Transport, Safety and Energy Challenges
ESA Centre, Harwell on 12 November, 2009

Unmanned Aircraft for Disaster Management

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Unmanned Aircraft come in all sizes, although most are for military applications....

From the 12,110 kg Global Hawk on the right...

to the 2.7 kg Dragon Eye shown below.

The Unmanned Aircraft System

The UA flying beyond line-of-sight has an always-on satellite (Intelsat or Iridium) link to a ground station for telemetry and VHF radio relay.

The ground staff must reply to any Air Traffic Control voice communications with the UA so the UA appears to an Air Traffic Controller to be a conventional manned aircraft.

Unmanned Aircraft have already been used in civilian activities

Oil pipeline monitoring

Aeronautics Defence Systems provide pipeline monitoring services in Angola to ChevronTexaco under a **$ 4 million** contract.

More recently, Aeronautics Defence Systems have provided a similar service in Nigeria.

Problems with use of satellite imagery are:

-"It can take up to 14 days for the LEO satellite to be over the area of interest."

-"Bandwidth is **limited** and **expensive."**

UAV Systems The Global Perspective 2005
by Blyenburgh & Co

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.

Aerial photography: the most popular civilian application of Unmanned Aircraft

Aerial photography using CropCam

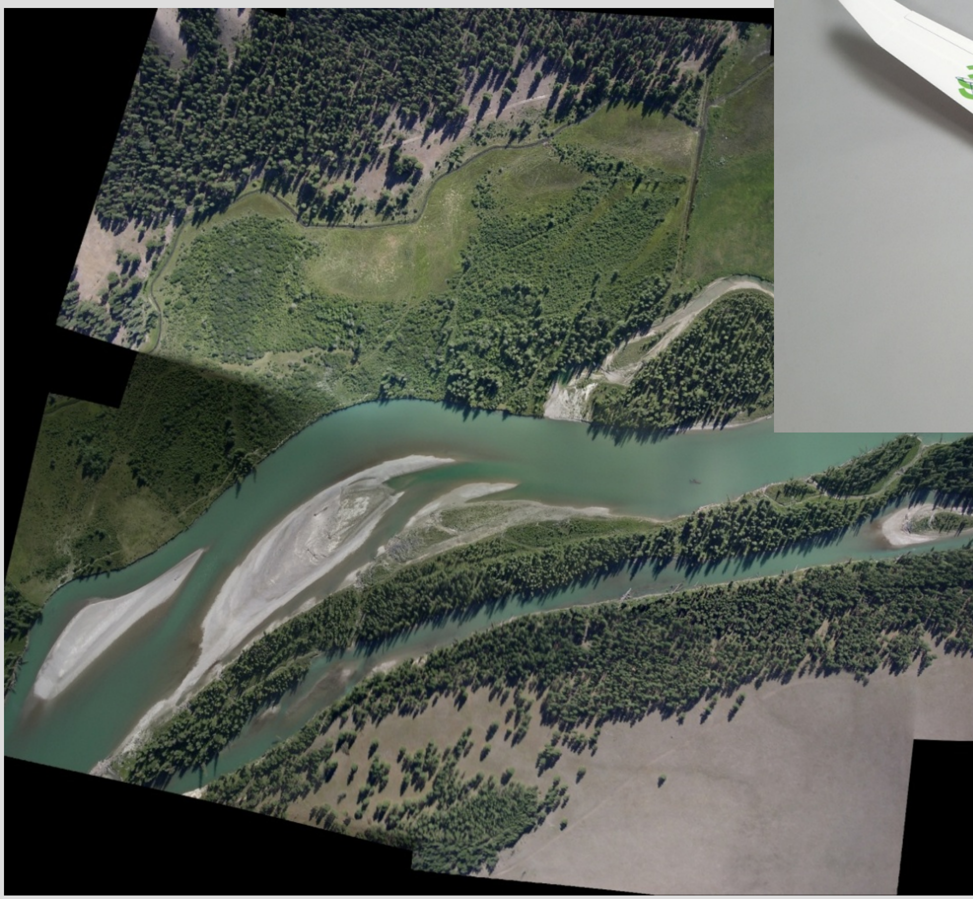


Image of 160 acres of land in British Columbia, derived from stitching together 12 separate images using the CropCam: from www.cropcam.com

The search part of “Search and Rescue”

This is an embryonic activity.

An example is the Australian
“Find Outback Joe Competition”

Queensland, Australia

28 September – 1 October 2009

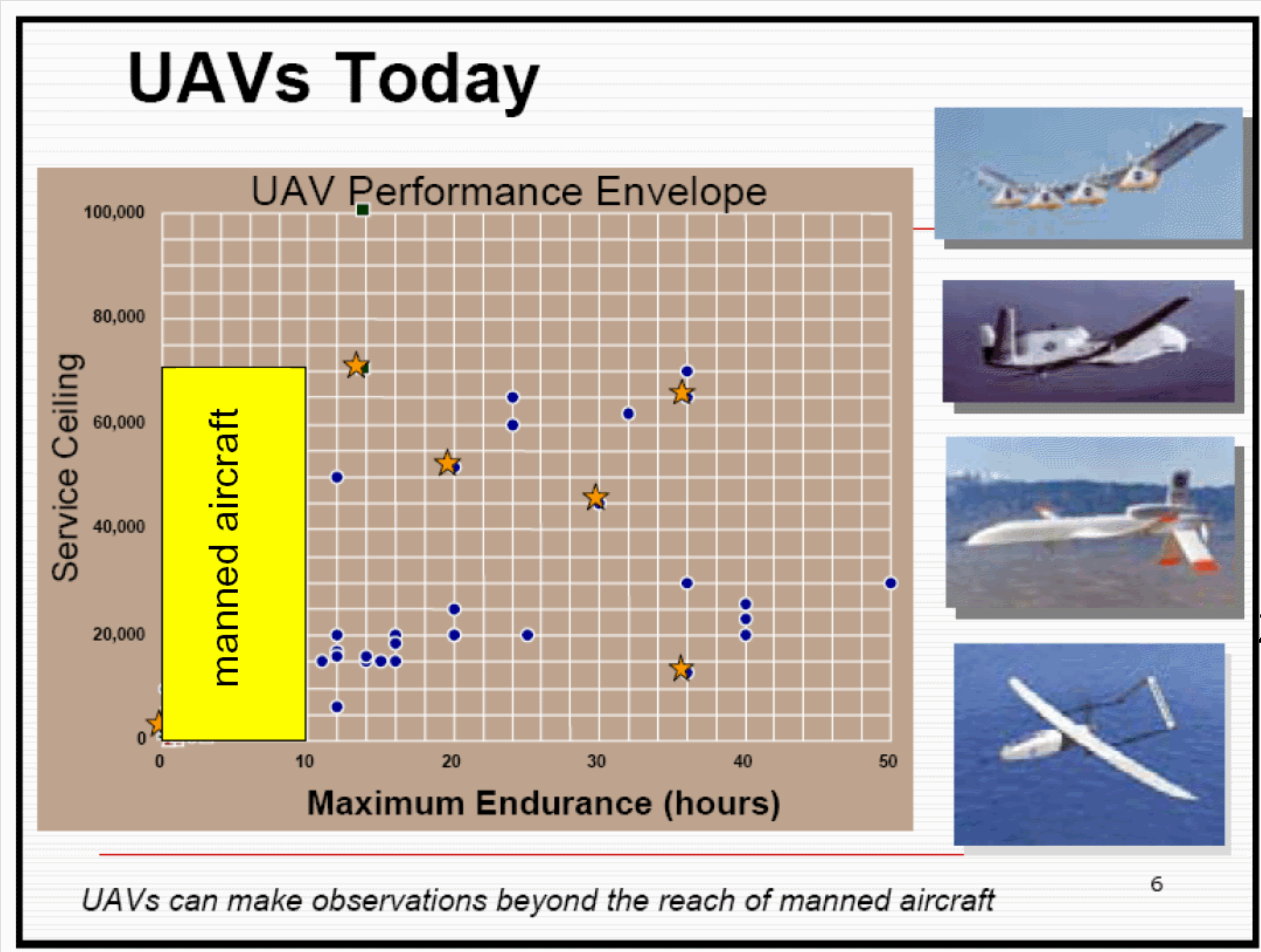
The system must be capable of finding Joe in the *Search Area*, located near Kingaroy airport. The UAV must fly through a defined corridor of approximately 1 nautical mile (nmi) in length and 0.2nmi in width to the Search Area. The *Mission Boundary,* allocated for the competition, is approximately 2 x 3nmi. The rural search area for locating Outback Joe will be 0.5nmi within this boundary. If at any time the UAV flys outside the Mission Boundary for the competition, the UAV’s mission will be terminated by the *Range Safety Officer (RSO).*

Results from this year's "Outback Joe" competition

In the open Search and Rescue Challenge, teams were unable to successfully rescue Outback Joe. However for the first time in the history of the UAV Challenge, two teams were able to pilot their UAV to the search area, earning encouragement awards of $7,500 each. Four other teams were awarded encouragement awards totalling $6,000.

The Unmanned Airborne Vehicles Outback Challenge was held at the Kingaroy Airport in Queensland.

What are the compelling capabilities of Unmanned Aircraft?



☆ Zephyr

Unmanned Aircraft can fly where pilots prefer not to go

Unmanned Aircraft can operate in areas where it would be irresponsible to expect pilots to fly:

- ❑ low level, night flights over the Arctic Ocean;

- ❑ flights over regions in which there is low level strife, where the larger manned survey aircraft provide target practice and some excitement for the locals.

The advantages of using Unmanned Aircraft in E & P activities

❑ Unmanned Aircraft **can fly lower and longer than a manned aircraft**. They can take-off and land on an unprepared patch of land, and can fly over dangerous terrain, and through plumes of toxic, radioactive, or unknown, gases.

❑ **Unmanned Aircraft cost less to operate per line km**, since:

- an Unmanned Aircraft operator can manage several UA at the same time;
- the Unmanned Aircraft uses less than 20% of the fuel used by a manned aircraft

❑ **Small Unmanned Aircraft are more environmentally friendly** since they:

- require less materials to build and is easier to dispose of at the end of its life;
- use less fuel and creates less pollution per km travelled;
- make less noise in flight.

❑ **Unmanned Aircraft can routinely fly missions covering the same area, day after day, night after night, to perform measurements for use in change detection and data averaging:**

- detecting people in rubble using differential thermal imaging, for example.

However, Unmanned Aircraft ("UA") have not yet seen widespread deployment...

- Unmanned Aircraft are not permitted to fly in commercial ("un-segregated") air space.

- UA do not have a protected aeronautical frequency band.

- UA are not sufficiently reliable. Almost all present day Unmanned Aircraft are single engine experimental aircraft which do not have air worthiness certificates

- UA have not yet clocked up sufficient flight hours to provide data for a convincing safety case, without which the National Aviation Authorities, such as the FAA, the CAA, and the like will not issue of Certificate of Authorization ("COA") to fly even in restricted air space.

- In the absence of sufficient flight hours, and a legally sound safety case, the insurance costs are astronomical, and blow any business case out of the water. Insurance costs are inversely related to flight hours: $10 million insurance cover cost = $k / n*100K_flight_hours.

- UA do not yet have a ~~**sense**~~ **detect and avoid system** to enable them to detect and avoid other airborne objects, such as the farmer flying a Cessna in the Canadian outback...

- Government security services need to be sure the Unmanned Aircraft cannot fall into the hands of, or be used by, or be taken over in flight by, criminals or terrorists.

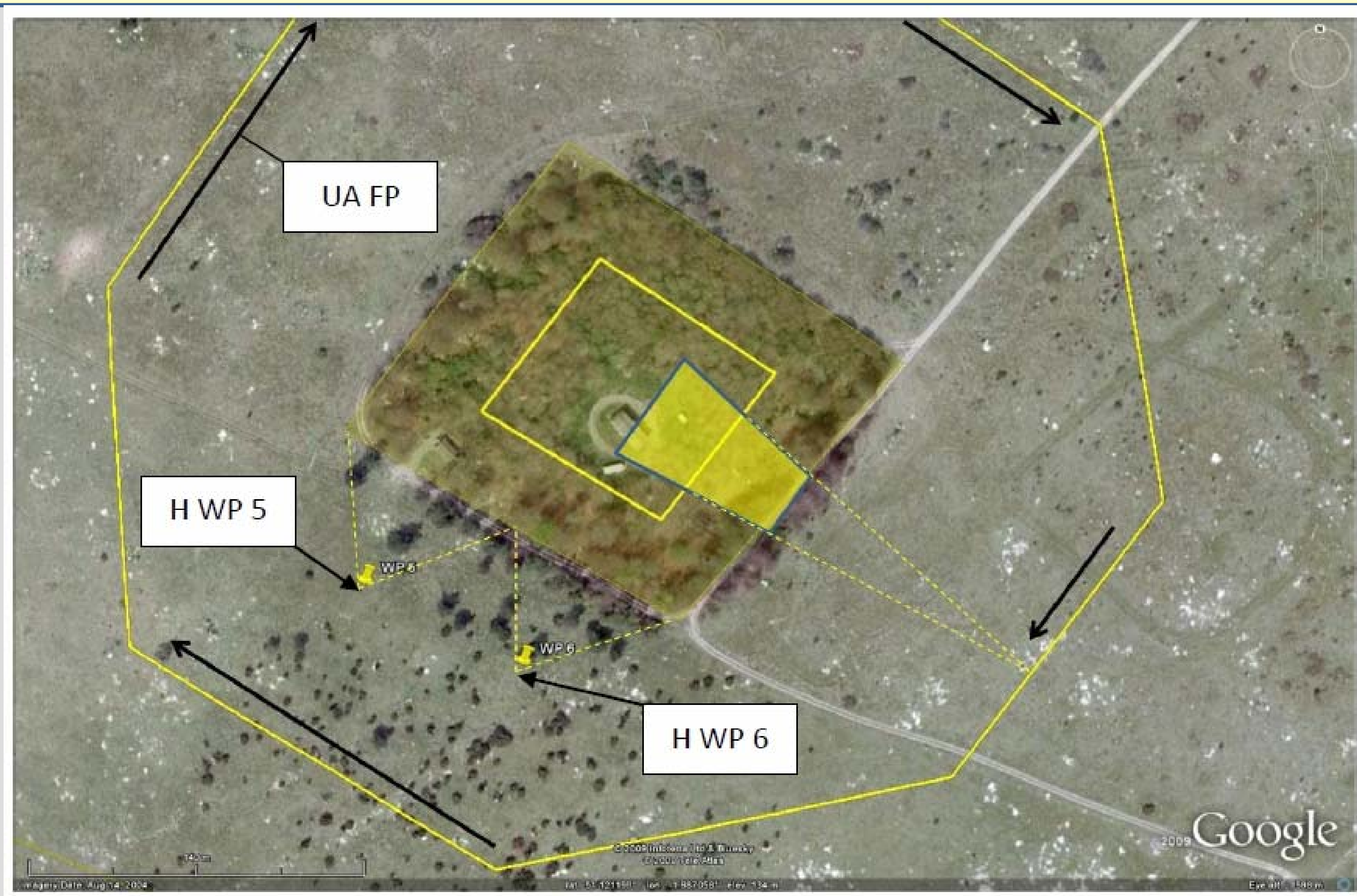
It will take a few years before we see UA in widespread commercial applications...

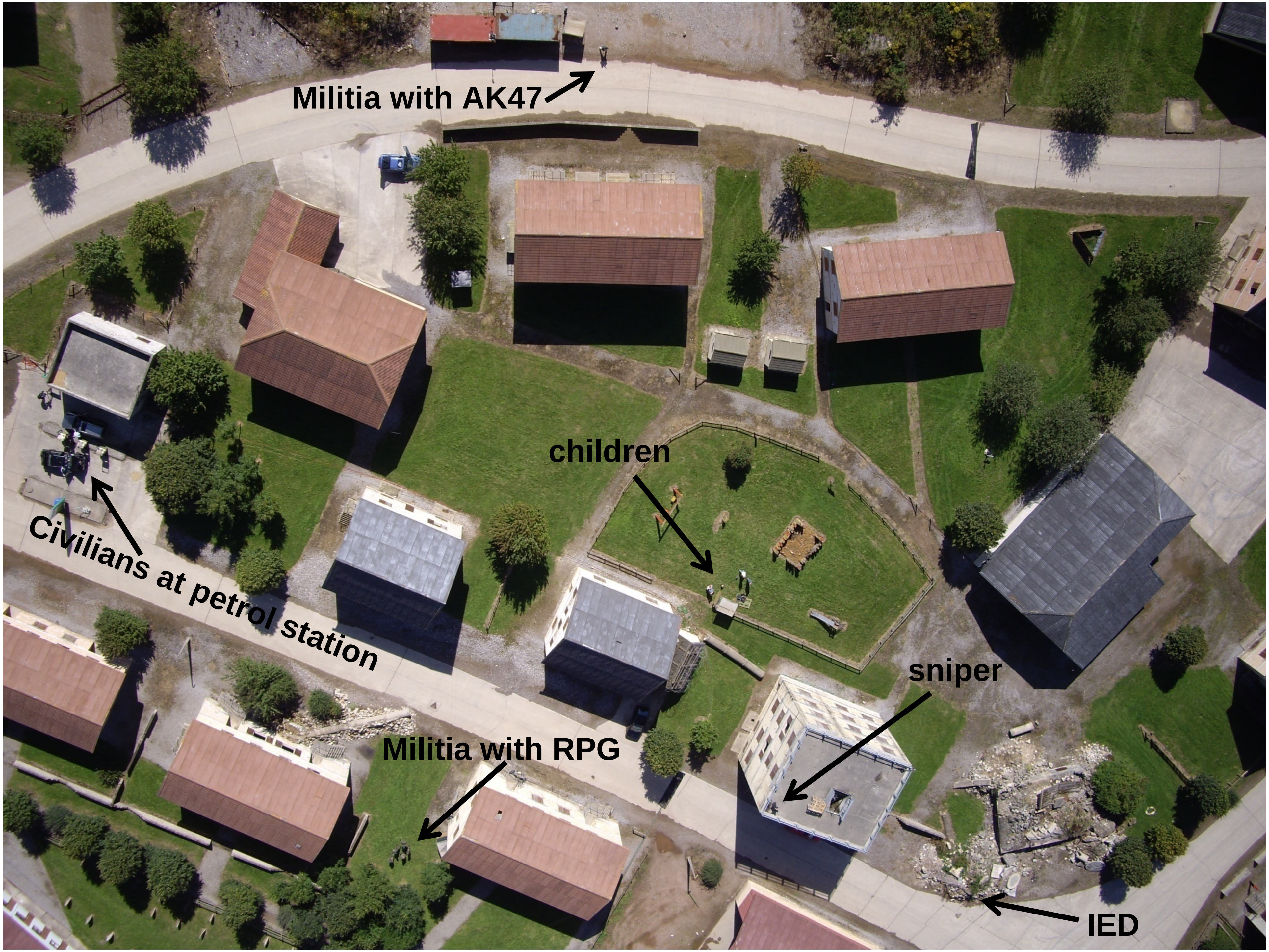
- UA systems developers are getting their flight hours and experience in the military sector.

Very useful operational experience is being gained in military surveillance work...

ranging from image resolution enhancement...

to persistent surveillance strategies, including data communication...




Militia with AK47
children
Civilians at petrol station
sniper
Militia with RPG
IED

For disaster management, UA need to operate in some cold parts of the Earth...

From a climate point of view, the Arctic region has some of the most severe weather conditions one could encounter:

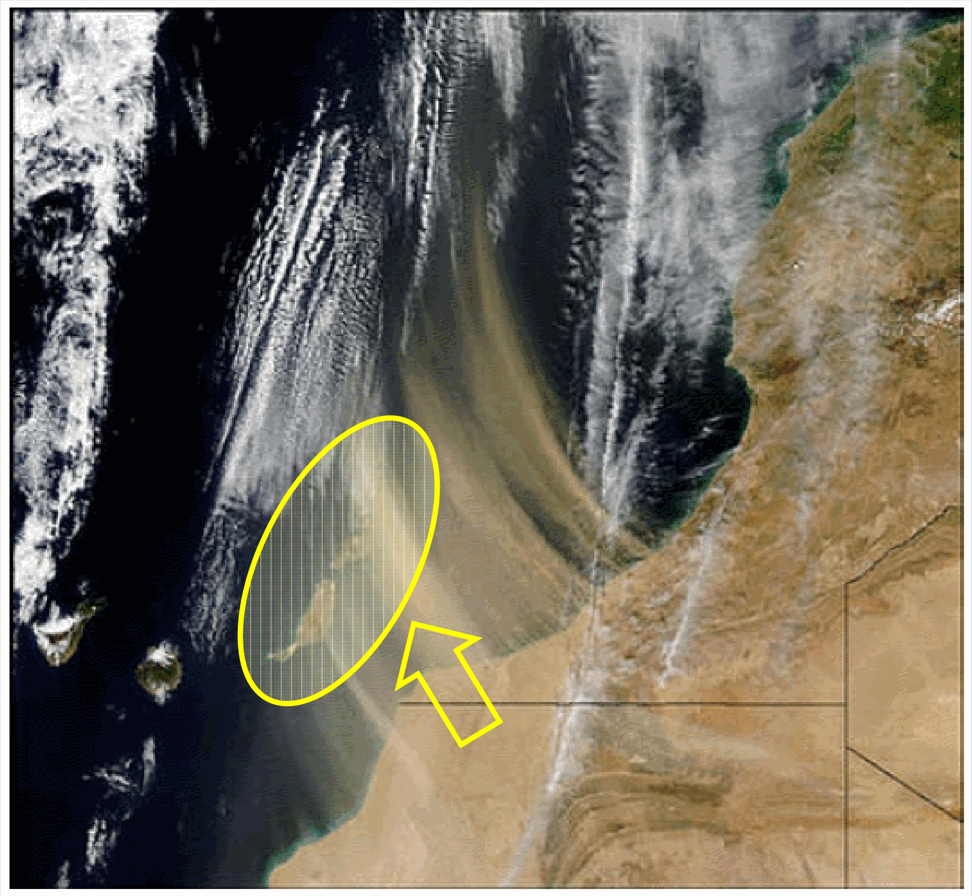
- ❑ Total darkness (in winter time)
- ❑ Temperatures: drop to -40C
- ❑ Spray icing
- ❑ Snow and ice

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

and in some very hot parts of the world...

In North Africa and in the Middle East, a survey plane could encounter:

- ❑ temperatures that reach +50C during the day;
- ❑ abrasive sand storms.

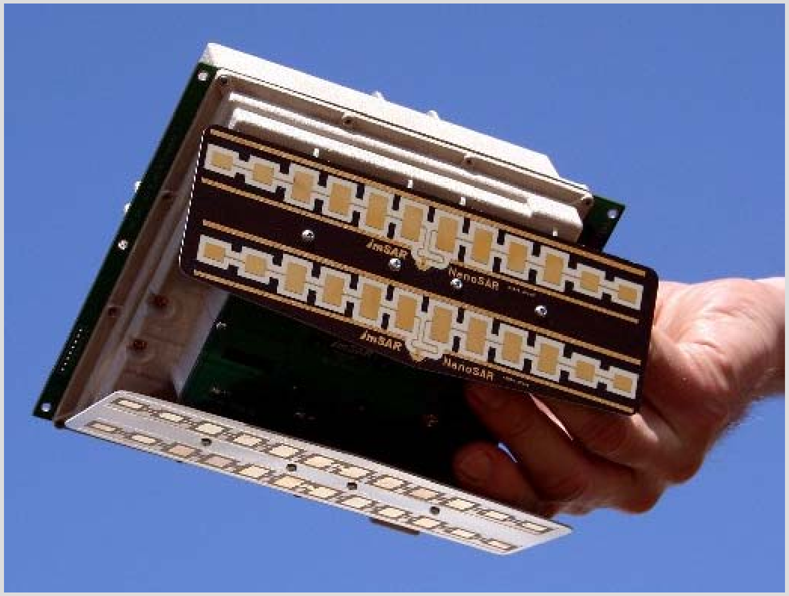


Satellite photograph of a dust storm showing fine sand from Morocco and Western Sahara (below Morocco) being blown over to Lanzarote and Fuertaventura.

Disaster area survey instruments typically weigh less than 10 kg

- ❑ High resolution (24.6 MPixel) digital camera
- ❑ 1.55 um InGaAs based near infrared and thermal imaging cameras
- ❑ Polarimetric (dual polarization) hyper-spectral imaging system
- ❑ Scanning LIDAR or mm RADAR unit for digital elevation mapping (DEM)
- ❑ Caesium or Potassium magnetometer for use in magnetic mapping
- ❑ Quantum cascade laser for ethane detection
- ❑ miniature SAR (such as the ImSAR NanoSAR)

Ideal Payload = 9 Kg



Above: the 1 kg NanoSAR from ImSAR, http://www.imsar.net/ has flown on a Scan Eagle

Synthetic Aperture RADAR (SAR) need not be hugely expensive...

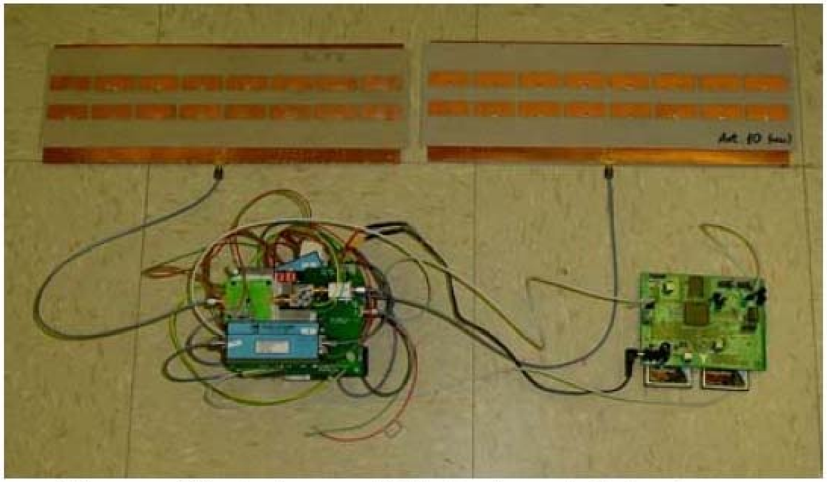


Figure 10. Antenna, RF stack and data storage device produced by BYU, operated by CU, flown by ACR

BYU = Brigham Young University
ACR = Advanced Ceramics Research

Figure 17. The MicroSAR mounted onto the electric Silver Fox UAV prior to launch in Greenland.

The ideal range for an Unmanned Aircraft engaged in disaster area survey work

A **high resolution survey typically covers an area of 20 x 20 = 400 square kilometers**:

2 flights x **1,569 line km** each.

For a typical **surrounding area survey can cover a 100 x 100 = 10,000 square km region:**

24 flights x **1,560 line km** each

An Unmanned Aircraft with a range of **1,800 km** would be suitable for disaster area survey work. From a logistics point of view, having a UA flying at 100 kph for 18 hours per flight, gives sufficient time for a regular aircraft servicing period and take-off time each day.

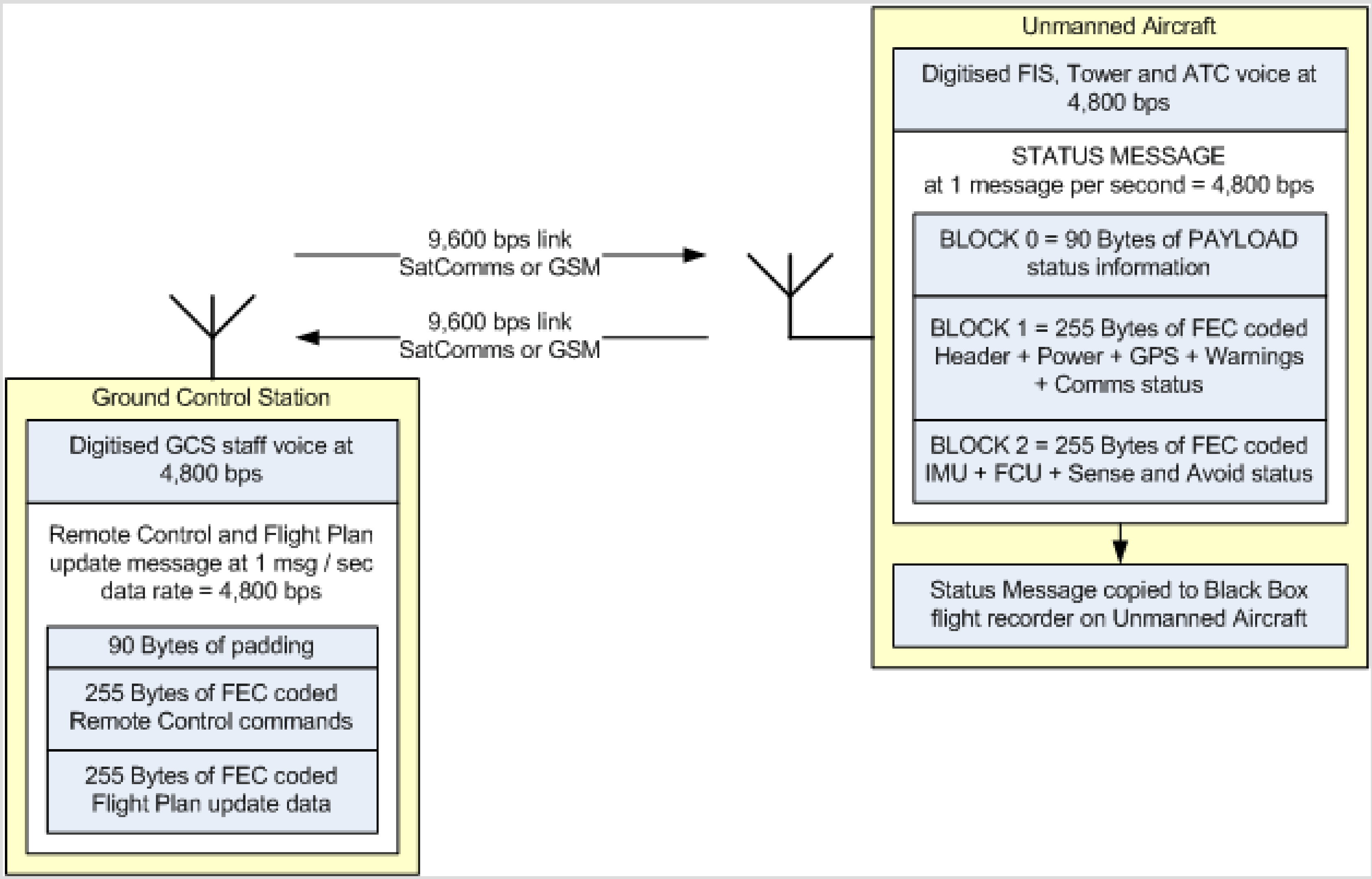
Ideal Range = 1,800 km BEYOND LINE OF SIGHT.

We need a Satellite Communications link!

Let's have a look at the communications link situation…

The above arrangement, or more sophisticated and costly variations, can be used for line-of-sight telemetry and video data links.

BLOS in-flight communications requirements if things are going well…



BLOS in-flight requirements if an emergency is encountered…

12.5 kHz bandwidth for Command and Control data link not including the video link required for take-off and landing (including emergency landing)			
Channel 1 BW = 6.25 kHz		Channel 2 BW = 6.25 kHz	
BW = 4.800 kHz CELP digitised voice at 4.8 kbps UA_VHF_Rx = FIS + TWR + ATC1 + ATC2 UA_VHF_Tx to TWR or ATC1 or ATC2	1.450 kHz guard band	BW = 4.800 kHz rate = 1 message / sec downlink UA to GCS = Status Message uplink GCS to UA = Remote Control + FPU	1.450 kHz guard band

+

n x BW = n x 12 MHz 3 video channels required per Unmanned Aircraft at take-off and landing (including emergency landing)			BW = 4 MHz emergency landing channel forward MPEG-2 VIDEO
BW = 4 MHz forward left MPEG-2 VIDEO	BW = 4 MHz forward MPEG-2 VIDEO	BW = 4 MHz forward right MPEG-2 VIDEO	

If a problem (sensor or systems failure, collision detected) is encountered en route, we very quickly require **<u>live video feed</u>** from cameras on the Unmanned Aircraft with a sudden and urgent need for a low latency, high bandwidth, high reliability satellite communications link.

Some considerations of a satellite communications link

Legal:

- Who assumes responsibility to assure the UA user of the availability of the link?

- If a satellite communications link malfunction is established as the cause of an accident, who will assume legal responsibility for the consequences of the accident?

- How will usage of the available, protected, bandwidth be policed?

Technical:

- A low latency (< 1 second) is required for Air Traffic Control voice relay.

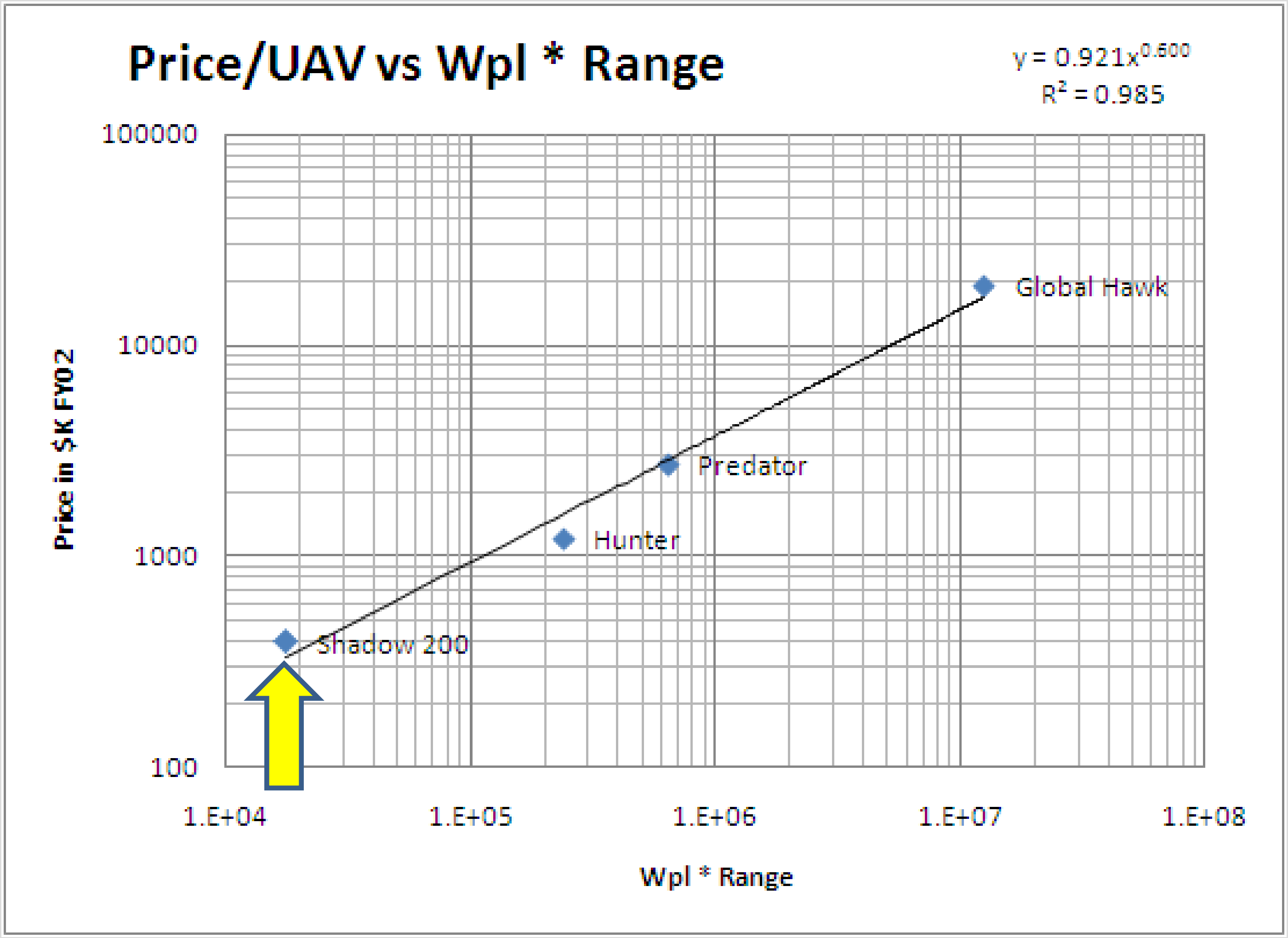
- Streaming video signals may be required, for example, in the monitoring of activities of pirates at sea. Each video channel could require a bandwidth of around 4 MHz.

- Global coverage is essential for developers to design in usage of a satellite system link.

Commercial:

- This solution will, in certain cases, compete with other solutions.

Estimated price for the ideal survey UA System = $310,000 FY [02]



9 kg x 1,800 km range *= 16,200 kg.km and price = 0.921 * 16,200^0.6 = $ 310,000.*

Caution over Unmanned Aircraft System prices... (UA Systems can be expensive)

The price of an Unmanned Aircraft System 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.

Reason:
- UA have a high Non Recurring Engineering ("NRE") expenses.
- The NRE costs of the Cessna are in the past.
- The Cessna is produced in larger quantities on equipment that has been written off.

Navigation instrument equipped Cessna Skylane 182-T

Max payload = 517 kg

Max range = 1,722 km

Price = $349,500

- from www.cessna.com

For disaster area survey and management, one requires an Unmanned Aircraft:

- ❑ with a long range, to enable the Unmanned Aircraft to cover a large survey area, cost effectively, between refueling;
- ❑ with low vibration engines to enable quality aerial photography and to increase the reliability of the Unmanned Aircraft;
- ❑ 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 Unmanned Aircraft on launcher, from uav_roadmap2005.pdf.

Work is taking place to enable UA to be used in un-segregated air space.

- Work on the development of ~~sense~~ detect and avoid systems is underway in the USA, Europe and in the Far East. The view is that once proven on Unmanned Aircraft, these systems will become mandatory on manned aircraft.

- The World Radio Conference will next meet in 2011, where it is hoped there will be progress on an assignment of a protected aeronautical frequency band for UA use.

- Many of the National Aviation Authorities have assigned staff to develop the regulations for Unmanned Aircraft flight in non-segregated air space:
  - US FAA and RTCA SC-203
  - EUROCONTROL and EuroCAE Working Group 73 on UAVs
  - Australian, Belgian, Canadian, Dutch, Austrian, South African, Swedish and U.K. CAA

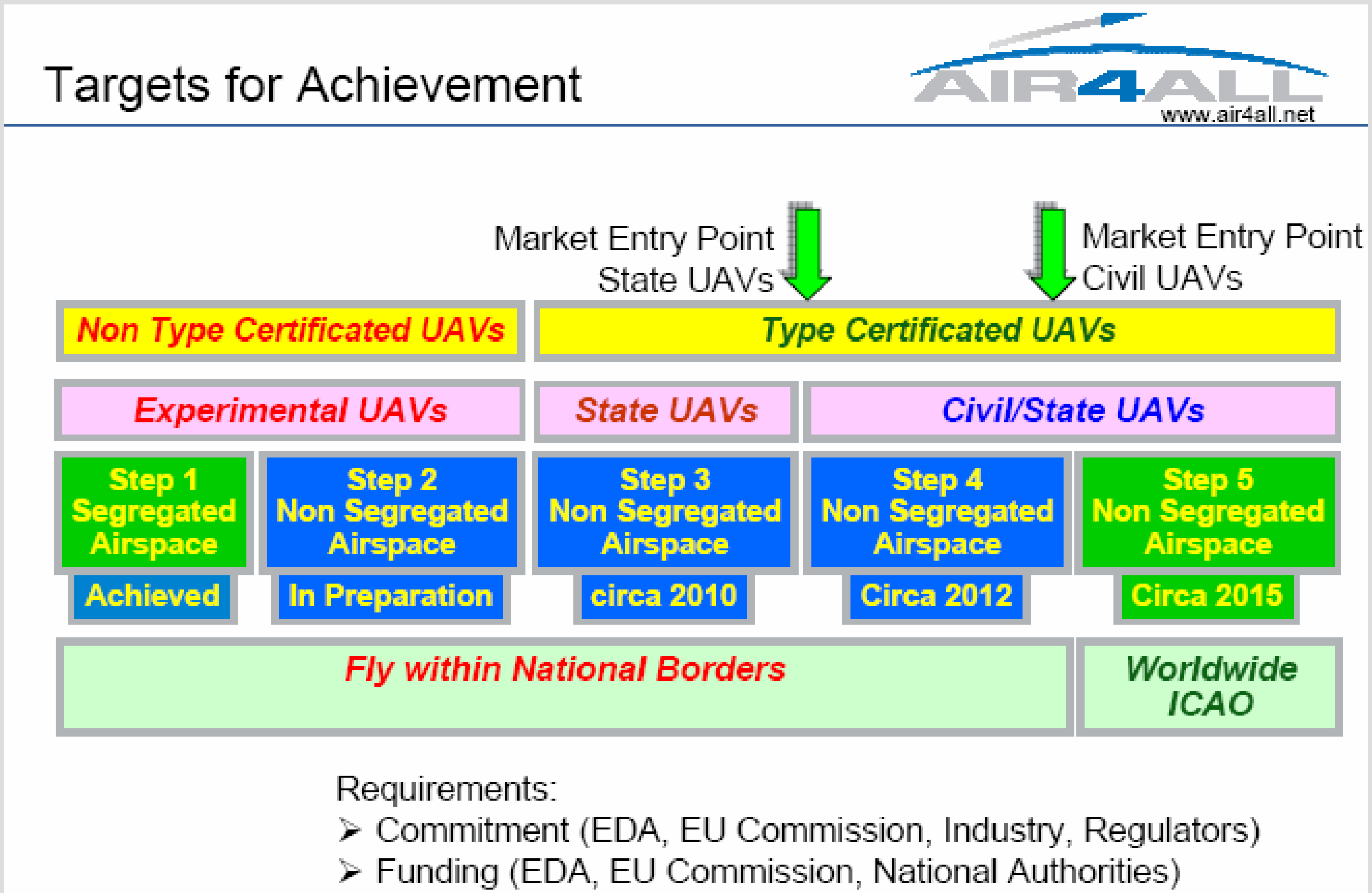
- Both the FAA and EUROCONTROL are investigating solutions to the UA security aspects.

- The EU, ESA and EDA have initiated funding for Unmanned Aircraft related projects.

- If experiences in the military area are anything to go by, Unmanned Aircraft will provide copious amounts of high quality data. Developing software to interpret high resolution data will become a high priority and a new market area for scientific and AI software developers.

The time table, give or take a few years...

It will take about five years to develop and test high performance, Unmanned Aircraft for geophysical applications. **That will take us to circa 2015**.



In conclusion

The Unmanned Aircraft has much to offer in the areas of disaster area survey and management. However, the reliability of the Unmanned Aircraft needs to be improved.

Unmanned Aircraft need to fly in un-segregated air space before large scale use can be made of this technology. Work is underway at EuroCAE WG-73, the European Space Agency, the European Defence Agency and the US RTCA SC-203, to name a few organizations, to develop recommendations to enable Unmanned Aircraft to fly in un-segregated air space.

- ❑ A huge amount of experience is being gained in military operations.
- ❑ Satellite communication is an essential component of Unmanned Aircraft operation when flying Beyond-Line-of-Sight.
- ❑ In this respect, it is important at an early stage to consider:
    - ❑ the detailed legal and insurance aspects of this service
    - ❑ the technical aspects, including reliability, latency and bandwidth
    - ❑ commercial aspects, since some activities can be performed using manned aviation