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Increases in computational power, improved energy efficiency in electronics, and the growth of the IoT industry in recent years are supporting advances in consumer and enterprise drones.

Why are drones so fascinating to technology aficionados? Well for starters they're just plain awesome. Then there's the fact that they allow us to solve everyday problems in the most high-tech, complicated ways possible. You may ask how that's practical, but that's like asking a 10-year old boy if his nuclear powered car really needs a rocket booster strapped to the roof . . . yes, obviously. However, just because something is complicated doesn't mean it's not efficient, and that's where drones make sense in business. Let's say you're filming a movie scene that requires a breathtaking aerial shot. Now the simplest solution is to tell your cameraman to get in a plane and start filming, but what if he could do it without you having to rent a plane and pay for the services of a pilot? Suddenly a high-tech drone doesn't sound so silly anymore.

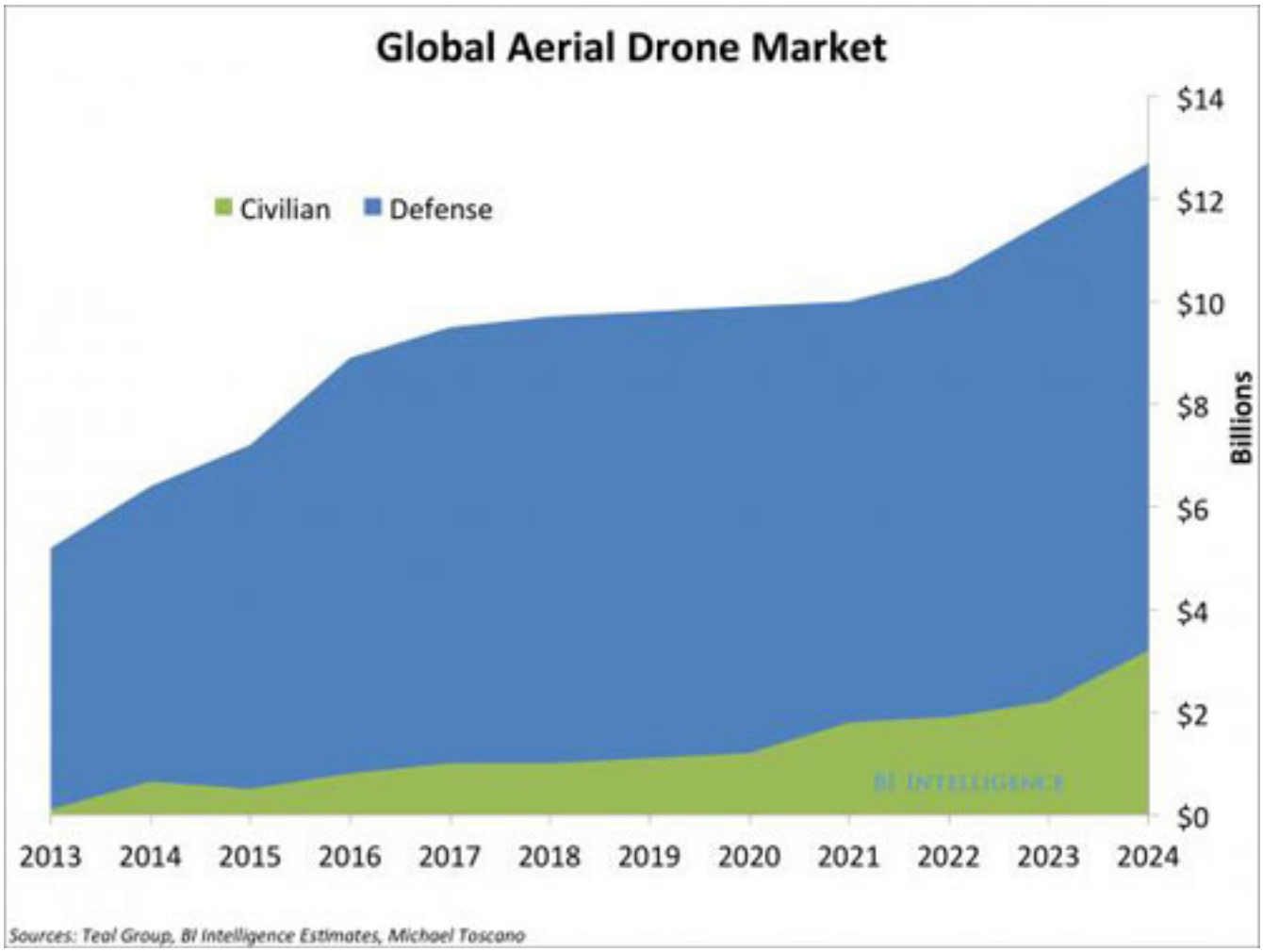

Figure 1: The commercial/civilian sector does not currently have the lion's share of the drone market, but this sector is anticipated to have compound annual growth rate of 19% between 2015 and 2020.

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According to the Business Insider Drones report, worldwide drone sales (both civilian and military) are projected to exceed $12 billion in 2021 [1]. As shown in Figure 1 the largest portion of the drone market

belongs to the military, but the commercial/civilian market is set to have the highest growth with a compound annual growth rate of 19% between 2015 and 2020 [1].

With the increases in computational power, improved energy efficiency in electronics, and the growth of the IoT industry in recent years we have seen great advances in consumer and enterprise drones. At this year's CES there were drones as far as the eye could see. The Phantom 4 from DJI offers 4K video recording and the ambitious Ehang Drone Copter wants to be your flying Uber.

Figure 2: DJI Phantom 4 [Courtesy http://www.dji.com/product/phantom-4

Figure 3: Ehang Drone Copter

Figure 4: Lily Camera - Image from: https://www.lily.camera

Traditionally drones have been quite tricky to fly, but companies like DJI and Lily Robotics have come up with artificial intelligence that allow a drone to follow the user. The Lily Camera drone wants to make action videos a breeze. Although this drone isn't in production quite yet, the concept is that you just toss it into the air, and that would start the video. You can then ski down that slope, knowing that your trusty drone is filming.

For a drone to fly around your neighborhood, it needs multiple systems working in harmony. First, it needs a flight system to keep it upright and to ensure that each electric motor provides enough thrust for the drone to move in the desired direction. Second, it requires a communication system so that the user can tell the drone where to go. Modern drones also have video systems so that the user can control the drone without directly looking at it. To avoid crashes it may need some more sensors and a collision avoidance system. Finally, if you want the drone to be autonomous then it will need a navigation system to plan its route. Even if you're not designing a drone, your product may still need one of these technologies. Grab your scalpel and forceps; next we're going to dissect a few of these systems.

Communication System

The communication system is responsible for sending the user's commands to the drone, and reporting the drone's state back to the user. If it cannot send commands to the drone quickly enough, the user will experience lag and be unable to control the drone. While the lag and throughput of the communication system are important, it should also be power efficient. Drones use a lot of power to stay in the air so every watt is precious. One last thing to consider is the range of the communication, does the drone need to have a range of 10m, 100m or 1000m?

For simple short-range drones up to 100m, Bluetooth Smart is an attractive technology. It features extremely low power consumption, but the low throughput means that streaming video is out of the question. Symmetry offers many options for Bluetooth Smart modules such as the Silicon Labs **BGM111** and **BGM113** modules, which make integration a breeze. You can start your design with a module, and when production volumes increase you can take advantage of using the Blue Gecko Bluetooth Smart SoC directly, without having to change your firmware. Nordic also offers Bluetooth Smart SoCs such as the **nRF51822**, which is now available as a thin WL-CSP variant measuring only 3.83 x 3.83 x 0.35mm and the **nRF52832**which supports Bluetooth Smart, Ant and proprietary 2.4GHz protocols with data rates up to 2Mbps.

For longer ranges a module that operates in a lower frequency band, such as the 868MHz or 915MHz bands can be used. The Multitech **MultiConnect mDot module** offers a range of up to 10 miles in the open and 1 to 3 miles through buildings. The price of extra range is a lower throughput, so these modules give a maximum data rate of 300Kbps. This would be ideal for a surveillance drone, which does not communicate constantly. Another scenario where this technology can be useful is for retrieval of a drone that has crashed or is out of power. The low power consumption and long range of these modules means that a lost drone can send its GPS coordinates to the user on an almost empty battery.

Most of the consumer drones today use WiFi for all communication including streaming video. That's because it's easy to connect to existing devices such as smartphones and tablets, and it supports high data throughput needed for video. The Silicon Labs **WGM110** module is great for easy incorporation of WiFi. It measures only 14.4 x 21.0 x 2.0mm and can provide data rates of 72.2Mbps.

Video System

Most commercial drones have an onboard video camera. A drone can either just store this video onto removable memory, or it can also stream a live feed back to the user. This is handy in situations where the user needs to see from the vantage point of the drone. For real-time video it needs to send its frames to the user as quickly as possible. If the video lags or waits to load, the user may crash the drone. For a video to have a decent frame rate (> 30 fps) there are two main components of the video system that are required: a good compression solution to reduce the size of each video frame, and a good communication system to transmit the compressed frames.

The data requirements for video feeds are significant. For uncompressed 1080p video at 60fps the required data rate is around 1-3Gbps, depending on the pixel format. These are extremely high data rates. So how can we get a live HD stream from our drone? We compress each of the frames to get a data rate we can transmit in real-time. Averlogic offers some great SoCs for this purpose, like the **AL582C** and **AL360A**, which are small and provide a vast amount of functionality. Lattice Semiconductor also offers low-cost video FPGAs and development kits to get you started. Using these, the video system can encode the video stream using the H.264 compression standard and then transmit the compressed stream to the receiver, which could be another of the same module, a smartphone, or any other device capable of receiving H.264 encoded data. For anyone requiring a fast to implement solution, the **GainSpan HD Video AEK** is a good option. This provides a simple-to-use development board that can send a live video stream to a mobile phone, allowing for rapid development of the application.

Navigation System

GPS is another essential component of any drone which aims to be autonomous. Autonomous drones generally allow the user to define a set of waypoints that the drone will then follow. This is very useful for any sort of surveillance/monitoring, or to send the drone to a specific location. To make sure that the drone is heading in the right direction and has not strayed from the path, the drone needs to have a good GPS unit, which is accurate and uses minimal amounts of power so that the battery is not drained too quickly. To ensure that your drone gets reception in difficult areas, you may want to consider a GNSS component that not only uses the GPS constellation of satellites, but also GLONASS, Beidou, and Galileo. Telit supplies a whole range of GNSS modules like the **SE873**, which is only 7 x 7 x 1.85mm and uses an external antenna, and the **SE868**, which features an onboard antenna. GNSS location also enables safety technologies like Geo-, which can keep drones away from restricted areas such as airports.

Following GPS waypoints is quite simple, but what if the drone needs to decide where to fly based on its own video? This gets back to our examples of the DJI and Lily drones that can follow the user. Well then you will need a bit more intelligence, artificial intelligence to be specific. To run your artificial intelligence software, the drone needs a good processor. The **AMD G-series SoC** (Figure 5) offers the combination of a dual or quad-core processor, integrated GPU, as well as an I/O controller on the same die. Their small footprint reduces overall system costs and supports the development of small form factor designs.

Choosing a processing solution can be tricky because you don't know exactly how much speed you really need before the software development is done. You don't want to end up having to change the whole hardware design because it's too slow, but you also want to keep your costs down. This is where the G-series SoC really comes in handy. It offers a scalable platform of processors that allows you to trade up to a more powerful solution without having to change your board or software designs. It also offers advanced graphics acceleration, with support for OpenGL, OpenCL, DirectX, and open source Linux development. The latest addition to the G-series family has 4K hardware video support, dual channel DDR4/DDR3, and ECC support for high bandwidth memory access and integrity.

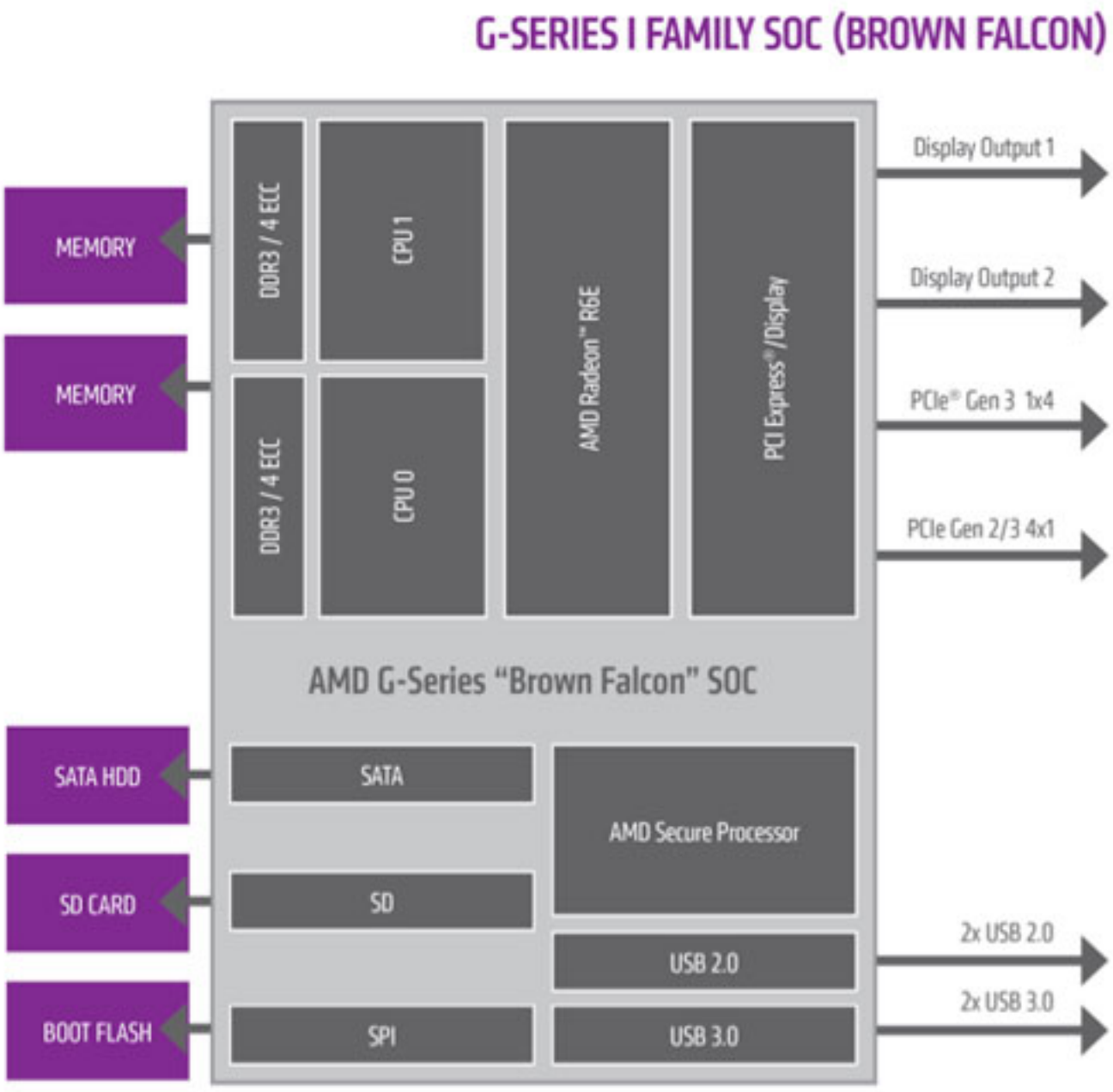


Figure 5: Courtesy AMD

Antenna System

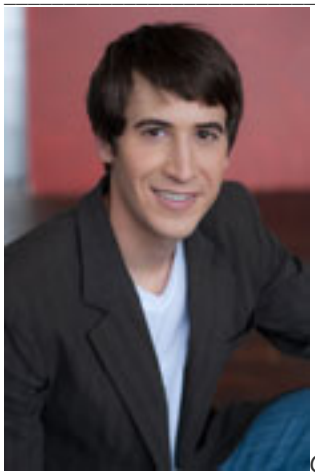
To ensure that you can control your drone, and that it can stream its video feed back to the user, it will need a few antennas. It would be nice if these antennas are small and light, so you don't waste valuable space and battery life. Antenova offers small form factor antennas for all your communication needs. For GNSS, they have SMD antennas such as the **Brevis-GNSS**, which is 11.0 x 6.1 x 3.2mm, and the high tech **Sinica**at only 7.0 x 5.8 x 0.4mm. If you'd rather have a cabled antenna, the adhesive mount **Bentoni GNSS Antenna** is easy to integrate with an IPEX MHF connector. You might be wondering if you could just get one antenna that will take care of both GNSS positioning as well as WiFi, and for that the Asper antenna is a great choice.

So what have we learned? First, that drones are pretty awesome. Second, there are many systems which must function simultaneously for a drone to operate efficiently. These systems should be tailored to the application for which they will be used. For a live video feed a compression module is a requirement, and

some of these come as complete SoCs, which provide the other required systems for the drone. Communication is also important, and the tradeoffs between performance and cost must be made. GPS is a requirement for an autonomous drone, and again the choice must be made between performance and cost. Last, a drone must save power whenever possible, so always consider the power consumption of the component you are choosing. Hopefully this article has provided a better understanding of some of the components that make up a drone, and what the tradeoffs are for each of these components.

References

1. Carnhi J. The Drones Report: market forecasts, key players and use cases, and regulatory barriers to the proliferation of drones. Business Insider Intelligence; 2016



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