THE UNIVERSITY OF ADELAIDE AUSTRALIA

Mechanical Engineering

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AERONAUTICAL ENGINEERING
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CLASSIFICATION OF UNMANNED AERIAL VEHICLES

http://www.airforce-technology.com/projects/x47/

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1. Introduction

Unmanned Aerial Vehicles, or UAVs, as they have sometimes been refered to, have only been in service for the last 60 years. UAVs are now an important addition to many countries air defences. Modern UAVs have come a long way since the unmannned drones used by the USAF in the 1940s. These drones were built for spying and reconnaissance, but were not very efficient due to major flaws in their operating systems. Over the years UAVs have been developed into the highly sophisticated machines in use today. Modern UAVs are used for many important applications including coast watch, news broadcasting, and the most common application, defence.

With a growing number of UAVs being developed and flown in recent years there is the problem of classifying these new UAVs. As UAVs are used in a variety of applications it is difficult to develop one classification system that encompasses all UAVs. It has been decided that the UAVs will be classified into the two main aspects of a UAV, their performance specifications and their mission aspects. The specifications of a UAV include weight, payload, endurance and range, speed, wing loading, cost, engine type and power. The most common mission aspects are ISTAR, Combat, Multi-purpose, Vertical Take-off and landing, Radar and communication relay, and Aerial Delivery and Resupply. It is important to have a classification system for UAVs as when a specific UAV is needed for a mission it can be easily chosen from the wide varity of UAVs avaliable for use.

1.1 UAVs considered in this report:

1) Pioneer 2) Predator 3) Global Hawk 4) Darkstar	Tier UAVs
5) Hunter 6) Outrider 7) Shadow 8) Fire Scout 9) Predator B	RQ UAVs

10) Neptune
11) Dragon Drone
12) X-50
13) LEWK
14) Finder
15) Dragon Eye
16) FPASS
17) A 160
18) SilentEyes
19) Dragon Warrior
20) GNAT
21) Silver Fox
22) Herron
23) Phoenix
24) RPO Midget
25) Pointer
26) X-45
27) Crecerelle
28) Raven
29) Luna
30) Sperwer
31) Seeker
32) Shadow 600
33) Brevel
34) Cypher
35) Javelin

1.2 UAV Characteristics Table

UAV	Weight (kg)	Payload (kg)	Endurance (hr)	Range (km)	Ceiling (m)	Speed (km/h)	Wing Span (m)	Wing Loading (kg/m^2)	Engine	Power(kW)	Cost
Pioneer	125	64	5	373	4,572	175	5	34	two-stroke	22	$ 650,000.00
Predator	1,020	600	20	740	7,920	217	15	89	piston engine	78	$ 1,700,000.00
Global Hawk	11,600	900	30	22,000	20,000	636	35	199	turbofan		$ 20,000,000.00
Darkstar	3,900	454	12	925	19,800	464	21	74	turbofan		
Hunter	800	226	15	200	6,100	222	7	152	push and pull diesel		$ 1,200,000.00
Outrider	227	50	3	200	4,570	203	4	72	UEL Rotary	31	
Shadow	149	75	5	125	4,270	204	4	79	UEL Rotary	28	$ 325,000.00
Fire Scout	1,159	90	6	400	6,096	231	9	69	rolls royce allison	315	$ 1,800,000.00
Predator B	4,500	3,000	24	1,500	15,200	405	20	83	turboprop	670	
Neptune	36	10	4	75	2,440	156	2	74	2-stroke piston	11	
Dragon Drone	41	11	3	148	3,048	160	2	22	piston engine		
LEWK	364	91	8	1,600	4,572	278	5	117	puller prop		
Finder	26	6	10	648	4,570	70	3	28	Piston		
Dragon Eye	2	0	1	5	305	65	1	5	Twin Electric motors		$ 35,000.00
FPASS (Desert Hawk)	3	1	1	10	300	92	1	18	Electric Motor		
A 160	818	136	30	4,625	9,144	225	11	18	piston engine	300	
SilentEyes	5	2	0	122	7,620		1	93			
Dragon Warrior	91	11	1	90	5,486	185	3	66	Twin Electric	29	
GNAT	516	63	40	4,818	8,000	130	11	74	Rotax Piston	60	
Silver Fox	12	0	9	41	3,657	203	2	34	1-cylinder		
Herron	1,087	227	40	3,300	10,000	207	17	70	4 stroke turbo	115	
Phoenix	177	50	4	100	2,700	155	6	32	wae 342	19	
RPO Midget	45	20	4	100		150	2		Two Stroke	11	
Pointer	4		1	2	300	73	3	6	electric motor	0	
X-45	3,636	681	3	920	10,668	950	10	79	Honeywell		
X-50	811	91	4	400	3,048	741	4	212	Turbofan		
Crecerelle	120	35	6	59	3,353	246	3	9	Piston	20	
Raven	84	17	4	100	4,267	204	3	57	Electric	10	$ 250,000.00
Luna	40	10	4	80	4,000	160	4	40	Electric Motor	5	
Sperwer	350	45	5	193	5,182	256	4	146	pusher prop	53	$ 3,000,000.00
Seeker	255	50	12	200	4,877	222	7	29	Piston		
Shadow 600	273	41	14	200	4,877	190	7	88	Rotary	39	
Brevel	150		4	80	3,962	150			1-piston	16	
Cypher	136	20	3	30	1,524	148			rotary piston	39	
Javelin	9	1	1			101			electric		

2. History

2.1 Timeline

1922 – First Launch of an unmanned aircraft (RAE 1921 Target) from an aircraft carrier (HMS Argus).

3 September 1924 – First successful flight by a radio controlled unmanned aircraft without a safety pilot onboard; performed by the British RAE 1921 Target 1921, which flew 39 minutes.

1933 – First use of an unmanned aircraft as a target drone; performed by a Fairey Queen for gunnery practice by the British Fleet in the Mediterranean.

12 June 1944 – First combat use of an unmanned aircraft (German Fi-103 “V-I”) in the cruise missile role.

19 October 1944 - First combat use of an unmanned aircraft (U.S. Navy TDR-1 attack drone) in the strike role, dropping 10 bombs on Japanese gun positions on Ballale Island.

April 1946 – First use of unmanned aircraft for scientific research; performed by a converted Northrop P-61 Black Widow for flights into thunderstorms by the U.S. Weather Bureau to collect meteorological data.

1955 – First flight of an unmanned aircraft designed for reconnaissance; performed by the Northrop Radioplane SD-1 Falconer/Observer, later fielded by the U.S. and British armies.

12 August 1960 – First free flight by an unmanned helicopter; performed by the Gyrodyne QH-50A at NATC Patuxrnt River, Maryland.

20-21 August 1998 – First trans-Atlantic crossing by an unmanned aircraft; performed by the Insitu Group's Aerosonde Laima between Bell Island, Newfoundland, and Benbecula, Outer Hebrides, Scotland.

22-23 April 2001 – First trans-Pacific crossing by an unmanned aircraft; performed by the Northrop Grumman Global Hawk "Southern Cross II" between Edwards AFB, California, and RAF Edinburgh, Australia.

2.2 Country

The two main countries involved in UAV development are the USA and Israel, both these countries are the world leaders in UAV design.

- The USAF tends to classify their main operational UAVs using the RQ abbreviation.
- The prefix IAI (Israel Aircraft Industry) is used for the majority of the UAVs that Israel produces.
- These two main countries then sell these developed UAVs to other world countries, depending on their needs. As some counties need then for reconnaissance while other need them for battle purposes.
- Not only is there interest in battle UAVs, but there is also a commercial interest for non-military UAVs. This commercial interest has lead to private developers in different countries designing and developing UAVs.
- The Australian aerospace industry has been developing UAVs since the early 1950s. The development of UAVs in recent years has assisted the Australian army in surveillance and coast watch.

3. Classification by Performance Characteristics

UAVs can be classified by a broad number of performance characteristics. Aspects such as weight, endurance, range, speed and wing loading are important specifications that distinguish different types of UAVs and give rise to useful classification systems. The cost, wing span and maximum altitude are also features which can be considered to compare and classify UAVs. Further, the engine type and maximum power developed will also be examined and a classification based on these parameters will also be presented. All the UAVs considered in this report are presented in the following table which displays all the performance characteristics mentioned above. This table can be used as a reference to look up specific values of performance for any UAV.

Classification by performance characteristics is useful for designers, manufacturers and potential customers because it enables these groups to match their needs with the performance aspects of UAVs.

Important Performance Characteristics:

1) Weight
2) Endurance and Range
3) Maximum Altitude
4) Wing Loading
5) Engine Type
6) Power/Thrust Loading

3.1 Classification by Weight

UAVs cover a wide range of weights, from micro UAVs which weigh only a few pounds, right up to the massive Global Hawk (Tier III) which weighs over 11 tonnes. The following graph shows the weights of all the UAVs considered and it can be seen that there are only a few that weigh more than two tonnes and the majority of UAVs are quite light.

Upon examination of the subsequent graphs four classifications are proposed to distinguish UAVs by weight.

- Firstly ‘super heavy weight’ UAVs which are those with take-off weights of over 2 tonnes. This classification will include the X-45, Darkstar, Predator B and Global Hawk.

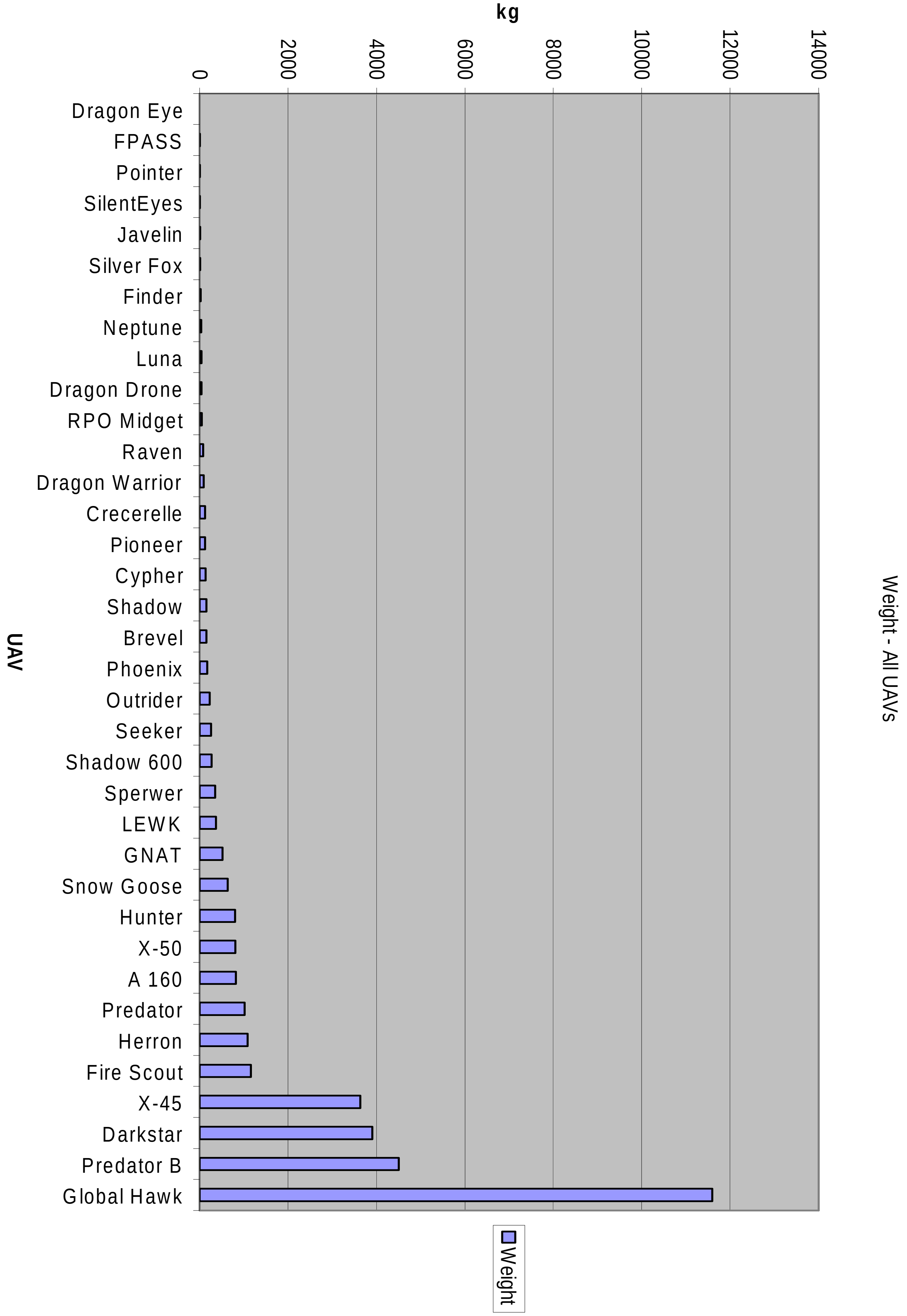
- The next classification would be the ‘heavy weight’ UAV which would be UAVs which weigh between 200 and 2000 kg. The ‘heavy weight’ classification would include all UAVs between the Outrider and the Fire Scout.

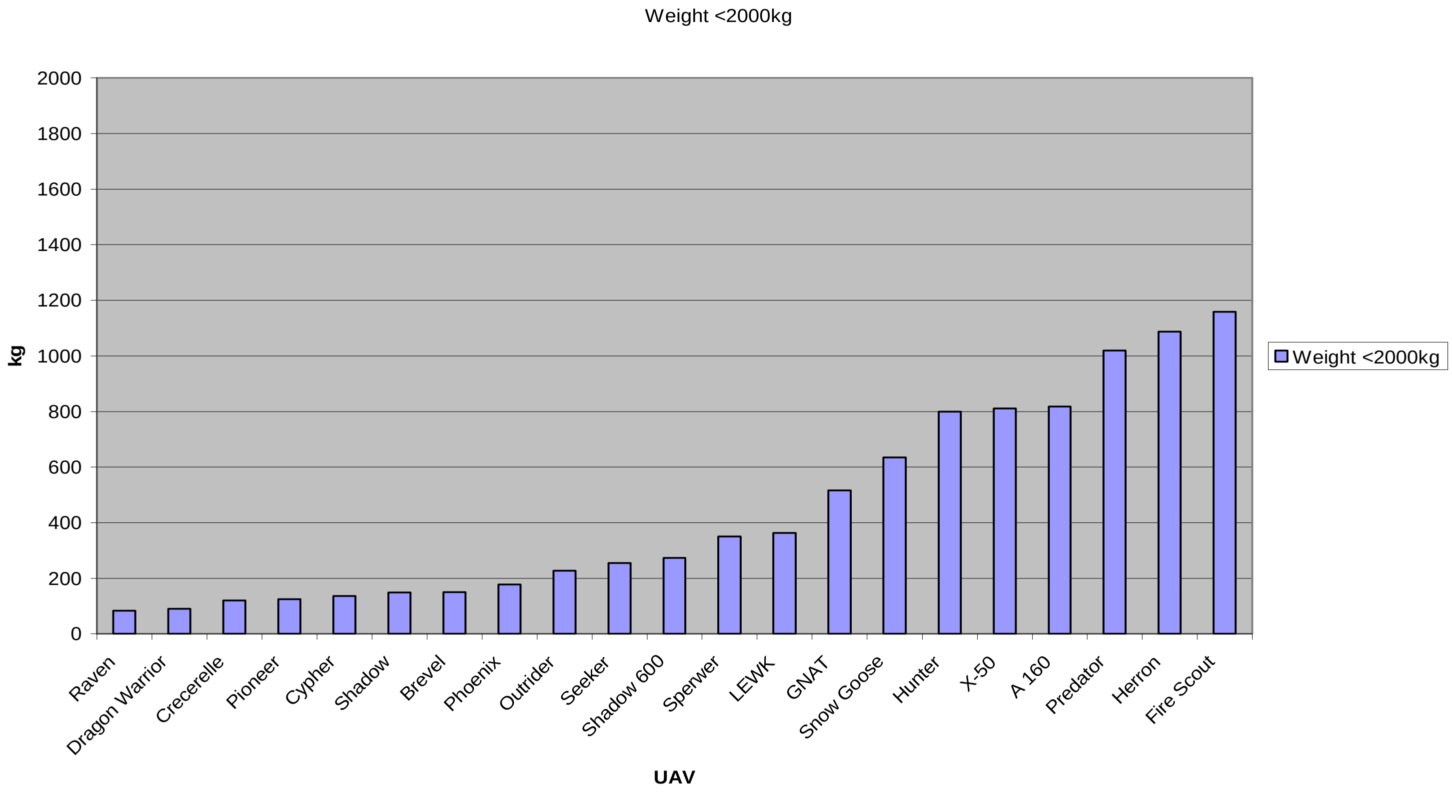
- The third classification would be the medium weight UAV which includes weights 50kg up to 200 kg. This includes the Raven up to the Phoenix. Another classification is the ‘light weight’ UAVs which are between 5 and 50 kg.

- Finally there is a micro UAV (MAV) classification for UAVs under 5 kg. This included the Dragon Eye, FPASS, Pointer and SilentEyes. Many of the other performance characteristics are related to the weight of the UAV. For example more lift and thrust will be needed for increased weight therefore wingspan will increase and the type of power plant chosen will differ. The light weight UAVs use primarily electric motors while the super heavy weights commonly use turbo jets or turbo fan engines.

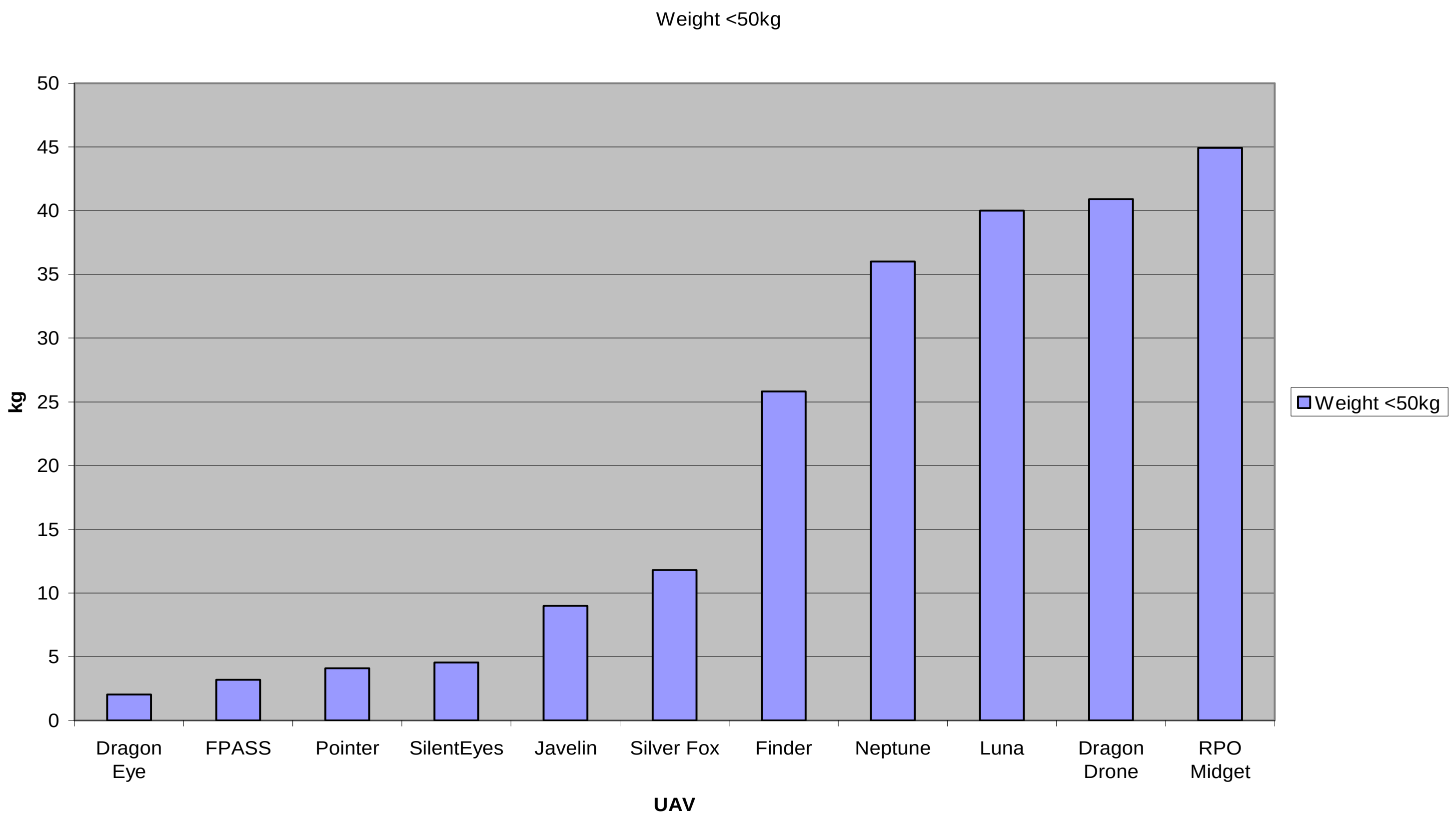
Classification by Weight		
Designation	**Weight Range**	**Example**
Super Heavy	>2000 kg	Global Hawk
Heavy	200 – 2000 kg	A-160
Medium	50 – 200 kg	Raven
Light	5 – 50 kg	RPO Midget
Micro	<5 kg	Dragon Eye

The Dragon Eye Micro UAV, Internation Defence Online Magazine (2006).


Weight - All UAVs
kg
0
2000
4000
6000
8000
10000
12000
14000
UAV
Dragon Eye
FPASS
Pointer
SilentEyes
Javelin
Silver Fox
Finder
Neptune
Luna
Dragon Drone
RPO Midget
Raven
Dragon Warrior
Crecerelle
Pioneer
Cypher
Shadow
Brevel
Phoenix
Outrider
Seeker
Shadow 600
Sperwer
LEWK
GNAT
Snow Goose
Hunter
X-50
A 160
Predator
Herron
Fire Scout
X-45
Darkstar
Predator B
Global Hawk
Weight



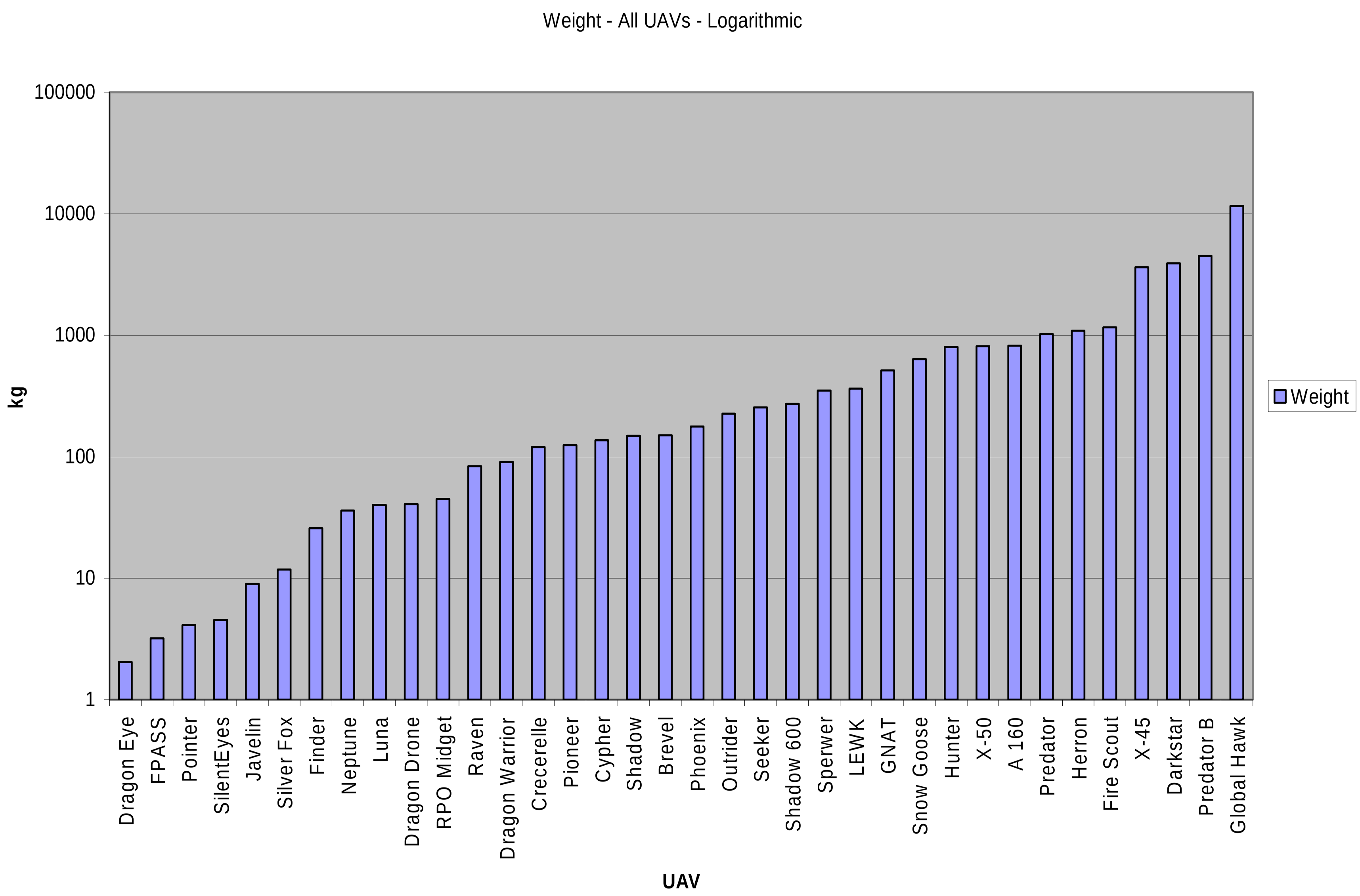
This graph shows the medium and heavy weight UAVs in more detail.



The above graph shows the micro and light weight UAVs in more detail.

The following graph shows the weights of all the UAVs on a logarithmic scale.

This more clearly shows the distribution, especially of the lighter UAVs.


Weight - All UAVs - Logarithmic
kg
100000
10000
1000
100
10
1
Dragon Eye
FPASS
Pointer
SilentEyes
Javelin
Silver Fox
Finder
Neptune
Luna
Dragon Drone
RPO Midget
Raven
Dragon Warrior
Crecerelle
Pioneer
Cypher
Shadow
Brevel
Phoenix
Outrider
Seeker
Shadow 600
Sperwer
LEWK
GNAT
Snow Goose
Hunter
X-50
A 160
Predator
Herron
Fire Scout
X-45
Darkstar
Predator B
Global Hawk
UAV
Weight

3.2 Classification by Endurance and Range

Another useful classification method for UAVs is to categorize them by endurance and range. These two parameters are usually interrelated as obviously the longer a UAV can say airborne the larger its radius of operation is going to be. It is important to consider range and endurance because it enables the UAV designer to determine the type of UAV required depending upon how far the mission objective is from the launch site. Also it determines how regularly refuelling is required and would effect how much time can be spent with the UAV performing its task and how much time it needs to spend grounded.

Three classifications are proposed and these are long, medium and short endurance/range.

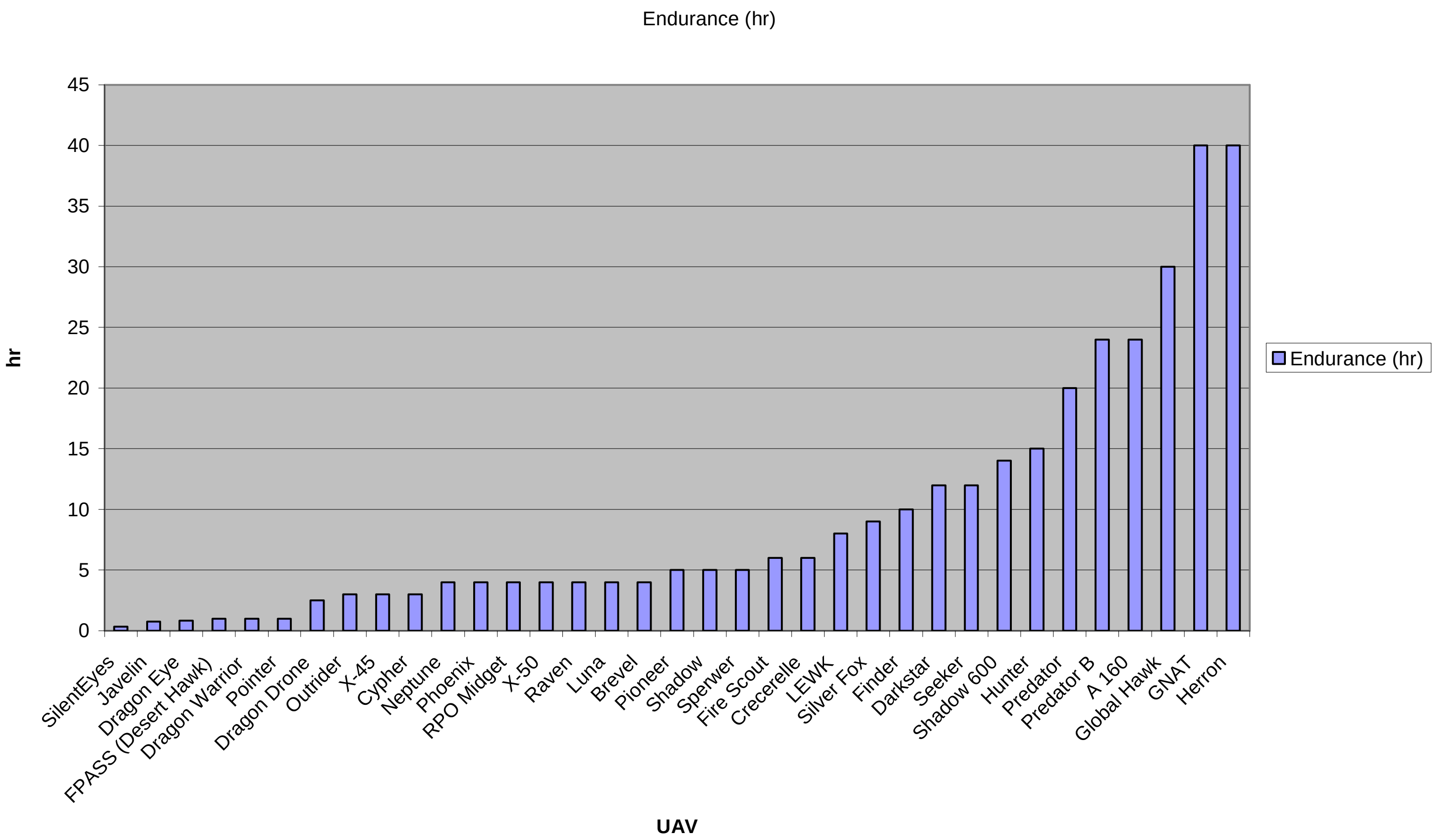
- The long endurance UAVs are those that can stay airborne for 24 hours or more. The range for these UAVs are also high, starting from 1500 km up to 22000 km for the Global Hawk.

- The medium endurance UAVs are those with endurance between 5 and 24 hours. These include the shadow 600 up to the Predator. This is the most common type of UAV.

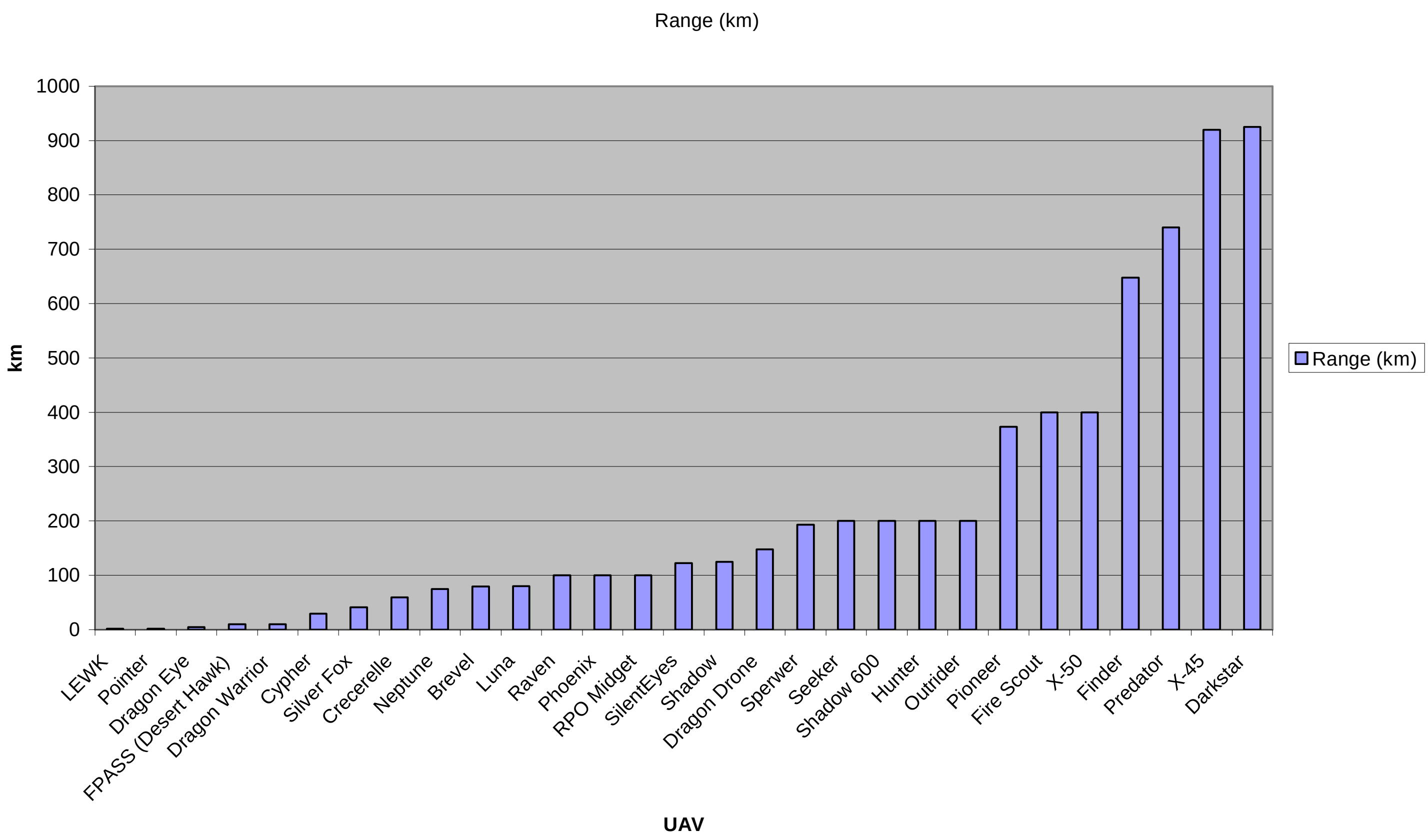
- The third class is the low endurance UAV which have less that 5 hours endurance. These are used for short missions such as ‘seeing over the next hill’ which is a safer method of reconnaissance than sending troops into unfamiliar territory.

Range and Endurance			
Category	**Endurance**	**Range**	**Example**
High	>24 hours	>1500km	Predator B
Medium	5 – 24 hours	100 – 400 km	Silver Fox
Low	< 5 hours	< 100 km	Pointer

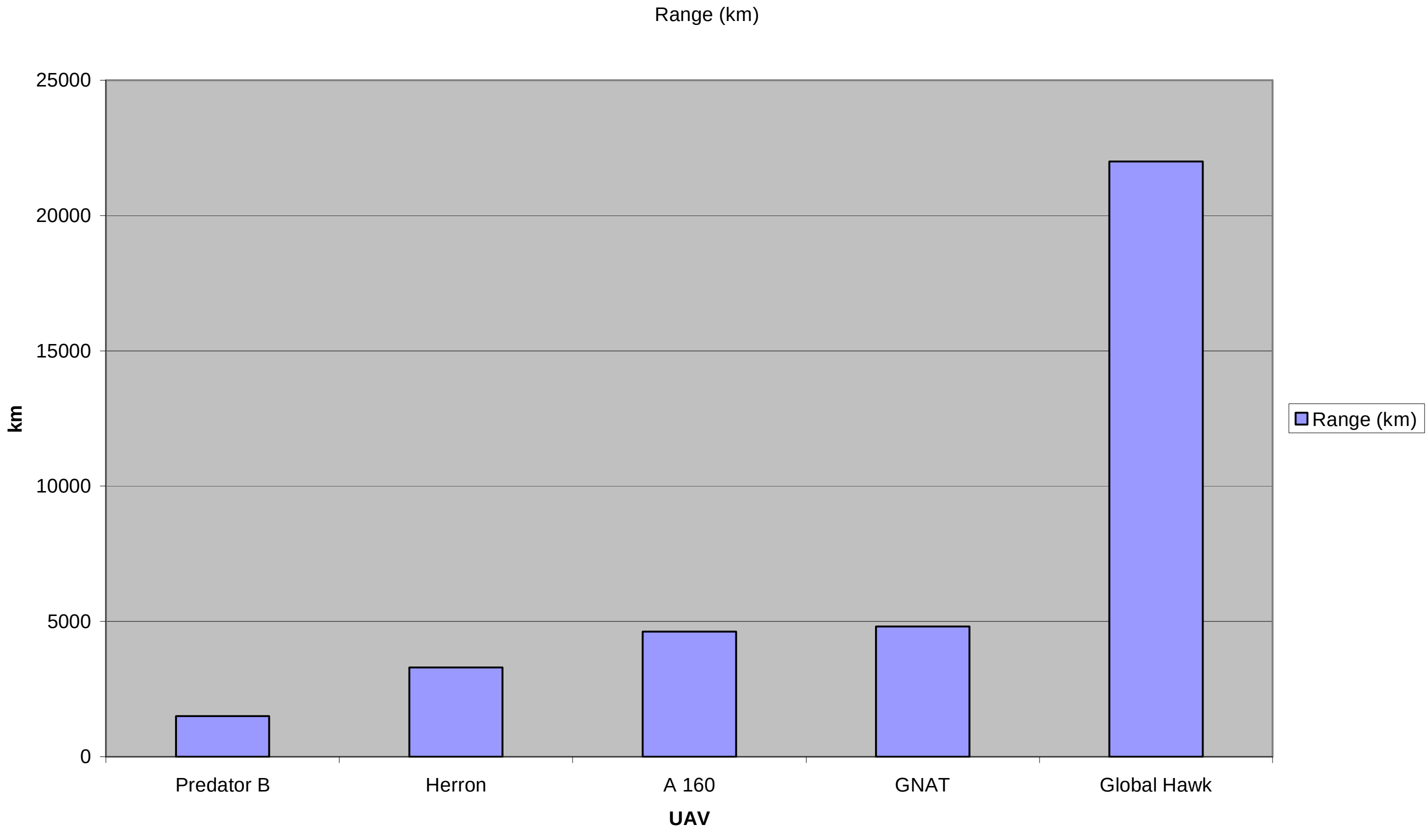
The Pointer UAV in use on the battlefield, AeroVironement Inc (2006).



Endurance for all UAVs.



Range of the UAVs excluding those over 1000 km for scale purposes.



Range for the UAVs over 1000km. These are the high endurance UAVs.

3.3 Classification by Maximum Altitude

The maximum operational altitude, or flight ceiling, is another performance measure by which UAVs can be classified. This is also useful for designers or choosing a UAV to purchase so the customer can select a UAV that meets their altitude needs. Some UAVs in military situations are required with low visibility to avoid being detected and destroyed by the enemy therefore high altitude is an important requirement. Also for imaging and reconnaissance a high altitude is required to obtain images of the maximum amount of terrain.

A low, medium and high altitude classification is proposed for dividing the UAVs by maximum ceiling.

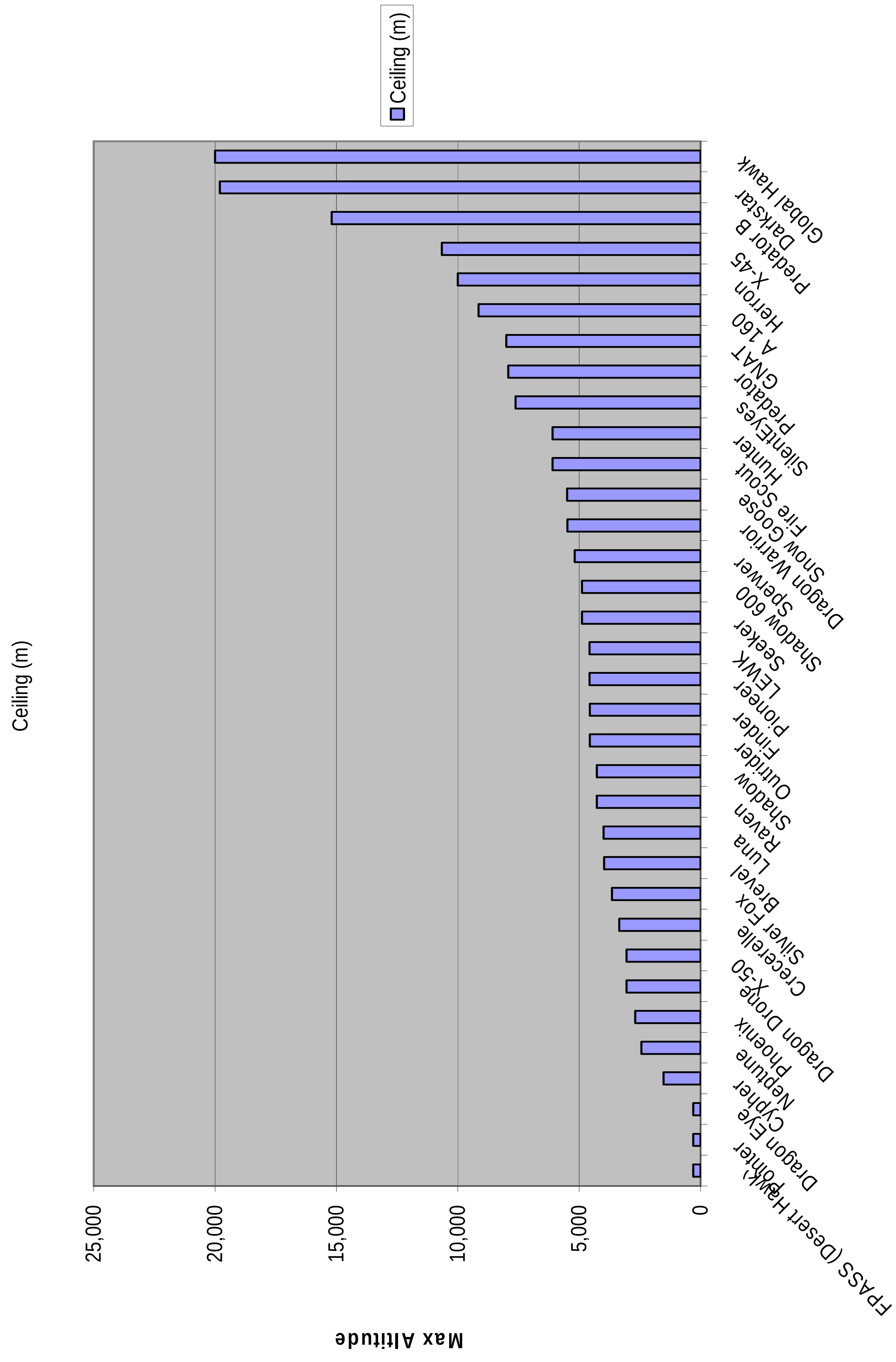
- Low altitude is any UAV that flies up to 1000m. These UAVs are the micro UAVs and include the FPASS, Pointer and Dragon Eye. These UAVs don’t have much use at this stage and are primarily experimental.

- Medium altitude is the category of UAVs with maximum altitude between 1000m and 10000m. The majority of UAVs fall into this category.

- High altitude is all UAVs that can fly over 10000m. This includes the X-45, predator B, Darkstar and Global Hawk. There is concern that these UAVs may interfere with commercial and military manned aircraft and high tech collision avoidance systems are being developed and integrated into these UAVs that fly in populated airspace

Classification by Maximum Altitude		
Category	**Max Altitude**	**Example**
Low	< 1000 m	Pointer
Medium	1000 – 10000 m	Finder
High	> 10000 m	Darkstar

The Darkstar on display at a USAF base, Aeronautics (n.d.)



Ceiling (m)
Ceiling (m)
Max Altitude
25,000
20,000
15,000
10,000
5,000
0
UAV
FPASS (Desert Hawk)
Pointer
Dragon Eye
Cypher
Neptune
Phoenix
Dragon Drone
X-50
Crecerelle
Silver Fox
Brevel
Luna
Raven
Shadow
Outrider
Finder
Pioneer
LEWK
Seeker
Shadow 600
Sperwer
Dragon Warrior
Snow Goose
Fire Scout
Hunter
SilentEyes
Predator
GNAT
A 160
Herron
X-45
Predator B
Darkstar
Global Hawk

3.4 Classification by Wing Loading

Another useful way of classifying UAVs is using their wing loading ability. To calculate the wing loading of a UAV the total weight of the UAV was divided by the wing area.

- For the UAVs consider the wing loading values ranged from 5.34kg/m^2 for the relatively small Dragon Eye, to 211.84kg/m^2 for the high tech X-50.

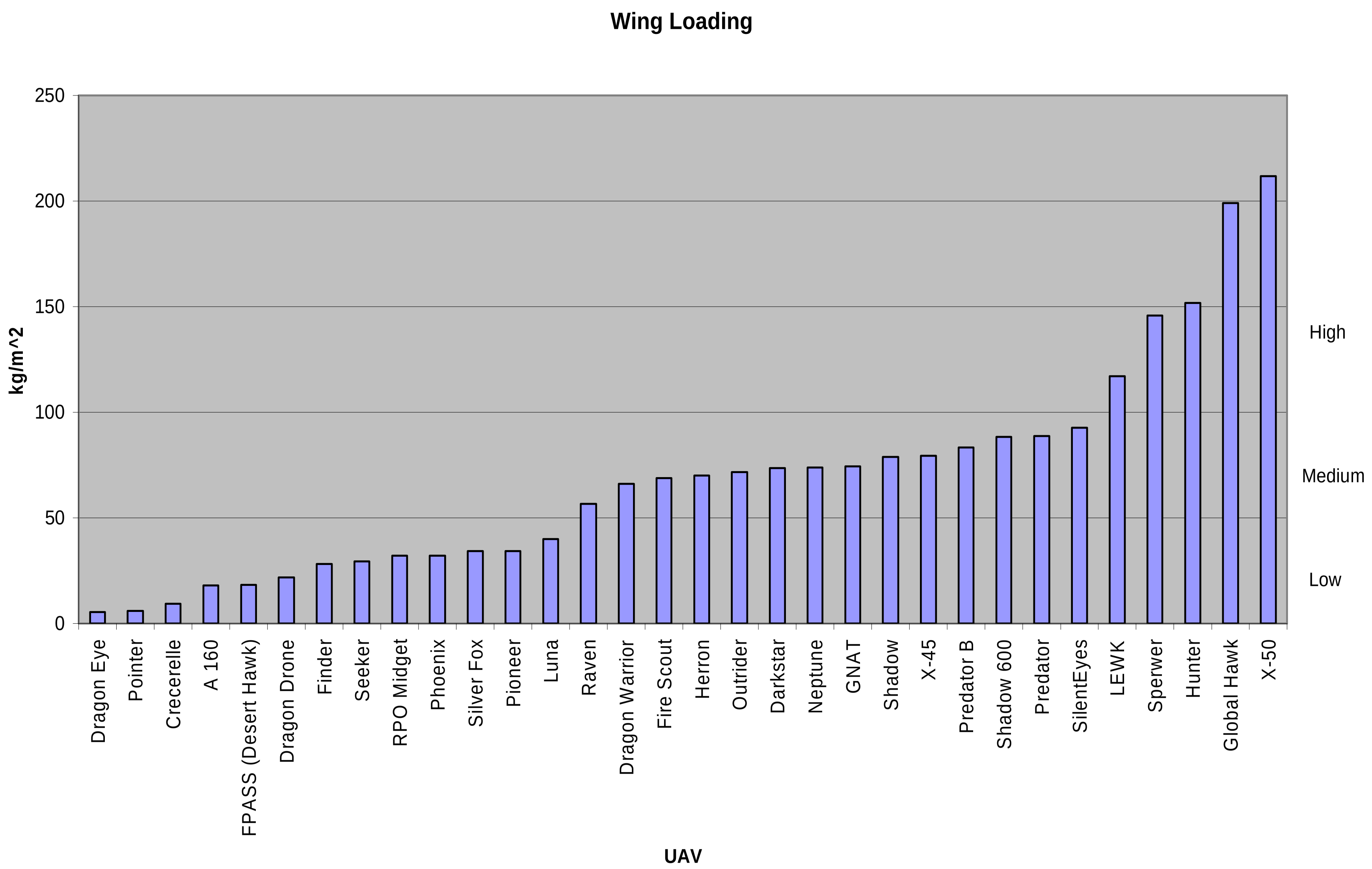
- Consequently to classify these UAVs using their wing loading values three classes have been created.

- The UAVs that have a wing loading above 100kg/m^2 are classified to be of high loading.

- For the UAVs that have a wing loading less than 100kg/m^2 but greater than 50kg/m^2, these will be classified as medium loading.

- While the remaining UAVs with a wing loading of less than 50kg/m^2 will be classified as low loading.

Classification by Wing Loading		
Category	**Wing loading kg/m^2**	**Example**
Low	<50	Seeker
Medium	50-100	X -45
High	>100	Global Hawk


Wing Loading
kg/m^2
0
50
100
150
200
250
Low
Medium
High
Dragon Eye
Pointer
Crecerelle
A 160
FPASS (Desert Hawk)
Dragon Drone
Finder
Seeker
RPO Midget
Phoenix
Silver Fox
Pioneer
Luna
Raven
Dragon Warrior
Fire Scout
Herron
Outrider
Darkstar
Neptune
GNAT
Shadow
X-45
Predator B
Shadow 600
Predator
SilentEyes
LEWK
Sperwer
Hunter
Global Hawk
X-50
UAV

3.5 Classification by Engine Type

As UAVs are used for a variety of different tasks they need different engines to complete these missions.

- Some of the different types of engines found in UAVs are Turbofans, Two strike, Piston, Rotary, Turboprop, Push and Pull, Electric, and Propeller. Out of these engine types the electric and the piston are the most common engines used in the UAVs considered in this project.

- As with the majority of aeronautical applications as the weight of the plane increases so does the size of the engine, this was found to be the same with UAVs.

- The lighter, smaller UAVs tended to use electric motors, while the heavier, battle ready UAV tend to use piston engines.

- Other UAV classifications that are affected by the type of engine in the UAV are endurance and range. A properly chosen engine will increase the endurance and range of a UAV.

Engine Type

UEL Rotary	Turbofan	Two-stroke	Piston	Turboprop	Electric	Push & Pull	Prop
Outrider	Global Hawk	Pioneer	Predator	Predator B	Dragon Eye	Hunter	LEWK
Shadow	Darkstar	RPO Midget	Neptune		FPASS		Sperwer
Shadow 600	Phoenix		Dragon Drone		Dragon Warrior		
Cypher	X-45		Finder		Pointer		
	X-50		A 160		Raven		
	Fire Scout		GNAT		Luna		
			Crecerelle		Javelin		
			Seeker				
			Brevel				
			Snow Goose				
			Silver Fox				
			Heron				

4. Mission Aspects

Much of the development of unmanned aerial vehicles is military orientated. Different military mission requirements have created various types of UAVs. For this reason, it is often useful to categorise UAVs in terms of their mission capabilities.

According to the UAV Roadmap 2002, mission capabilities can be divided into the following categories:

- Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR)
- Combat (UCAV)
- Multi-Purpose
- Vertical Take-Off and Landing (VTOL)
- Radar and Communication Relay
- Aerial Delivery and Resupply

4.1 ISTAR

ISTAR is a system using UAVs to gather enemy information, locate target and petrol hostile air space without risking lives of the operators. Often in battles, ground combat commanders require real time information of the up coming enemy forces. For example, what type of enemy defence is lying over the next hill? Gathering such information by reconnaissance UAVs is more effective and voids putting soldier lives at risk.

This category contains the most UAVs, which are shown in the list below together with their key features.

4.1.1 Brevel

- Used for reconnaissance and target locating
- Very low radar, acoustic and thermal signatures.

4.1.2 Cypher

- Can be fitted with video cameras, Infra-Red cameras, chemical detectors, magnometers, radio and satellite links, microphones to relay pre-recorded announcements
- Can be fitted with non-lethal payloads such as tear gas, smoke canisters or steel spikes to puncture tires or printed propaganda

4.1.3 Dark Star

- Used to overfly only the most heavily defended areas, it has neither the performance specifications nor the payload capacity of Global Hawk, but it will have low-observable characteristics that should enable it to penetrate the best air defences and survive.
- The Tier III Minus UAV

4.1.4 Dragon Eye

- Made of lightweight Styrofoam-like materials, weighs 5-Ib.
- Back-packable, modular unmanned aerial vehicle (UAV) providing organic aerial reconnaissance and surveillance for the US Marine Corps at low tactical units levels.
- Dragon Eye is made
- The missions is programmed on the control station and transmitted to the UAV via wireless modem.

4.1.5 FPASS/Desert Hawk

- Designed for conducting area surveillance, patrolling base perimeters and runway approach/departure paths, and performing convoy over watch

4.1.6 Global Hawk

- With a endurance of 36 hours and range over 21720 km, the Global Hawk is the most advanced UAV in extended surveillance, and target acquisition missions
- High cruise ceiling of 19800m to minimise surface-air missiles (SAM) threat
- Two are deployed in I
- The Tier II Plus
- Equipped with ISS (Integrated Sensor Suite), SAR/MTI (Synthetic Aperture Radar/Moving Target Indicator) and IR/EO (Infrared/Electro-Optical) sensors for high quality imagery with targeting accuracy
- Also fitted with an AN/ALR-69 radar warning receiver and AN/ALE-50 towed decoys for self-defence
- Operationally used in Afghanistan and Iraq

4.1.7 GNAT

- Long endurance surveillance UAV which later evolved into the predator

4.1.8 Heron

- Deep-penetration, wide-area, real-time intelligence to national agencies, theatre commanders and lower echelons.
- medium altitude and long endurance strategic UAV System ISTAR

4.1.9 Hummingbird Warrior

- Provide reconnaissance, surveillance, target acquisition, communication relay, precision re-supply, sensor delivery and eventually precision attack capabilities.

4.1.10 LEWK

- The Loitering Electronic Warfare Killer (LEWK) is an affordable, recoverable UAV of similar size to a 1000Ib bomb that can be released in from aircrafts or other UAVs in flight
- Deploys extendable wings and can loiter in the target area for up to 8 hours before recovery by parachute.
- Capable of providing limited radar jamming and/or lethal/non-lethal munitions delivery for the SEAD mission.
- Can also act as communication relay and imagery receipt

4.1.11 LUNA

- A family of advanced lightweight reconnaissance drones
- Easily transported in ground vehicles, the aircraft feature an automated flight control and navigation system that does not require skilled pilots to operate and can be rapidly assembled. Designed for mobility and a minimal logistics trail, the aircraft can operate from forward areas without the need for a runway.

4.1.12 Neptune

- Specially suited for operations over water.
- The payload is either a colour camera or a thermal imaging device
- Transports compactly and optimised for quick launch from ground and sea

4.1.13 Shadow

- Tactical Unmanned Aerial Vehicles to gather intelligence
- Colour video image in daylight and black and white thermal images at night

4.1.14 Outrider

- Tactical intelligence UAV for near-real-time reconnaissance, surveillance, and target acquisition information to Marine air/ground task forces, Army brigades, and deployed Navy units
- A range of 200 kilometres and target on-station time of four hours.
- Launch from unprepared ground strips and Navy LHA/D ships.
- Electro-optical and infrared sensors to provide 24-hour battlefield surveillance.
- Small enough for an entire system to be contained on two High Mobility Multipurpose Wheeled Vehicles (HMMWVs) and trailer and transported on a single C-130 cargo aircraft.

4.1.15 Phoenix

- Real time surveillance and target acquisition UAV designed to integrate with the Battlefield Artillery Target Engagement System (BATES) and indirect fire weapon systems against depth targets.
- All weather day and night surveillance capability

4.1.16 Pioneer

- Pioneer was procured starting in 1985 as an interim UAV capability to provide imagery intelligence (IMINT) for tactical commanders on land and at sea.
- It flew 300+ combat reconnaissance mission
- battlefield management
- Successful deployments have been accomplished by the USN aboard battleships, by the USMC aboard amphibious ships and on land by the USA.

4.1.17 Predator A

- RQ-1 Predator is a long endurance, medium altitude unmanned aircraft system for surveillance and reconnaissance missions.
- Surveillance imagery from synthetic aperture radar, video cameras and a forward looking infra-red (FLIR) can be distributed in real-time both to the front line soldier and to the operational commander, or worldwide in real-time via satellite communication links.
- A armed version of the Predator is the MQ-1 which will be discussed in Multi-purpose UAV section.

4.1.18 Raven

- Search for improvised explosive devices (IED),
- Provide reconnaissance for patrols and flies the perimeter of camps

4.1.19 Silver Fox

- Designed to provide low cost aerial surveillance imaging and carry sensor payload packages weighing
- Video images are transmitted from the Silver Fox to the ground station for quick reference

4.2 UCAV

UCAV stands for unmanned combat aerial vehicles. This category contains aircraft that are highly manoeuvrable and are able to engage in air to air combat and also provide precision weapon delivery to surface targets. Comparing to the other UAVs, UCAVs have higher cruise speed but often shorter endurance.

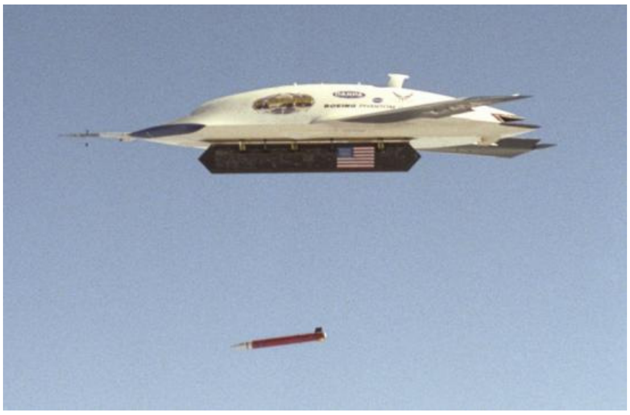
All UCAVs are currently in experimental and testing stage. The design goals are:

- Engage in deep strikes using precision weapons such as bombs or guided missiles
- Used to complement manned fighter and bomber forces
- Highly adaptable to changing battle conditions
- Can provide 24/7 electronic attack
- Secondary missions include high-risk reconnaissance, surveillance and intelligence gathering
- Be refueled by Air-to-Air Refueling
- Operate independently, fully integrate with manned aircraft operations or execute multi-vehicle coordinated operations.
- Be deployed from one location and controlled by another

Some characteristics for the X45 UCAV

- Cruise speed of Mach 0.85
- Carry a 4,500--lb. payload
- Fly 40,000 feet with a mission radius of 1,200 nautical miles
- Transport eight 250-lb. Small Diameter Bombs
- Carry auxiliary fuel tanks and other payloads
- Hit a ground target with a 250-lb. inert near-precision-guided weapon

4.2.1 X45A



X45A, SPG Media Limited (2006).

X45C

X45C, Boeing (2006).

X46

X46, SPG Media Limited (2006).

X47A

X47, SPG Media Limited (2006).

X47B

X47B, *SPG Media Limited (2006).*

X50

X50, *SPG Media Limited (2006).*

4.3 Multi-Purpose

Multi-purpose UAVs are usually modified reconnaissance UAVs that are weaponised. Their primary mission is usually interdiction and conducting armed reconnaissance against critical, perishable targets. These UAVs can also and strike using self-guided weapons. When arms are not required for the mission, multi-purpose UAVs are also very capable for reconnaissance, surveillance and target acquisition in support of the Joint Forces commander.

4.3.1 MQ-1 Predator

MQ-1 Predator, Howstuffworks (2006).

- Multi-purpose version of the reconnaissance predator
- Can carry and use two AGM-114 Hellfire missiles
- Armed reconnaissance against critical and perishable targets

4.3.2 MQ-5B Hunter

MQ-5B Hunter, SPG Media Limited (2006).

- A Hunter variant which has been further optimized for the multi-mission role with longer center-wing section, improved avionics and Mercedes Benz heavy-fuel engines
- Operate at higher altitudes of 6,100m (20,000ft) and increase endurance from 12 hours to 15 hours
- Carries a BAT weapon called the Viper Strike, which is a high precision laser guided bomb suitable for urban combat

4.3.3 MQ-9 Predator B

MQ-5B Hunter, SPG Media Limited (2006).

- Essentially a scaled-up derivative of the RQ/MQ-1 Predator capable of striking and reconnaissance
- Can be weaponised with AGM-114C/K Hellfire missiles and other guided weapons

4.4 VTOL

Vertical take-off and landing UAVs are those that are able to generate downward thrust and take off within very limited space. This section contains UAVs that overlaps with the other categories. However VTOL UAVs are selected to form a class of their own because the unique capability of taking-off and landing vertically is critical for some missions. For missions where run way facilities are inaccessible, such as operations in forest or bush areas, or launching and recovering from non-carrier battleships. Therefore it is obvious that VTOL UAVs are a very important fleet to the military.

- Hummingbird Warrior
- Fire Scout
- Killer Bee
- X50

Features of these UAVs refer to overlaps in other categories

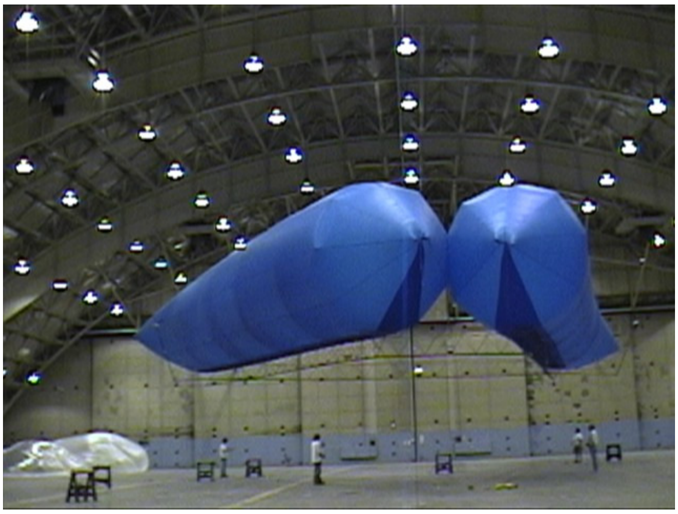
4.5 Radar and Communication Relay

4.5.1 Tethered Aerostat Radar System

Tethered Aerostat Radar System, FAS (2006).

- Essentially an aerodynamic balloon filled with helium and air
- Low-level surveillance system that uses aerostats as radar platforms
- On designed mission is to provide low-level trafficking
- May also be used to relay television and radio signals

4.5.2 Near Space Maneuvering Vehicle (NSMV)/Ascender/V-Airship



Near Space Maneuvering Vehicle (NSMV)/Ascender/V-Airship Space Frontier Foundation (2006).

- Operates between 100,000 and 120,000ft in the region above fixed-wing aircraft and below low-earth orbit satellites, i.e. a region virtually free from aircraft and SAM threats
- To compliment other systems like the Global Hawk and provide a more dedicated and responsive communications, intelligence and reconnaissance capability

4.6 Aerial Delivery/Resupply

The UAV in this category are designed for pin-point delivery of small cargo items such as ammunition and food supplies to Special Forces. The only UAV in this category is the CQ-10 Snow Goose.

CQ-10 Snow Goose, Parsch A (2005)

- Consists of a central fuselage module which houses payload and fuel
- GPS-based navigation and control system and the single piston engine driving a pusher propeller
- Can be air-dropped or launched from a HMMWV

4.7 Mission aspect classification

Section 4.7.1 shows the tabulated version of the mission aspect classifications as discussed throughout chapter 4. Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR), Combat (UCAV), Multi-Purpose, Vertical Take-Off and Landing (VTOL), Radar and Communication Relay and Aerial Delivery and Resupply are mission aspect criteria for UAVs. The UAV mission aspects have been rated from 1 to 4, depending on the UAVs ability to fulfil all performance characteristics.

Rating:

0: Does not perform mission aspect at all

1: Performs mission aspect with the lowest performance characteristics.

2: Performs mission aspect with medium performance characteristics.

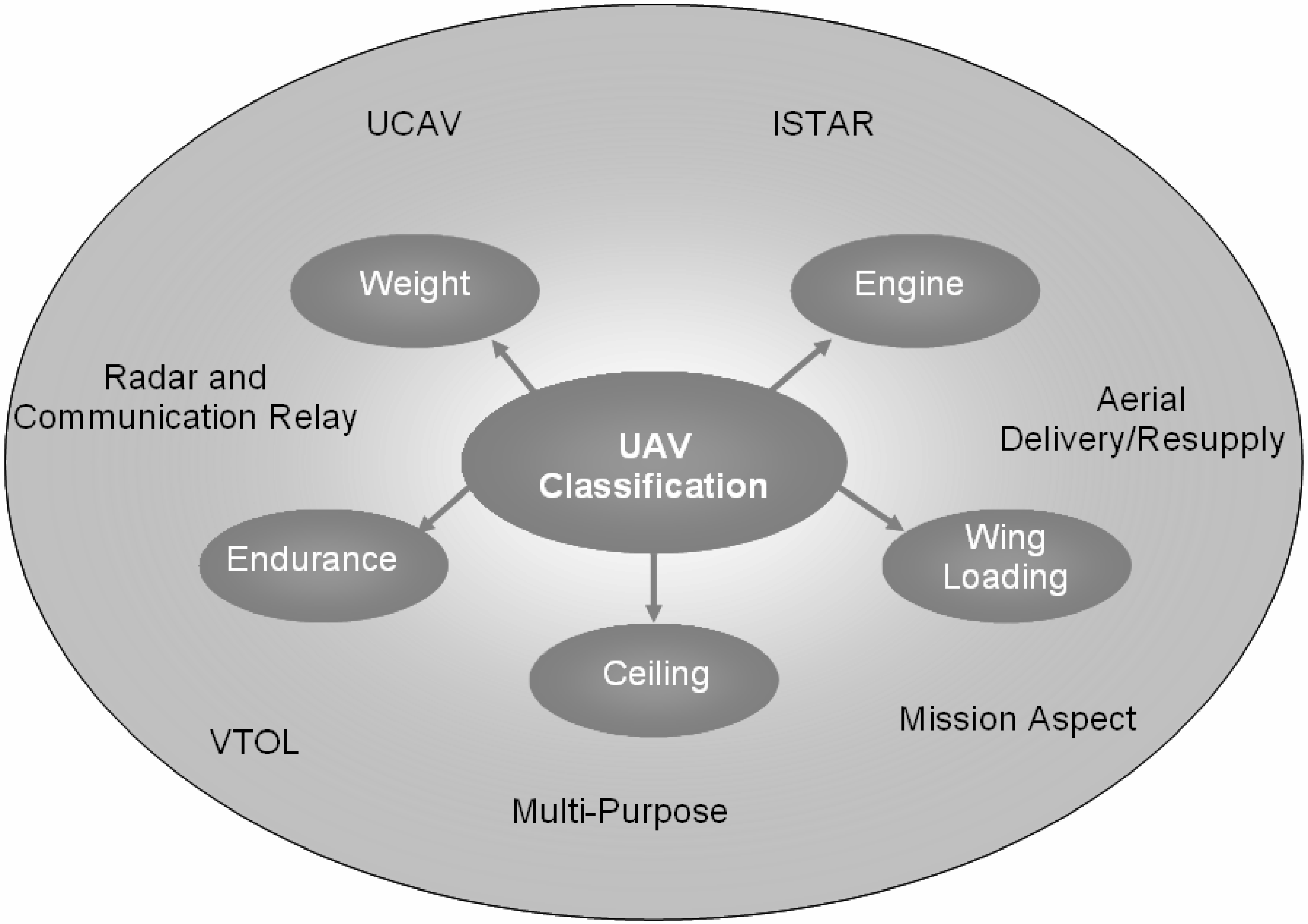
3: Performs mission aspect with high performance characteristics.

4: Performs mission aspect with the greatest performance characteristic capabilities.

4.7.1 UAV Characteristics: Classification of UAVs

UAV	Payload (kg)	Endurance (hr)	Range (km)	Ceiling (m)	ISTAR	UCAV	Multi-Purpose	Radar and Communication Relay	Aerial Delivery and Resupply
Pioneer	64	5	373	4,572	1.5	0	0	0	0
Predator	600	20	740	7,920	3	0	4	0	0
Global Hawk	900	30	22,000	20,000	4	0	0	0	0
Darkstar	454	12	925	19,800	2	0	0	0	0
Hunter	226	15	200	6,100	0	0	3	0	0
Outrider	50	3	200	4,570	2	0	0	0	0
Shadow	75	5	125	4,270	1.5	0	0	0	0
Fire Scout	90	6	400	6,096	0	0	0	2	0
Predator B	3,000	24	1,500	15,200	0	0	0	0	0
Neptune	10	4	75	2,440	1	0	0	0	0
Dragon Drone	11	3	148	3,048	0	0	0	0	0
LEWK	91	8	1,600	4,572	1	0	0	0	0
Finder	6	10	648	4,570	0	0	0	0	0
Dragon Eye	0	1	5	305	1	0	0	0	0
FPASS (Desert Hawk)	1	1	10	300	1	0	0	0	0
A 160	136	30	4,625	9,144	0	0	0	0	0
SilentEyes	2	0	122	7,620	0	0	0	0	0
Dragon Warrior	11	1	90	5,486	0	0	0	0	0
GNAT	63	40	4,818	8,000	2	0	2	0	0
Silver Fox	0	9	41	3,657	1	0	0	0	0
Herron	227	40	3,300	10,000	3	0	0	0	0
Phoenix	50	4	100	2,700	1.5	0	0	0	0
RPO Midget	20	4	100		0	0	0	0	0
Pointer		1	2	300	0	0	0	0	0
X-45	681	3	920	10,668	0	4	0	0	0
X-50	91	4	400	3,048	0	2	0	2	0
Crecerelle	35	6	59	3,353	0	0	0	0	0
Raven	17	4	100	4,267	0	0	0	0	0
Luna	10	4	80	4,000	1	0	0	0	0
Sperwer	45	5	193	5,182	0	0	0	0	0
Seeker	50	12	200	4,877	0	0	0	0	0
Shadow 600	41	14	200	4,877	0	0	0	0	0
Brevel		4	80	3,962	2	0	0	0	0
Cypher	20	3	30	1,524	2	0	0	0	0
Javelin	1	1			0	0	0	0	4

4.8 UAV Applications



5. Distinguishing Characteristics of a UAV

The fundamental aspects that distinguish UAVs from other types of small unmanned aircraft (such as models) include the operational purpose of the vehicle, the materials used in its manufacture, and the complexity and cost of the control system.

A model aircraft is used for sport and the pleasure of flying it. The only exception to this is the use of a model aircraft for training purposes. This is only a limited use utilised at the beginning of a pilot's training. If a model is used for commercial gain or payment, it is then being operated as a UAV and aviation regulations need to be considered.

The materials used in UAV manufacture are high tech composites delivering maximum strength at a low density to increase performance. These are expensive materials and are not used in models and recreational aircraft where balsa wood and basic plastics are the primary materials used and not composites due to the cost.

Control systems employed for UAVs enable greater performance characteristics to suit its mission aspect. Autopilot systems, radio-controlled and high complicated control systems, help operate the UAVs during missions. However the operational requirements of model aircraft are less complicated than that of a UAV and thus the use radio controlled system are used, without implementing the use of autopilot and other complicated engineering systems.

Reliability of UAVs is essential, not only for completing a mission successfully, but also to ensure that the cost of the mission does not exceed projected funding. However model aircrafts are not completing missions, whereby reliability is essential. Therefore the reliability of a UAV is much more significant than that of a model aircraft, due to the mission aspect and cost involved.

6. Discussion / Conclusion

Performance characteristics and mission aspects have resulted in many different types of UAVs being researched and developed. With all these new and varied UAVs now in service, improved classification methods need to be developed so the correct UAV can be chosen for the right mission. Subsequently to address this problem this report has classified UAVs using their two main characteristics: performance and mission aspects. When classifying UAVs using their performance, characteristics such as weight, range, endurance, altitude, payload and wing loading will help determine what the UAV is used for. Thus from the tables produced in this report, a UAV can be designed from data given to suit its necessary mission.

Once the mission aspect (such as ISTAR, UCAV, multi-purpose, VTOL, radar and communication relay and aerial delivery/resupply) has been determined for a given UAV, its required performance characteristics can be found to suit its mission criteria. This report will help as a reference for a future classification of UAVs for designers and manufacturers.

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