Executive Overview

The Market Outlook

In terms of worldwide military budgets, the unmanned aerial vehicle (UAV) segment has been one of the most dynamic growth sectors this past decade. And during the next decade we estimate that the sector will continue to increase by about 79% overall, going from the current level of $6.4 billion to $11.5 billion (see Figure 1). If operations and maintenance expenditures were to be added, these totals would be even greater.

Please note that in our tables and charts "procurement" and "production value" are two different, but related numbers. The former represents the annual amount production funding included in a particular country's annual defense budget, usually on a fiscal-year basis. The latter represents the value of UAV systems delivered during a particular calendar year (see Figure 3). In rough terms, the funds "procured" during one year result in "delivered: units the following year.

The most significant catalyst to this market has been the enormous growth of interest in UAVs by the US military, tied to operations in Iraq and Afghanistan, as well as the general trend towards information warfare and net-centric systems. UAVs are a key element in the intelligence, surveillance and reconnaissance (ISR) portion of this revolution, and they are expanding into other missions as well with the advent of hunter-killer UAVs. Our research suggests that the US will account for 65% of the RDT&E spending on UAV technology over the next decade, and about 41% of the procurement (this latter percentage does not take into account potential UCAV (including UCLASS) procurement later in the decade, which is highly speculative at this point and would drive this number much higher). In addition, there is an indeterminable "black" US budget for UAVs which is not accounted for in our unclassified numbers. A tangible example of this is the RQ-170 Sentinel program which only came to light when one of the stealth drones was downed (or came down) in Iranian territory.

These US UAV funding shares for R&D and procurement represent

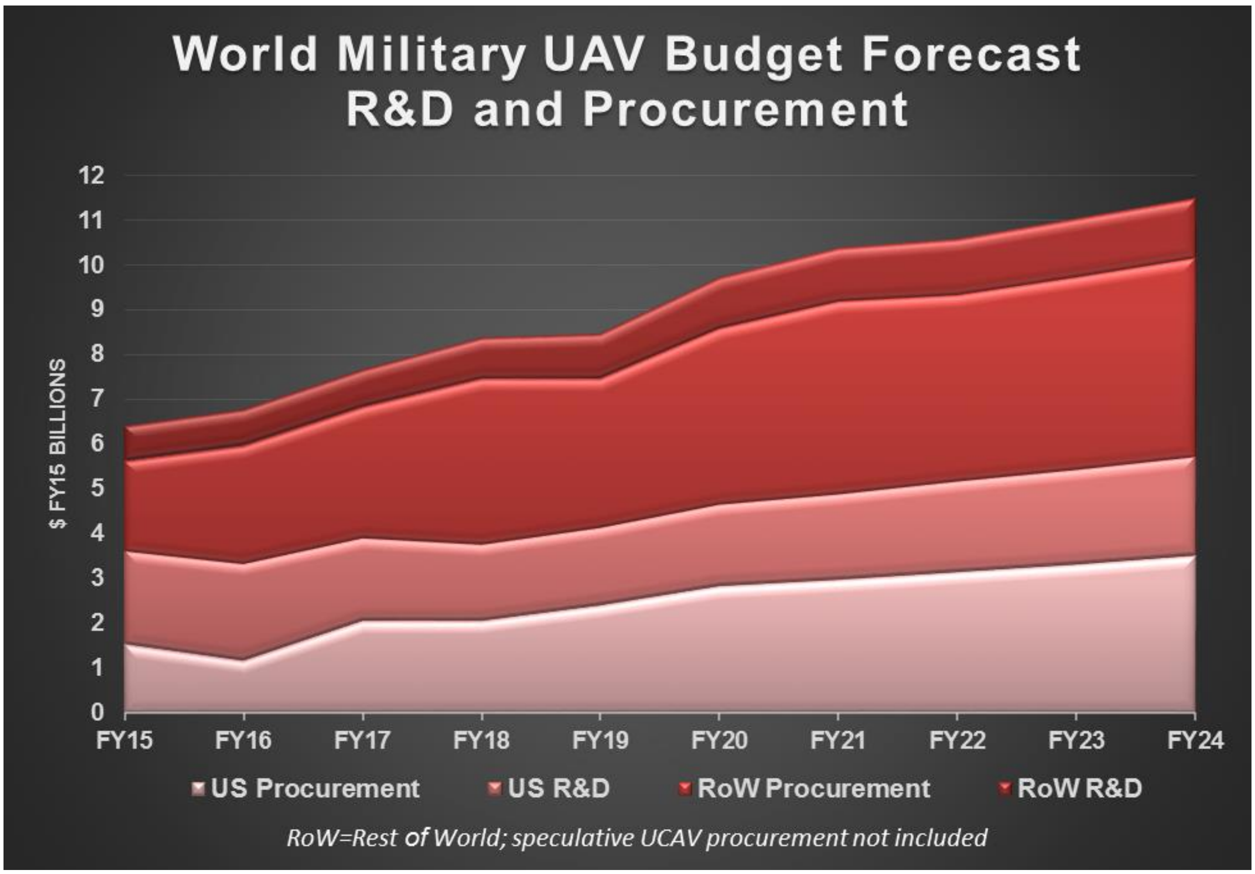

Figure 1

higher shares of the market than for defense spending in general where the US accounts for about 64% of total worldwide R&D spending and 38% of procurement spending, according to Teal Group's ***International Defense Briefing*** forecasts. This difference is due to the heavier US investment in cutting-edge technologies and the marked lag-time in such research and procurement elsewhere, especially major aerospace centers such as Europe. This follows trends in other cutting-edge technologies observed over the past decade by Teal Group analysts in such areas as precision-guided weapons, information and sensor technology, and military application of space systems.

Teal Group expects that the sales of UAVs will follow recent patterns of high-tech arms procurement worldwide, with the Asia-Pacific area representing the second largest market, followed by Europe. Indeed, the Asia-Pacific region may represent an even larger segment of the market, but several significant players in the region, namely Japan and China are not especially transparent about their plans compared to Europe. As in the case of many cutting edge aerospace products, Africa and Latin America are expected to be very modest markets for UAVs.

Some warnings are needed when viewing the summary tables and charts here. There appear to be wide swings and dips in unit acquisition over the forecast decade that is not matched by similar swings in the production value. This is primarily due to the volatile mini-UAV market which represents very large numbers of air vehicles even though unit costs are extremely low compared to other UAVs, especially the endurance types. This forecast expects a drop in US mini-UAV acquisition as combat operations wind down in Iraq and Afghanistan, which has a significant effect on unit numbers though not on dollar values.

The summary tables below include a budget forecast, as well as UAV production forecasts based on the various program unit forecasts. As can be seen, the procurement aspect of the budget forecast is higher than the production forecast (by value). The procurement forecast captures costs other than the acquisition costs alone such as modification programs, acquisition of system components such as sensors, ground control stations and support equipment.

The US lines are derived from the US budget procurement forecast found in the US section, but adapted to match calendar vs. fiscal year, as well as time-shifted to recognize the time lag between appropriations and actual production. The "Rest of the World" procurement line is based on the production forecast plus a fractional addition to account for the other UAV costs.

World UAV Budget Forecast

R&D ($ Millions)	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	Total
USA	2,100	2,161	1,879	1,708	1,739	1,826	1,917	2,013	2,114	2,219	19,676
Rest of World (RoW)	770	805	850	910	1,000	1,150	1,200	1,250	1,300	1,340	10,575
Total R&D	**2,870**	**2,966**	**2,729**	**2,618**	**2,739**	**2,976**	**3,117**	**3,263**	**3,414**	**3,559**	**30,251**

Procurement ($ Millions)	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	Total
USA (less UCAVs)	1,530	1,173	2,052	2,060	2,401	2,830	2,988	3,154	3,330	3,516	25,035
RoW (less UCAVs)	2,010	2,644	2,895	3,711	3,335	3,925	4,291	4,171	4,296	4,425	35,704
Total Procurement	**3,540**	**3,817**	**4,946**	**5,771**	**5,736**	**6,756**	**7,279**	**7,326**	**7,627**	**7,941**	**60,739**

($ Millions)	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	Total
World R&D	2,870	2,966	2,729	2,618	2,739	2,976	3,117	3,263	3,414	3,559	30,251
World Procurement	3,540	3,817	4,946	5,771	5,736	6,756	7,279	7,326	7,627	7,941	60,739
Total	**6,410**	**6,782**	**7,675**	**8,389**	**8,475**	**9,732**	**10,397**	**10,589**	**11,040**	**11,501**	**90,990**

World Production Forecast by Type

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Mini-UAVs	2,255	1,812	1,712	2,128	2,351	3,251	3,440	3,919	4,187	4,672	29,727
STUAVs	243	207	159	203	219	250	249	240	257	257	2,284
TUAVs	170	127	132	132	168	236	271	260	264	234	1,994
Naval UAVs	38	14	31	45	44	53	43	58	66	60	452
MALE	104	122	75	104	110	95	77	123	125	139	1,074

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(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
HALE	—	1	3	11	11	15	14	16	22	24	117
UCAVs	—	—	—	—	2	5	16	16	23	17	79
Total	**2,810**	**2,283**	**2,112**	**2,623**	**2,905**	**3,905**	**4,110**	**4,632**	**4,944**	**5,403**	**35,727**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Mini-UAVs	168	144	138	166	188	251	269	308	323	373	2,329
STUAVs	111	91	73	97	105	113	112	113	121	122	1,057
TUAVs	530	394	407	393	499	715	809	763	789	686	5,982
Naval UAVs	530	170	323	439	402	466	394	563	627	579	4,493
MALE	1,972	2,343	1,444	1,959	2,048	1,704	1,393	2,262	2,302	2,582	20,009
HALE	—	75	200	1,000	920	1,260	1,210	1,390	1,920	2,150	10,125
UCAVs	—	—	—	—	300	750	2,050	2,050	2,800	2,200	10,150
Total	**3,311**	**3,218**	**2,585**	**4,054**	**4,462**	**5,259**	**6,237**	**7,449**	**8,881**	**8,692**	**54,146**

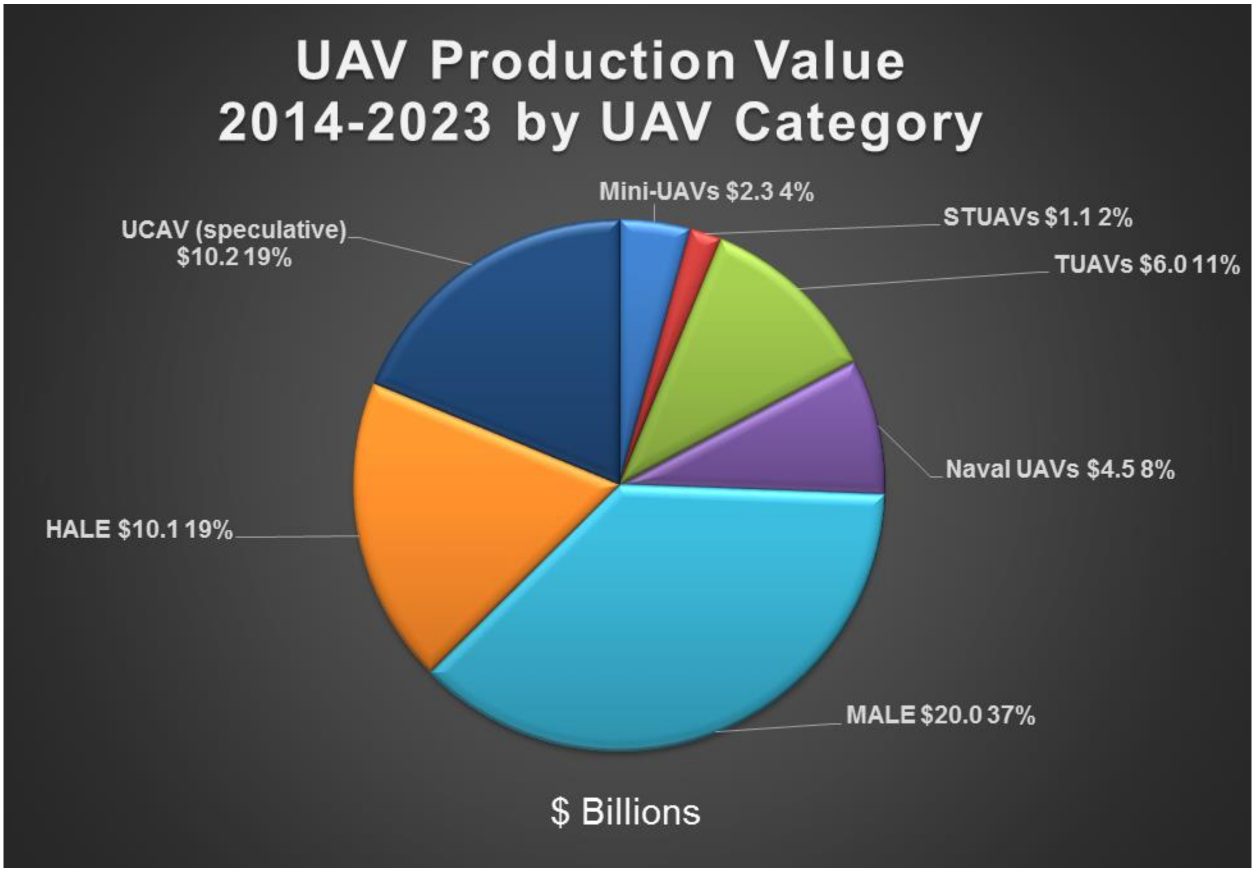

Figure 2

World Production Forecast by Region (less UCAVs)

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	**1,052**	**1,054**	**999**	**1,134**	**1,345**	**1,579**	**1,779**	**2,103**	**2,111**	**2,625**	**15,781**
Rest of World (RoW)	**1,758**	**1,229**	**1,113**	**1,489**	**1,558**	**2,321**	**2,315**	**2,513**	**2,810**	**2,761**	**19,867**
Europe	573	427	351	436	533	757	729	685	769	846	6,106
Mid-East	604	250	250	285	192	121	381	479	639	514	3,715
Africa	91	80	77	12	24	178	170	77	94	94	897

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Asia-Pacific	361	399	392	749	771	1,071	977	1,234	1,227	1,226	8,407
Americas	129	73	43	7	38	194	58	38	81	81	742
Total	**2,810**	**2,283**	**2,112**	**2,623**	**2,903**	**3,900**	**4,094**	**4,616**	**4,921**	**5,386**	**35,648**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	**1,790**	**1,755**	**758**	**1,650**	**1,530**	**1,135**	**1,155**	**1,830**	**2,180**	**2,700**	**16,483**
Rest of World (RoW)	**1,521**	**1,463**	**1,827**	**2,404**	**2,632**	**3,374**	**3,032**	**3,569**	**3,901**	**3,792**	**27,513**
Europe	456	409	627	872	857	918	852	964	1,014	979	7,949
Mid-East	401	315	428	420	377	508	434	541	549	507	4,481
Africa	37	34	22	26	45	55	69	75	69	69	500
Asia-Pacific	416	475	531	1,051	1,307	1,717	1,499	1,656	1,998	1,965	12,615
Americas	211	229	219	35	45	177	178	333	272	272	1,969
Total	**3,311**	**3,218**	**2,585**	**4,054**	**4,162**	**4,509**	**4,187**	**5,399**	**6,081**	**6,492**	**43,996**

Study Parameters

The aim of this study is to examine the future worldwide market for unmanned aerial vehicles. Teal Group already covers the UAV market in its World Missiles & UAVs Briefing which examines the UAV market on a program-by-program basis. The aim of this study is to complement the WMUB by examining the market from a different perspective, namely national requirements. This approach has been taken because a study based on existing programs has distinct limitations. Unlike more established markets such as missiles or aircraft, the UAV market is so new and undeveloped that another approach to market assessment is necessary.

The approach taken in this market is requirements-driven and from the micro-perspective. Rather than use a macro-approach consisting of an estimate the current market size and an extrapolation of growth rates from that point, the study examines likely requirements for UAVs on a country-by-country basis and estimates the likely scale and pace of acquisitions. The reason for this is that the market is very new and so past trends provide little guidance for the future. The primary forecasts are based on UAV deliveries, not orders or budget appropriations. In the US case where more data is available, both budget and production forecasts are provided. The primary focus of the study is the military requirements for reconnaissance and strike UAVs. The study does not cover target drones, nor does it cover terminal attack drones which are more properly categorized as loitering missiles. It does not cover any form of lighter-than-air vehicle such as aerostats, blimps, and so on. Due to the requirements orientation of the study, it is organized on a regional/country basis. Countries which have been assessed to have a likely UAV requirement are included; those with a low probability of acquiring UAVs are not included.

From a technical standpoint, the market has been divided into various categories that are common in the industry. Some of these begin to blend together at the margins, but the categories are useful both in terms of requirements assessments and costing estimates. The categories are:

- **Micro UAVs**—A UAV small enough to be held in the palm of the hand, usually weighing less than a kilogram.

- **Mini UAVs**—A UAV small enough to be launched by a person; typically deployed by army units at platoon or company level. A typical example is the AeroVironment RQ-11 Raven. Sometimes called "Over-the-Hill" UAV or "back-pack" UAV

- **Small Tactical UAVs (STUAVs)**—A UAV between mini-UAV and TUAV in size, typically small enough to be lifted by a human, but too large to be launched by hand. Typically launched by a bungee or similar system, and deployed at battalion level. A typical example would be the Boeing/Insitu ScanEagle or the German Luna.

- **Tactical UAVs (TUAVs)**—A UAV used for reconnaissance by Army formations of regiment, brigade, or division size, with endurance of several hours and operating radius of 200 km or less. Some typical examples are the British Watchkeeper, US Shadow, French Crécerelle/Sperwer, and Israeli Searcher.

- **Naval VTUAVs**—A tactical vertical-take-off UAV adapted for shipboard use with a customized ground controls station for shipboard operations. This does not include small tactical UAVs or MALE UAVs operated by navies from shore bases or ships. Typical examples are the Schiebel Camcopter and the MQ-8 Fire Scout.

- **MALE UAVs**—A Medium Altitude/Long Endurance UAV with endurance of about 24 hours and long range capability, generally used for operational reconnaissance. Typical examples are the Predator and Heron.

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- **HALE UAVs**—A High Altitude/Long Endurance UAV with endurance of a day or more and long range capability, generally used for strategic reconnaissance. The Global Hawk is a typical example.
- **UCAVs**—Uninhabited Combat Air Vehicle, a high performance UAV designed primarily for ground attack. Tactical UAVs and MALE UAVs with secondary strike capability such as the MQ-9 Reaper are not included in this category, but in their original platform/size category.

Forecast Assumptions

Forecasting is by its nature, an art, not a science. To stretch this analogy further, the forecasts in this report should be regarded as "impressionism" not "realism." The numerical forecasts in this report may seem to provide a highly detailed "realistic" portrayal of the market. The reader should not be fooled by the seeming precision of these numbers. By its nature, this forecast is based upon assumptions, summaries, and simplifications which invariably involve large margins of imprecision.

Forecasting can be viewed metaphorically as a tree. We have a fairly solid knowledge of the trunk, that is, the recent size of the market over the past few years. The future can be viewed as the limbs- the limbs representing major alternative scenarios such as future conflicts, major political upheavals, etc. The branches on the limbs represent variations within these major scenarios influenced by new technologies, local political developments, and so on. At one extreme is the possibility of global Armageddon in which case, zero UAVs will be built; on the other extreme is the Nirvana of global peace and tranquility in which case, zero military UAVs will be built. There are endless variations in between with varying numbers of UAV systems likely to be built. Our forecast is only one possible branch of the many potential branches of the tree. Many other possible forecasts are plausible given different scenarios or assumptions. We attempt to make clear our assumptions and rationale in each of the sections in this report. We do not claim that this is the only possible scenario, or the only plausible forecast. In recent years, UAV acquisition has been very strongly affected by war-related demands of the US armed forces in Iraq and Afghanistan. Our presumption is that future US involvement in Iraq will be very modest and confined mainly to UAV surveillance missions and that US commitments in Afghanistan will taper off over the next few years. The forecast does not include any new major regional conflicts that might spur UAV sales, although such events are quite likely, such as potential US involvement in Syria/Iraq. More drastic international events such as a potential conflict over disputed islands in the East China Sea are not considered in this scenario.

Cost Evaluation

The cost of UAV systems can be assessed in a wide variety of ways including the basic "fly-away" cost of the system, the cost of a system including spares and support, the cost of a system including these costs plus a share of the RDT&E spending, and these costs plus operations and maintenance expenses. So for example, the RQ-4 Global Hawk in FY12 had a fly-away cost of $103,675,000 and a weapon system cost of $131,821,000.

A second problem in estimating future UAV spending is the variety of systems on offer. Some tactical UAVs are quite elementary with simple commercial-off-the-shelf TV cameras while others have elaborate sensor suites. Likewise, UAV systems vary enormously in complexity and some systems include multiple modular payloads. Finally, the number of air vehicles per system varies so that some systems include four air vehicles but other packages might include six or eight. Some systems can include one ground control station (GCS) while others can include two or more. In order to provide a basic idea of UAV costs based on public budget data, the table below summarizes some recent cost data from US UAV programs.

System	Cost	Notes
USMC Dragon Eye Mini-UAV system	$154,000 (FY06)	two air vehicles and one GCS
USMC SURSS Mini-UAV system	$140,078 (FY08)	three a/v and one GCS
US Army RQ-7A Shadow	$14,900,000 (FY09)	three a/v, two GCSs, other equipment
USN MQ-8 Fire Scout	$13,550,000 (FY07-12 avg.)	system program cost; air vehicle cost $191,985 in FY12
USAF MQ-1B Predator	$3,810,000 (FY09)	air-vehicle fly-away cost
USAF MQ-9 Reaper	$12,214,000 (FY12)	air-vehicle fly-away cost

System	Cost	Notes
US Army MQ-1C Grey Eagle	$5,404,900 (FY12)	air-vehicle fly-away cost
USAF RQ-4 Global Hawk	$103,700,000 (FY12)	air-vehicle fly-away cost

A further complexity in assessing cost is the time factor, with innumerable variables affecting price including economies-of-scale once production ramps up to optimal levels, increasing complexity of the aircraft, added features, and inflation factors. The cost fluctuations of the Predator MALE UAV provide an example of this. The following charts lists fly-away costs through time:

USAF RQ-1/MQ-1 Predator Fly-Away Price

FY99: $7,632,800
FY02: $2,909,000
FY03: $3,727,000
FY04: $4,459,000
FY05: $4,924,000
FY06: $3,664,000
FY07: $4,263,000
FY08: $5,561,000
FY09: $3,810,000

The cost of imported UAV systems presents its own set of complexities. The contracts are seldom released in public beyond bare-bones information about the number of aircraft acquired or the overall price of the program. In addition, import programs contain a varied mixture of content, sometimes being a straightforward off-the-shelf acquisition, but in other cases including provisions for training, spares, incorporation of local technology and other features. Some insight into the complexity of these issues can be gained from the few large UAV sales that have been publicly detailed. In 2011, the French Senate released cost data about the competition between the IAI Heron TP and the General Atomics MQ-9 Reaper Block 5 for the French interim MALE UAV requirement. Both offerings covered seven aircraft, two GCSs and initial spares.

The program included a requirement for the O&M and spares costs for 10 years of operations at a level of 2,000 flight hours per aircraft. The program also included a requirement for "Francization," i.e., the incorporation of French subsystems. The cost per flight hour was assessed as €6,000 for the Reaper and €7,150 for the Heron TP.

MALE UAV Cost Comparison: French Interim MALE Program (2011 €millions)

Type:	Heron TP	MQ-9 Reaper
System costs:	177	67
Initial client costs:	included	4
FMS cost:	included	3
System subtotal:	177	74
O&M, spares 10 years:	143	135
Program subtotal:	320	209
Francization:	50	88
Total	**370**	**297**

Due to the complexity of these cost issues, a simplified cost forecast has been used here. Costs have been estimated for specific categories of UAV systems, and a portion of the system costs have been assessed against each UAV. So for example, a typical tactical UAV system might cost about $10 million and have five air vehicles. As a result, to formulate the value of tactical UAV market, each air vehicle has been assigned a cost of $2 million ($10 million @ five air vehicles per system) even though the actual cost of the air vehicle is typically less than $2 million. This study also presumes that UAV costs will vary from region to region, in part due to a varying mixture of more and less sophisticated systems as well as variations between domestic production systems and imported systems. A sample of price ranges used in this study is listed below. Once again, it is important to emphasize that this is not an assessment of the cost of each aircraft, but rather an attempt to create an assessment of the cost of the aircraft plus a portion of the system cost.

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UAV Assessed Cost Ranges ($ in thousands)

Mini-UAV	$50,000-65,000
Small Tactical UAV	$300,000-500,000
Tactical UAV	$1,500,000-4,000,000
Naval VTUAV	$8,000,000-15,000,000
MALE UAV	$9,000,000-20,000,000
HALE UAV	$75,000,000-115,000,000
UCAV	$20,000,000-150,000,000
Civil Small/Mini UAV	$50,000-200,000
Civil Large UAV	$5,000,000-20,000,000

While not ideal, this simplified pricing approach is more practical than a more precise, but unwieldy if not impossible, approach such as estimating different costs for different systems for each individual country requirement.

We do not include operations and maintenance costs associated with UAV operations in this report as the numbers are lacking, especially for international expenditures outside the US.

For the purposes of this study, lower cost UAVs of less than $10,000 have not been included in either the market or unit numbers.

Military UAVs

Forecasting the size of the future UAV market is far more problematic than in other areas of aerospace technology. There are several reasons for this. The most important is that UAVs are a revolutionary new technology. They are not an established technology (such as missiles, combat aircraft, etc.) where there are clearly defined requirements and established bureaucratic organizations that foster their procurement. While there has been a considerable amount of attention to UAVs in the press, and considerable experimentation with UAVs by many armies, there are still an enormous number of unanswered questions about the nature of UAVs and their operation that make any forecasting difficult. Until recently, the UAV market was relatively small. In the mid-1990s, for example, the market was probably less than $100 million annually worldwide. It has expanded more than ten-fold in less than a decade, and currently about $6 billion is spent annually worldwide on UAVs. As a result, traditional methods of estimating market size such as extrapolations based on past growth rates do not offer a plausible method to assess the future market size. To further complicate matters, UAVs have been proliferating not only in numbers but also in missions. While UAVs have traditionally been thought of as an intelligence collection platform, in recent years they have expanded into potential combat strike platforms which could substantially increase their market potential.

The Past as Prologue

It is useful to take a brief look at the recent history of UAVs to better appreciate the current and future market. Drones have been in existence since 1917. The first practical use for drones was to serve as air defense targets and numerous target drones were manufactured in the years before World War II. The first armed drones such as the TDR-1 were developed in World War II and first used in combat in the autumn of 1944 by the US Navy. Early drones were not especially effective due to limitations in flight controls and sensors.

After World War II, a number of countries began to deploy drones for reconnaissance and surveillance purposes. The two most common roles were to serve as the forward eyes of the field artillery and to conduct shallow reconnaissance of enemy positions. The first extensive operational use of UAVs for reconnaissance purposes can be traced back to US use of the BQM-34 Firebee and its derivatives at the time of the Vietnam War. Their mission was primarily strategic reconnaissance. These systems used wet film cameras and infrared line-scanners; they had no real-time data capability. The European NATO countries showed an early interest in tactical reconnaissance drones starting in the 1970s such as CL-89, CL-289, and the Italian Mirach family. Once again, these systems generally carried wet film cameras and IR lines-canners with no real-time data transmission features. The Israelis used both the US Firebee and Chukar in the 1973 October War and 1982 Lebanon War.

The US Navy again pioneered the use of armed drones in the form of the QH-50 DASH which was deployed aboard destroyers to extend the range of anti-submarine torpedoes. More than a thousand were built, but the type was quickly retired from service due to an extremely high attrition rate due to accidents.

Israel acquired a number of drones from the US in the late 1960s including both reconnaissance drones, target drones and early types of decoy drones. Early experiences with these drones led Israeli firms in the late 1970s to begin developing small

RPVs that could provide real-time intelligence using the new generation of simple video cameras. Israeli systems like the Scout and Mastiff were the forerunners of many contemporary tactical drone programs. However, contrary to much of the hype surrounding this subject, there is little evidence that there was extensive use of these RPVs in actual combat in the 1982 war although there was use of US drones.

In the wake of the 1982 Mid-East War, the US reinvigorated its own RPV programs. However, the US Army stumbled badly in the real-time intelligence field in the early 1980s with its overly ambitious Aquila program, which significantly put back US RPV efforts.

Through the 1990s, the UAV market was very small and was dominated by Israeli firms, especially Israel Aircraft Industries' Malat branch. IAI Malat represented about 90% of the world production of real-time UAV systems in the 1990s, a telling comment on how small this market was in spite of all of the publicity. Malat's annual business during the period averaged under $100 million. IAI produced only 600 UAVs through the beginning of 1998, and less than a hundred UAV systems. Besides these programs, there was an established UAV program in Europe, but this concentrated on the earlier generation of reconnaissance UAVs such as the CL-289 Piver which did not have real-time intelligence capability.

Gulf War Lessons

At the time of the Gulf War, several countries had a handful of UAV systems, many having been purchased as technology demonstrators. The French operated a handful of ALTEC Mart systems, while the US operated a small number of AAI/IAI Malat Pioneers from US Navy battleships to provide gun fire correction and target location data. These rather modest operations in 1991 were probably the first large-scale use of tactical UAVs with real-time data transmission capability.

Balkan Lessons

The utility of UAVs in contemporary conflicts was highlighted during the air campaign over Kosovo. The new style of warfare is dependent on low casualties, especially politically sticky incidents such as captured pilots. In an age of "information warfare", someone or something has to go out and collect the information. In past wars this might have been a manned reconnaissance aircraft like the U-2 or SR-71, or a spy satellite. Space based reconnaissance remains important, but UAVs are far more flexible and offer real time imagery immediately after the mission is assigned. In addition, operation at low altitudes offers better imagery resolution which is often needed in peacekeeping operations where individuals and small objects need to be tracked. Kosovo saw the use of a wide range of UAVs including the RQ-1 Predator, BQM-155 Hunter, and CL-289 Piver.

On the down side, Kosovo also revealed the vulnerability of UAVs to contemporary air defenses. A total of 27 UAVs were lost, some to air defense missiles, some to operational problems. This was about ten times the scale of aircraft losses, though in terms of expense, the UAV losses were considerably less significant. Furthermore, the loss of a UAV does not compel a risky search-and-rescue operation as was the case with the downed F-117 aircraft. Technology losses are less as well. The Kosovo experience raises the question of the inclusion of counter-measures on future designs. What are the trade-offs in terms of weight, cost, and payload to include countermeasures, and how might they be activated? It seems likely that countermeasures are not worthwhile for small tactical UAVs that are much smaller than contemporary fighter aircraft, but they might be considered on large, high-cost systems such as the Global Hawk.

Lebanon Air Campaign 2006

During the fighting with Hezbollah in Lebanon in August 2006, the Israeli Defense Forces conducted 1,502 sorties amounting to 16,418 hours of UAV operations of which 13,000 hours were intelligence missions; in contrast, manned combat aircraft conducted 10,337 sorties totaling 12,000 flight hours. This was one of the first air campaigns where UAVs flew more hours than manned aircraft, The Hermes 450S was credited with 15,000 hours of flight time and other types such as the Searcher-2, Hermes 450S "Zik" and the Heron-1 "Shoval" accounting for the remainder. Besides the tactical UAVs, the IDF also used low-rate production versions of the Elbit Skylark and Rafale Skylite B mini-UAVs.

Afghanistan and Iraq

UAVs have become a ubiquitous feature on the modern battlefield since the combat operations in Iraq and Afghanistan starting in 2001. The US armed forces by 2001 had started to field a wide array of UAVs, with the Air Force taking the lead. Predator has become synonymous with UAVs in the public mind. The relevance of UAVs to the operations was due to a variety of factors. Both Iraq and Afghanistan were benign environments from the standpoint of air defense threats. As compared to UAV operations over the Balkans or Georgia where UAVs were often shot down, UAVs could operate over Iraq and Afghanistan with virtually no opposition. In low-intensity peace-keeping operations, the minimization of casualties becomes a political and tactical necessity. The use of UAVs becomes especially attractive for their value in conducting intelligence operations at no risk to pilots. The use of tactical UAVs including mini-UAVs reduces the need of army units to conduct dangerous scouting and patrolling missions where the risk of ambush is great. When reconnaissance missions or convoys were needed, UAVs could

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be used to conduct route security and to aid in the detection of IEDs.

From a political standpoint, the hunter-killer UAV took on enormous importance. The armed Predator and Reaper UAVs entered service on an experimental basis early in the campaigns, but became so valuable so quickly that they fundamentally changed the nature of air combat in peace-keeping operations against insurgent forces. Unlike conventional aircraft, they could be used to maintain a continuous, persistent presence to monitor suspected insurgent areas, and could conduct precision strikes when needed. In contrast to conventional strike aviation which is best suited to attack conventional military formations, the primary tactical mission of the hunter-killer UAVs has been decapitation strikes against the command elements of the insurgent force. The substantial value of these missions has been reflected in the continual increase in the USAF inventory requirements for the Predator/Reaper.

The availability of the Predator and Reaper hunter-killer UAVs in US Air Force service has led to a shift in combat dynamics in theaters such as Iraq and Afghanistan. While the Clinton administration in the 1990s preferred the use of Tomahawk cruise missiles as a means of projecting power in conflict zones, the Bush and the Obama administrations have shifted in favor of hunter-killer drones. The Predator/Reaper permits persistent surveillance coupled with near-time target engagement, along with much greater precision in targeting. The US use of Tomahawk cruise missiles has almost entirely evaporated, while Predator/Reaper combat use has increased dramatically. In 2004, the US Air Force was able to maintain five simultaneous Predator combat air patrols (CAP); by 2009 this had risen seven-fold to 38 simultaneous CAPs; and to 50 CAPs by 2011.

Unmanned Combat Air Vehicles (UCAVs)

The latest visionary role for UAVs is to replace conventional combat aircraft. Once again, this is a revival of an old idea rather than an entirely new concept. The US Air Force experimented with Firebee drones, armed with laser-guided bombs and Maverick guided missiles back in the late 1960s and early 1970s. The early experiments were aimed at developing a surrogate for attack aircraft, primarily to carry out dangerous ground attack missions. Today's futurists see a role for UCAVs not only in the ground attack role, but even as fighter aircraft.

UCAVs became a bit less futuristic in October 2001 when UAVs were used in combat for the first time over Afghanistan. The US Air Force had been experimenting with a RQ-1 Predator armed with Hellfire antitank missiles earlier. This was more of a technology demonstration effort than a scheme to actually arm the Predator. But when conflict broke out in the wake of the 11 September attacks, the Predator was deployed to the Afghanistan Theater including the armed version. During one mission in October 2001, it was used to track the convoy of a senior government official, and then to fire a missile near a bunker where the delegation took shelter. The mission was not successful, but press accounts suggest the problem had to do with rules of engagement, not with the basic technology. Further armed UAV operations took place outside the nominal battle areas, such as the attack on an Al Qaeda official in Yemen in the autumn of 2002. These first demonstrations of the armed UAV in combat are reminiscent of the first use incidents of air-to-air combat in 1914 with pilots dueling with guns, bricks, and other improvised weapons. They provide only a hint of their future potential.

The first use of the Predator as an armed UAV raises an interesting question about future UCAVs. The US Air Force and Navy had been studying air vehicles that perform like conventional strike aircraft. Their flight computer is briefed on a strike mission, and then the air vehicle flies out to the target and attacks it, perhaps under human control. The Predator mission in Afghanistan suggests that there will probably be several types of armed UAVs. The Predator has been used as a "hunter-killer" UAV that serves both as a reconnaissance platform and a strike aircraft, searching out the target before attacking it. A relatively slow UAV like the Predator is more versatile than a high speed jet UAV for such missions. Indeed, in the forecast period here, the procurement of these hunter-killer UAVs such as the MQ-9A Reaper is far more significant than the stealth UCAVs mentioned below.

Two jet-powered, stealth UCAVs were under development in the US for future requirements, the Air Force's X-45 being developed by Boeing, and the Navy's X-47 being developed by Northrop Grumman. These are sleek, stealthy, unmanned strike jets, and bear little similarity to the ungainly and slow armed Predators. Initial flight trials have begun which should help to clarify the tactical potential of UCAVs. The US program has undergone considerable turmoil over the past few years with the Navy now in charge of a rump demonstration program concerning carrier landing capabilities. It is assumption of this study that the US Air Force UCAV program has gone "black," i.e., into the world of secret compartmented programs.

Several of the European air forces have expressed interest in UCAVs, but so far little developmental funding has been committed outside the United States. France tried to push its Neuron program as the basis for a European UCAV, but Britain has funded its own Taranis effort and Germany flew its Barrakuda demonstrator. France and Britain are committed to a joint UCAV effort under the recent Lancaster House Treaty. Russia had plans for a number of

UCAVs back in the Soviet days, and appears to be getting back into this business with designs like the MiG Skat.

There are three main attractions to UCAVs. On the one hand, the removal of the pilot promises to reduce the size of the air vehicle by eliminating the space and weight required for the aircrew and related support systems. In addition, the lack of an aircrew makes the UCAV desirable for use in international crises where the loss or capture of a pilot would be politically unacceptable. Finally, stealthy UCAVs will be more suitable to use in a more threatening air defense environment than the benign environment over Iraq and Afghanistan.

Although advanced concept demonstrations of tactical UCAVs will take place in the next decade in the United States, their actual deployment is problematic. A brief examination of the difficulties the US has faced in fielding even simple tactical UAVs should help provide a more sober perspective on the practical obstacles to such a system. The challenge to the tactical UCAV will come from three directions: human, missile, and arms control politics. It remains to be seen when it will be possible to design and field an integrated computer, flight control, and electro-optical sensing system that is as small, intelligent, and versatile as a human pilot. There is no existing combination of computers and sensors of similar size that can duplicate a pilot under a wide range of real life conditions. For example, there is little doubt that a UCAV can be built to deliver guided weapons against a target. But what happens when the UCAV is threatened by hostile fighters? Is it simply a sitting duck? This was certainly the case in Kosovo where a number of UAVs were shot down by Serbian helicopters flying alongside and attacking them with simple door-mounted machine guns. Unlike reconnaissance missions over a predetermined objective, a fighter mission requires a wide range of abilities that are not currently achievable with existing technology. The fighter mission currently seems the most distant for a UCAV.

In the case of ground attack missions against a predetermined target, a UCAV may be attractive as air defenses continue to become more sophisticated. But in this role, the UCAV will have to compete against missiles. This will come down to life-cycle costs. Is it cheaper to deploy a $50-75 million UCAV with an expected survivability of 15 missions and high maintenance costs, or to deploy 50-75 $1 million Tomahawk cruise missiles with relatively low maintenance costs? This tradeoff will be the center of much of the future debate, assuming UCAV technology proves practical and affordable. In view of recent experiences with tactical reconnaissance UAVs, this cannot be lightly assumed.

Teal Group believes that UCAV production will be quite small in the forecast period. Our assumption is that the USAF is developing a stealthy strike UCAV to replace the F-117 strike fighter and that it will enter production in the forecast period. We expect that “hunter-killer” UAVs such as MQ-9A Reaper will prosper, but forecasts for these UAVs are included under the relevant UAV headings since they are based on existing UAV airframes.

Future Perils

US tactical UAV development of the current generation has exploited the relatively benign air defense environment of the current operating theaters in Afghanistan and Iraq. In essence, enemy air defense is basically non-existent except in the crudest sense, small arms fire. What happens when current UAVs are thrust into a more dangerous air defense environment? The UAVs of the current generation are sitting ducks for existing missile-based air defense systems, since they are large, slow-moving, and visible to radar. They are extremely vulnerable to enemy fighters, as was shown in the short Russian-Georgian war where Russian forces shot down several Georgian UAVs over the disputed territory of Abkhazia.

The Europeans have tried to create the distinction between surveillance and reconnaissance missions, acknowledging that slow, loitering platforms such as Predator and Global Hawk are well suited to benign air defense environments. However, should the air defense environment turn hot, a fast air vehicle capable of penetrating and surviving air defenses would be needed. This was the catalyst behind the EADS-Germany Barrakuda demonstrator, a program which has elicited little or no serious attention. The US Air Force is examining similar high sub-sonic, stealthy penetrator UAVs such as the Lockheed Martin RQ-170 Sentinel, but there is practically no open-source information on the scale of their production. Until these programs begin to emerge from the “black world”, their role in the overall UAV market will be very difficult to determine. The US Navy is attempting to address these issues with its new UCLASS program.

New Directions

A variety of new missions and new technologies have been suggested for military UAVs. These are worth a brief mention even though we are not yet including some of these types in the forecast for reasons elucidated below.

The US Marine Corps has been pioneering the use of UAVs for the delivery of cargo. Demonstrations of cargo UAVs using an unmanned version of the Kaman K-MAX helicopter since November 2011. This requirement was closely tied to the circumstances in Afghanistan, especially the hazard of moving supplies by road due to the persistent IED threat. It remains to be seen whether dedicated cargo UAVs will win much support in other tactical scenarios, and this forecast does not include

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future UAVs in this category due to skepticism over this application.

Numerically, mini-UAVs have represented the fastest growing segment of the UAV market in terms of units, though not in dollar terms. Even though these small UAVs are limited in their sensors and tend to offer only a "soda-straw" view, they are extremely versatile since they can be readily used by small combat units with little need to coordinate their flights with local air traffic control. Some infantry officers suggest they will become as ubiquitous as binoculars. One of the most likely growth areas for mini-UAVS is in the area of "quad-copter" UAVs. Most military mini-UAVs at the moment are based on electric-powered Styrofoam aircraft. The "quad-copter" configurations are small air vehicles with four small lift rotors, one on each corner. These offer a more stable platform than more conventional single rotor mini-helicopters. The main attraction of this class of mini-UAVs is that they offer "hover-and-stare" capability. They can take up position over an area and continue to monitor it for the duration of flight. Early quad-copters took considerable skill to pilot, but the current generation are fitted with a simple inertial measurement unit to keep them stable. The operator simply indicates the flight path of the mission and does not actually fly the air vehicle with joysticks.

These quad-copters are already on the market such as the Datron Scout and they have already been purchased by military and government agencies. The main drawback at the moment is a relatively short endurance of about 30 minutes due to the limitations of existing battery technology. Attempts to build similar hovering UAVs with gasoline engines such as the RQ-16 T-Hawk have not been especially successful due to the noise levels. Further advances in battery technology may extend the endurance of these mini-UAVs. However, another key breakthrough is likely to come in the form of commercialization of the technology into the mass-market. Hobby firms are already starting to produce such air vehicles for consumers, and it is likely that mass market production will substantially drive down the unit costs of such systems. Current military systems cost in the range of $65,000 to $100,000 including four air vehicles and the hand-held GCS. Commercialization of the technology could drastically reduce the unit cost. It is quite possible that these will become ubiquitous over the next decade as a standard means of reconnaissance for infantry squads. Production of winged mini-UAVs such as the RQ-11 Raven have been close to ten-thousand, but inexpensive quad-copters could number in the hundreds of thousands. We have not included a forecast of these here since they fall below our cost threshold.

A number of firms are developing "parasite" UAVs, that is, small UAVs that can be launched from other platforms. This includes UAVs launched from other UAVs, UAVs launched from helicopters, and UAVs launched from ground platforms such as tanks. Some of these are simply a variation of traditional mini-UAVs. Others have a configuration better suited to such launch conditions such as a folded air vehicle within a launch tube that unfolds its wings and prop after exiting the tube. These parasitic UAVs are intended for short-term reconnaissance, and in most cases are expendable. In this respect, they are more like a munition than a conventional UAV and at the moment we are not including them in the forecast due to this.

Besides armed UAVs, there is a growing assortment of pseudo-armed UAVs. These are primarily missiles or loitering munitions that are based on UAV technology. A good example is the AeroVironment Switchblade. Although the hardware is based on mini-UAV technology, the mission is different since the air vehicle is primarily intended for a one-way mission and is therefore a missile. Some of these loitering munitions have a nominal "return-to-base" mode, but their primary role is to act as a surface-to-surface missile. There are larger examples of this type of technology such as the Israeli Harop, and the British Fire Shadow. Finally, some non-state groups have adapted UAVs into crude cruise missiles by fitting them with a warhead. Hezbollah on a number of occasions has attempted to use small UAVs fitted with a warhead.

Civil Government and Commercial UAVs

The market for UAVs outside of the military is extremely small at the moment, but promises to be one of the fastest growing segments in the next decade. As airspace opens worldwide over the next 10 years, UAVs increasingly will be used in a variety of new applications in border patrol, law enforcement, agriculture, mapping, and natural resources.

The long-term issue is whether UAVs might blossom in the civil aviation market, matching or exceeding the scope of military UAVs. While this is an intriguing issue, this study is limited to the likely growth of the market over the next decade. Within this time frame, Teal Group believes that the civil market will remain small but begin to experience rapid growth as access to national airspace becomes more accessible.

To begin with, it is helpful to distinguish at least three elements of the civil UAV market:

- Government UAVs for uses ranging from border security to law enforcement to research on wildlife.

- Commercial UAVs for uses including agriculture, mapping, and natural resource extraction support.

- Hobbyist UAVs which are mass produced around the world for low end UAV applications.

Of these categories, the third will be largely ignored in this study as it involves relatively low cost systems ranging from several hundred to several thousand dollars. While these systems may have commercial applications such as providing support for real estate agents trying to market properties, generally they go to a different market from the higher cost, professional UAVs addressed in this study.

Teal Group believes that non-military government use of UAVs will be the largest single portion of the civil UAV market over the next decade due to easier access to airspace for governmental UAVs as well as the much higher value of those UAVs compared to the small/mini UAVs that will dominate the commercial market.

Major Uncertainties about Civil Government/Commercial Market Development

The rapidity and degree to which the civil/commercial market develops will depend on several factors that are yet to be determined.

Liberalized rules for UAV access to national airspace worldwide will be critical. The degree to which UAVs are allowed be freely used will directly affect the economics. In the United States, the current Certification of Authorization (CoA) process is extremely time-consuming and impractical. Currently unmanned systems need to be transported by ground to the areas at which they to be used. For unmanned aerial systems (UAS) to be economically feasible, there is a need to move to a significantly freer use of UAS.

Sense and avoid technology may be another hurdle. Some UAV manufacturers are very concerned about whether sense and avoid technology will be required for their systems. If it is required, it could raise the cost of those systems and undermine their viability. There also are concerns about the technological maturity of sense and avoid technology although manufacturers generally seem to think it will be available. Even so, the cost of the technology will also be critical in determining the viability of commercial systems.

The debate over safety is also coming to the fore over the possible spoofing of UAVs. In July 2012, a University of Texas team was able to take control of a UAV and send it off course using a GPS spoofing device that cost less than $1,000. While that can be remedied, fixes will add to the cost of UAS. It is not yet clear whether or how the FAA or other agency would deal with that potential threat.

The debate over privacy will also have a direct impact on the use and applicability of UAS. There is considerable sensitivity on the issue and it could lead national, state and local governments to enact laws that would undermine the efficacy of UAS. Some US localities have actually imposed a ban on the use of the systems or imposed restrictions or bans on their use by law enforcement.

The economics of UAS will also be a critical factor. It is clear that inexpensive UAS systems in the mini and small range are often economically viable commercially. They can do missions that would be considerably more expensive using a manned aircraft. In some cases, they can prevent a pilot from going in harm's way to execute that mission.

As the size of the UAV grows, its cost-effectiveness appears to decline. Systems like the Shadow 200, Reaper, and Global Hawk are simply too expensive to have commercial applications at this point. They have high procurement costs, high operating costs and high cost of telemetry. Nor are they likely to be permitted to operate in national airspace in Europe or the United States anytime soon.

A 2010 report by the Congressional Research Service on the Department of Homeland Security's Predator UAVs found that "the costs of operating a UAV are more than double the costs of operating a manned aircraft." This is because UAVs require a significant amount of logistical support and specialized operator and maintenance training. Operating one UAV requires a crew of up to 20 support personnel. Nor did the relevant performance justify that cost. "The use of UAVs has resulted in fewer alien apprehensions per flight hour than the use of manned aircraft," the report noted.

As new systems are developed with more focus on affordability, the economics of using medium-altitude, long-endurance and high-altitude, long-endurance UAVs may change in the future particularly as airspace opens over time.

The reliability of systems will be a serious concern for commercial users even if airspace restrictions are lifted. They will be reluctant to use systems until there is little risk of a crash that would destroy the payload, particularly with larger more costly UAVs, or that might cause greater damage to the air vehicle or targets on the ground. Larger companies may also be reluctant to expose themselves to liability that would come with such a loss.

As a result, the systems with the most commercial viability for the first five years after liberalization of airspace will be mini and small UAVs.

Many of these systems are new and relatively untested. They will take time to develop a safety record that insurance companies and users are able to assess. As a result, insurance costs initially will be high. Reducing those costs will require the establishment of safety records for UAVs.

A study by NASA's Civil UAV Assessment team came to similar

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conclusions in a study released in August 2006. “A major reduction in operating cost is necessary if this class of vehicles is to become a significant part of the air space,” according to the study. The study noted that “metrics such as cost-per-hour for UAV use are often misleading in that they address only a portion of the total cost, i.e., recurring costs of actually flying the vehicle.”

Obviously, law enforcement and public safety will be an important market and one of the first to develop outside of the federal government since it will be an early beneficiary of liberalization of air safety rules. There will be other markets in agriculture, oil and gas and mapping.

The FAA and Progress in Opening National Airspace

The opening of US airspace promises to be a long, arduous process. The FAA is adopting a cautious, phased approach rather than the faster pace pushed by the aerospace industry.

As a result, the timing of the development of US commercial markets remains uncertain.

Although Congress set September 2015 as the date for full integration of UAS into US airspace, it is clear that the FAA will not meet that date.

Small UAS, defined as being under 55 pounds, will be the first step in integrating unmanned systems into the airspace. Not only is that the market with the most immediate commercial viability, but that is also where the FAA is focusing the first steps of its phased approach to opening US airspace.

The FAA is likely to put out a notice of proposed rulemaking by late 2014 for small UAS. There will be a period of public comment that will then last 18 months. That can be extended in the event, as expected, that the rule is contentious. Powerful lobbying groups are lined up on both sides of the issue.

It remains unclear exactly how much the process will be delayed for larger systems. What is clear is that there will be an incremental approach that could result in the larger systems being integrated into airspace gradually in a process likely to take five to 10 years.

FAA Movement in Allowing US Commercial UAS Operations

The FAA is taking measured steps toward allowing commercial operations of UAS in national airspace although the pace is now quickening.

The first step came with the FAA’s issuance of type certificates in the restricted category to the Boeing Insitu ScanEagle and AeroVironment Puma AE small unmanned aircraft systems in July 2013. That would allow both companies to begin UAS commercial operations in the Arctic.

Before that, private companies required a special experimental airworthiness certificate that would prohibit them from being used commercially.

Diversified oil major ConocoPhillips then began to fly the catapult-launched ScanEagle off the Alaska coast in international waters. It was seeking to observe wildlife and provide support for any emergency requirements for oil spill monitoring.

The FAA followed its moves to open up the Arctic to commercial UAS operations with the June 2014 grant of the first-ever over-land restricted type certificate. AeroVironment Puma AE UAS will be allowed to operate in day-to-day operations at the BP Exploration (Alaska)-operated Prudhoe Bay oil field on Alaska’s North Slope, the largest oil field in North America.

As a next step, FAA is considering a streamlined approval process for flights of small UAVs for filmmaking, utilities inspection, agriculture, and other low-risk operations. The approval of a process for limited applications for small UAVs could speed up the development of the commercial market in the United States.

The six test sites that the FAA was supposed to have established by August 2012 were finally announced in December 2013. The test sites are to be used to do flights and conduct the research necessary to safely integrate UAVs into national airspace.

There are also extraneous factors that could affect the speed with which commercial markets develop. Serious safety problems or misuse of the systems to infringe on people’s privacy could result in rules that would undercut development of the market.

Progress in International Airspace Access

A number of countries are well ahead of the United States in providing access to their airspace for commercial UAV operations.

Many European countries, in particular, are well ahead of the United States. Generally regulations for UAVs less than 150 kilograms are being handled by individual European Union nations. Regulations for larger ones are expected to be handled by the European Commission. Eventually the European Commission may take on the role of harmonization of the national requirements to allow a free flow of services across borders within the European Union.

United Kingdom, France, Italy, Germany, Netherlands, Sweden, Czech Republic, Norway and Switzerland are all allowing flights of small UAS in their airspace for commercial operations. These are generally restricted to line-of-sight operations of mini UAVs. Still, this is allowing the creation of a UAS industry in Europe.

For example, United Kingdom legislation established four years ago allows UAS commercial operations for systems up to 20 kilograms. As of mid-2014, some 230 operators were approved to work under the regulations.

More broadly, as many as 2,000 commercial UAV operators are now working in Europe. These are generally very small companies working to establish the commercial viability of using UAS for different applications. Almost all of them are using systems with 15 kilograms or less weight.

Other areas as well are ahead of the United States in allowing access to their airspace.

Australia, one of the most advanced countries in the world when it comes to airspace access. As of mid-2014, Australia had 94 UAS operator certificate holders. These companies, generally small, experimental firms, were working on projects in aerial photography, surveying, power lines, spotting, and crop applications.

Canada, which like Australia, lacks the dense airspace of the United States and Europe, is also in the forefront of airspace opening. It established two test centers three years ago, which have now been operating for two years.

The Japanese government has been very supportive of the establishment of a UAV crop spraying industry due to the aging of the Japanese farming population.

In addition, in many areas of the world without the congested airspaces such as Latin America and the Middle East it will be easier to use the systems for years to come.

"Detect-Sense-and-Avoid" Requirement

One of the technological issues connected to airspace access will be the need for detect-sense-and-avoid (DSA) systems on UAVs operating in controlled airspace. To summarize, requirements for DSA systems will have an impact on the civil UAV market since the technology is not yet mature and until it is mature, it will be difficult for a civil UAV market to emerge. Once the technology does reach maturity, issues such as size, cost, and weight will affect the civil UAV market since a high-cost, large, power intensive system will favor large UAVs but discourage the proliferation of low cost, small UAVs. As a result, there may end up being different DSA requirements for different types of UAVs operating under different conditions.

Durability: Civil vs. Military Attitudes

Even once the issue of access to air space is resolved, other obstacles remain. UAVs continue to have a higher loss rate than conventional manned aircraft. In the case of the military, this is not a big issue if the mission justifies the cost. However, in a non-war situation such as police traffic monitoring, it is difficult to see a city council funding police UAV operations if the UAVs suffer accident rates far in excess of police helicopters. Many proposed civil UAV applications are not life-or-death situations, and so fiscal constraints and operating costs will be a far more substantial issue than in the military case.

This is even more the case with potential commercial extensions of the surveillance UAV such as their use by TV news stations for collecting video imagery. Once again, until UAVs prove cost-effective with relatively high reliability rates, their use in such a role remains financially unattractive.

The durability issue is tied to another commercial issue, namely insurance. Commercial operation of UAVs will be inhibited if insurance firms feel that UAVs are not durable enough, and if they present a distinct liability hazard, such as high potential for crashes in a dense urban environment. For example, in 2010, a Japanese agricultural VTUAV used for crop-spraying crashed and killed a man, the first such incident in Japan which is one of the few countries where there is widespread use of civil UAVs. In May 2012, a Schiebel S-100 Camcopter crashed in Incheon, South Korea, killing an engineer involved in the program.

Beyond the Airspace Access Barrier

Assuming that industry and the FAA and other international organizations manage to create a flexible environment for the operation of civil UAVs, how soon will a significant civil/commercial market emerge?

To begin with, some brief assessment is needed of the current market. This is fairly easy to answer as at the moment there is essentially no market except in the margins. Outside the US, there have been civil UAV markets in place since the 1980s, notably in Japan where there is a significant infrastructure for the use of small helicopter UAVs for crop-dusting. Although the Japanese crop-dusting UAVs have been on offer for several years on the international market, they have not caught on to any significant extent, which suggests that the market may be based on peculiarities of Japan's geography and the government's agricultural policies and subsidies as well as a sympathetic attitude towards airspace access within Japan.

In the US, commercial UAV purchases have been minimal. In April 2005, Tactical Aerospace Company (TAG) in California received a $2.8 million contract to provide 14 helicopter UAVs to Rotor F/X, a firm that provides airmobile cameras to the film industry and television. It's worth noting that TAG claimed that was the largest non-military UAV purchase to date in the US. Since then, the FAA has worked hard to shut down any commercial UAV operations within the United States.

In view of the fact that the US civil/commercial market is nearly non-existent at the moment aside from these rare sales, where are the sales of civil UAVs likely to emerge? Existing military UAVs are for the most part reconnaissance platforms equipped with various types of sensors. So, parallel applications in the civil sector seem the most likely starting point for UAV proliferation. This is already happening with the

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use of Puma AE and ScanEagle in the Arctic, with FAA approval.

One of the first broad applications of UAVs outside the military is likely to be in the paramilitary sphere where the requirements and missions are fairly similar. This will include coast guard and border guard applications for monitoring maritime traffic, monitoring borders, and similar quasi-military homeland security roles. The Department of Homeland Security's Office of Air and Marine has purchased Predator UAVs to patrol the US borders with Mexico, Canada and the Caribbean.

Brazil embarked on a border patrol UAV effort by acquiring Heron UAVs from Israel. The Mexican Federal Police have purchased the Hermes 900 UAV. The European Union has examined the possible purchase or lease of UAVs for border patrol. UAVs have been used in Israel for police surveillance patrols and off Angola for patrol of oil rigs. Saudi Arabia has been considering a comprehensive border security system including UAVs.

Civil Disaster Surveillance

Another potential surveillance market would be forest fire patrols such as those of the US Forest Service (USFS). The applications would be for a variety of different platforms. In 2006, the Coast Guard employed a Predator/Mariner UAV it was using for demonstration purposes to conduct surveillance on wildfires in Alaska. Safran and the French research agency ONERA began a test campaign in 2005 to use older Busard UAVs for fire patrol.

The USFS has tested a NASA General Atomics Altair (Predator derivative) for monitoring a remote wildfire and providing real-time video. The USFS also plans to examine other roles for UAVs including their use as a communication relay which could be a substitute ground based repeaters in remote areas. So far, USFS studies have concluded that operating such UAVs is likely to be more expensive than manned aircraft. Similar trials are occurring in France and elsewhere in Europe. Japan has already acquired small numbers of helicopter UAVs which have been used for similar disaster surveillance, for example surveillance of earthquake areas and volcanic eruptions. The small Japanese UAV monitoring force was found wanting in the wake of the 2011 tsunami, and the US provided a variety of UAVs for disaster monitoring, including the use of the Global Hawk to monitor stricken nuclear reactors.

This market is likely to be slow in emerging due to the usual litany of reasons: airspace access, durability, and cost concerns, as well as the ample availability of alternate platforms, namely manned aircraft. Besides these issues, civil disaster surveillance is, by its nature, an occasional event which may not merit the maintenance of a dedicated UAV force. As in the case of fire-fighting aircraft, this could lead to the emergence of a commercial UAV service which leases UAVs to state and local government for emergency applications.

UAVs in Other Federal Applications

It seems likely that UAVs will eventually penetrate other government agencies. The FBI made its first UAV purchase in 2005 in a limited program, spending $3 million on the systems since then. It has sought the ability to broaden the deployment scenarios for UAVs in discussions with the FAA.

Comparable federal police organizations overseas are likely to also adopt UAV systems.

There are already numerous experimental programs by police departments in the US, Britain, and elsewhere.

Other federal law enforcement agencies are also potential customers once the cost of UAV operations becomes competitive to manned aircraft operations. For example, this could include drug enforcement activity such as surveillance of terrain for drug cultivation; this has already been done in South and Central America with US government assistance. At the moment, these applications seem more distant and on a smaller scale than other government applications noted above. Since the requirements seem less pressing, these agencies are more likely to wait until UAVs are a proven technology with an established record of operational costs. At the moment, there is no reliable track record to determine costs, air vehicle reliability or other factors. US military costs have significant weaknesses due to their use in a combat environment and the willingness of the military to operate UAVs in risky situations where a civil UAV would probably be grounded. Nevertheless, the high rate of attrition of military UAVs serves as another impediment to UAV proliferation into other segments of the government

Surveillance of Critical Infrastructure

There have been suggestions that UAVs might be used for non-governmental security roles such as patrolling critical infrastructure. This could include surveillance against criminal/terrorist threats such as to nuclear power plants, or the use of UAVs as a substitute for manned aircraft for surveys of pipelines, power-lines, airports and the like. At the moment, the use of UAVs for critical infrastructure protection of fixed sites such as nuclear power plants, chemical plants and so on appears to be remote due to the many factors inhibiting the civil use of UAVs already mentioned.

In addition, UAVs have to compete against existing technologies on a cost basis. Fixed sites such as power plants and other industrial facilities can use less expensive surveillance methods including both manned patrols as well as fixed surveillance devices such as CCTV.

Should a significant domestic terrorist threat emerge, attitudes could change rapidly. For example, if terrorists manage to smuggle man-portable anti-aircraft missiles (MANPADS) into a country, or even rocket propelled grenades (RPG) and begin attacking airlines from the perimeter of commercial airports, there would likely be a call for heightened perimeter security. This could include UAV surveillance, but even in these dire circumstances, other more traditional patrol and surveillance methods would probably be the preferred choice until UAVs mature.

The use of UAVs for survey of power lines and pipelines is a niche market that could be satisfied by specialist aviation firms contracting out UAV services rather than outright purchase by firms which do not need enough flight time to justify ownership.

Commercial Applications

Besides the adaptation of military-like reconnaissance UAVs to paramilitary and surveillance roles, numerous applications have been suggested for civilian UAVs. Some of these seem contrived and commercially dubious. Endurance UAVs have been suggested as the basis for a low-cost alternative to satellites to serve as orbiting communication relays for communication networks and as airborne cellular antennas. Nevertheless, such an application has not yet emerged and may never do so. It is possible that such a function could be more economically addressed by antennas mounted on tethered balloons or on minimally controlled balloons.

This possible application to bring the internet to new areas and provide low cost imagery has attracted interest from firms outside of aerospace. Google and Facebook purchased Titan Aerospace and Facebook, respectively, precisely to work in this area, creating a new generation of low-cost, long-endurance UAVs able to stay up for months or years.

However, there are considerable technological challenges in such an effort so Teal Group has not included these applications in its base forecast.

In addition, the military is beginning to look at communication relay UAVs as a solution to the use of line-of-sight data links in urban areas and in other types of restricted terrain that inhibit UAV operations. This could pave the way for civilian off-shoots.

Commercial UAV Fee-for-Services

One of the first commercial applications for UAVs may not be direct commercial applications but rather commercial ownership of UAVs which are in turn leased out to government or industrial firms for surveillance missions. As suggested above, some organizations have surveillance or survey needs that might be met by UAVs, but the cost of acquiring UAVs, training crews and operating the systems may be more complex and expensive than is warranted. As a result, a small number of firms have already been organized to provide UAV services. The Israeli firm Aeronautics was one of the first in this field, contracting with the Israeli government in 2004 to conduct surveillance operations over Gaza in a quasi-military/police role. Boeing Insitu and Textron Unmanned Systems which have provided extensive fee-for-service work to the US military plan to move into commercial fee-for-service operations in the United States and internationally.

A number of other firms have expressed an interested in doing fee-for-service commercial operations, but access to US airspace remains the major impediment.

The US Forest Service has already stated that at least in the near term, it would prefer to lease UAV services than acquire and operate UAVs. As a result, the UAV services option may prove to be a popular commercial route for UAVs in the short-term until UAV technology matures.

Agricultural Applications

Precision agriculture promises to be a strong potential market for UAVs over the longer term although it may take time for some of the applications to develop, particularly since it tends to be a relatively conservative market. Yet it is also the commercial market with the most current use of UAS and it promises to be the largest commercial market for UAS over the long-term.

Agriculture does have appeal as a potential UAV market. It is a large $183 billion business in the United States alone with a much larger global market. Vast tracts of land are involved in agriculture. Worldwide 914 million hectares are being cultivated, only 100 million of which are in the United States.

The overall trends in agriculture are favorable. There is a need for more food worldwide which can be dealt with by reducing crop lost to disease and pests.

There are basic potential applications for UAVs in imaging and crop spraying. Both areas have potential for UAV sales.

UAV crop spraying promises to have international applicability. For example, Brazil and Argentina have 100 million hectares per year under cultivation in grain. In meeting the requirement for spraying 2,200 manned fixed wing aircraft and 25,000 land sprayers are used in a $5 billion annual market, according to figures developed by Aerodreams, an Argentine UAS company.

There are technical advantages for an unmanned system. A robotic helicopter will fly low and slow, making the spraying more effective. There are other obvious benefits such as avoiding putting a pilot at risk.

Flying a robotic helicopter means that there is more consistent application of chemicals because there is no need for a pilot to pull up to make a turn at the end of the field.

There has been some early adopting of crop-spraying systems in Japan. Due to an aging farm popula-

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tion, the Japanese government approached Yamaha in the early 1980s about creating a UAV that could help that population cultivate their rice.

Yamaha developed the RMax, which has gone through several models, with 2,400 flying in Japan. There are another 100 RMax and similar models flying in Korea. In all, RMax has 85% of the world market for unmanned crop-spraying aircraft.

The other major potential agricultural market for UAVs is in imaging. The results here have been mixed so far in terms of the applicability and economics of such systems.

UAS imagery can be effective in studying crop health and detecting plant stress early. Multi-spectral, thermal imaging and LIDAR can be used to identify areas of different crops or varieties, diseased crops, pest damage, among other uses. In Chile, farmers are using multispectral imagers to pick grapes at the right time.

There are a variety of challenges in gaining acceptance of UAVs in addition to the cost and effectiveness issues, according to other agricultural experts. There are concerns about software crashes, developing the technical experience to operate the systems, liability for accidents and a shift in farming traditions.

The agricultural market will be even greater outside the United States. Promising areas include Brazil, Chile, Australia, and Africa. Those areas may actually develop more quickly than the United States, as the US waits for the FAA to open up airspace.

In many ways, agriculture is an ideal area for UAVs. Operating areas are low, flat, rural areas in which risks to aircraft and populated areas are quite limited.

Research UAVs

UAVs have been used extensively for civilian scientific research, but none of this has transitioned to high volume commercial applications. Scientific applications can be easily envisioned for UAVs such as environmental monitoring, weather/atmospheric data collection, oceanographic data collection, agricultural monitoring, and high altitude geological mapping of magnetic, radiological and gravimetric data. Some of these research applications could become commercial. For example, the US Department of Defense has discussed contracting private firms to operate research UAVs over the Pacific to collect weather data. For the time being, Teal Group is not forecasting these non-commercial UAVs as they are likely to be single air vehicles, not serial production.

Civil/Commercial UAV Market Outlook

Teal Group sees the beginning of the development of a non-military UAS market.

This market will take time to develop. The speed and size of the market will directly relate to the specific rules adopted by regulatory bodies worldwide regarding access to the airspace. The more restrictive those rules are the slower will be the adoption by civil government and commercial customers. The longer those rules take to develop for routine access to airspace, the less valuable the market will be during the forecast period.

The efficacy of UAVs is being hobbled by their lack of access to national airspace worldwide. Developing the procedures to remedy that is likely to take time. It is clear that the FAA will not be able to completely open airspace in the United States by September 2015. Rather there will be a series of steps that will be determined by political pressures such as the debate over privacy and technological developments such as sense-and-avoid technology.

The initial growth in the civil government UAV field will be quasi-military security applications such as maritime patrol and border patrol and the air vehicles are likely to be identical to their military counterparts.

As the commercial market develops it will be based on inexpensive mini and small UAVs and will be much more price sensitive than the governmental market. Even local law enforcement agencies will be buying inexpensive mini-systems rather than much more costly larger UAVs. While the unit numbers of these UAVs purchased in coming years promise be substantial, their value will be a small fraction of that of the costly, sophisticated systems such as Global Hawk and Predator.

As a result, the civil/commercial UAV market is likely to be small through this forecast period, and in our estimate, well under 10% of the overall market by value. However, its growth rate (albeit from a low base) will be explosive.

UAVs today are probably in a situation analogous to aircraft at the end of the First World War or helicopters at the end of World War II. The bulk of aircraft manufacture up to 1920 was for the military, with modest numbers of aircraft in civilian hands. As aircraft technology became more mature through the 1920s, civil applications of aircraft became more plausible for roles such as mail delivery and eventually for passenger transport, and within a decade had become a significant market. Likewise, helicopters were largely confined to military roles well into the 1950s until they reached maturity, not entering the civil market in substantial numbers until the 1960s.

Another more relevant analogy which may illustrate the time frame of civil UAV proliferation is the military example. In the case of the US Army, the Army attempted to field a tactical UAV in the late 1970s (Aquila) but was frustrated by and overly ambitious design. The army again tried repeatedly in the 1990s to field a tactical UAV but was frustrated by bureaucratic interference when the DoD forced the Army and Navy to join their disparate requirements in a joint program (Hunter), followed by poor Army decision making on the follow-on program (Outrider). At no time was there any specific technological barrier since in the same time frame the Israelis managed to field tactical UAVs. Rather it was a combination of technological ambitions, bureaucratic hurdles, poor decision making, and other normal impediments to technological innovation that crippled the Army program. The Army finally settled on the Shadow and began deploying it in Iraq roughly 30 years after the Army tactical UAV program began. The Shadow includes numerous improvements over Israeli UAVs of the 1980s, but it can hardly be considered a revolutionary technological advance.

The US Air Force example is perhaps less messy and less prolonged, but it should be recalled that the US Air Force also took decades with a long period of experimentation with systems such as Compass Cope (1970s), and Condor (1980s) before the advent of Predator and Global Hawk. If non-real-time reconnaissance UAVs are included such as the Vietnam-era Firebee drones, then the Air Force UAV time-line is even more protracted.

These historical analogies suggest that the civil/commercial UAV market will take time to develop and that it's most rapid rise will probably not occur until well outside this forecast period.

A likely scenario is that there will be a spurt of small-scale UAV acquisition by government agencies such as the Coast Guard and Border Patrol, as well as modest acquisitions by a number of commercial firms establishing a small UAV services/leasing industry to cater to other government agencies, as well as for initial commercial demand in areas such as agriculture and natural resources extraction support. This spurt will be noticeable in the mid-term of this forecast (2018/19) assuming that the FAA standards for airspace access are formalized and are not too onerous. Should the FAA restrictions remain in place or include substantial technological hindrances such as a restrictive sense-and-avoid requirement, complicated and expensive certification procedures, or onerous insurance levels, this would probably push back this spurt to the end of the forecast period.

Only after these issues are settled is there likely to be significant growth in non-military governmental and commercial use of UAVs. A rapid rise in US civil UAV acquisition is unlikely to occur before 2019/2020 due to the current federal budgetary problems that are slowing acquisition plans for Customs and

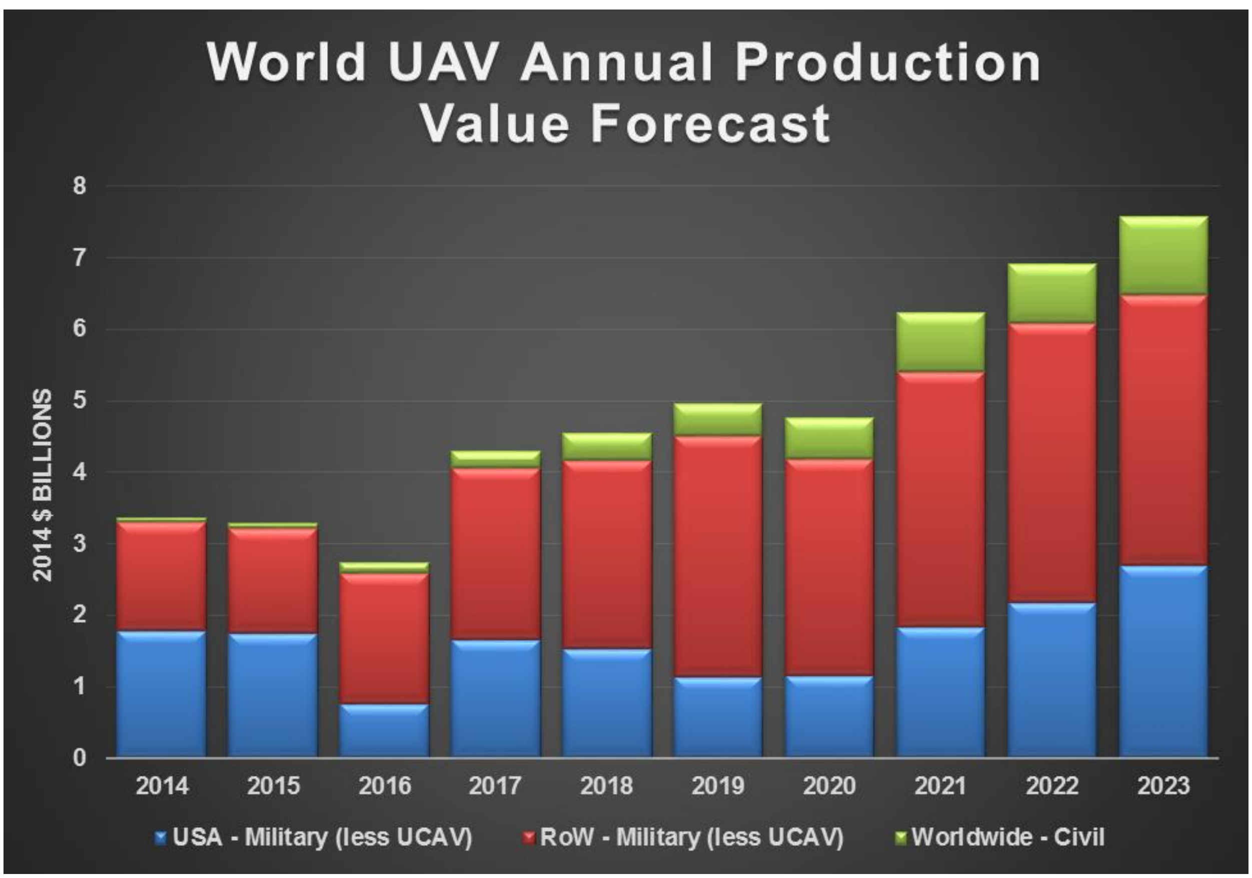

Figure 3

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Border Protection and the Coast Guard.

The bottom line is that Teal Group believes that the potential for civilian use of UAVs will come, but it will take time to develop and will not be anywhere near the value of the military market anytime soon.

International civil UAV production will remain larger than US production throughout the forecast period and is likely to develop earlier. In part that reflects the greater ease with which such systems are used in countries with less strict rules on their national airspace and with less congested airspace. That is allowing earlier adoption of the systems overseas.

In addition, the vast tracts of agricultural land in areas such as Latin America may offer strong potential for the adoption of UAS there, particularly in higher income countries such as Chile and Brazil.

Lengthy oil and gas pipelines overseas, which do not have the established pipeline patrol infrastructure and companies of the United States, are likely to spur the use of UAS in these areas.

Lastly, the use of UAVs for border patrol has lagged their use in the United States and these countries are expected to catch up on the use of such systems in areas such as European borders and Latin America.

The Numbers

Mini-UAV Production Forecast by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	950	950	950	1,050	1,250	1,500	1,700	2,000	2,000	2,500	14,850
Europe	405	307	222	253	336	556	540	485	535	620	4,259
Mid-East	480	155	165	215	120	55	280	347	507	407	2,731
Africa	80	45	70	—	—	135	110	37	50	50	577
Asia-Pacific	255	320	305	610	615	850	780	1,040	1,040	1,040	6,855
Americas	85	35	—	—	30	155	30	10	55	55	455
Total	**2,255**	**1,812**	**1,712**	**2,128**	**2,351**	**3,251**	**3,440**	**3,919**	**4,187**	**4,672**	**29,727**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	95.0	95.0	95.0	105.0	125.0	150.0	170.0	200.0	200.0	250.0	1,485.0
Europe	26.3	20.0	14.4	16.4	21.8	36.1	35.1	31.5	34.8	40.3	276.8
Mid-East	24.0	7.8	8.3	10.8	6.0	2.8	14.0	17.4	25.4	20.4	136.6
Africa	4.0	2.3	3.5	—	—	6.8	5.5	1.9	2.5	2.5	28.9
Asia-Pacific	14.0	17.6	16.8	33.6	33.8	46.8	42.9	57.2	57.2	57.2	377.0
Americas	4.7	1.9	—	—	1.7	8.5	1.7	0.6	3.0	3.0	25.0
Total	**168.0**	**144.5**	**138.0**	**165.7**	**188.3**	**250.9**	**269.2**	**308.5**	**322.9**	**373.4**	**2,329.3**

Small Tactical UAV Production Forecast by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	10	20	15	30	40	50	50	50	50	50	365
Europe	92	55	49	107	109	84	85	89	113	128	911
Mid-East	78	78	62	50	54	31	52	70	70	55	600
Africa	5	30	—	—	5	20	35	8	18	18	139
Asia-Pacific	37	12	11	16	11	35	11	23	6	6	168
Americas	21	12	22	—	—	30	16	—	—	—	101
Total	**243**	**207**	**159**	**203**	**219**	**250**	**249**	**240**	**257**	**257**	**2,284**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	5.0	10.0	7.5	15.0	20.0	25.0	25.0	25.0	25.0	25.0	182.5
Europe	46.0	27.5	24.5	53.5	54.5	42.0	42.5	44.5	56.5	64.0	455.5
Mid-East	35.1	35.1	27.9	22.5	24.3	14.0	23.4	31.5	31.5	24.8	270.0
Africa	1.5	9.0	—	—	1.5	6.0	10.5	2.4	5.4	5.4	41.7
Asia-Pacific	14.8	4.8	4.4	6.4	4.4	14.0	4.4	9.2	2.4	2.4	67.2
Americas	8.4	4.8	8.8	—	—	12.0	6.4	—	—	—	40.4
Total	**110.8**	**91.2**	**73.1**	**97.4**	**104.7**	**113.0**	**112.2**	**112.6**	**120.8**	**121.6**	**1,057.3**

Tactical UAV Production Forecast Summary by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Europe	64	52	51	32	46	80	64	65	75	50	579
Mid-East	34	4	4	4	4	22	44	44	44	34	238
Africa	3	3	6	11	17	22	23	29	23	23	160
Asia-Pacific	54	51	59	79	95	112	136	109	109	114	918
Americas	15	17	12	6	6	—	4	13	13	13	99
Total	**170**	**127**	**132**	**132**	**168**	**236**	**271**	**260**	**264**	**234**	**1,994**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Europe	224.0	182.0	178.5	112.0	161.0	280.0	224.0	227.5	262.5	175.0	2,026.5
Mid-East	102.0	12.0	12.0	12.0	12.0	66.0	132.0	132.0	132.0	102.0	714.0
Africa	4.5	4.5	9.0	16.5	25.5	33.0	34.5	43.5	34.5	34.5	240.0
Asia-Pacific	162.0	153.0	177.0	237.0	285.0	336.0	408.0	327.0	327.0	342.0	2,754.0
Americas	37.5	42.5	30.0	15.0	15.0	—	10.0	32.5	32.5	32.5	247.5
Total	**530.0**	**394.0**	**406.5**	**392.5**	**498.5**	**715.0**	**808.5**	**762.5**	**788.5**	**686.0**	**5,982.0**

Naval UAVs Production Forecast Summary by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	30	6	5	5	—	—	—	5	5	5	61
Europe	8	8	20	22	25	21	25	32	32	32	225
Asia-Pacific	—	—	6	18	18	30	18	21	27	21	159
Americas	—	—	—	—	1	2	—	—	2	2	7
Total	**38**	**14**	**31**	**45**	**44**	**53**	**43**	**58**	**66**	**60**	**452**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	450.0	90.0	75.0	75.0	—	—	—	75.0	75.0	75.0	915.0
Europe	80.0	80.0	200.0	220.0	250.0	210.0	250.0	320.0	320.0	320.0	2,250.0
Asia-Pacific	—	—	48.0	144.0	144.0	240.0	144.0	168.0	216.0	168.0	1,272.0
Americas	—	—	—	—	8.0	16.0	—	—	16.0	16.0	56.0
Total	**530.0**	**170.0**	**323.0**	**439.0**	**402.0**	**466.0**	**394.0**	**563.0**	**627.0**	**579.0**	**4,493.0**

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MALE UAV Production Forecast Summary by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	62	78	29	44	52	25	25	42	48	60	465
Europe	4	5	8	21	16	15	15	12	12	14	122
Mid-East	12	13	19	15	13	10	2	18	18	18	138
Africa	3	2	1	1	2	1	2	3	3	3	21
Asia-Pacific	15	15	9	22	26	37	25	33	33	33	248
Americas	8	9	9	1	1	7	8	15	11	11	80
Total	**104**	**122**	**75**	**104**	**110**	**95**	**77**	**123**	**125**	**139**	**1,074**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	1,240.0	1,560.0	580.0	880.0	1,040.0	500.0	500.0	840.0	960.0	1,200.0	9,300.0
Europe	80.0	100.0	160.0	420.0	320.0	300.0	300.0	240.0	240.0	280.0	2,440.0
Mid-East	240.0	260.0	380.0	300.0	260.0	200.0	40.0	360.0	360.0	360.0	2,760.0
Africa	27.0	18.0	9.0	9.0	18.0	9.0	18.0	27.0	27.0	27.0	189.0
Asia-Pacific	225.0	225.0	135.0	330.0	390.0	555.0	375.0	495.0	495.0	495.0	3,720.0
Americas	160.0	180.0	180.0	20.0	20.0	140.0	160.0	300.0	220.0	220.0	1,600.0
Total	**1,972.0**	**2,343.0**	**1,444.0**	**1,959.0**	**2,048.0**	**1,704.0**	**1,393.0**	**2,262.0**	**2,302.0**	**2,582.0**	**20,009.0**

HALE UAV Production Forecast Summary by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	—	—	—	5	3	4	4	6	8	10	40
Europe	—	—	1	1	1	1	—	2	2	2	10
Mid-East	—	—	—	1	1	3	3	—	—	—	8
Asia-Pacific	—	1	2	4	6	7	7	8	12	12	59
Total	**—**	**1**	**3**	**11**	**11**	**15**	**14**	**16**	**22**	**24**	**117**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	—	—	—	575.0	345.0	460.0	460.0	690.0	920.0	1,150.0	4,600.0
Europe	—	—	50.0	50.0	50.0	50.0	—	100.0	100.0	100.0	500.0
Mid-East	—	—	—	75.0	75.0	225.0	225.0	—	—	—	600.0
Asia-Pacific	—	75.0	150.0	300.0	450.0	525.0	525.0	600.0	900.0	900.0	4,425.0
Total	**—**	**75.0**	**200.0**	**1,000.0**	**920.0**	**1,260.0**	**1,210.0**	**1,390.0**	**1,920.0**	**2,150.0**	**10,125.0**

UCAV Production Forecast Summary by Region

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	—	—	—	—	2	5	9	9	10	10	45
Europe	—	—	—	—	—	—	7	3	9	3	22
Asia-Pacific	—	—	—	—	—	—	—	4	4	4	12
Total	**—**	**—**	**—**	**—**	**2**	**5**	**16**	**16**	**23**	**17**	**79**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
USA	—	—	—	—	300.0	750.0	1,350.0	1,350.0	1,500.0	1,500.0	6,750.0
Europe	—	—	—	—	—	—	700.0	300.0	900.0	300.0	2,200.0
Asia-Pacific	—	—	—	—	—	—	—	400.0	400.0	400.0	1,200.0
Total	**—**	**—**	**—**	**—**	**300.0**	**750.0**	**2,050.0**	**2,050.0**	**2,800.0**	**2,200.0**	**10,150.0**

Civil Government & Commercial UAVs

(Units, Air Vehicles)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
US CBP (Endurance UAV)	—	—	1	1	1	1	2	2	2	2	12
US Coast Guard (Endurance UAV)	—	—	1	1	1	2	2	2	2	2	13
Other US Gov. (Endurance UAV)	—	—	—	—	—	—	2	2	2	2	8
US Civil (Mini/Small UAV)	15	35	100	500	1,000	1,000	1,200	2,000	2,000	3,000	10,850
Int'l Civil (Endurance UAV)	2	2	4	4	6	6	8	8	8	8	56
Int'l (Mini/Small UAV)	250	350	450	900	1,500	2,000	2,200	4,000	4,000	5,500	21,150
Total Worldwide	**267**	**387**	**556**	**1,406**	**2,508**	**3,009**	**3,414**	**6,014**	**6,014**	**8,514**	**32,089**

($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
US CBP (Endurance UAV)	—	—	17.0	17.0	17.0	17.0	34.0	34.0	34.0	34.0	204.0
US Coast Guard (Endurance UAV)	—	—	17.0	17.0	17.0	34.0	34.0	34.0	34.0	34.0	221.0
Other US Gov. (Endurance UAV)	—	—	—	—	—	—	34.0	34.0	34.0	34.0	136.0
US Civil (Mini/Small UAV)	1.5	3.5	10.0	50.0	100.0	100.0	120.0	200.0	200.0	300.0	1,085.0
Int’l Civil (Endurance UAV)	34.0	34.0	68.0	68.0	102.0	102.0	136.0	136.0	136.0	136.0	1,646.0
Int’l Civil (Mini/Small UAV)	25.0	35.0	45.0	90.0	150.0	200.0	220.0	400.0	400.0	550.0	2,115.0
Total Worldwide	**60.5**	**72.5**	**157.0**	**242.0**	**386.0**	**453.0**	**578.0**	**838.0**	**838.0**	**1,088.0**	**5,407.0**

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