UAVs and the Balance of Power

April 2017

UAVs - Current State of the Market

The rapidly growing Unmanned Aerial Vehicles (UAVs) market consists of both Commercial and Consumer applications. Both are seeing significant growth as various areas of technological improvements advance the industry.

Major contributors from the Commercial side come from Construction, Agriculture, Insurance, Oil/Gas, Police, Fire, Coast Guard, Journalism with Customs/Border Protection and Real Estate rounding out the top 10 (i). According to Grand View Research, the global commercial UAV market is expected to reach $2.1 Bn (USD) by 2022(ii).

The consumer side is less significant and only represents a small fraction of the overall consumer electronic market. However, the industry is expected to grow significantly. According to Goldman Sachs Research, by 2020, 7.8 million consumer drone shipments and $3.3bn in revenue will be achieved. This is compared to 450,000 shipments and $700 million in revenue in 2014(iii).

Like most electronic devices, the major key component both allowing for major advancements and serving as barriers to progress is the battery pack. Unlike other industries however, for the most part, lithium is the only suitable family of batteries for UAVs.

Battery Considerations:

UAVs require both high energy and high power from batteries. In designing drive systems for UAVs, the main battery consideration is how to approach the tradeoff between energy and power:

- Batteries that provide enough power have less flight range than higher energy batteries
- High energy batteries will overheat if pushed (used for high power)
- Overheating is a potentially significant problem, both in terms of cutting the flight short and creating major safety issues
- Different Lithium formats and chemistries will govern power and energy options
    - Pouch style cells can safely discharge at extremely high power levels
    - 18650 style cells provide higher specific energy than pouch cells
    - Sample pack comparison:

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Pouch vs. Cylindrical

	LiPo Pouch Pack*	Cylindrical Pack High Power (HG2)	Cylindrical Pack High Energy (MJ1)
Ah	10	12	13.6
V	22.2	21.6	21.8
Mass (g)	1442	1342**	1342
Current Cont Pulse	 250 500	80	27
Volume	165* 65 *62mm	129*90*80mm	129*90*80mm
Wh/kg	152	193	221

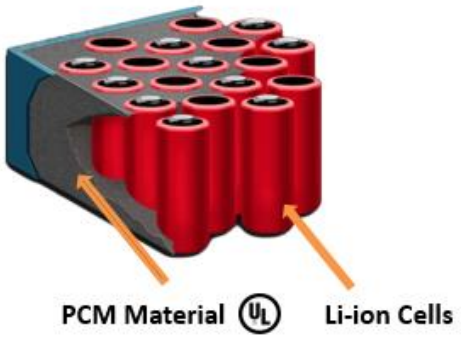
If C-rate is <8C, cylindrical option provides best specific energy

*http://www.dronetrest.com/t/lipo-batteries-how-to-choose-the-best-battery-for-your-drone/1277
**(1150g cells+92g PCC+75g clad+25g TV)

The ideal scenario is to enable the discharge of high energy 18650 cells at high power levels. Safe high power discharging can be achieved if there is a mechanism in place to keep the cells at a lower uniform temperature during flight.

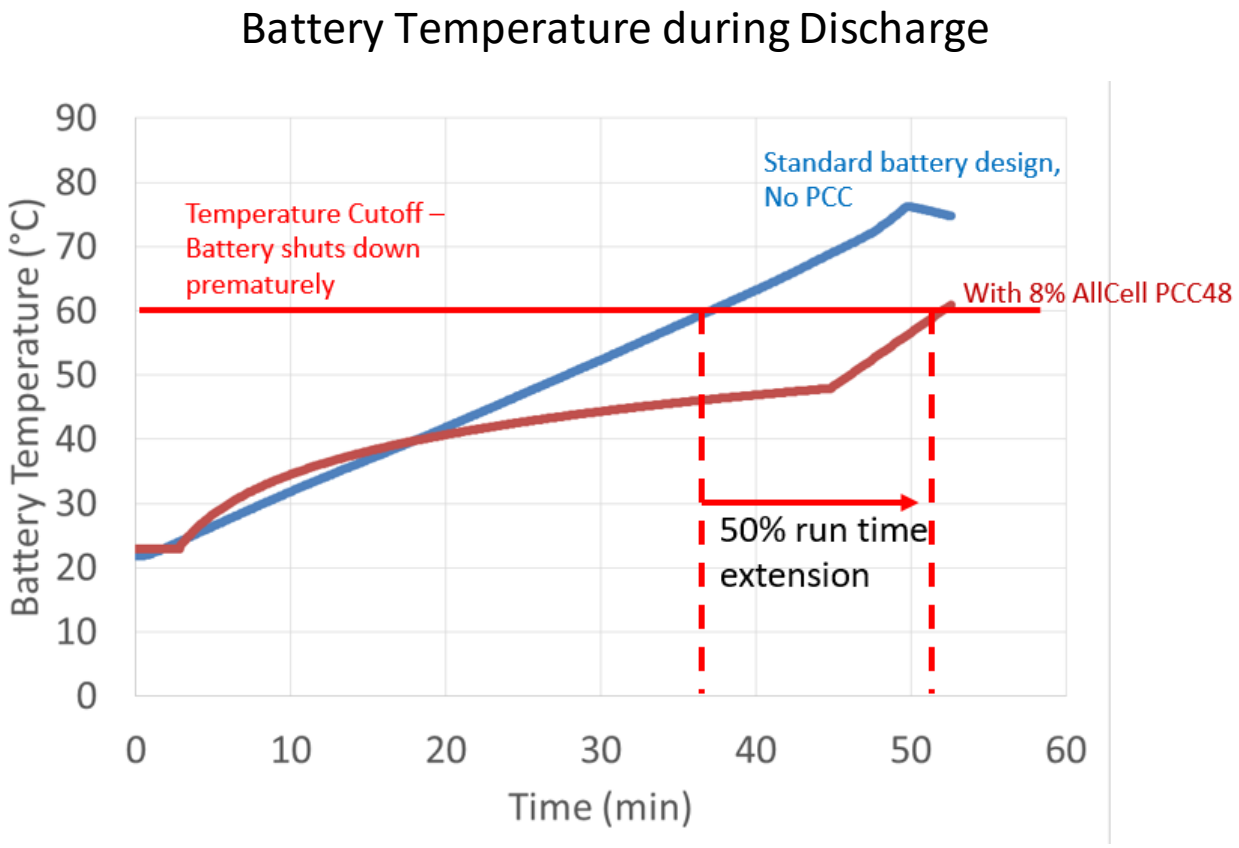
Effectively Managing the Heat

There are many ways to provide thermal management for lithium battery packs, but very few are achieved completely passively. Passive thermal management provides a key benefit of not utilizing any of the battery's useable energy during charge or discharge. With increasing safety and improving performance in mind, AllCell Technologies (AllCell) developed a passive material known as Phase Change Composite (PCC). AllCell inserts 18650 style cells into this phase change material/graphite composite to keep them cooler during high power discharge.



High temperature cutoff protection (a requirement for all lithium battery packs) ensures that a battery pack will not approach unsafe temperatures. Unfortunately, this means a flight can be cut short while there is still a significant portion of the battery available. If the pack's temperature can be kept lower during this crucial portion of the flight, the result is longer flight time while still pushing at high power.

The following figure compares sample 18650 style 280Wh packs during a 320W continuous discharge. The blue line represents a battery pack with no thermal management while the pink line shows a battery pack assembled with PCC.

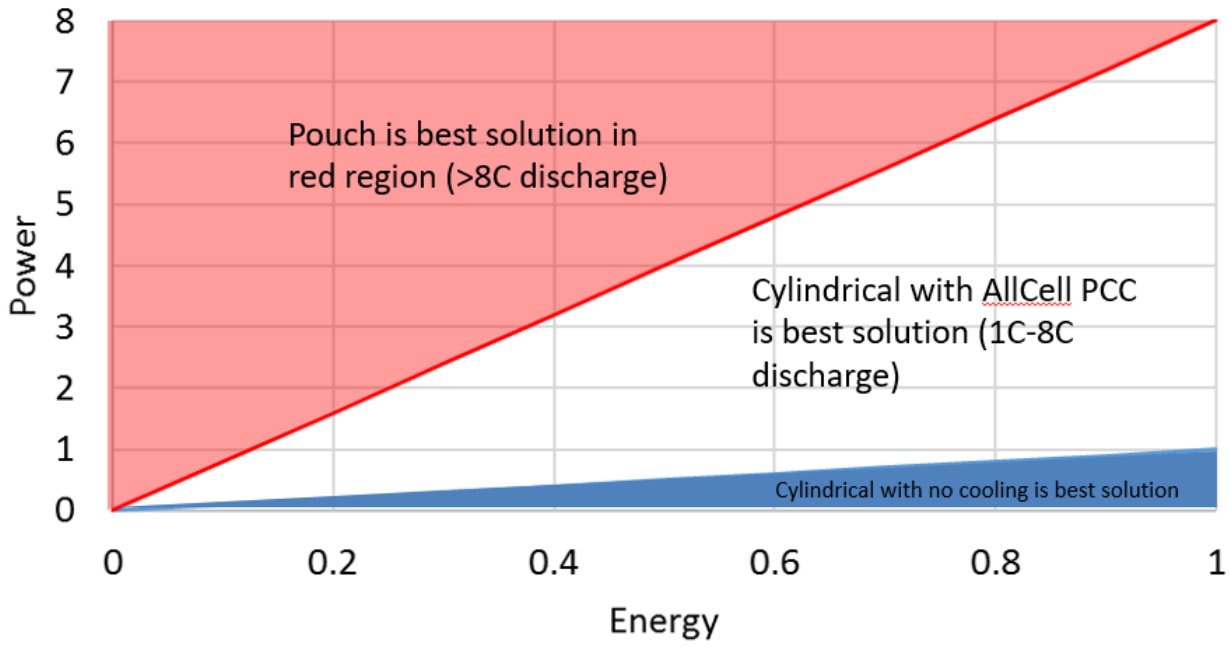


While the blue pack reaches 60 degrees after 36 minutes, the pink pack is able to stay below that cutoff until 52 minutes, resulting in a nearly 50% increase in run time. PCC staves off the high temperatures allowing longer use of high capacity cells even at high power.

Is Pouch Style Still Relevant?

There are scenarios where the power requirements warrant the use of pouch style cells. When a continuous 8C or higher discharge rate is needed, pouch style cells can deliver the needed power at the expense of energy. The figure below details the power vs energy tipping point where the optimal battery chemistry and system is appropriate:

Power-Energy Range Chart



Conclusion

With technological advances across the board, the market for both commercial and consumer UAVs is rapidly expanding. With more and more capabilities and increasing payloads, the need for longer flight range without sacrificing power is increasing. While it is challenging to find the appropriate balance of power to energy, effective thermal management makes it safer and easier to achieve the power without the loss of much needed usable capacity. As energy density continues to improve so will the importance of keeping the cells cool. This is critical from not only a flight range approach but also from a safety perspective. With the increase in UAV deployments, the risk of failure while flying in densely populated areas becomes very real.

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(i)http://www.goldmansachs.com/our-thinking/technology-driving-innovation/drones/
(ii)http://www.grandviewresearch.com/press-release/commercial-drone-market
(iii)http://www.goldmansachs.com/our-thinking/technology-driving-innovation/drones/