Component Selection

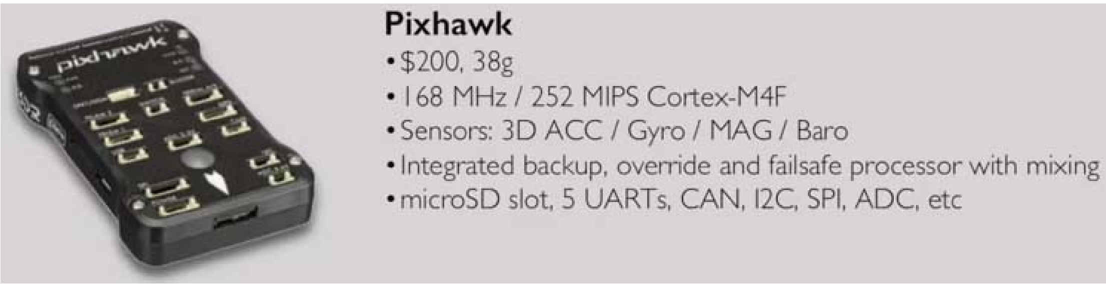
Let's think about the components that go into a robot and try to understand the effects of these components on the agility of the robot. More specifically, we'll be looking at the effect on the stopping distance of the robot.

So, this chart illustrates some of the design choices available online.

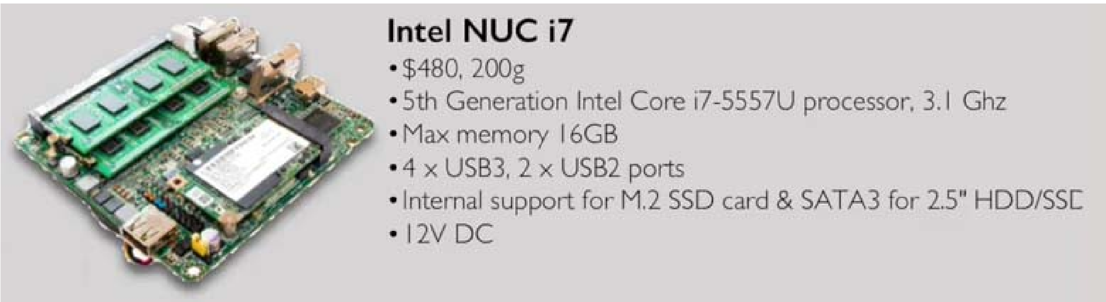
	FRAME + PIXHAWK + PROPULSION	BATTERY	COMPUTE + SENSORS	TOTAL WEIGHT	MAX THRUST	THRUST/ WEIGHT	Propeller
3DR X8+	1855	817	600	3272	10560	3.227	11" x 4.7"
DJI F550 + E600	1494	721	600	2815	9600	3.410	12" x 4.2"
DJI F450 + E310	826	400	600	1826	3200	1.752	9.4" x 5"
DJI F450 + E600	970	721	600	2291	6400	2.794	12" x 4.2"
DJI F550 + E310	1278	400	600	2278	4800	2.107	9.4" x 5"
DJI F550 + E310 @ 4 cell	1278	600	600	2478	5316	2.145	9.4" x 5"
DJI F550 + E305 @ 4 cell	1134	600	600	2334	5100	2.185	9.4" x 5"

We see a selection of frames from dji.com that are available "off the shelf". DJI is currently the largest manufacturer of drones and they offer a wide selection of frames, batteries, propellers and motors.

In addition to this, we need an autopilot. Pixhawk is one that's open source and sold by 3D Robotics.

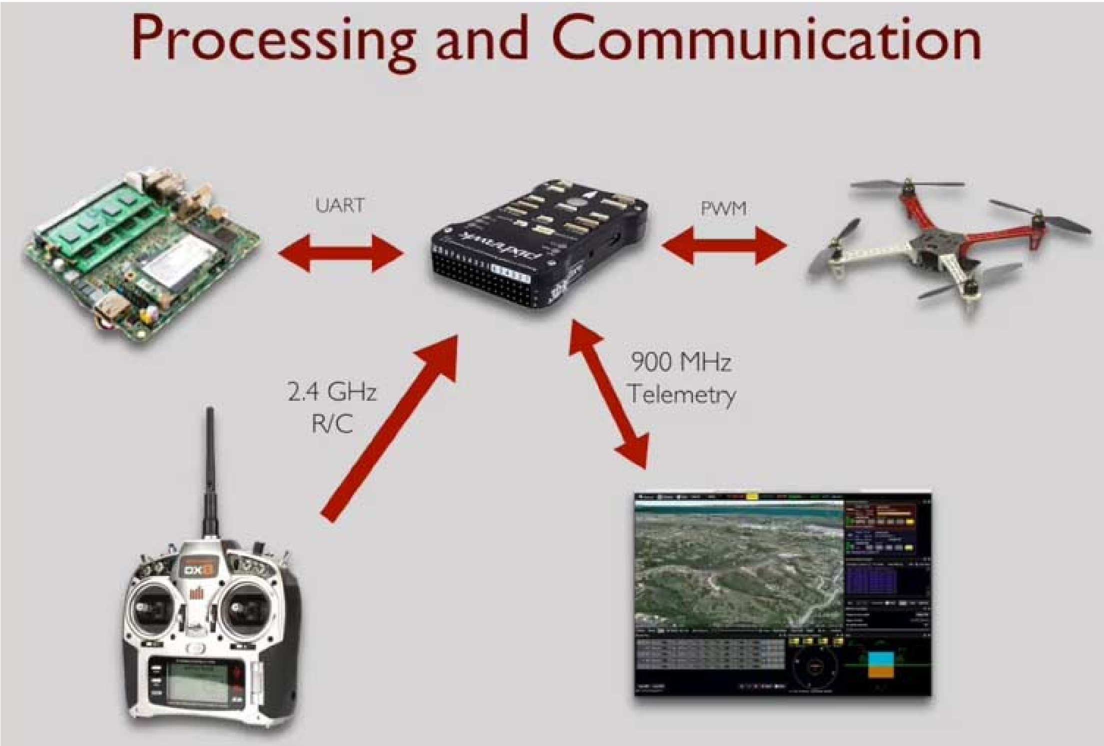


You can also buy high level processors such as those made by Intel.



The autopilot is a requirement for low-level control, and something like the Intel processor shown above will be needed for the high-level computations. Particular attention should be given to the weight of these components because eventually your robot will have to carry them when it flies.

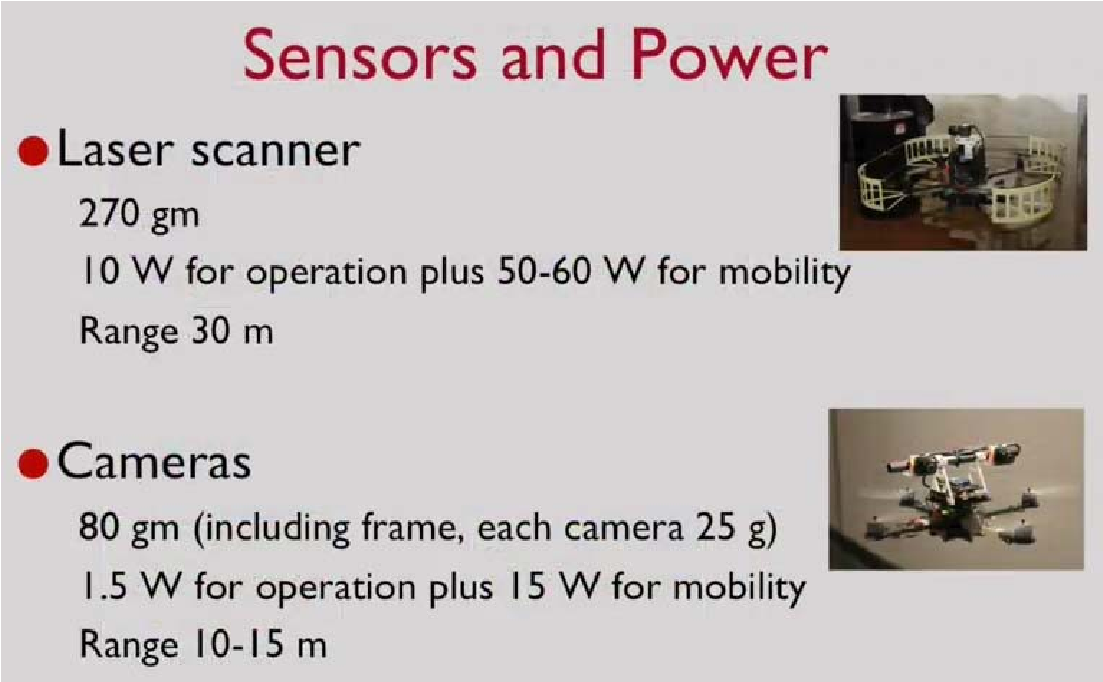
An architecture, which you might want to consider, using standard components which can be bought off the shelf, is shown below:



A high-end processor runs the controller and drives the vehicles. This communicates with a low-level processor which actually drives the motors and propellers. Further communication channels allow telemetry to be relayed to the ground, and provide the facility for remote control in case you have to take control of the vehicle.

When testing a vehicle, we might use a simulated payload such as an inert aluminium block. It is important to maximise the thrust-to-weight ratio, since this essentially maximises the acceleration. A thrust-to-weight ratio greater than about 2.7 was suggested.

In addition to the processors, our robot will also carry a sensor package. We met some of these, including a laser scanner and camera system, earlier:



The laser scanner weighs about 270 grams and the camera system about 80 grams. In addition to the weight, you need to think about power consumption. This comes under two headings:

1. First, the power consumed by the device itself. This is about 10W for the laser scanner, and 1.5W for the scanner system.
2. Second, the power required to lift the additional weight. Carrying a 270 gram laser scanner means you're burning roughly 50 to 60 W of power, while carrying an 80 gram camera burns another 15W.

We need to consider how heavy sensors are, what range they operate over, and how much power they draw. These all effect how fast a vehicle can go in practice. The further away it can detect obstacles, the more time the vehicle has to stop, and the longer the stopping distance can be. This in turn allows it to go at a higher speed.

Of course, sensors with a longer range might be heavier, which increases the weight of the platform. The increase in weight decreases the thrust-to-weight ratio.

Here are some examples of platforms built and tested in the Penn Engineering laboratory in the last year. All these platforms are autonomous. They are different sizes, carry different sensors, weigh different amounts and consume different amounts of power.

Examples

1750 g (laser, 3 cameras, GPS, IMU)

650 g (camera, IMU)

740 g (2 cameras, IMU)

1800 g (laser, Kinect, IMU)