The use of small UAVs in exploration and production

May 2007

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Existing uses of Unmanned Air Vehicles in E & P activities

1. Pipeline monitoring

Aerostar - Aeronautics Defence Systems, Israel

As well as operating several Aerosky vehicles on behalf of the IDF, ADS is currently using its short-range Aerostar UAV to provide protection and patrol services for Chevron Texaco's operations in Angola under a two-year contract awarded last year and reportedly worth US$ 4 million. The Aerostar carries a payload of up 50 kg and has an endurance of 14 hours. According to the manufacturer, it logged more than 10,000 flight hours after being selected in 2002 to carry out routine security missions for the Israel Defence Force.

from UAV Systems:
The Global Prespective 2005 by Blyenburgh & Co

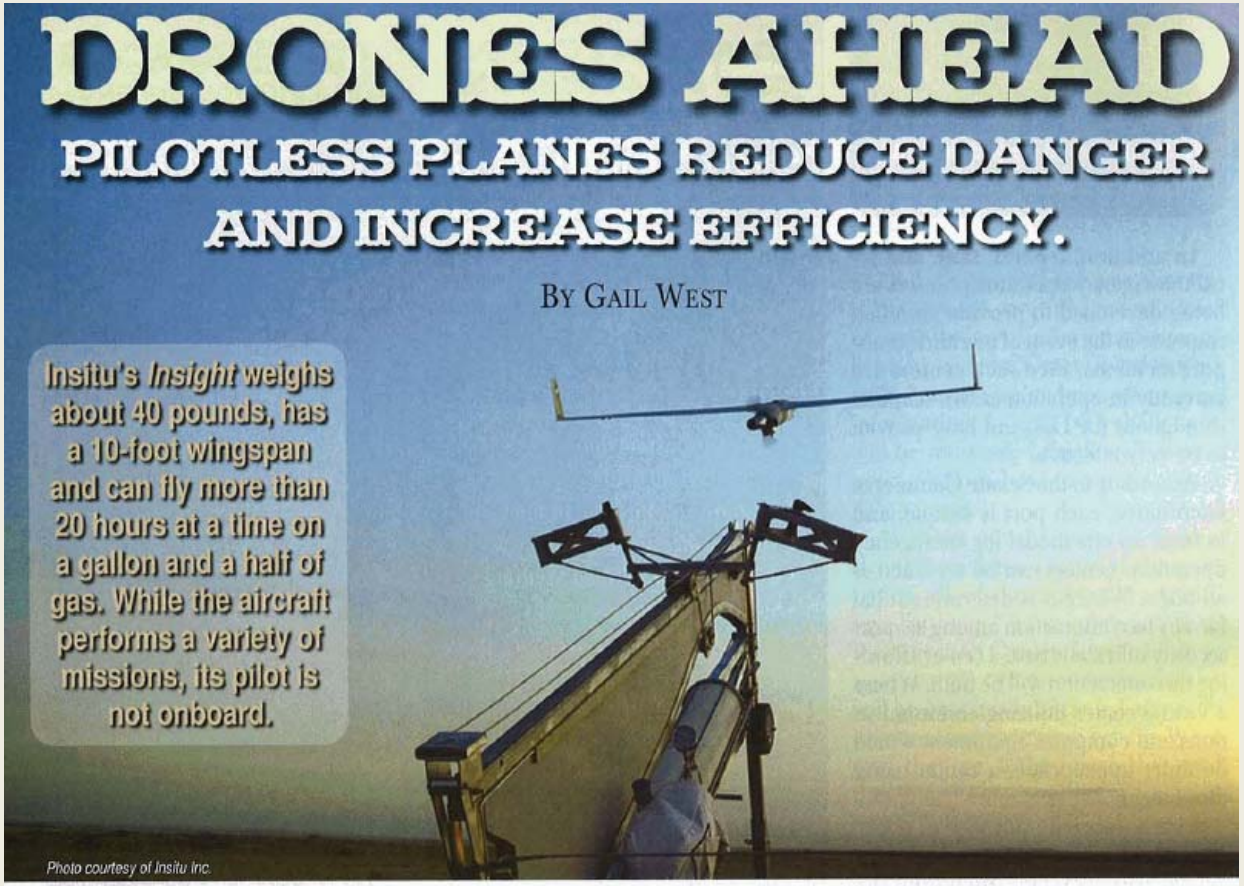
Existing uses of Unmanned Air Vehicles in E & P activities

2. Magnetic field survey

MagSurvey Prion by Magsurvey Limited, from http://www.magsurvey.co.uk/

Existing uses of Unmanned Air Vehicles in E & P activities

3. Whale monitoring, especially in the Arctic area...



Insitu Inc.'s Insight Unmanned Aircraft System can be launched from land or ship, giving it great flexibility for exploration and monitoring.

From Alaska_Business_Monthly_April_200.pdf

Existing uses of Unmanned Air Vehicles in E & P activities

4. Aerial imagery using CropCam

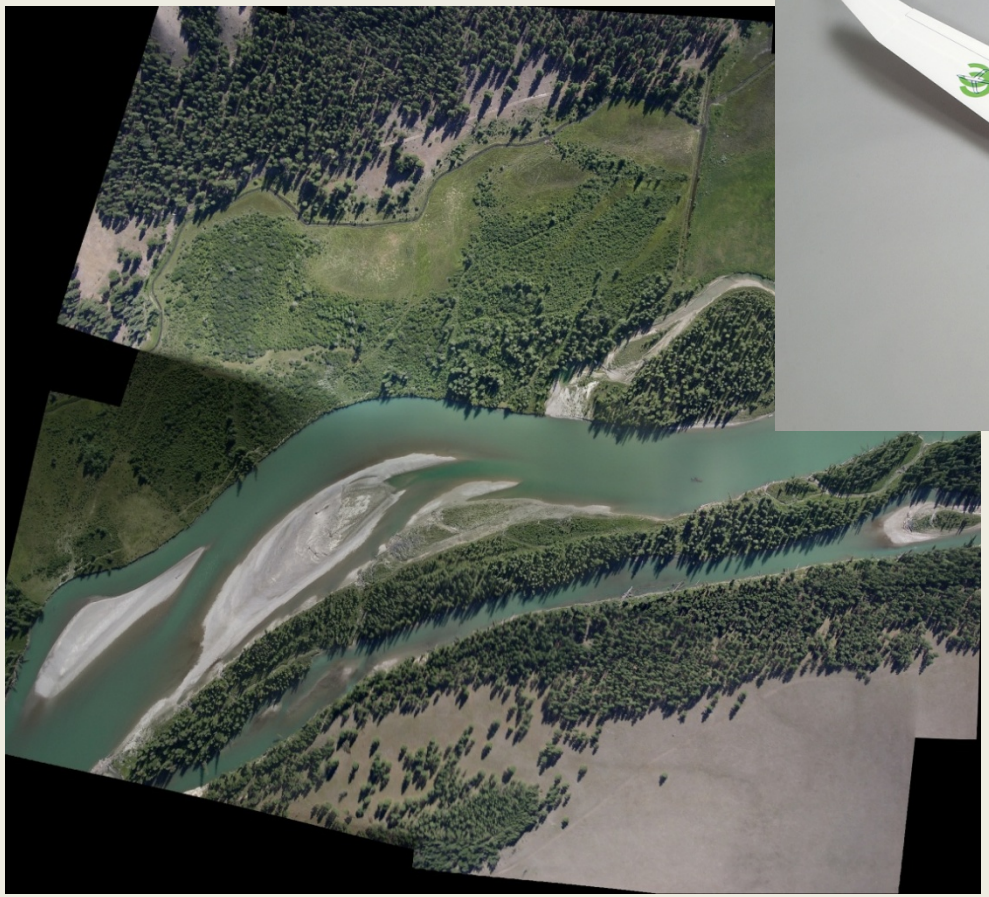


Image of 160 acres of land in British Columbia, derived from stitching together 12 separate images using the CropCam: from www.cropcam.com

UAV characteristics

Aerostar	Max takeoff weight	210 Kg
	Max payload	50 Kg
	Max range	1,550 Km
MagSurvey Prion	Max takeoff weight	30 Kg
Scan Eagle	Max takeoff weight	18 Kg
	Max payload	3 Kg
	Max range	1,350 Km

A common theme is the use of **small** UAVs in commercial applications.

The advantages of using UAVs in E&P activities: Part I

- **The UAV can stay in the air for up to 30 hours.** This is far in excess of the duration of a manned aircraft, where the concentration span for a pilot is considered to be at most around five hours.

- **The UAV can fly in hostile regions,** where there is a real risk to the life of a pilot:
  - over the Arctic Region;
  - in the vicinity of extreme weather conditions
  - over regions experiencing low level civil strife

- **The UAV is always "flying on instruments,"** using advanced navigation systems, such as GPS and a scanning laser based altimeter, in combination with precise computer control and can:
  - perform a very precise raster scan of a region
  - fly at night, to take advantage of the lower interference from both sunspot activity and cultural noise (such as mobile phone signals, radio signals)
  - fly at night and at very low levels (such as 20 m above ground level) to increase data resolution.

The advantages of using UAVs in E&P activities: Part II

❑ **The UAV creates less of a disturbance to the parameters being measured,** such as the magnetic, or, gravitational field, since it is physically smaller than its manned counterpart

❑ **The UAV costs less to operate per line Km**, since:

- The UAV with a typical payload of 9 Kg is less expensive to purchase than a manned aircraft
- The UAV has lower operating costs:
- a UAV operator can manage several UAVs at the same time;
- the UAV uses less than 20% of the fuel used by a manned aircraft (payload dependent)
- a small UAV can often take off from a flat field, rather than from an airfield

The advantages of using UAVs in E&P activities: Part III

❑ Because of the lower operating cost of the UAV, relative to a manned aircraft, **one can perform repeated surveys over the same area, to detect changes that occur over time**, for example, the depletion of an oil reserve, or, leakage from a pipeline. One can use the data from extensive measurements of either the magnetic or the gravitational fields in a computer programme, to derive the three dimensional (3D) geology of the underlying ground. If the extensive measurements are made on a regular basis, one can visualize the changes taking place to the 3D structure of the ground (such as depletion of oil from an oil reserve) over time. This representation of changes to the 3D geology over time T is often referred to as a "4D" (ie. 3D + Time) representation.

❑ **The UAV is more environmentally friendly** since it:

- requires less materials to build;
- uses less fuel per Km travelled;
- creates less pollution per Km travelled;
- makes less noise in flight
- is easier to dispose of at the end of its life

The advantages of using UAVs in E&P activities: Part IV

❑ **UAVs can fly in total darkness** at night, or, at any other time when the sunspot activity and the cultural noise level is at its lowest, enabling measurements to be taken with minimal background noise.

❑ **UAVs can fly very close to the ground** ("tight drape"), through the use of precision navigation and computer controlled flight. This low level flying enables higher precision data to be gathered.

❑ The use of several UAVs:

▪ **introduces a fault tolerance to the survey**. If one UAV experiences problems of any sort, that UAV can be returned to base, allowing the other UAVs to continue and complete the survey.

▪ to cover the same area enables an **improvement in the accuracy of the data**, through the application of data averaging. Using several UAVs means that the results from several measurement systems can be correlated, so that errors and drift in any of the instruments can be identified.

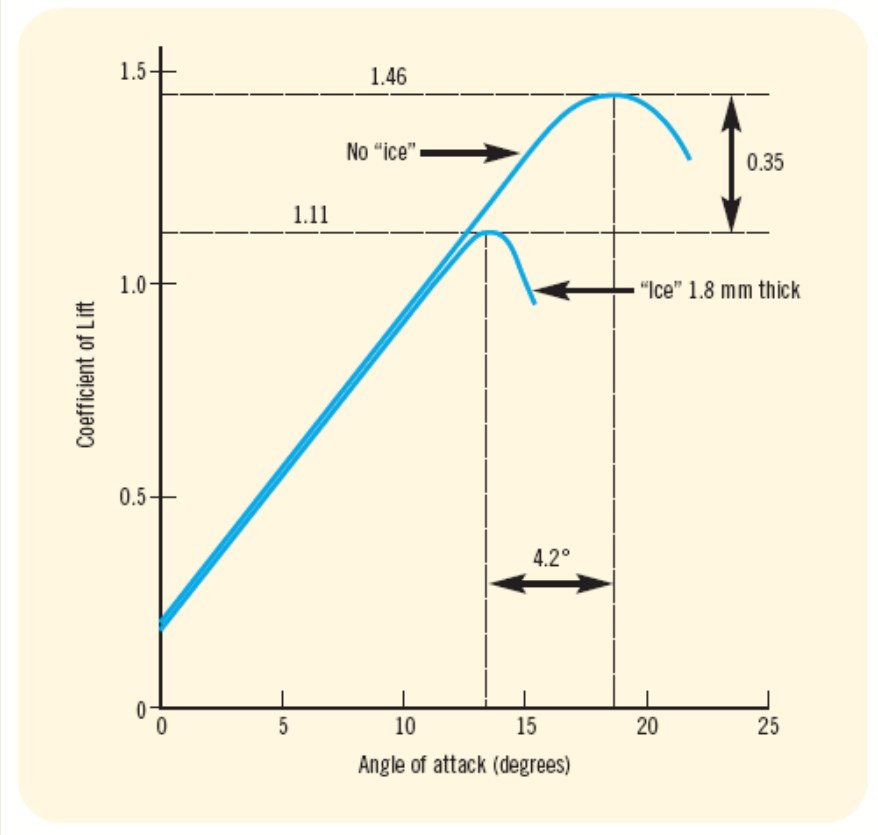
Exploration and Production activities take place throughout the world...

In the Arctic region, a survey plane could encounter:

- ❑ temperatures that drop to -40C;
- ❑ icing of the wing, causing a potentially catastrophic loss of lift...

Part of the Trans Alaska Pipeline, from http://www.usgs.gov

Wing icing



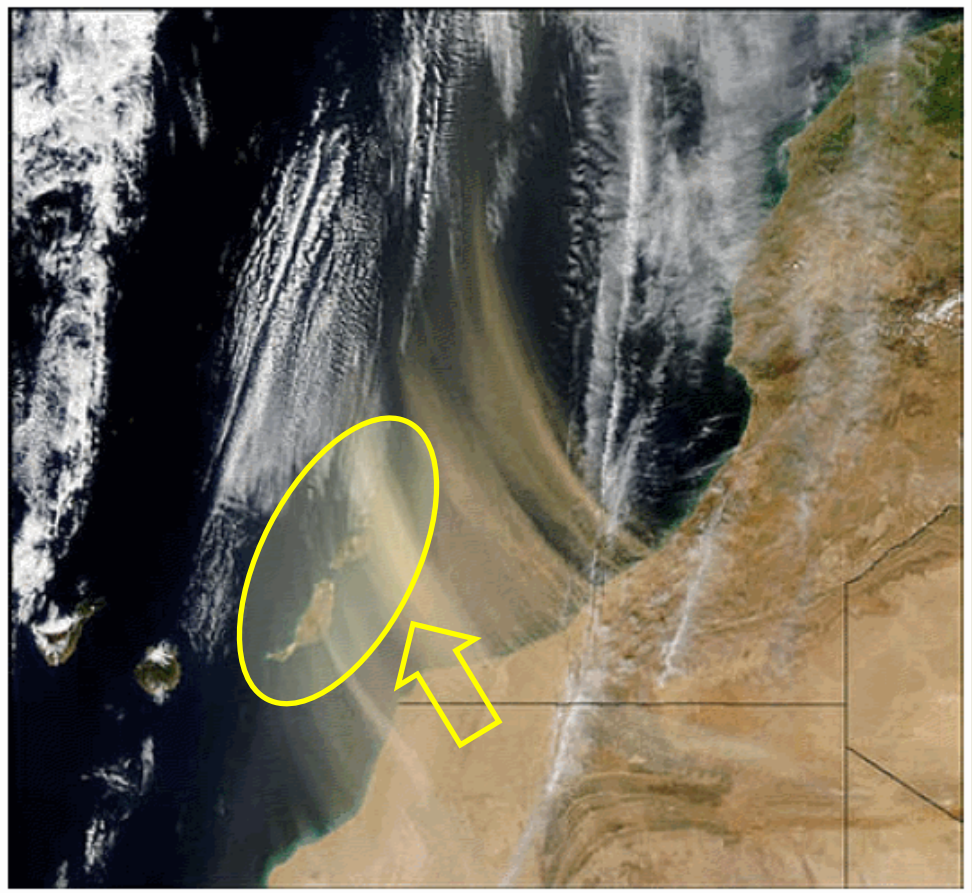
Results of wind-tunnel studies of the effects of very thin layers of ice on a full scale Russian Yak-40 wing with flaps extended 11 degrees.

http://www.icao.int/icao/en/jr/2006/6104_en.pdf.

Exploration and Production activities take place throughout the world...

In North Africa, a survey plane could encounter:

- ❑ temperatures that reach +50C;
- ❑ abrasive sand storms;
- ❑ random small arms fire...



Satellite photograph of a dust storm showing fine sand from Morocco and Western Sahara (below Morocco) being blown over to Lanzarote and Fuertaventura.

The instruments used in a survey can be divided into two groups:

- ❑ Type I weighing less than 10 Kg
- ❑ Type II weighing 10 Kg or more, but less than 500 Kg

Overhauser (GSM-19) console with sensor and cable. Can also be configured with additional sensor for gradiometer (simultaneous) readings.

precision magnetometer: 1.5 Kg
http://www.gemsys.ca/

Gravity gradiometer: 350 Kg+
http://www.ga.gov.au/image_cache/GA4750.pdf

Geophysical survey instruments weighing less than 10 Kg

- ❑ Aerial and stereo imagery using visual, IR and thermal imagers
- ❑ 3D visual imagery, using five, high resolution CCD imagers
- ❑ Hyper-spectral imaging system
- ❑ Scanning LIDAR unit
- ❑ Cesium or Potassium magnetometer for use in magnetic mapping
- ❑ Quantum cascade laser for ethane detection

Ideal Payload = 9 Kg

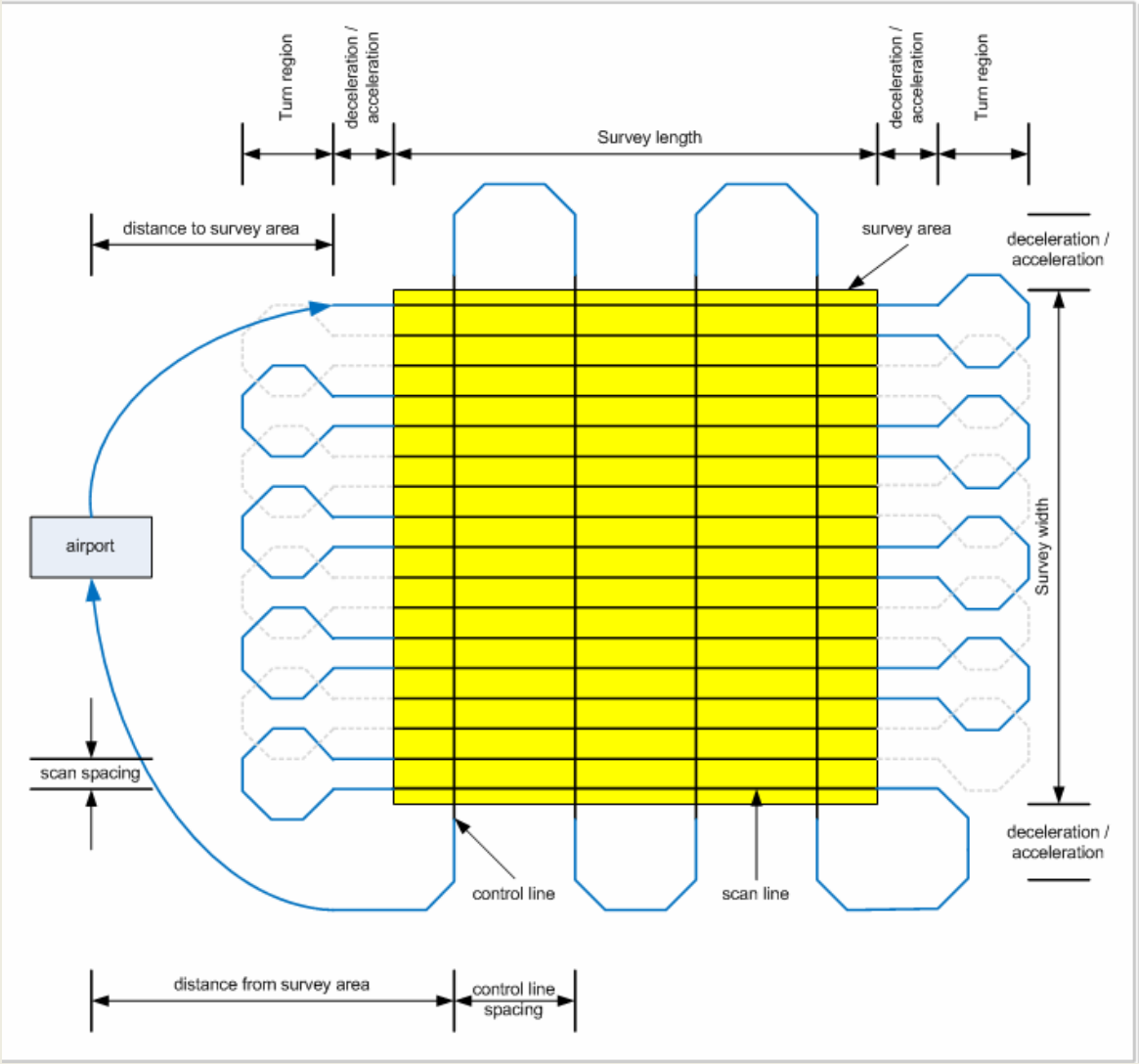
Flir Merlin IR imager 1.5 – 5.0 um

Geophysical survey instruments weighing 10 Kg or more

- ❑ Synthetic Aperture RADAR (SAR): 12.3 Kg in 2005 (Sandia SAR system)
- ❑ Gravity meter (absolute or gradient): 450 Kg + (could be made lighter)
- ❑ Gamma ray sensor: ~250 Kg (very difficult to make lighter)
- ❑ Airborne ElectroMagnetic (AEM) probing: 1,000 amp pulses, 4 mS long into a 24 m diameter, 6 turn, coil...

MEGATEM, Dash 7

A typical survey pattern...



The ideal range for a UAV engaged in geophysical survey work

A development survey typically covers an area of 400 square kilometers. For a typical 400 square Km development survey we calculate that 2 flights are needed, each flight covering **1,569 line Km** in just under 15.7 hours, for a UAV cruising at 100 Kph.

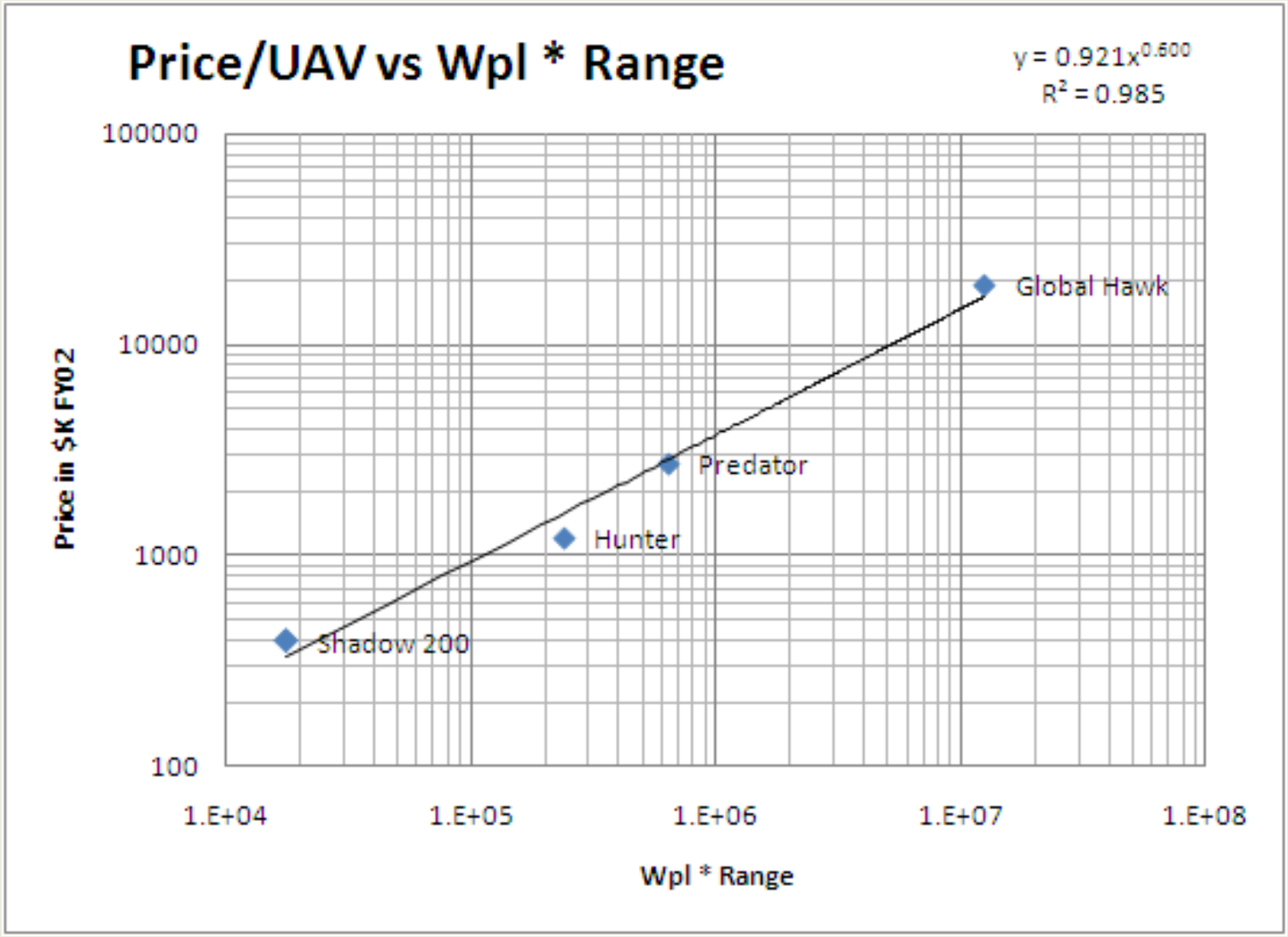
For a typical exploration survey covering a 10,000 square Km region we calculate a requirement for 24 flights, each flight covering **1,560 line Km** and lasting 15.7 hours, at a cruising speed of 100 Kph. This allows plenty of time to turn the UAV around for the next flight.

One of the longest oil pipelines in the world is the **1,768 Km** long Baku-Tbilisi-Ceyhan (BTC). In this case, one could locate a UAV base midway along the pipeline and fly the UAVs from the base to each end of the pipeline and back again.

From the above considerations, one concludes that a UAV with a range of **1,800 Km** would be suitable for both geophysical survey and pipeline monitoring work. From a logistics point of view, having a UAV flying at 100 Kph for 18 hours per flight, gives sufficient time for a regular aircraft servicing period and take-off time each day.

Ideal Range = 1,800 Km

Estimated price for the ideal GeoSurvey UAV: $310,000 FY [02]



Caution over UAV prices...

The price of a UAV that would be needed to transport a payload in excess of 10 Kg over a distance of 1,800 Km would exceed the cost of a light aircraft.

The reason for this disparity in price results from the contrast between the sharing of the high development costs between a small number of UAVs and the situation in which the development costs for most light aircraft have long been written off and popular light aircraft have been and are produced in large numbers.

Nav equipped Cessna Skylane 182-T

Max payload = 517 Kg

Max range = 1,722 Km

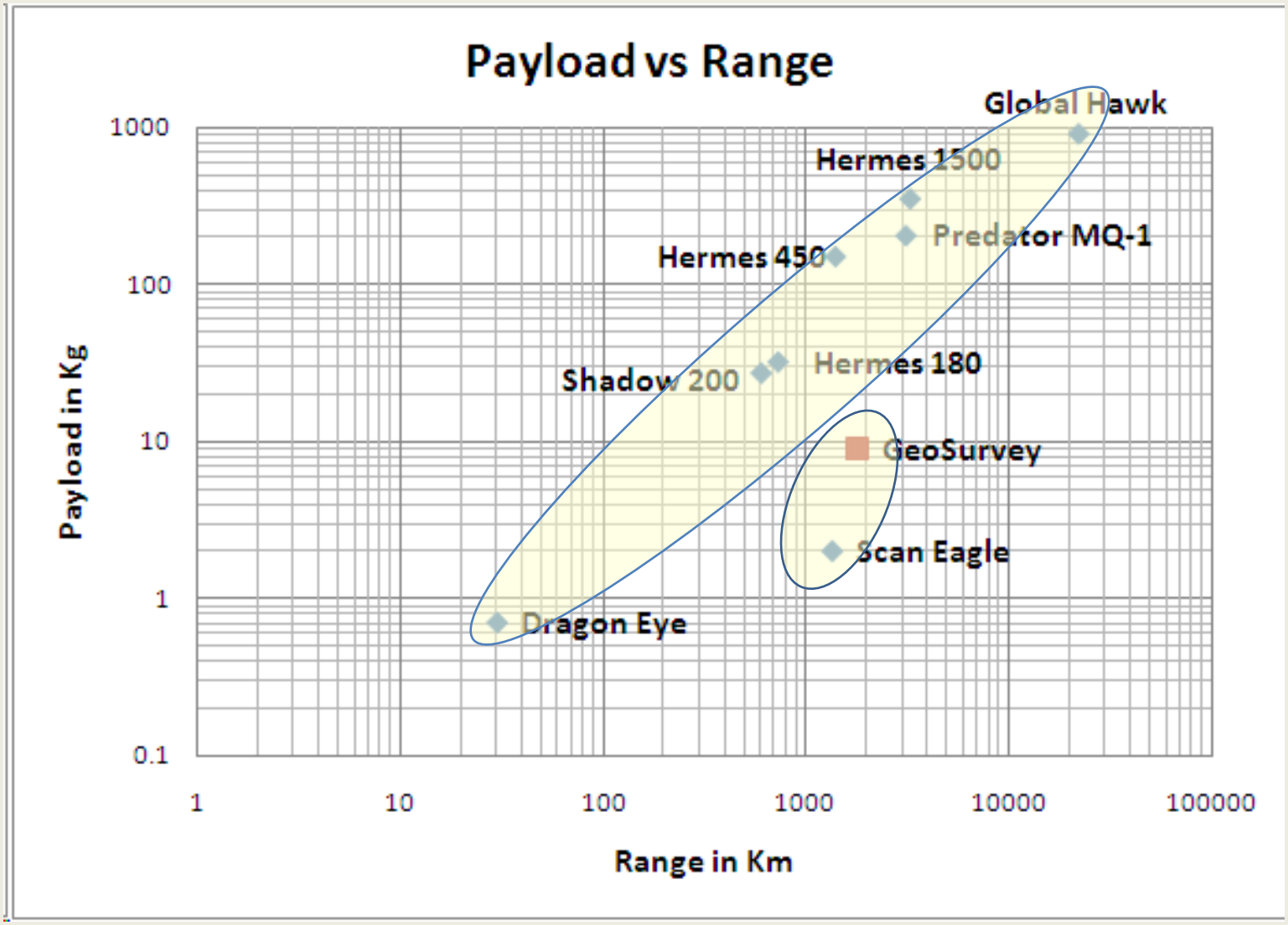
Price = $349,500

- from www.cessna.com

Specifications for the ideal GeoSurvey UAV

- Payload = 9 Kg
- Range = 1,800 Km
- Take-off weight estimated to be 100 Kg
- Cruise speed = 100 Kph
- Power plant: two, low vibration, four stroke engines, each 80 cc capacity
- Price: less than $ 310,000 [FY02] each

GeoSurvey UAVs carry a lighter payload



The military requires UAVs:

- with long endurance times, to enable them to loiter over an area of interest and watch what is going on below;

- that have stealth characteristics, so that they are not easily seen as they loiter over an area of interest;

- that are agile, so they can escape any attack that might be mounted against them;

- now, with the hope and expectation that improved reliability will follow with time, usage and the number of vehicles produced.

AAI Shadow 200 UAVs with US Forces in Iraq (photo supplied by AAI Corp)

For geosurvey and pipeline monitoring work, one requires a UAV:

❑ with a long range, to enable the UAV to cover a large survey area, cost effectively, between refueling;

❑ with low vibration engines that also have a low magnetic “signature,” so as not to perturb the sensitive measurements being made and to increase the reliability of the UAV;

❑ that flies on a smooth and well controlled flight path, to minimize the overlap required between scan lines and maximise measurement accuracy;

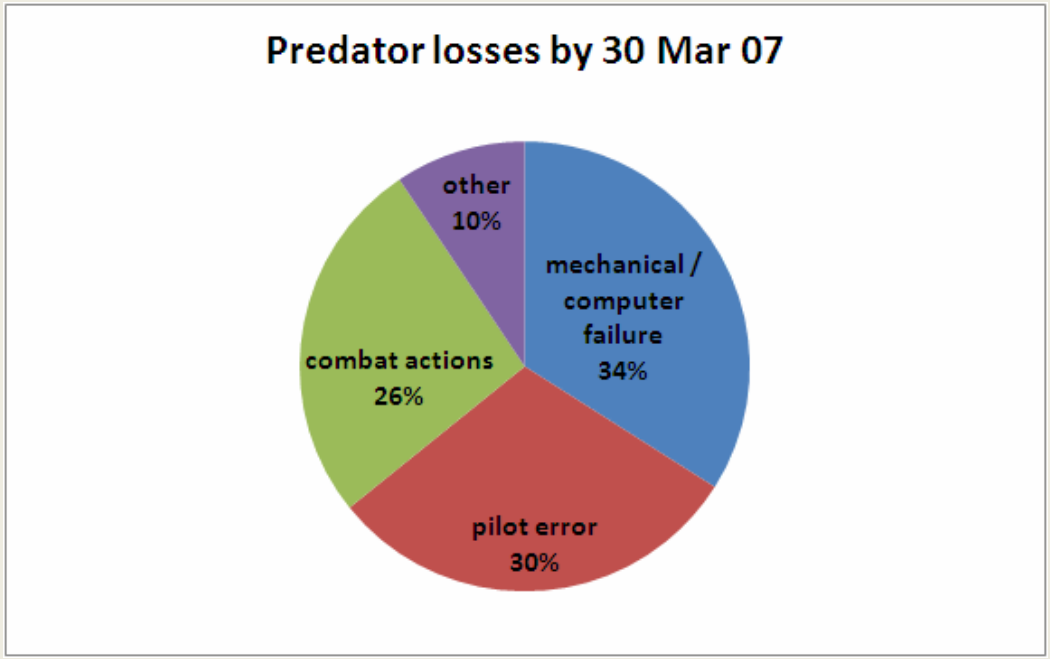
❑ with a high reliability from the outset.

InSitu Scan Eagle UAV on launcher, from uav_roadmap2005.pdf.

The outstanding challenges

1. Reliability

Because many of the current UAVs are intended for use in military applications, where the need for the UAV has outweighed the lack of reliability, most of the UAVs require improvements to be made to their reliability. One obvious issue is the predominant use of a single engine. One would expect an improved reliability through the use of two low vibration engines, with the UAV being able to fly on one of the two engines.



The outstanding challenges

2. Flight in civilian airspace.

For a UAV to fly in civilian air space, the UAV must:

❑ satisfy national air worthiness criteria if the all-up-weight at takeoff is less than 150 Kg, or, international criteria, if it is larger;

❑ be able to respond to ground-to-air and air-to-air voice communications. For long range UAVs, one needs reliable satellite communications;

❑ support a “sense and avoid” capability with respect to other aircraft, equivalent to that of a piloted plane. Sense and avoid systems are currently at an early stage of development. There are some interesting papers on this topic at this Conference.

11.00-11.25	**Sense & avoid evaluations & standards for civil airspace access** Andrew Zeitlin, Mitre Corp., USA
11.25-11.50	**National technology project OUTCAST- Flight testing a sense & avoid concept** Michiel Selier, NLR, The Netherlands
11.50-12.15	**Small sense & avoid system (SSAASy)** James Utt, Defense Research Associates, USA

The outstanding challenges

3. Loss of life, damage to property and reputational damage resulting from a UAV crash

One major concern is the possible loss of life, damage to property and damage to the reputation of an exploration organization caused by the crash of a UAV. This "reputational damage" can lead to the loss of the exploration licence by the exploration company associated with the use of the UAV.

The damage caused by a flying vehicle is related to the kinetic energy of the vehicle: using light, slow flying, UAVs helps to minimize damage associated with a crash.

On the 3rd October, 2006, an IAI / Belgian Hunter crashed in Kinshasa, killing two people and injuring another two. The cause of the accident is ascribed to operator error. This is the first time someone has been inadvertently killed by a UAV.

In conclusion

The Unmanned Air Vehicle has much to offer in the areas of oil, gas and mineral exploration and pipeline and facility monitoring.

More attention needs to be paid to the reliability of the UAV.

UAVs have to be able to fly in non-segregated air space before large scale use can be made of this technology. There is a lot of work taking place in Europe, in the Middle East and in the USA, in particular, to resolve the outstanding issues.

- ❑ Increasingly, oil, gas and mineral exploration companies are considering the potential roles of Unmanned Air Vehicles in Exploration and Production activities.
- ❑ We conclude the maximum impact is to be gained from the use of a:
  - relatively small UAV,
  - with a payload of around 9 Kg,
  - a range of around 1,800 Km,
  - and a take off weight of 100 Kg,
  - that has been developed for Exploration and Production applications.