

Introduction to RC electrics

Cliff Creese

BMFC Introduction to RC Electric By Cliff Creese

TERMINOLOGY OF COMPONENTS

Battery = Energy source



ESC = Electronic Speed Controller



BEC = Battery Eliminator Circuit

UBEC = Universal Battery Eliminator Circuit



BASIC ELECTRICAL UNDERSTANDING

HEAT IS THE BIGGEST KILLER OF ELECTRICAL COMPONENTS

Check cooling/ventilation even on prebuilt craft

Air vent in may look good, but how can it get out.

Air flow to some component may be blocked by other

Overloading components produce heat, this applies to IC also.

Bearings and mechanical parts also effected.

SIMPLE AND NEAT WAY TO INCREASES VENTILATION

Plastic spoons



BASIC ELECTRICAL UNDERSTANDING

Volts = V (Pressure) Amps = A (Flow) Watts = W (Work to Do) Resistance = R (ohms)

Ohms Law

 $V \times A = W$ W/A = VW/V = A



<u>1HP = 746W</u>

Good supply of good quality knowledge

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Engines & Accessories Field Equipment General Tools Materials Propellers Radio Control Servos by Brand Keil Kraft Kits Stan's Kits Stan's Kits Stan's Mk1 Plans Stan's EPP Plans Aircraft Kits for Callers	Brushiess Speed Controllers UBECS Plugs and Sockets Heatshrink Tubing Electric Flight Accessories Glass Epoxy Motor Mounts Gliders Electric Flight We recommend that you read this article on Simple Electrics if you are neuranto the hobby or thinking of flying electric models.	Not Published	Radio Controlled Systems Prepare to Flap Choosing a Slope Site Crossed Wires Receivers Simple Electrics Li-Poly Battery Failure Batteries - The "C" Rating & Time to Charge (new) Brushless Motors (new) More about Chargers (new)
Gift Vouchers Plan Copying/Scanning Service Special Offers - Limited Stocks New Products	Brushless Motors Also this article on Brushless Motors by Stan Yeo	Radio Control Model World	Prepare to Fly Prepare to Land Prepare for Slope Aerobatics Prepare to Charge Prepare to Design
New Products 1. Futaba R617FS FASST 2.4Ghz Receiver (Ref: RR602)	SIMPLE ELECTRICS By Stan Yeo Definition of Terms		Prepare for Lift-off Prepare to Survive Flying in Gales Repairing Foam Wings Slope Soarer Design Foaming Experiences
	Ohms Law	Radio Control Model &	Starting in Slope Soaring
	<u>Power (watts)</u>	Electronics	Flying in Jersey
	<u>Selecting the Battery, Speed Controller and Motor</u> <u>Brushless Motors</u> <u>Electronic Speed Controller (ESC)</u> Electric Elight Packs	Silent Flight <u>Back to top</u>	The EPP Revolution
	Converting IC Model to Electric Useful Tools		

a number of modellars electrics is a black art that induces a mental black

Noise / Interference Suppression

BATTERIES

Most common Types

Nicad batteries (NiCad) Nickel Metal Hydride batteries (NiMH) Lithium Polymer batteries (LiPo) Lithium Iron Phosphate and A123 (LiFePO4)

Lithium Ion (Li-ion)

Lots of advise on batteries , Most sound!

Like any fuel type the higher the amount the greater the bang.

MOST COMMONLY USED TODAY IS LIPO



CHARGING AND STORAGE

There are some pretty simple basic rules of thumb that can extend the life and performance of your batteries:

don't overcharge or run your batteries flat

don't subject batteries to extremes of heat or cold

choose an appropriate battery for the job

only use a charger designed for the type of battery you're using never short-out a battery

never leave batteries in a fully discharged state

A neglected or mistreated battery will seldom last long and may cost you a model so try to treat them with the respect and care they deserve.

Don't charge when hot.

Site usage : Don't leave in the sun. Don't use if below temperature (winter days left in car or on grass.

WHAT IS THE BATTERY



Gens Ace Lipo

Capacity 2200mAh (2.2 Ahr)

Nominal Voltage 11.1V (Consider this running load Voltage)

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25C This is peak Amp rating (25x2.2=55A)
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3s1p 3 cells in series, single pack no parallel packs. Each cell 3,7v

Also listed normally on the back is its charge rate, could be expressed as 1C.

So charge rate would be 1x 2.2 (2.2A or 2200mA)

C Rating is it maximum current (Amps)

Increasing C rating will not give you any more capacity, Only peak current.

If it was stated 3S2P this would mean:



If you what more power, either.....

Get a bigger battery or put 2 in parallel

Weight is a good indicator of capacity when comparing makes/cost.

Paying for high C rating when not needed is a waste of money.

So what will it give you

If Loaded to 2.2A it will last an hour

If loaded to 22A it will last 10% of a hour. 6mins

If run at 55A it would last 2.4mins

i.e. 2.2 x 60 divided by 55

But always head for 10% minimum left to ensure we never over discharge the battery. I go for about 20%

Best long term storage around 11.4 - 11.8V

If a Lipo goes below 3V per Cell this is terminal for the Battery

CHARGING





Charging

Use balanced charging. Select correct voltage and current .

Charge rate no more than that specified on battery. Usually 1C

So a 2200maHr equates to 2.2A@1C

Evan if specified 2C or 5C most people will charge at 1C to get better long term life





VOLTS TO CAPACITY

A good battery should read 12.6V fully charged.

Each cell 4.2V

If Cells are not balanced total voltage will be lower, therefore less capacity.

Measure voltage at least 10 minutes after flight when pack has cooled down.

These measurements are approximate and may differ from battery to battery

-		
V/Cell	V-3S	%
4.20	12.60	100
4.17	12.51	98
4.13	12.39	95
4.10	12.30	92
4.07	12.21	89
4.03	12.09	86
4 .00	12.00	82
3.96	11.88	78
3.93	11.79	74
3.90	11.70	69
3.87	11.61	64
3.83	11.49	59
3.80	11.40	53
3.77	11.31	47
3.73	11.19	36
3.70	11.10	22
3.66	10.98	12

STORAGE VOLTAGE

Short term any voltage but say above 11v Even at 12.6 O.K.

Long term around 11.4v

Need to discharge use a charger on storage mode or quickly by:



Low Volts alarm

Set Min 3.7v/cell 3S 11.1 Don't leave unattended, only you can switch off discharge

Charge Safely



CHARGING STATIONS





Metal boxes lined with insulation. Can use plasterboard

STORAGE STATION



Small box on top (small batteries)

Shelf separators

IN FLIGHT BATTERY CARE

Set timers or use telemetry for battery voltage if TX will support.

Or use simple low level alarm

Or Transmitter and receive

BEC or UBEC

Battery Eliminator Circuit Universal Battery Eliminator Circuit

Can be stand alone or incorporated into a ESC

These are voltage converters

Will have voltage in and out rating with current rating Can be used with IC controls

Output usually 5v or 6v

Input could be expressed as voltage or cells and cell type

Input voltage is normally From – To (Auto Detect)

ESC

Electronic Speed Controller Can be Brushed or Brushless motor

Can come with BEC incorporated and also Opto Controlled/Isolated

Units with BEC on earlier units and some low voltage inputs only have linear BEC

Most units now have switching BEC's These can now handle higher voltage input and Current

Typical information: Current (A) Voltage input 3S 2-4S 6S Voltage (V) Lipo NiMH Burst (A) short time Secs ?????

BEC if fitted will have Voltage output and Maximum Current Listed

Controlled same as a servo input.

ESC convert D.C Voltage to a form of 3 Phase AC voltage output

Normally rate them 20% - 30% over maximum expected current. If expecting current 30A fit 40A

Basic Circuit ESC and Combined BEC

Basic Circuit ESC Separate BEC

Some ESC will have a FERRITE core on the lead this is to help prevent electronic noise generated by the ESC being transferred to other components.

On any electrical circuit if noise is suspected (jittery servo or receive) try a ferrite core.

Wrap wire around 3 or 4 times

ESC TYPICAL CONTROLS

Can be change via Transmitter or Programme card

All will have default setting in instruction manual

1. User programmable brake setting (recommend using brake for only folding props applications)

2.User programmable battery type(LiPo, NiCd or NiMH)

3. User programmable low voltage cut off setting

4.User programmable factory default setup restore

5.User programmable timing settings (to enhance ESC efficiency and smoothness)

6.User programmable soft acceleration start ups (for delicate gearbox and helicopter applications)

7.User programmable governor mode(for helicopter applications)

8.User programmable motor rotation(clockwise\counter clockwise)

9. User programmable switching frequency

10.User programmable Low voltage cut off type (power reduction or immediate shutdown)

TRANSMITTER

Phrases 2 Programming

After 3 seconds, the controller will start beeping a sequence of tones - a musical tone followed by one or more beeps. Each sequence represents a parameter that you can program and is repeated 3 times. The parameters are: 1_ Music Tone + 1 Beep Options 1. Cell Type and No. of Cells ♪___ Music Tone +2Beeps Options 2. Throttle Setting **♪**____ Music Tone + 3 Beeps Options 3. Brake Setting ♪____ Music Tone + 4 Beeps Options 4. Direction and Cutoff Type **♪**____ Music Tone + 5 Beeps Options 5. Timing Mode ♪____-Music Tone + 6 Beeps

Option 2. Throttle Setting *J*—— •• — 2 Short + 1 Long Auto Throttle Range * •• — — 2 Short + 2 Long 1.1ms to 1.8ms •• — — -2 Short + 3 Long Hard Acc* •• — — — 2 Short + 4 Long Soft Acc Option 3. Brake Setting J — — — ••• — 3 Short + 1 Long No Brake ••• — — 3 Short + 2 Long Soft Brake* ••• — — — 3 Short + 3 Long Medium Brake \cdots — — — 3 Short + 4 Long Hard Brake **Option 4. Direction and Cutoff Type** ∫____ •••• — 4 Short + 1 Long Clockwise Rotation * •••• — — 4 Short + 2 Long Counterclockwise Rotation •••• — — — 4 Short + 3 Long Soft Cutoff •••• — — — 4 Short + 4 Long Hard Cutoff * **Option 5. Timing Mode Setting** ♪____ ••••• — 5 Short + 1 Long 1° - For 2-4 Pole Inrunner Motors * ••••• — — — 5 Short + 3 Long 15°- For 10-14 Pole Outrunner Motors ••••• — — — 5 Short + 4 Long 30° - For 10-14 Pole High-RPM Outrunner Motors

PROGRAMME CARD

Easy way

Different types Each are for there own group of ESC's

Select the setting you want, connect a motor + ESC and supply and setting are transferred. Simple

ESC low voltage cut off setting

Where this is present' normally supplied to either reduce motor power output or shut off motor at a percentage of input voltage

Lets assume it has a cut out to protect over discharging a battery at 3,2Volts per cell (73%). With a full battery (3S) 12.6V reduced motor power output or shut off motor will occur at around 9.6V or 73% Discharge Just safe!

If we disconnect the battery between flights or start off on not a fully charged Battery what will happen. The cut off will still be 73% discharge.

BUT!!!!!!

If the Voltage at start is now 11.8V the cut off will be 8.6V

One Duff Battery and possible other damage

MOTORS

Two common types

Brushed or Brushless

Brushed Type now mainly in Cars

Brushless mainly Aircraft

These fall into two common groups Inrunner and Outrunner

and

Brushless Outrunner is now far the most Common in flying

These are generally more flexible in use and produce more torque

Outrunner.....Outside of motor rotates and contains magnets (shown above)

InrunnerCentre rotates and contains magnets(usually less)

More power can be produced by design.

Motor is better balanced as rotating case and magnets are easier to manufacture to tolerance as opposed to magnets on a rotating core and less likely to come loose.

Some motors better efficiency than others. 72 - 82% Typical

Outrunner v Inrunner

Outrunners

- Low RPM's, high torque
- •Less efficient than inrunners
- •No gearbox required
- Narrow prop selection
- •Silent

Inrunners

- •High RPM's, low torque
- •More efficient than outrunners
- Require a gearbox
- •Wide prop selection
- •Noisy

MOTOR FAILURES

Mechanical: Usually bent shafts. I try to buy where possible motors with 5mm shafts.

Bearings sometime after a bump.

Electrical: Nearly always due to over temperature.

Reasons:

Over powering.

Over temperature due to lack of cooling.

Heat weakens magnet in turn producing more heat, Can lead to very quick burn out.

Reversing a Motor

Some ESC's also can reverse direction electronically

SIZING

Information is getting better

You get some but also some contradiction

A motor given as 2840 is likely to be case size, the bigger the size the more power.

If you look at power rating this could be nominal peak or made up you can see this if weight is given.

You cannot get a quart out of a pint pot!!!!

You get information? operates on 3 or 4 S?

O.K for 9x6 to 13x7 props

It's a 400 or 450 motor

WHAT WE ARE AFTER

The kV is expressed as revolutions per volt applied So a 1400kV motor will rotate at 1400 rpm @ 1V and 14000rpm @ 10V offload. Assume 3S nominal voltage 11,1 + 15540 RPM no load. We have to understand this will be lower on Load expect around -10%

Max Current (A) Power (W) Voltage V May be giver as 3-4s not really import in most cases

Expected prop size performance 9x6 200W? 11x7 350W?

Weight

Key Bits Power, Current and if correct prop data. 3 – 4S Any other data could be for operating on either voltage

 Prop 9x6 - 11x4
 Possible 9x6 on 4S
 11x4 on 3 S

Power 340W could be anything

If we have current (A) Say 30A this will be the maximum

So 30A x 3S 11.1 V = 333W Near enough! If 30A x 4S 14.8 this would be 444W So Wattage based on 3S

This is why if scratch building you need a Wattmeter

We could also run this motor on 6S, it would need to be a very small prop sized to stay within wattage. It would scream and we would need to find a prop capable of the RPM to remain safe.

MOTOR ARE VERY FLEXIBLE

What Prop size, is a case of how noisy or what size looks good on a given plane and will it produce enough power.

Big prop vintage planes?

We can get more loading (W) buy increasing prop diameter or ratio or altering the applied voltage.

We can get the reverse if we go the other way.

We can also reduce the speed RPM by loading or reducing voltage.

We don't have to use all the power we may just need the weight up front (Scale Models).

We can use it to Pull or Push a plane we can use a CW or CCW Prop

Do we what Speed or Torque or both.

You can change bearing and shafts.

Wattmeter

This one can measure: Volts, Amps running and peak, Watts, RPM Voltage each cell, battery tester, Servo Tester and more.

WATTMETER BENCH SET UPS

On static bench running it is the same as a I.C. engine the loading will be 10-15% higher.

So maximum bench set readings for Power or Current can be higher as this will reduce when moving through the air.

PROP SELECTION AND TYPES

Their limit is their structural strength, running them at higher RPM risks losing a blade.

APC Suggested RPM Limits:

1.Glow Engine and Speed 400 Electric Props Maximum RPM=190,000/prop diameter (inches)

2. Thin Electrics and Folding Electric Props - Maximum RPM=145,000/prop diameter (inches)

3.Slow Flyer props - Maximum RPM=65,000/prop diameter (inches)

4.Racing Props 8.75 N,W and 8.8 series 40 Pylon props - Maximum RPM=225,000/Prop diameter (inches)

For example, a 10" Slow Fly prop should be limited to 65,000/10 = 6500RPM

ANOLOG OR DIGITAL SERVOS

Signal and motor normally same

Digital quicker response on small movements, bigger price

PWM changed inside to give frequency response and more initial torque, so initially quicker response?

Fingers are slow for speed, digital would be best for reducing dead band and for gyro control?

Ripmax New Power XL-09HMB Servo

Specifications:

- Weight: 11g
- Torque (6.0v): 3.5kg
- Torque (4.8v): 3.0kg
- Speed (6.0v): 0.10 secs 60deg
- Speed (4.8v): 0.12 secs 60deg
- Gear Type: Metal
- Dimensions: 23.2 x 12 x 24.8mm
- Bearings: Ballrace
- Voltage Range: 4.8v 6.0v

Identical to the regular 09HM B version but with real, digital hold-ing power.

- Weight: 11g
- Bearings: Ballrace
- Dimensions: 23.2 x 12 x 24.8mm
- Gear Type: Metal
- Speed (4.8v): 0.12 secs 60deg
- Speed (6.0v): 0.10 secs 60deg
- Torque (4.8v): 3kg.cm

Need A Power Cheap Switch To Control Light Or Other Component

Use a servo, disconnect the motor output is 5 or 6v

Current : as rating of servo. Need a high current connect to a relay.

Switch it via a normal channel.

Servo size. i.c. big for vibration not just load?

Connector only good for 3A and come from electronic industry.

My thinking, if I think I need a 3kg servo at 1:1 cm ratio, would the control surface support 3 X 1kg bags of sugar without breaking.

HOW MUCH POWER DO I NEED

How much power do we need?

The simplest approach to figuring power systems in electrics is input watts per pound of "all up" airplane weight. The following guidelines were developed before brushless motors were common but it seems to hold pretty well so we will use it regardless of what kind of motor is being used.

25 W/lb = minimum for level flight, with a reasonably clean plane.
50 W/lb = Trainer/Casual/scale flying
75 W/lb = Sport flying and sport aerobatics
100 W/lb = aggressive aerobatics and mild 3D, effortless loops from level flight.
150 W/lb = all out performance.
200 W/lb = Unlimited high-speed vertical flight.

There's a slight addition to that:

For 3D flight you need thrust as well as power. Ideally at least 1.5 times the AUW

For a ducted fan you need something like 1.5 to twice the power of a prop, because ducted fans don't work well at low speeds.

Deltas really need at least thrust equal to their weight, or you can get 'stuck' with the nose up at low altitude with no way to gain speed.

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Gliders obviously don't need any power :-)
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ON LINE CALCULATORS

calculators for everything

Motor powers to weight, thrust, prop size, battery capacity required, esc etc

MASSES

CHECK SEVERAL

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vortid the ongline cannot retate a stalled progras fast as a lower-plick proground be rotated? By rotating hydro plick will having other details the same, the calculater can NOT update the o of ull increase in required parer (in vice) and will by increasing the land (damater or plich) the maximum NFM will be detenated, and by decomparing the land the maximum NFM will be detenated, and by decomparing the land the maximum NFM will be detenated. And by decomparing the land the maximum NFM will be detenated, and by decomparing the land the maximum NFM will be detenated. And by decomparing the land the maximum NFM will be detenated, and by decomparing the land the maximum NFM will be detenated. And by decomparing the land the maximum NFM will be detenated and by the standard supersonance find will be or users "amining" to the blacker with the same speed the ancest in forgs. The perimeter upwells fulles and a way routentiff. Bookil nees the light than the standard supersonance tim light of the blacker static to take a supersonal by high load do the the special and the maximum speed the standard supersonance time light of the standard supersonance time light of the blacker static to take a supersonance the lighter than the standard supersonance time light of the standard supersonance time lighto state state state state state states to state a superson	Air density ectering/moditying the inp e Calculate button ese	12045 (kg/m put dieta, Deice	²) Jara:		 • ØAl rigitizen volt (and a	Veniar y other than th	n 3 3 - Denwicpe is online websik Hungartan i	ed by Scalebolar II e usinge is people were too
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all counting with properfield "tightpatch staffing" is amounted the augmans is standing on the ground. The angleme is placed problem is the staffing of the staffing of the staffing of the base staffing of the staffing o	Air density entenginocollying the in e Catculate builton ass e Catculate builton ass e Catculate builton asse e Catculate	12045 (kg/m put data, Dato put data,	r) Janet a significant official is stalling more and orp as fast as a low	t on the required angine po more. It does generate highs wer pitch prog would be for by increasing the land (dam	© All systems word f word Therefore any results in the calculated angles i inducted turbulent resistance which takes engine pow atod Dy certaing hyber pick with takes engine pow atod Dy certaing hyber pick with takes engine pow	assing and a newer field prover field the same to decrease	veriar y ofter than th should be i to produce he calculator the load the	n 9 3 - Develope is office vecsile Hungarian s Transitioned c enough thrus r can MOT up is macomum F	ed ey Sankela r e usage 's pohl weries weries carefully! As at instead. In odate the enti
(a) The supersonic speed causes the blatter to take a very high food due to the special airflow waves generated by the subsonic and supersonic changes! And finally, the Estimated fiying speed lield give instead information alcost the copacted herzontal liying speed at full threttie. (The real speed may vary in externe situations like aceabalic flying.)	Air density etensity of the in Catculate button are catculate button are et path sign pech rotat for path sign pech rotat	12045 (kg/m put data, Deco populiar's pitch has is faster and faster it inter power (or low are are inversely propor	a significant effect is stalling mere and orp as fast as a low trool to each othe	r an the required angine po more. It does generate highs we pitch prop would be rot by moreasing the load (dams rf.	© All systems were the second of word "Therefore any results in the calculated angles, reducted turk-lent estimance which takes equip pre- tantial Dy seteming higher pick with learing other densits efter or pick) the maximum RPM will be decreased, and by	lassing and a between field s prover field the same s r decreasing	Verter y offer then the should be to to produce he calculate y the load the	n 3 3 - Develope s online vectoria Hangartan s maniformad c encugh thrus r can NOT up r maaamum fi	ed by Schoola F League & pocht wenter carefully! As at instead. In actar the entr RPM will nore
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Typical of standard 1200mm foam models

Static thrust =	46.20 oz
Static thrust =	2.89 pound
Static thrust =	1.31 kg
Perimeter speed =	132.92 m/s
Required engine power =	0.504 HP = 0.370 kW
Estimated flying speed =	66.2 mph = 57.5 Knots

Hard to compare i.c. to electric motor sizes

Not all 1600cc car engines perform the same!

Which electric motor is equal to what glow engine?

Q) How do you tell which <u>Electric Motor</u> is equal to what <u>Glow Engine</u>?

A) One of the biggest confusions for most people selecting an electric motor is, "What is a watt?" The glow guys are used to horsepower and electric power systems are measured in watts.

$$(1 hp = 746 watts or about 750 watts)$$

Don't go by the max rating for HP that engine manufacturers publish. That is a MAX figure and very seldom is an engine for sport use operated at that figure. The h.p. drops off quite a bit when the RPM is not at the rated figure which is usually around 16,000 RPM's or greater.

Glow Engines vs. Electric Motors

- 1. . . 20-size glow engine / 300w electric motor
- (OS Max 0.20 engine develops 0.4 hp = 300w electric motor (AXI 2820))
- 3. . 35-size glow engine / 500w electric motor
- 4. ♦ (Fox 0.35 stunt engine develops 0.7 hp = 522w electric motor)(AXI 2826)
- 5. ★ .40-size glow engine develops 1.0 hp = 750w electric motor (AXI 2826 or 4120)
- 6. \bigstar .60-size glow engine develops 1.3 hp = 975w electric motor (AXI 4120 or 4130)
- 7. \bigstar .90-size glow engine develops 1.6 hp = 1200w electric motor (AXI 5320 or 4130)
- 1.20-size glow engine develops 3.0 hp = 2250w electric motor (AXI 5330)
- 9. DA-50 develops 5.0 hp = 3750w electric motor (AXI 5330)
- 10. A DA-100 develops 9.8 hp = 7311w electric motor (Double AXI 5330)

See E-flite <u>Park 400</u> and <u>Power 60</u> series that mimic replacement sizes for old brushed motors and glow engines. <u>http://www.gregcovey.com/Glow_Conversions_Made_Easy.htm</u>

Himax Brushless Motors

HC50 Outrunner 800-1500 Watts HC50 - These motors are for large models weighing 6-8Lb for 3-D flight, 8-15Lb for aerobatic flight and 10-20Lb for leisure flight. • Gas equivalent - .46 - .90

HC63 Outrunner 1700-2200 Watts HC63 - These motors are for large models weighing 10-12Lb for 3-D flight, 17-22Lb for aerobatic flight and 22-30Lb for leisure flight. • Gas equivalent - 1.20 - 1.80

http://www.maxxprod.com/mpi/mpi-2601.html

Chart to ele to Ic

Engines give different power to CC depending on type/make

Motors less so

Most 3s 2200 fly 1.5kg /3lbs to 2.5kg/ 5 Lbs all up weight planes.

RUNNING HIGHER VOLTS BY DESIGN

Small cables, smaller esc, smaller lighter motors etc.

Planes have less all up weight, cheaper to make more profit margin!!!

Alternately put a bigger battery in and fly a bigger or heavier plane, you pay the price of the battery, the manufacturer is selling a cheap plane.