



## Drones: high-profile and niche

Deloitte predicts that in 2015, the active base of non-military drones costing \$200 or more should exceed one million units for the first time. We expect sales of non-military drones (also known as unmanned aerial vehicles or UAVs), to be about 300,000 units in 2015, with the majority being bought by consumers or prosumers. We expect total industry revenues to be \$200-\$400 million dollars in 2015 (equivalent to the list price of a single, mid-sized passenger jet). In short, while we believe that UAVs have a tremendous range of applications, particularly for enterprise and government, we are not foreseeing a breakthrough year for drones in 2015.

This prediction focuses on three categories of UAV, defined by price and performance (we have excluded toys, due to lesser range and potential impact).<sup>26</sup>

- Entry-level hobbyist models, typically priced at \$300 – \$500 per kit (including the drone itself, additional batteries, chargers, GPS modules and spares). These have four rotors, a range under direct control of up to fifty meters, and can fly for up to about 20 minutes on an extended battery. Basic models can fly at about 15 kilometers per hour (km/h) horizontally. They weigh less than half a kilogram, are about half a meter in length, incorporate a basic camera, and are typically controlled via smartphone or tablet apps.<sup>27</sup>
- Prosumer devices cost from around \$750 per kit.<sup>28</sup> These have four to six rotors and a flying range of up to a kilometer. They can fly at 50 km/h (about 15 meters a second) and can remain airborne for up to 25 minutes. They weigh about a kilogram and usually have a separate controller.
- Enterprise models, costing from \$10,000 and up. These usually have six or more rotors, large blades, and multiple motors and are capable of lifting more than three kilograms. Some units have wings and propellers. These units can be designed to maximize payload or range. Some models are capable of an hour's flying time.

The UAV market has benefited over the past decade from the surge in demand for consumer electronics, particularly at hobbyist level. For example, a key appeal of drones is their ability to capture high-definition (HD) video: the billions of sensors and lenses produced for devices such as smartphones each year have enabled better quality and lower prices for applications, such as drones.

Also, a smartphone or tablet can be used to control a drone, removing the cost of a separate controller. Routes can be defined using online maps and GPS positioning. The accelerometers and gyroscopes used in drones are bulk-produced for smartphones. Wi-Fi can be used to control the drone, and also to relay images.<sup>29</sup>

For consumers, UAVs blend the appeal of remote-controlled vehicles, high-definition photography and kite flying. The primary application by consumers of drones seems to be for aerial photography.<sup>30</sup> There are UAVs that are designed for “follow-me” footage: the drone is programmed to track and film from the air the progress of someone skiing down a slope.<sup>31</sup> As smartphone camera quality improves, this will be incorporated into UAVs, enabling ever more spectacular footage.

UAVs are also being deployed in a widening range of professional contexts. Drones provide some of the observational or sometimes transportation functionality of a helicopter from \$1,000 a unit, and without the cost of an onboard pilot, or even a pilot at all. They can undertake tasks that were previously too expensive to consider. Farmers can survey crops, without needing to visit their fields.<sup>32</sup> Livestock owners can undertake aerial searches for lost animals or even herd them.<sup>33</sup> Police forces and rescue units can use them to complement search and rescue missions, especially by using infra-red cameras.<sup>34</sup> Geologists can use them to map uncharted territories, or to survey for oil.<sup>35</sup> UAVs can inspect wind turbines, which reach several hundred feet in the air, removing the need for someone to climb up a structure.<sup>36</sup>

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26. An in-depth view on UAVs is available here, see: Unmanned aerial vehicle in logistics, DHL, 2014: [http://www.dhl.com/content/dam/downloads/g0/about\\_us/logistics\\_insights/DHL\\_TrendReport\\_UAV.pdf](http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/DHL_TrendReport_UAV.pdf)
27. The caliber of the camera depends on the price paid. See: Parrot's BeBop drone is a speed demon, Mashable, 19 November 2014: <http://mashable.com/2014/11/18/parrot-bebop-drone-2/>
28. The new BeBop drone from Parrot, one of the three largest consumer drone manufacturers, costs about \$900 as part of a kit including three batteries. See: Parrot's BeBop drone is a speed demon, Mashable, 19 November 2014: <http://mashable.com/2014/11/18/parrot-bebop-drone-2/>
29. As well as smartphones, other devices can be used to control drones, including smart glasses and virtual reality glasses. Currently our view is that the installed base of such devices is minimal. For more information on alternative controllers, see: Parrot AR.Drone 2.0: Even more piloting possibilities!, Parrot, 6 January 2014: <http://blog.parrot.com/2014/01/06/parrot-ar-drone-2-0-even-more-piloting-possibilities/>
30. To see some compilations of drone footage, see: The 7 most viral drone videos in the world, Business Insider, 27 September 2014: <http://www.businessinsider.com/7-best-viral-drone-videos-in-the-world-2014-9?IR=T>; The best drone videos from around the web, Time, 8 July 2014: <http://time.com/2967209/best-drone-videos/>; Killer whales caught in stunning drone footage, Livescience, 21 October 2014: <http://www.livescience.com/48371-drone-photographs-killer-whales.html>
31. This system combines a drone with a third-party camera, and uses long-range Bluetooth to follow the individual. For more information, see: AirDog: World's First Auto-follow Drone for GoPro Camera, Kickstarter, as accessed on 8 December 2014: <https://www.kickstarter.com/projects/airdog/airdog-worlds-first-auto-follow-action-sports-dron>
32. For example see: Farming takes flight drones save IL farmers time and money / public news service, Farming Drones, 21 July 2014: <http://farmingdrones.com/farming-takes-flight-drones-save-il-farmers-time-money-public-news-service/>
33. To see footage of cows being herded by drone, see: Cow drone herding, YouTube, 28 December 2012: <https://www.youtube.com/watch?v=kK9gv2VJIM#t=21>
34. For example, see: FAA allows drone use in missing person search, The Hill, 9 November 2014: <http://thehill.com/policy/transportation/217393-faa-allows-police-to-use-drone-in-missing-person-search>. Also see: Model drone finds elderly man, missing for three days, ArStechnica, 23 July 2014: <http://arstechnica.com/tech-policy/2014/07/model-drone-finds-elderly-man-alive-after-going-missing-for-three-days/>
35. UAVs can be used to provide additional aerial surveys between bore holes. See: Drones offer 360° vision for oil-hunting geologists, The Conversation, 15 January 2014: <http://theconversation.com/drones-offer-360-vision-for-oil-hunting-geologists-22022>
36. For an example of a company providing such a services, see: Wind Turbine Blade Inspections, Atmoscam, as accessed on 8 December 2014: <http://www.atmoscam.com/uav-industrial-services/wind-turbine-blade-inspections>
37. Cyberhawk UAV inspection cuts cost of decommissioning North Sea oil rig in IMechE PE magazine, Cyberhawk, as accessed on 8 December 2014: <http://www.the-cyberhawk.com/2013/02/cyberhawk-uav-inspection-cuts-cost-of-decommissioning-north-sea-oil-rig-in-imeche-pe-magazine/>
38. For more information on how drones are being used by archaeologists around the world, see: New to the Archaeologist's Tool Kit: The Drone, The New York Times, 13 August 2014: [http://www.nytimes.com/2014/08/14/arts/design/drones-are-used-to-patrol-endangered-archaeological-sites.html?\\_r=0](http://www.nytimes.com/2014/08/14/arts/design/drones-are-used-to-patrol-endangered-archaeological-sites.html?_r=0)

Off-shore oil rigs can be similarly inspected.<sup>37</sup>

Archaeologists have used drones to create 3D images of sites, and also to patrol for looters.<sup>38</sup> Finally, they can be used to distribute medicines, in the absence of viable roads, as part of disaster relief or other humanitarian campaigns.<sup>39</sup>

Aerial news footage no longer requires a helicopter or a trained pilot.<sup>40</sup> Some wedding photographers have used drones to capture the ultimate crowd shot.<sup>41</sup> Drones' newsworthy ability to film footage that would otherwise be hard to reach – from the sides of skyscrapers to the backyards of celebrities to the tops of power stations – has raised their profile significantly.<sup>42</sup>

Drones offer fantastic possibilities for enterprises and consumers, and will be used for an increasingly diverse range of observation applications. But it is unlikely that in there will be a surge in demand for UAVs, such that they become a mass-market (multiple millions of units) global market.

Three key factors are likely to constrain demand in the short – and medium-term.

### Drones crash

First, flying drones consistently well is challenging and crashes are common. We expect this will dissuade many from spending a few hundred dollars on a fast, hobbyist UAV in 2015.

An individual can fly a drone within minutes of assembly; but even an experienced pilot can suddenly lose control even in everyday conditions, that is with occasional gusts of wind and with cloud.<sup>43</sup> Piloting a drone, which can attain 50 km/h, but which travels in three dimensions, and which is readily buffeted by the elements is tricky. Even flying indoors can be challenging.<sup>44</sup>

Plotting the course for a drone is simple using an online map and GPS. But GPS can readily be lost – for example if a building blocks the signal, or simply due to dense cloud. Once contact is lost the drone would be flying blind. A lost drone might land safely in an unpopulated area; or it could crash into a building, or worse, land on an individual, with rotors still spinning.<sup>45</sup>

Drones' propensity to crash – either due to pilot error or mechanical failure – is reflected in the fact that drone kits often come equipped with a full spare set of rotor blades.

Someone considering what to spend a few hundred dollars on would likely purchase a new smartphone, which could be used every day, ahead of an equally-priced UAV, capable of taking awesome footage, but constrained by a fifteen-minute battery range, and with an odds-on chance of crashing.

A further constraint on consumer UAV usage is that it may be considered anti-social, particularly if used to capture images of areas of outstanding beauty.<sup>46</sup> The sight and noise of a single drone could tarnish a perfect sunset for hundreds of sightseers in the vicinity, as well as affect the behavior of wildlife.<sup>47</sup> Some people may consider a camera-equipped drone flying over their heads as an invasion of privacy – even if the camera is not turned on.

### Regulation is uncertain

UAV regulation is likely to constrain their use. In some markets, regulation is imminent, while in others, drones come under the same rules as apply to remote controlled aircraft.

In the US, the Federal Aviation Administration has published an initial plan to integrate unmanned vehicles into US airspace.<sup>48</sup> In the European Union, the Commission has set out its views on "how to address civil drones, or remotely piloted aircraft systems (RPAS), operations in a European level policy framework which will enable the progressive development of the commercial drones market while safeguarding the public interest".<sup>49</sup>

Controls can cover a range of UAV actions including the height drones can attain, the distance they can fly from the operator, the required distance between the vehicle and people and the qualifications the pilot needs. For example in the UK, the Civil Aviation Authority permits UAVs of under 20 kilograms in normal airspace so long as they are 150 meters from crowds, 50 meters from a person or a building and within line of sight (defined as within 500 meters' distance and under 122 meters' height). Commercial use of drones requires a license, for which there is a test commensurate with the demands of flying a UAV: as well as a theory test, the practical test requires demonstrating competence in flying figures of eight, or descending at a specific angle.<sup>50</sup>

In the US, there were 25 reported near misses involving UAVs and piloted planes at altitudes of several thousand feet between June and November 2014, some involving large passenger planes.<sup>51</sup> Hobbyist UAVs tend not to have anti-collision systems as these add cost, bulk and weight, reducing the vehicles range.<sup>52</sup> Because of this potential danger, it is likely that most markets will regulate the use of drones.

39. Low-income countries might get drone deliveries before the U.S. Here's why., The Washington Post, 3 December 2013: <http://www.washingtonpost.com/blogs/the-switch/wp/2013/12/03/low-income-countries-might-get-drone-deliveries-before-the-u-s-heres-why/>
40. For example see: Behind the mind-boggling shots captured by BBC drones, Wired.co.uk, 12 February 2014: <http://www.wired.co.uk/news/archive/2014-02/12/bbc-drone-journalism>. Also see: Hundreds of Thousands Evacuated as Typhoon Nears Philippines, NBC News, 5 December 2014: <http://www.nbcnews.com/watch/nbc-news/suburban-buffalo-snow-day-captured-by-drone-361764419988>
41. For example, see: Drone cameras take wedding photography to new heights, CBS News, 5 August 2014: <http://www.cbsnews.com/videos/drone-cameras-take-wedding-photography-to-new-heights/>
42. For example, see: France probes fresh drone flights over nuclear power plants, Euronews, 1 November 2014: <http://www.euronews.com/2014/11/01/france-probes-fresh-drone-flights-over-nuclear-power-plants/>. Also see: Attack of the drones: Hollywood celebrities are besieged by paparazzi spies in the sky. Worried? You should be... because they'll soon be a regular fixture over YOUR home. Mail Online, 9 September 2014: <http://www.dailymail.co.uk/news/article-2746231/Attack-drones-Hollywood-celebrities-besieged-paparazzi-spies-sky-Worried-You-ll-soon-regular-fixture-YOUR-home.html>
43. The majority of reviews of drones read as research for this chapter mentioned crashes during testing. In all the following reviews or other articles, the product reviewers experienced a major crash. See: Review: Using the DJI Phantom 2 Vision+ camera drone with Apple's iPhone, Apple Insider, 3 August 2014: <http://appleinsider.com/articles/14/08/03/review-using-the-dji-phantom-2-vision-camera-drone-with-apples-iphone>. Also see: I almost killed someone with a drone, The Verge, 13 November 2014: <http://www.theverge.com/2014/11/13/7205741/i-almost-killed-someone-with-a-drone>. There are also multiple examples of drones crashing, even when controlled by professionals, see: Drone crashes into spectators at Virginia bull run, The Verge, 26 August 2014: <http://www.theverge.com/2013/8/26/4659698/drone-crashes-into-spectators-at-virginia-bull-run>; A tourist who crashed a drone into Yellowstone has been banned from the park for a year, The Verge, 24 September 2014: <http://www.theverge.com/2014/9/24/6838561/drone-pilot-banned-from-yellowstone-after-crash>
44. Parrot AR.Drone 2.0 Quadricopter: A Drone Anyone Can Fly, Livescience, 15 February 2014: <http://www.livescience.com/43426-parrot-ar-drone-2-0-quadricopter-guide.html>
45. Drones can be hard to pilot precisely. For an example of this, see: Drone Quadcopter hits groom in the head // Epic Fail, YouTube, [http://www.youtube.com/watch?v=ocqB6\\_7TAE](http://www.youtube.com/watch?v=ocqB6_7TAE); one drone being used in the Grand Canyon failed while over the canyon, the owners descended into the canyon to retrieve it, despite the lack of any trails. See: New docs show drone landed on Lincoln head at Mount Rushmore in 2013, ArsTechnica, 27 September 2014: <http://arstechnica.com/tech-policy/2014/09/new-docs-show-drone-landed-on-lincoln-head-at-mount-rushmore-in-2013/>
46. One drone was stranded on the top of a national monument in the US. See: New docs show drone landed on Lincoln head at Mount Rushmore in 2013, ArsTechnica, 27 September 2014: <http://arstechnica.com/tech-policy/2014/09/new-docs-show-drone-landed-on-lincoln-head-at-mount-rushmore-in-2013/>
47. In the US, the Director of the National Parks has directed all parks to prohibit drones on grounds of nuisance and safety. See: NPS bans drones over safety, nuisance concerns, EE News, 20 June 2014: <http://www.eenews.net/stories/1060001697>
48. FAA unveils plan for integrating drones into U.S. airspace, Reuters, 7 November 2013: <http://www.reuters.com/article/2013/11/07/us-faa-drones-idUS8RE9A61H220131107>
49. This communication is available in a range of languages. See: Access to European Union law, EUR-Lex, as accessed on 8 December 2014: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0207>
50. Behind the mind-boggling shots captured by BBC drones, Wired.co.uk, 12 February 2014: <http://www.wired.co.uk/news/archive/2014-02/12/bbc-drone-journalism>
51. Near mid-air collisions with drones, The Washington Post, 26 November 2014: <http://www.washingtonpost.com/wp-srv/special/national/faa-drones/>
52. One approach to prevent collisions among UAVs is by using radar, but this can be inaccurate. See: Collision-free flying for UAVs in crowded skies, Robotics Business Review, 31 July 2012: [http://www.roboticsbusinessreview.com/article/collision-free\\_flying\\_for\\_uavs\\_in\\_crowded\\_skies](http://www.roboticsbusinessreview.com/article/collision-free_flying_for_uavs_in_crowded_skies)

A likely outcome in many markets is that UAVs will be integrated into current flight control systems.<sup>53</sup> This will likely require an upgrade of current systems to allow for significantly increased capacity.

The impact of regulation on consumers may well be to dissuade usage. In some cases mishaps occurring from drone usage have been met with fines.<sup>54</sup>

The legality of flying drones has already been the subject of litigation, and this may continue through 2015 and beyond. Some drone manufacturers are responding by incorporating safeguards into their devices. For example, one vendor programmed in no-fly zones near hundreds of airports around the world.<sup>55</sup>

### Enterprises will deploy UAVs by the dozen, not the thousand

We expect enterprise and government usage of UAVs to be increasingly widespread, where regulation permits, but for each entity to only use a single or a few drones per task. We do not expect drones to be deployed on a massive scale, for example to replace existing vehicles. Drones are cheaper than helicopters, but more expensive than conventional terrestrial vehicles for many enterprise tasks.

Drones will occasionally be used for transporting goods, but this will not be commonplace. For example a delivery company is using a UAV to deliver urgent packages, such as medication, to Juist, a small island 8 kilometers off the coast of Germany, and which otherwise can only be reached by boat at high tide.<sup>56</sup>

Drone delivery is unlikely ever to be viable for anything aside from high-value, lightweight and compact packages, as the cost of per delivery of up to 10 kilometers would be between \$8 and \$12. (see: Estimating the cost of drone delivery).<sup>57</sup> These costs are unlikely to decline markedly over the next five years, as there are few forecast technology advances in the medium term that would enable prices to fall significantly.

Drones can convey a package but cannot deliver it.<sup>60</sup> The package may require a signature; it may need to be re-routed to a neighbor. An unmanned UAV needs a lot of human support around it. The trial of delivery of goods to Juist is only to a reception area.<sup>61</sup> A worker receives the goods, and then delivers it to the recipient. This may seem convoluted, but at present it is the only approach, and may remain so for the foreseeable future.

### Estimating the cost of drone delivery

The key capital costs in provisioning a drone suitable for delivery of packages are:

- The UAV, at about \$10,000-\$50,000 per unit. The \$10,000 price-point assumes a bulk order or self-assembly. Each drone can make up to 5,000 round-trips of up to 10 kilometers length. Some drones may get stolen, lost in transit or damaged;<sup>58</sup>
- Rechargeable batteries, at about \$200-\$400 per pack. At this price, batteries would have a range of ten kilometers with a two kilogram payload. A battery lasts about 100 charges and its range declines following each charge.
- A system control unit which would control the flotilla of UAVs, provide air traffic control and log flight paths. This unit would cost from \$30,000.

These costs exclude operational costs, which could be significant. An autonomous UAV that can rely entirely on satellite navigation for guidance should need no piloting, however if the GPS fails the drone is basically blind. In some markets, this would not be legal, and a pilot would be required to guide the device. Other individuals may be required to perform flight control. One other task that a person would need to do would be to swap out exhausted batteries and replacing them with fresh ones.<sup>59</sup>

53. For example see: Communication from the commission to the European Parliament and the council, European Commission, 8 April 2014: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0207&from=EN>
54. One person in the US was fined \$2,200 for flying a drone in New York City; the drone landed twenty feet from a pedestrian having hit two buildings before its unplanned landing. See: Drone operator fined after almost hitting nyc pedestrian, Bloomberg, 3 May 2014: <http://www.bloomberg.com/news/2014-05-02/drone-operator-fined-after-almost-hitting-nyc-pedestrian.html>. One person in the UK was fined £800 for flying his drone within 50 meters of a bridge and over a nuclear power installation. See: UK's first drone conviction will bankrupt me, says Cumbrian man, The Guardian, 2 April 2014: <http://www.theguardian.com/world/2014/apr/02/uk-first-drone-conviction>
55. Chinese manufacturer programs Phantom drones with no-fly zones to protect Australian airports, ABC News, 14 April 2014: <http://www.abc.net.au/news/2014-04-14/chinese-made-drones-programmed-with-no-fly-zones/5388356>
56. DHL launches first commercial drone 'parcelcopter' delivery service, The Guardian, 25 September 2014: <http://www.theguardian.com/technology/2014/sep/25/german-dhl-launches-first-commercial-drone-delivery-service>
57. The major costs of drones large enough to carry packages are in the parts of which the drones are made of. Motors, propellers, and carbon fiber frames are made in low volumes and require high mechanical precision. Radio control elements, ESC speed controllers, accelerometers, gyroscopes and other components most likely to benefit from the depreciation delivered by Moore's Law are a relatively small part of a UAV's costs and have already benefited from Moore's Law. Large scale manufacturing of parts would enable unit costs to fall significantly (in the region of 30 percent), but this is not likely to happen in 2015.
58. Some consumer drones have been destroyed in flight, for example, see: The future of drones: Getting them shot out of the sky by neighbors with shotguns, Esquire, 2 October 2014: <http://www.esquire.com/blogs/news/quadrcoptide-100214>
59. There are some examples of working battery-swapping stations, however every so often the inspection of a drone health state would still be needed.
60. One approach to addressing the issue of delivery to the recipient is to lower the package using a string. See: Inside Google's Secret Drone-Delivery Program, The Atlantic, 28 August 2014: [http://www.theatlantic.com/technology/archive/2014/08/inside-googles-secret-drone-delivery-program/373306/?single\\_page=true](http://www.theatlantic.com/technology/archive/2014/08/inside-googles-secret-drone-delivery-program/373306/?single_page=true)
61. DHL launches first commercial drone 'parcelcopter' delivery service, The Guardian, 25 September 2014: <http://www.theguardian.com/technology/2014/sep/25/german-dhl-launches-first-commercial-drone-delivery-service>

## Bottom line

Individuals have long been fascinated of the possibility of replicating our bustling terrestrial highways above ground: the notion of personal or unmanned vehicles flying around the sky in vast quantities has long been a feature of science fiction. A future in which fully-automated UAVs deliver packages to our homes is a compelling one; however it is not at all likely in 2015.

This is not to say that drones are not useful or compelling. Any invention that counters gravity is a marvel; one that combines flight with other recent innovations, such as lightweight high definition cameras and accelerometers should be lauded.

We expect drones will have multiple industrial and civil government applications, building upon the diverse uses they are already being put to. Any task requiring aerial inspection could be undertaken by a camera equipped drone, transmitting footage to ground staff in real time.

The global aerial imaging market was worth about \$1 billion in 2014.<sup>62</sup> Hollywood chase scenes make up a small part of that; the majority is for aerial imaging in construction and development, geospatial technology, and natural resource management. Much of that is from helicopters and drones which will capture a percentage of this market. But some of this market will remain inaccessible as drones are not for purpose for all current aerial imaging work. UAVs have lower ranges, lesser tolerance of adverse weather, and smaller payloads than helicopters: the lightest stabilized camera, for example, weighs around 20 kilograms.<sup>63</sup>

This implies a ceiling for sales of drones for the aerial imaging market, but it is also the case that the lower cost of drones will widen the aerial inspection market. If a drone can do a better job of inspection of building sites than sending a team up with ladders and ropes, then the usage of visual inspection will broaden considerably.

Regulators considering how best to incorporate drones into existing air space will need to balance the many positive contributions they can make, as well as the obvious negative externalities they can inflict. An irresponsibly piloted semi-professional two kilogram drone, whose battery expires in mid-flight above a crowd, may cause serious injury. A drone deployed on search and rescue missions may save lives.

Enterprises should examine every potential application of UAVs while recognizing their limitations: these are lightweight, battery-powered devices, many with modest payloads and short ranges.

62. The market was worth \$869 million in 2012, and is growing over 12 percent per annum, suggesting revenues in excess of \$1 billion in 2014. See: Growth and factor of Aerial Imaging Market 2013 – 2019, LinkedIn, 13 July 2014: <https://www.linkedin.com/pulse/article/20140613105811-340063519-growth-and-factor-of-aerial-imaging-market-2013-2019>

63. Aerial Filming, Hello Air, as accessed on 8 December 2014: [http://www.helloair.com/aerial-tyler\\_mount.php](http://www.helloair.com/aerial-tyler_mount.php)

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