altitude flight. It commenced flight tests in 1991, and was later deployed by the IDF.

The searcher configuration was based on the known "Sachs" engine. No other mature engine was available. Various development efforts were undertaken. The result was an improved new engine "Limbach" in the 45 HP class. A searcher configuration with this engine is in use with some customers.

1.5 Searcher II

The availability of a new rotary engine - Alvis 682 with high power capability aroused new interest for a "Searcher" upgrade. The new configuration with an Alvis 682 engine, moved the center of gravity backwards, and in order to compensate for this shift, the outer wing panels were rotated slightly backwards. The higher engine power enabled increased weight, which in turn necessitated modification of the wing with higher area and upgraded landing gear. This improved Searcher configuration, called Searcher II, flew for the first time at the beginning of 1996. This configuration with a higher payload and performance capability (endurance of 12 hours, with up to 100KG of payload). Figures 5 show Searcher II in flight.

The Searcher UAV is in service with the Israeli Air Force (where it is already deployed as the "Work Horse" of the tactical UAVs), and with other customers. It is also selected for civilian operations in Israel. The accumulated experience has resulted in considerable improvement in mission reliability to be greater than 90%.

Fig. 5 – Searcher II

1.6 Heron

The primary mission of UAVs is tactical real time surveillance. Additional potential missions were identified by the IMOD, the industry and users. These missions required heavier payloads in the weight class of 100-250 kg, greater electrical power capacity, higher altitude, longer endurance and higher systems reliability. The potential applications included electronic intelligence, communications relay, electronic warfare and other missions.

The "Heron" UAV was conceived in response to the above requirements. The sizing was tailored around the new advanced and matured, general aviation certified Rotax 912/914 engine. The Heron preliminary design started in the Spring of 1993 and a "go ahead" for manufacturing was given in January 1994 with the first flight taking place in October that year. This was a relatively short and low cost demonstration program. The Heron has a 17m span, and is in the weight class of 1100 kg. The Heron has demonstrated remarkable performance reaching a continuous flight altitude of 32,000 ft and a long endurance flight of 51 hrs (a world record for this type of UAV).

In a competition held in France at the end of 2000, in collaboration with E/ADS, the Heron won and was chosen for SIDM mission and renamed Eagle. The Heron SIDM Eagle with SATCOM communications, EO and SAR payloads is illustrated in Figure 6. It flew for first time at the beginning of June 2003.

Fig. 6 – SIDM EAGLE

The EAGLE is designed with automatic take-off and landing, and anti-icing system enabling flight in icing conditions. The planned endurance with full mission payload is 26 hrs. Today the Heron is in serial production for a number of customers. The Heron has participated and will continue to participate in technological demonstration missions with various customers. A successful demonstration was performed in Kiruna Sweden in June 2002, where its capabilities with a SAR radar and electro-optic payload were demonstrated for military applications. This demonstration also included a civil application demonstration.

Twin Boom Characteristic Configurations Of IAI Uavs

The UAV twin boom configuration was first introduced in the Scout UAV in 1974, following extensive wind tunnel testing. It was defined in the footsteps of the Arava STOL aircraft which was being developed by IAI at that time. In fact it could be said that this became the IAI ”house” configuration even today with Pioneer, Searcher, Hunter, Heron. During all these years there were many attempts to design different configurations e.g. Eye View which was a single boom configuration. We examined configurations with a rear propeller and with a forward propeller like classical piston aircraft, but generally we returned to the twin boom configuration. The main reasons are:-

a) Ease of modification – changing engine, modifying tail, modifying wing.
b) Convenience of integrating payloads, including nose space and the use of the booms for antennae and installations.

Close Range (CR) UAV Developments

Following the success of the short range program, IAI started in 1990 to look for potential solutions to the close range requirements which were then in preparation by the US army. The main challenge was to operate the UAV under field conditions from limited zones of about 100 x 25 meter strips with a 15 meter height barrier. Different approaches were evaluated and demonstrated at IAI.

1.7 Close Range (CR) Family

Several configurations were developed:

- The CR-10 Eyeview in the 90 Kg class and 4 M. span. This configuration was demonstrated in flight at the beginning of 1996 and is shown in Figure 7.
- The CR-11 Firebird in the 150 kg class and 5 m span, designed for civil missions. The first flight was in July 96. A Successful flight demonstration was performed in a fire-monitoring role in Sept. 96 in Montana USA.
- The CR-3 configuration, which introduced recovery by controlled parafoil.
- The CR-17 configuration in which recovery is characterized by steep descent using specially designed flaps for high lift and drag.

Fig. 7 – CR10 (Eye view)

VTOL UAV

The potential of VTOL (Vertical Take Off and Landing) vehicles for UAV missions is very promising. The principle of not having to provide takeoff, launch and landing facilities opens up a whole new field of mission capabilities.
Since 1977, following the success of the fielding of the Scout system in the Israel Air Force, IAI began seeking development solutions for this type of vehicle. Some examples of this activity, which still have not provided a “working” solution, are presented here.

1.8 Autogyro Configuration

As part of IAI’s activity to provide a solution for the army close range requirements, it was decided to develop an autogyro UAV configuration. This configuration is shown in figure 8.

Fig. 8. – Autogyro UAV

This was an interesting experience for IAI to develop from “scratch” a new configuration, including rotor and flight control. A very short flight at the beginning of 1995, which ended in a crash, virtually brought this program to a halt.

1.9 Hellstar

Another rotary vehicle program, similar to that of Dornier’s “SEAMUS”, was conducted during the 1990–93 period by IAI. The main mission was tailored to maritime operation. The UAV was based on the QH-50 rotor helicopter, which was produced during the Vietnam war era. Figure 9 illustrate the “Hellstar” configuration. The designed payload was 450 lbs and the planned endurance was 6 hrs. This program was cancelled, mainly due to the marginal performance capability potential of payload, weight and flight endurance.

Fig. 9 – Hellstar

Hale UAVs

Employing a high altitude of around 60,000 ft. for the operation of UAVs has considerable advantages. The flight is above all the normal air traffic and the winds. The line of sight to the horizon is greater, enabling a wider field of coverage, and there is a potential for more efficient performance capability and longer endurance. Since 1987 IAI has been involved in various feasibility studies and definition studies in a search for a high altitude, long endurance UAV, capable of bearing a heavy payload.

1.10 HA-13

The high altitude reconnaissance configuration was designed for the US tier II+ mission. The IAI “Tier II+” (HA-13) configuration was submitted together with TRW in 1994, as a proposal for the Tier II + requirement.

1.11 HA-10

Within the framework of the advanced design activity, we examined a number of additional high altitude advanced configurations: e.g. HA-10 configuration whose configuration is shown in Figure 10. The HA-10 configuration was proven in wind tunnel tests to have an aerodynamic efficiency (L/D) greater than 33.0.

Fig. 10 – HA-10

2. Main Issues

The accelerated development today of UAV systems worldwide, stems from the operational success of these systems since they were used in the 1982 Lebanon war. The additional conflicts of the 1991 Gulf war, Bosnia, Kosovo, and more recently Afghanistan and the Iraq war, have all contributed to proving their considerable potential. Evolving technologies in the fields of computation, propulsion, communications, payloads, materials and manufacturing etc. all provide additional tools to enable successful operation. The leading figures of merit which are becoming the main drivers for future development of UAVs are:

- **Safety**
  Airworthiness of the UAV systems
  Integration into commercial air traffic
- **Mission Reliability**
  Capability to perform the required mission without interruption and when required. The Goal is to increase the MTBCF (Mean Time Between Critical Failure).
- **Affordability**
  Reduction of the system acquisition cost and the operational costs.
- **All Weather Operation**
  Adaptation to bad weather conditions:- rain, ice, winds etc.
- **Flight Performance**
  Improved payload capability with longer flight endurance.

2.1 Approach To UAV Safety

There is a lot of activity today worldwide looking for regulation for UAV airworthiness and UAV airspace integration. In Europe JAA task force was first in U.S. ACCESS 5 and many local approaches in many countries. IAI created basic regulations with the different customers, together with the local military & civil authorities, for continuous operation: in Switzerland – Ranger UAV (1997), in France F-Hunter (1998), in Belgium B-Hunter (2000), in France Eagle-1 (2004) and other countries.

UAV safety risks consist mainly of hazards to persons & property on ground and of air traffic collision hazards. The approach towards dealing with these safety hazards is composed of the manufacturer responsibility to obtain airworthiness (by safe & reliable design according to regulation) and the operators responsibility for safe airspace integration (ATC/ATM integration).

Airworthiness

When considering safety, the UAV system must be viewed in its entirety – Air vehicle, ground control station and communications data link. Considerations include:

- Pilot taken out of the loop - the system becomes more and more autonomous.
- Health monitoring and fault tolerant systems enable automatic computer aided monitoring of faults and subsequent decision taking.
- Employing mature and reliable propulsion systems.
- Utilizing components with high reliability.

ATC & Airspace Integration

Safe operation of UAV systems consist of three layers : airspace management, separation provision and collision avoidance. The first layer is the integration of UAVs into national airspace through airspace organization, demand balancing and traffic synchronization. The second layer – separation provision is the tactical process of keeping aircraft away from hazards by at least appropriate separation minima. The last layer, collision avoidance, must be activated when separation mode has been compromised.
The objective of a safe and reliable UAV system in line with the above criteria, demands the following :-

- Qualified UAV operators / crew qualification requirements.

- Flight plan and ATC co-ordination as per airspace category and constraints.
- Pre-flight risk analysis / well defined emergency procedures including flight termination.
- Close co-operation with ATC (military or civil) :
  - Safe communication capability (air vehicle to ATC, ATC to GCS via air vehicle).
  - Compliance with ATC instructions (altitude & navigation accuracy).

The current means available for mitigating the risk of collision are as follows :-

- IFF/ATC Transponder
- Two Way Communications Voice Relay
- Anti-collision Lights
- Forward Vision Camera
- TCAS Feature

Other means of “Sense&Avoid” that are at an advanced stage of development and test, offer improved means of collision avoidance or evasion. A particularly promising system is ADS-B (Automatic Dependent Surveillance Broadcast), which is planned to be incorporated within aviation traffic.

2.2 Approach To UAV Mission Reliability and Readiness

The readiness or availability of a UAV system is influenced by the following factors: built-in reliability and redundancy (air vehicle, avionics, payloads, communications, ground control systems), maintainability, logistic support.
The MTBCF of UAVs improves with operational time following maturity of the systems. The achieved and projected numbers are beginning to be quite high. Hunter is approaching about 400 hours, which translates to about 98% mission reliability for a 12 hr designed endurance.

2.3 UAV Affordability

One of the main issues, which will influence the UAV industry in the future, is the capability to provide affordable solutions to the diverse missions, compared to other competing solutions.
The main elements of cost breakdown include: acquisition cost (air vehicles, payloads, ground control stations, communications, initial ILS cost) and total operating cost per flight hour. The aspects presented here are principally the air vehicle acquisition cost and its operational costs. The cost of the mission payload is beginning to be the main cost driver and must also be considered.

Acquisition Cost Reduction Potential

Acquisition costs of the air vehicle have considerable potential to be reduced means of:

- Efficient and innovative use of composite materials manufacturing .
- “Lean” concepts for manufacturing as employed in the aircraft industry.
- Lower subsystems cost due to production quantity increase, and competition.
- Lower avionics costs due to the use of COTS, MEMS and automotive electronics.
- More efficient propulsion systems (production, materials, electronic control)
- Re-use of software.

Total Operating Cost (TOC)

The total operating cost of a system depends directly on the operational scenario of the UAV. The total operating cost is the sum of the direct (DOC) and indirect (IOC) operating costs. Direct Operating Costs can be reduced by:

- Reducing operational personnel (Automation, autonomy, Automatic take-off and landing, New concepts of operation, Fuel efficient engines)
- Maintenance cost reduction (Automatic health monitoring and BIT (using advanced sensors), Longer life elements (designed in), Improved reliability, More

electronic control, More electrical systems)
- Lower insurance (safety improvement)

Indirect Operating Costs can be reduced by:
- New concepts of operation and training
- Manpower organization
- Infrastructure organization

2.4 All Weather Operations Of UAVS

Today the operation of UAVs using EO/IR and radar payloads is potentially possible around the clock (day and night). All weather operation capability is constrained mainly due to rain, icing and wind gusting conditions. In order to improve the capability of UAVs to operate under all weather conditions, the following approaches are being taken:

- Anti-icing and de-icing systems – such a system based on TKS technology is incorporated in Eagle. The penalty to the aircraft is not low, and new methods are being explored.
- Icing warning system built-in to the UAV or transmitted to the UAV.
- Design of the airframe to withstand humidity and rain conditions.

2.5 Flight Performance Improvement

New design approaches and evolving technologies will improve the flight performance. Endurance time has a potential to be increased by 100% with reference to performance of today, mainly by a combination of:
- Cleaner lower drag configuration with expected improvement of 25-30% in cooling, payload, antennas, landing gear drag
- Lighter empty weight with improvement of 20 % in electronics, mechanical systems and avionics weight. More optimized structural design to facilitate a higher fuel fraction.
- Improved propulsion with potential for improved specific fuel consumption of 20-30% using improved engines, controls and turbofan diesel propulsion.

3. The Road Ahead

This section presents some examples of new UAVs, which are in different stages of development in IAI. In the MALE/HALE category: Heron-TP, Heron-TJ, HA-50, Fuel cell propelled UAV; In the next generation tactical UAV: I-VIEW, TA-67 and in the small/mini/micro class: 50K, “Spythere”, and Mosquito.

MALE/HALE UAVs

3.1 Heron-TP

Immediately following the first flight of Heron in October 1994, the idea was raised for a Heron derivative based on a turbo-prop engine in order to broaden its flight envelope, increase its altitude and speed and its payload carrying capability, and utilize an engine which is inherently more reliable. Figure 11 shows a general configuration view of Heron-TP.

Fig. 11 – HERON-TP

At the present, the Heron TP is in full scale development phase (for several customers). It is based on the existing Heron UAV, and is designed ,using flexible system architecture, for Medium Altitude (45,000ft) Long Endurance (more than 24 hours) with capability to carry more than 450KG payload. The Heron TP will incorporate integrated SAR payload & radio relay, satellite communication for long range operation and also a deicing system for all weather operation.

3.2 Heron-TJ (HA-21)

Potential hale UAV configuration which is being studied today, include the HERON-TJ. This is a derivative of the HERON-TP. This configuration is based on the use of two Williams FJ-44 class engines, replacing the existing turboprop propulsion of Heron-TP. This configuration has a 32m wing span with a takeoff weight of 4300 kg. Its performance potential is 24 hrs endurance at 60 kft. altitude.

3.3 Hale UAV (HA-50)

New potential directions for civil applications are being explored today by IAI in a study taking place in Europe within Framework 5, with projects such as CAPECON, USICO and UAVNET. The goal of these projects is to show that there is an economic viability (CAPECON), and a way of determining safety standards and flight rules (USICO). UAVNET is a thematic network for the exchange of ideas and information. New UAV systems are being defined as part of this activity, such as the HA-50 defined by IAI, shown in Figure 12.

The HA-50 is designed for high altitude and long endurance, having a payload capability of 500 kg, 36 hours endurance at 60 kft altitude and a take-off weight of about 6,000 kg. The UAV is designed for basic modularity, providing a large volume for installation of payloads and the required electrical supply and cooling. The target operational cost of this UAV is planned to be an order of magnitude lower than that of an equivalent military UAV.

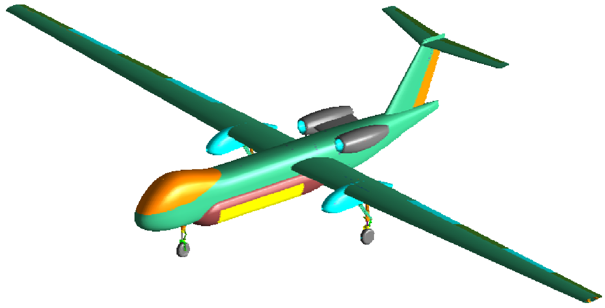

Fig. 12 HA – 50

3.4 Fuel Cell Propelled UAV

Rapidly emerging fuel cell propulsion technologies (derived from the automobile industry) may be used to launch a new revolution of electric propulsion systems for aircraft.

Fig. 13 HA-310/HA-315

The future potential HA-310/HA-315 high altitude, long endurance UAVs are illustrated in Fig. 13. with a wingspan of 40m, take off weight of 1000 kg and a payload capability of 200 kg. The goal is an endurance of 7 days at altitude of 50Kft.

TACTICAL UAVs

3.5 I-View

The main conclusion from the Close Range (CR) activity presented above was that if you want to use a parafoil solution for point / short landing, you need forward engine installation.

The original EYE-VIEW configuration was modified to a new configuration "I-VIEW" that is shown in figure 14. The new Vehicle carries 70 lbs of payload, loiters at 15 kft. has an endurance of 6 hrs, and lands with a parafoil. It can be used for a standard landing or emergency recovery. A complete system, including Automatic TakeOff and Landing (ATOL) will be demonstrated during 2004.

Fig. 14 - IVIEW.

3.6 Next Generation Tactical UAV

UAVs are fundamentally changing the tactical concepts of warfare and plans are being laid for the next generation advanced tactical UAV to replace the existing Hunter, Searcher, Ranger UAVs, etc. The future tactical UAV illustrated in Fig. 15 will have a multiple payload carriage with a payload and endurance of two to three times that of existing UAVs at twice the altitude and a 50% maximum speed increase capability. Reliability and safety will be improved, as well as availability and maintainability. Acquisition costs will be reduced by a third to a half and total operating costs by an eighth to a quarter.

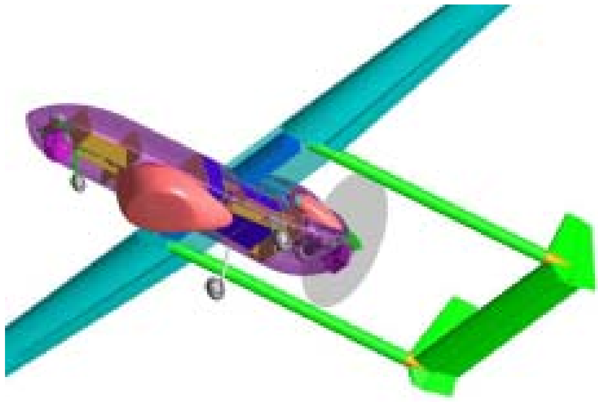

Fig 15. Next generation tactical UAV

3.7 Small UAV - 50K

Small UAV (MTOW=50kg) for security and commercial information gathering missions. It will be able to carry about 10kg payload. The first phase of the project is a demonstration at the beginning of 2005. A promising technology for producing inflatable wings, will be demonstrated within this program. The advantage of this technology is that it enables very compact storage of the aircraft and ease of transportation. The 50K configuration is illustrated in Figure 16 (wing span: 2.5m, total length: 2.3m).

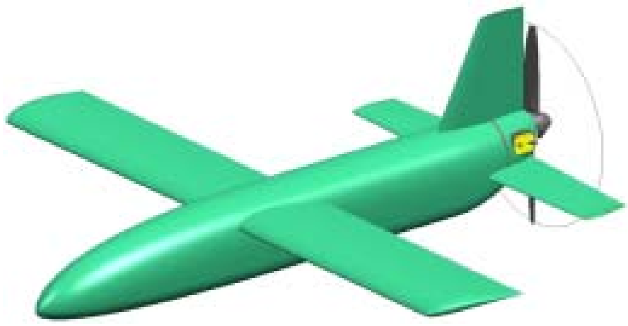

Fig. 16 – 50K UAV Configuration

SMALL & MINI / MICRO UAVs

In contrast to the large HALE UAVs previously mentioned, there are at the other end of the spectrum, micro and mini UAVs. Technological developments in the fields of computers, sensors, navigation, communications, photography, MEMS etc. facilitate the production of these smaller UAVs. The potential for these categories is being evaluated by IAI and the following UAVs have recently been flown:

3.8 "Spythere" Mini-UAV

The "Spythere" is a conventional UAV configuration with an electric engine. It is designed to fly at a maximum speed of 90 km/hr at an altitude of 500 to 1500 ft with a mission endurance of more than one hour under standard conditions. The UAV is constructed from composite materials combining minimum weight with maximum strength. It has span of 2m, weight of 5kg and is using an advanced gimbaled camera. The "Spythere" is shown in Figure 17 in flight.

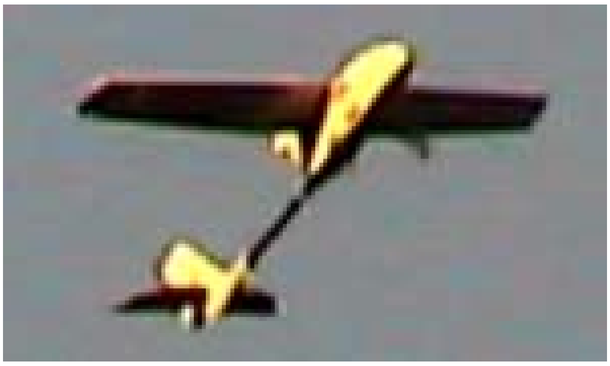

Fig 17 – "Spythere"

3.9 Mosquito Micro-UAV

The Mosquito shown in Figure 18, is a micro UAV with a span of 300 millimeters and weighing only 250 grams. It was flown in January 2003 and achieved an endurance of about 35 minutes using zinc/air batteries and provided on-line video information. This is basic development prototype for technology exploration.

Fig. 18 – "Mosquito".

3.10 Mosquito 1.5 Micro-UAV

The Mosquito 1.5 is another UAV from the micro-UAV class. It weights 500gr and is completely autonomous with waypoint control. Principle characteristics are semi gimbaled high quality daylight video camera, and high level survivability . Major performance objectives are: Range-1mile, Endurance-1hour. The first flights took place in March 2004. Figure 19 shows an installation sketch of mosquito 1.5

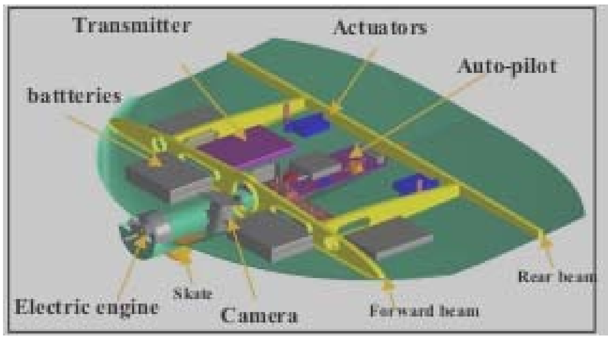

Fig. 19 – "Mosquito1.5"

3.11 Cargo UAV

Using advanced technologies of avionics and flight control, a new generation of aircraft will emerge: "Autonomous aircraft" – inhabited aircraft which will fly autonomously. These autonomous aircraft with proven safety and high mission reliability will have lower operating costs. IAI envisages that these will first appear as cargo UAV aircraft as illustrated in Fig 20.

Typical configuration in stage of feasibility is with payload of 20,000lbs.

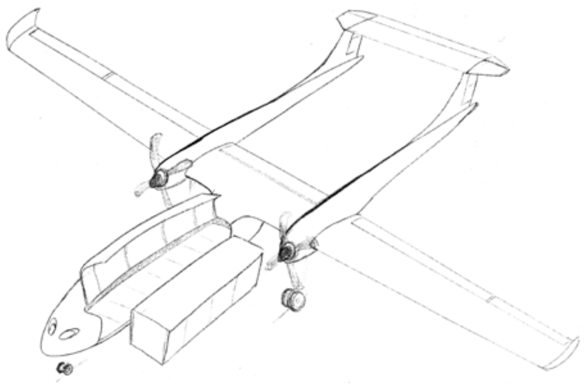

Fig. 20. ACV-B

Conclusions

PRINCIPLE LESSONS

In summarizing the long period of 30 years of UAV development in IAI, principle lessons can be learnt. These lessons and conclusions should be the cornerstones for future improvement and for the development of new directions. The lessons are enumerated and prioritized as follows :

1. **Available UAV Technologies And Infrastructures**

   These are required for enabling development and fielding of UAV systems.
2. **Careful Development Approach**

   Based on past experience using existing elements with a clear definition of ground rules, design principles and methodology.
3. **Choice of The Right Propulsion System**

   The propulsion system is a key factor in UAV success, from the point of view of UAV performance, operation, reliability and engine integration. Certified piston engines and certified commercial engines, including turboprop and turbojet/fan engines have a clear advantage.
4. **Design for Reliability**

   This is a major issue in UAV design. The UAV reliability must be based on reliable basic elements, reliable systems including electronics systems (avionics, flight control, electrical actuators) and the correct take-off and landing approach to minimize the external pilot's interface.
5. **The UAV Is Part of A Total System**

   The UAV system includes the control station, ground systems for transport and mobility, support systems, spare parts, communications and antennas. The UAV design must take into account all of these elements.
6. **Design For Affordability**

   The design of the UAV system should provide an affordable solution, minimizing the life cycle cost by reducing the cost of development, acquisition and operation (crew, reliability, maintainability). The Affordability Issue is becoming the main challenge. New evolving Technologies in the field of aerospace (manufacturing, electronics, automation, maintainability) together with new concepts of operation will be the key to achieving competitive operating costs.

THE ROAD AHEAD

I.A.I has been very active in the field of unmanned air vehicles systems for the last 30 years. Development activity is continuing for future generations. Activity today spreads from 250gram micro-UAVs to vehicles in the class of 6000 kg and covers most of the different classes of UAVs including tactical missions, VTOL, CLOSE-RANGE, MINI/MICRO, MALE, HALE and civil missions UAVs.

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