the Monitor

March The MRCS Officers 2018

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Next Meeting: Date: Wednesday, March 7
Time: 7 PM Video & 7:30 meeting, EAA building

What's In This Issue:

The 7 P.M. Aviation Video

A documentary on the Messerschmitt Me 163 Komet rocket intercepter was shown.

Reading and Understanding LiPo Labels and Specifications

A Presentation by Ken Myers

The Label:

The G5, at the top left of the label, indicates that it is a 5th Generation Hyperion brand LiPo battery. The SV, at the upper left and right indicate that it is a Standard Voltage type.

Helicopter Frequencies
21,27,29,39, 41
Sailplane Frequencies
11, 12

There are High Voltage (HV) LiPo batteries, with a charge termination voltage of 4.35V/cell

The 4.20V/Cell Max Charge, under the SV on the right side of the label, indicates that it is to be charged to a termination voltage of 4.20V per cell. Again, this indicates that this is a SV LiPo and not a HV LiPo.

The 3S/11.1V indicates that the battery is 3 cells connected in series (S) and that it has a nominal voltage of 11.1V. The 11.1 is not a cardinal number, it is a nominal number, a number that names something. It has no useful numeric value. Each SV LiPo cell is said to have a nominal (naming) value of 3.7V per cell, therefore, three cells in series is the sum of three nominal 3.7V cells.

All that the notation of 3S/11.1V is doing is confirming that this is a 3 cell in series SV LiPo battery.

It should be noted that some chargers also display a similar 'confirmation' screen before the charger can be started by the user when balance charging.

50C Maximum states the manufacturer's maximum recommended **discharge** rate.

2100mAh is the manufacturer's stated capacity.

A Comment Before A Closer Look at the Specifications

For almost all of our electrically powered flight systems, we measure the current in amps (A), not milliamps (mA). The becomes relevant when discussing capacity, charge rates and discharge rates.

Breaking Down the Specification Numbers

The following specifications were cut and pasted directly from the supplier's Web site for this battery.
https://www.rcdude.com/product-p/hp50c2100s3.htm

* * * * *

Hyperion G5 50C Max - 2100mah 3S Lipo
Specifications:
Capacity: 2100mah
Voltage: 3S, 11.1v nominal
Discharge Rate: 50Cmax (50C burst, 25~30C continuous)
Charge Rate: 6C maximum, 5C recommended
Weight: 163 grams
Dimensions: 105 x 34.1 x 21.7mm
Power Connector: XT-60
Balance Connector: JST-XH
CMax = Continuous C-Rate for 100% rated capacity delivery is 1/2 C-Max rate.

* * * * *

Hyperion G5 50C Max - 2100mah 3S Lipo
Specifications:
Capacity: 2100mah (should be mAh)

The manufacturer's stated battery capacity is based on the constant current load that they say is required to take a cell/battery from 'full volts (V)' to 'empty volts (V)' in one hour.

What is the 'Full' and 'Empty' voltage?

Full voltage for a Standard Voltage LiPo cell is usually stated as 4.20V per cell, as noted on the label. Therefore, a pack with 3 cells in series (3S) has a stated voltage 3 times 4.20V. That is 12.60V for the 3S example pack.

Empty voltage for a Standard Voltage LiPo cell is usually given as 3.00V per cell. A pack with 3 cells in series (3S) has a voltage 3 times 3.00V or 9.00V for the 3S example pack.

Even though the pack's actual 'capacity', stated as a constant load current per hour, to go from 'full V' to 'empty V', varies with the constant load current, the value is treated as a constant.

The manufacturer is saying that when a constant load of 2100 milliamps (mA) is placed on this pack for 1 hour the voltage drops from 'full V' to 'empty V'.

It is somewhat difficult for us to 'think' in milliamps.

A milliamps (mA) is one thousandth of an amp.

To 'think' in amps, divide milliamps (mA) by 1000.

2100milliamps (mA) / 1000 = 2.1 amps (A)

When amps (A) are used as the unit, the previous statement is easier to comprehend.

The manufacturer is saying that when a constant load of 2.1 amps (A) is placed on this pack for 1 hour the voltage drops from 'full V' to 'empty V'.

Capacity is measured by the manufacturer to a certain standard.

* * * * *

"By international standard, all cells are rated for capacity at 0.2C, where C = nominal capacity of the cell when discharged at a rate equal to 0.2 times the predicted capacity for the cell. The rated cell capacity

is actually statistically established since the actual is not known until tested."

FMA LiPo Handbook Section 3, p. 18

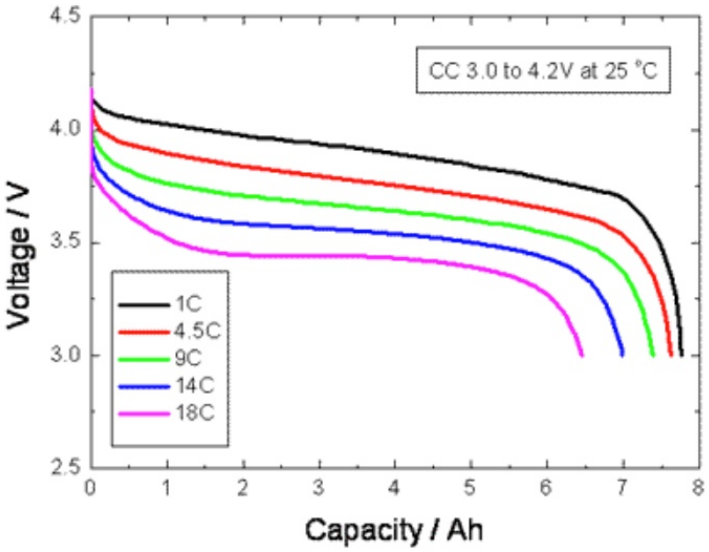
https://www.rcgroups.com/forums/showatt.php?attachmentid=2895498

* * * * *

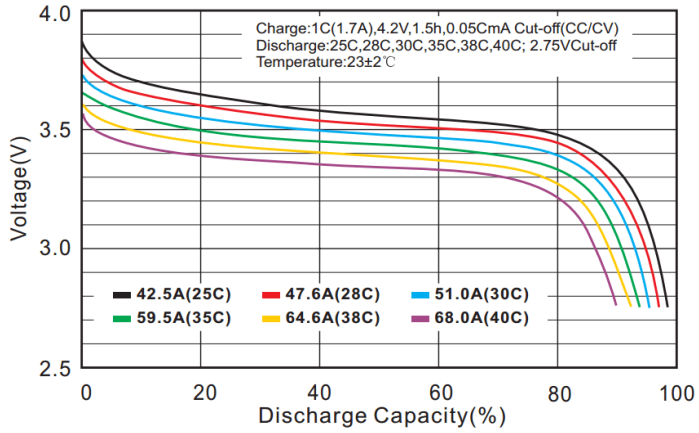
Is this a chicken or egg statement?

0.2C for this pack is 0.42A per hour. That's right, **42 hundredths** of an amp.

Usable Capacity MUST Be Understood
Usable Capacity Based on Discharge Rates



"The discharge curves show the effective capacity of the cell is reduced if the cell is discharged at very high rates (or conversely increased with low discharge rates). This is called the capacity offset."
http://www.mpoweruk.com/performance.htm



The table illustrates why no more than 80% of the stated capacity should be removed from a battery.

It is important to remember that the actual battery capacity diminishes over time.

Again, the capacity we use in practice is **how much usable capacity the manufacturer says the battery 'holds'** - 2.1A for an hour for the example.

DO NOT MISTAKE charge and discharge rates with the capacity, since they are in the same units. Rates vary. Capacity is 'considered' to be and used as a constant.

Next on the specification list is Nominal Voltage:
Voltage: 3S, 11.1v nominal

This confuses many beginners. It is NOT a voltage. Why they list it as 'Voltage' is unknown.

The 3S, 3 cells in series, was already stated in the nomenclature for the pack. It is redundant information.

11.1V nominal is not a cardinal number, it is a nominal number that names something. It is just another way to note that this pack is a 3S LiPo. It is redundant information, and a bit confusing.

As previously noted, 3S 11.1V is sometimes noted on a confirmation screen of a charger, so it might be useful in that situation.

Charge termination voltage is more important and NOT listed in the specifications. It should be;
Charge Termination Voltage: 4.20V/cell, 12.6V for 3S

Discharge Rates

A rate is some type of unit for a time period; mph, gallons per minute, amps (A) per hour (h) = (Ah).

For rechargeable batteries, the charge and discharge rate is stated as a factor times the capacity, which also happens to be a rate.

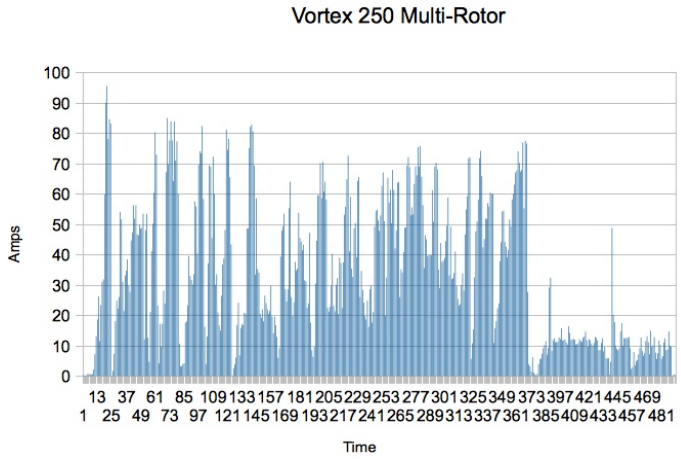
When dealing with charge and discharge rates, it is best to use capacity in amp hours (Ah) or amps per hour or amps/hour.

From the example battery specifications -
Discharge Rate: 50Cmax (50C burst, 25~30C continuous)
50C Rate = 50 (the factor) * 2.1Ah (the capacity) = 105Ah or 105 Amps for/per 1 hour

In theory that discharge rate is 50 times higher than the rate used to identify the capacity of the battery.

In theory, this rate will "empty" the battery 50 times faster.

The constant load amps to achieve the 50C rate is 105A; 50 times 2.1A.



What does 'Burst' mean. Typically it means something of short duration, but how short is short?

The table shows the amp draw over a 1 minute 47 second flight of a Vortex 250 multi-rotor.

https://www.youtube.com/watch?v=XkQi0tSr0UQ

The pack was a Turnigy Graphene 4S 1300mAh 65C cont./Burst 130C LiPo.

The highest recorded amp draw was 95.5A. That is a discharge rate of 73C, which is well under the stated 130C. The average amp draw for the flight was 35.1A. That yields an average of 27C for the discharge rate.

The stated burst amps value might be useful to rotor-craft pilots with telemetry or onboard data recorders including data recording ESCs.

It is not generally too useful for plane pilots.

Stating high C-rate numbers are great hyperbole for the company's advertising department.

From the example battery specifications - (25~30C continuous)

The ~ symbol means about. It's not a – which means through.

Why is a range stated?

The note on the specifications reads "CMax = Continuous C-Rate for 100% rated capacity delivery is 1/2 C-Max rate."

In theory, a constant current equal to the Maximum Continuous Amps, 52.5A, would only last 1 min. 55 sec. from 'full' to 80% of the capacity used.

On average, a 4 min. flight on this pack, which is pretty aggressive for electrically powered model airplanes, from 'full' to exactly 80% of the manufacturer's stated capacity used: 1.68Ah (80% capacity) * 60 minutes = 100.8 A minutes / 4 minutes = 25.2A as the flight average amp draw.

25.2A / 2.1Ah = 12C for the average C-rate.

The Charge Rate

From the example battery specifications - Charge Rate: 6C maximum, 5C recommended

From the previous examples for discharge rate;

6C = 6 * 2.1Ah = 12.6A per hour

5C = 5 * 2.1Ah = 10.5A per hour

For the rest of the specifications with grams and mm changed to Imperial Units, they could now be understood to mean;

Hyperion G5 50C Max - 2100mAh 3S LiPo

Specifications:

Capacity: 2100mAh = 2.1Ah

Nominal Voltage: 3S, 11.1V

Charge Termination Voltage: 4.2V/cell - 3S, 12.6V

Maximum Burst Amps: 105A

Maximum Continuous Amps: 52.5A

Maximum Charge Amps: 12.6A

Recommended Charge Amps: 10.5A

Weight: 5.75 oz. (grams / 28.439)

Dimensions (nearest 1/16"): 4-1/8" x 1-5/16" x 7/8" (mm / 25.4)

Power Connector: XT-60 (somewhat typical)

Balance Connector: JST-XH (almost a standard)

Practical Discharge Rate Table

Rate	Capacity Min. to "Empty"	Min. to 80% Cap.	Rate	Capacity Min. to "Empty"	Min. to 80% C	Rate	Capacity Min. to "Empty"	Min. to 80% C
1C	**60**	**48**	**11C**	**5.5**	**4.4**	**21C**	**2.9**	**2.3**
2C	30	24	12C	5	4	22C	2.7	2.2
3C	**20**	**16**	**13C**	**4.6**	**3.7**	**23C**	**2.6**	**2.1**
4C	15	12	14C	4.3	3.4	24C	2.5	2.0
5C	**12**	**9.6**	**15C**	**4**	**3.2**	**25C**	**2.4**	**1.9**
6C	**10**	**8**	**16C**	**3.8**	**3.0**	**26C**	**2.3**	**1.85**
7C	8.6	6.9	17C	3.5	2.8	27C	2.2	1.78
8C	**7.5**	**6**	**18C**	**3.3**	**2.7**	**28C**	**2.1**	**1.71**
9C	6.7	5.3	19C	3.2	2.5	29C	2.1	1.66
10C	**6**	**4.8**	**20C**	**3**	**2.4**	**30C**	**2**	**1.60**

Practical Limitations to the C-Rate

The numbers on the table are "in theory" numbers when a constant load is applied to go from the manufacturer's full stated capacity to 80% of that capacity.

They can also represent the average C-rate over that time period.

Calculating Average Amp Draw & Average C-rate, a How to Example Using the 2S 2100mAh Pack

Example numbers are in parentheses.

Time the flight (6 min. 12 sec. or 6.2 min.)

After a cool down period, charge the pack and note the mAh returned by charger - It will be slightly higher than the actual removed. Depending on the

charger the returned capacity could be shown as either mAh or Ah. If it is Ah then change mAh to Ah (1550mAh / 1000 = 1.55 Ah)
Change Ah to A minutes by multiplying Ah * 60 minutes - 1.55Ah * 60 = 93A minutes
Divide amp (A) minutes by flight time in minutes. That yields the average amp draw for the flight. 93Amin / 6.2 min = 15A avg.
Divide the average amp draw by manufacturer's stated capacity in Ah 15A / 2.1Ah = 7C (7.14...) as the average C-rate.

This a question that maybe *Monitor* readers can answer, I can't. Many electrically powered sport, sport scale and trainer planes typically fly about a 6 minute flight. With a 6 minute flight to 80% of the manufacturer's stated capacity averaging between 8C and 7C, how are users reportedly puffing so many LiPo packs on a 6 minute flight?

More Pack C-rate Related Info

This company chose not to state the discharge wire AWG (wire gauge size).

It is important.

The suggested continuous current amps should determine the required power wire size.

It is not unusual to find power leads with too small of a wire gauge used on power leads compared to the advertised maximum continuous current.

Unfortunately, wire gauge is a debatable topic.

Lucien Miller, of Innov8tive Designs, suggested in a post on RC Groups, that for our purposes, "in RC applications, we can use 100 circular mils per amp or even 75 circular mils per amp..."

"**The size of the wire depends on 2 things, the actual application and the length of the wire.**"
https://www.rcgroups.com/forums/showpost.php?p=5454395&postcount=4

I created a table, top right, using a conservative 120 circular mils per amp, as he later 'hinted at' in his post when he finished by noting, "Based on 100 circular mils per amp, our 50 amp case needs 5000 circular mils of wire, which is equal to a 13 gauge wire. To be on the safe side, I would step that up to a 12 gauge wire which has 6,530 circular mils, and would provide 130.6 circular mils per amp."

My table is NOT in agreement with Progressive RC's amperage recommendations for their silicone multi-strand wire.

AWG	Amps		AWG	Amps
4	347		16	21.5
5	276		17	17
6	219		18	13.5
7	173		19	11
8	137		20	8.5
9	108		21	7
10	87		22	5.0
11	69		23	4
12	54		24	3
13	43		25	2.5
14	34		26	2.0
15	27		30	0.8

Progressive RC: 12AWG 90 amps
http://www.progressiverc.com/prc-silicone-wire-12-awg.html

After much searching, I found that the power lead wire on the Hyperion G5 2100mAh 3S LiPo is 14AWG.
Progressive RC: 14AWG 60 amps
http://www.progressiverc.com/prc-silicone-wire-14-awg.html

Practical Considerations Concerning the Use of LiPo Batteries

Never discharge lower than 80% of the manufacturer's. stated capacity.

LiPo batteries deteriorate rapidly when left at full charge – store at storage voltage.

Always balance charge when charging a LiPo.

Charge in an area where a possible fire and and huge volumes of smoke won't be a problem.

The user MUST be in the immediate charging area in case of a charging 'incident'.

A means of containing and extinguishing a fire should be on hand in the LiPo charging area.

Practical Considerations When Choosing A Charger

Li-xx chargers use a constant current (CC) constant voltage (CV) profile (CCCV) when balance charging.

For Li-xx batteries, charge current, set on the charger, is 'feed in' until the charger detects 4.2V per cell. It then switches to a constant voltage with the charger voltage at 4.2V and stays there while the current decreases. Once the current decreases to a specified amount, the charger signals that the balance charge is completed. (simplified)

Revolectrix has added a new algorithm called "Ioniq profile" to the Gt chargers. It alters the current during the switch from CC to CV stage to reduce cell damage for HV LiPos.
https://www.rcgroups.com/forums/showpost.php?p=38798202&postcount=6

Keep in mind that packs to be used soon are, more often than not, charged from a storage state of about 50% charged not 'empty'.

A Charge Rate Test

Charger Revo Gt500 Pk Dinogy 3S 1000mAh
The pack was at room temperature, about 22-deg C.

1C 35 min. 39 sec. From 11.46V (3.819V, 3.823V, 3.824V) 485mAh returned to pack
12.6W Required

3C 12 min. 49 sec. From 11.45V (3.818V, 3.818V, 3.819V) 472mAh returned to pack
37.8W Required

5C 8 min. 22 sec. From 11.45V (3.816V, 3.817V, 3.818V) 470mAh returned to pack
63W Required

After the charge termination at 12.6V, or 4.2V per cell, the charge termination voltage drops toward the stabilized open circuit voltage (OCV) as the pack 'settles' down from its excited state.

The voltage drop for the 1C rate charge was very minimal. It stabilized, in a couple of hours, to an open circuit voltage (OCV) of about 4.195V per cell.

The pack charged at 3C reached a stabilize OCV of about 4.190V per cell.

The pack charged at 5C reached a stabilize OCV of about 4.185V per cell.

The percent (%) of the total charge time spent in the constant voltage (CV) stage increased with the charge rate.

On a Personal Note

For the first charge of the day, I use a 1C charge rate for my 3S 1000mAh packs, but I charge 4 packs in parallel at a time.

The required charging power is 4 amps * 12.6V = 50.4W to the end of the CC phase.

That is no sweat for my Revolectrix Gt500. A 50W AC/DC charger could almost do it in the same time, but not quite..

If I do charge at the field, I use a 2C (2A) charge on these 'small' packs, but I seldom charge them at the flying field.

Practical Considerations for Charging 2 of the Example 3S 2100mAh packs

2 of the 3S 2100mAh Hyperion's for a Morning Charge Before Flying
Two packs in parallel charged at 1C rate each
(2.1A) * 2 = 4.2A to 12.6V
4.2A * 12.6V = 52.92W

Again, a 50W charger would just about do it.

The fastest charge at flying field for 50W charger:
50W / 12.6V = 3.97A or 1.89C charge rate

If the pack was at an 80% discharged state 1.68Ah * 60 minutes = 100.8 amp minutes / 3.97A = 25.4 minutes is suggested. The actual charge time will be longer because of the CV phase and continued balancing.

At a 1C rate, 1 amp, 485mAh was returned to the Dinogy 3S 1000mAh pack mentioned in the **A Charge Rate Test** section.
485mAh = 0.485Ah x 60 minutes = 29.1 A minutes / 1 amp (A) = 29.1 minutes. It actually took 35 minutes 39 seconds (35 + 39/60 = 35.65 minutes) to charge. That is 1.225 times longer than suggest by the simple constant current charge rate.
35.65 / 29.1 = 1.225…

There are too many variables involved to suggest how much longer it will take to charge a pack at a given C-rate, but it will take longer than suggested by the simple C-rate time.

A Personal Note on using the Hyperion 3S 2100mAh Packs

I would charge it at 3C (6.3A) at the flying field. Required Power is 6.3A * 12.6V = 79.4W

For these packs, and all 3S 2000mAh to 2200mAh, a minimum of an 80W output charger would be okay.

Some Chargers That Suppliers Package or Recommend In Their RTF and PNP/BNF Aircraft

The 3S 2000mAh to 3S 2200mAh are a popular size.

They are used, and supplied, in the Hobbico Sensei Trainer and the Horizon Hobby Timber.

Tower Hobbies 'recommends' a Duratrax Li-24 30W 2S-4S AC Balancing Charger Star for the Sensei battery.
https://www.towerhobbies.com/cgi-bin/wti0001p?&I=LXGMGV&P=M

The Prophet Sport Plus 50W AC/DC Charger (DYNC2010CA) is recommended for the Timber battery.
https://www.horizonhobby.com/prophet-sport-plus-50w-ac-dc-charger-dync2010ca

What do you think, based on the data for the Hyperion 3S 2100mAh battery?

A Charger for the E-flite Apprentice 15e

Both the BNF and RTF versions of this plane come with a 30W 2S-3S LiPo charger.

The provided LiPo pack is 3S 3200mAh (3.2Ah) battery.
30W / 12.6V = 2.4A
2.4A is a C-rate of 0.75C

If the pack were flown to 80% of its capacity (2.56Ah) then 2.56Ah * 60 minutes = 153.6 amp (A) minutes.
153.6 A min. / 2.4A = 64 minutes **plus** to charge at the flying field.

What do you think?

Realistically Charging a 3S 3200mAh LiPo At 3C at Flying Field

Charger Required Output Power
12.6V * 9.6A = 121W

For all practical purposes, the AC/DC chargers 'top out at' 100W out.
100W / 12.6V = 7.94A
80% 3.2Ah = 2.56Ah
2.56Ah * 60 minutes = 153.6 A minutes / 7.94 A = 19.34 min. = a theoretical 19 minutes 20 seconds. Practically, that will be the better part of a half an hour to balance charge.

This is just an example demonstrating that for packs in the 3Ah to 3.5Ah range, a 100W output AC/DC charger is about the minimum to consider.

A Real Life Charger Choice

One of our members has an EDF that requires a 6S 4000mAh LiPo pack. The supplier's info is below.
Battery: 6S 4000mAh 60C 10AWG wire
Charge Rate: 3C
6S Terminal Charge Voltage: 25.2V
3C = 12A/h
Minimum Charger Output Power to charge at 3C at the flying field:
25.2V * 12A = 302.4W
Possible charging system choices:
The **Revolectrix Gt Eight** can do 400W out on 12V & 800W out on 24V. $129.99 w/24V 1000W power supply $326.99 - $0.41 per Watt Out (Wout)

The **iCharger 306B** can do 500W out on 12V & 1000W out on 24V. $159.99 w/24V 1000W power supply $349.99 - $0.35 per Watt Out (Wout)

A Look At Cost Versus Value of Chargers, A Word of Advice for Beginners

50W AC/DC $48.00 – $99.99
Cost per output power: $0.96/Wout to $2.00/Wout

60W AC/DC $59.99
Cost per output power: $1.00/Wout

80W AC/DC $49.99 - $79.99
Cost per output power: $0.62/W - $1.00/Wout

100W AC/DC $69.99 - $79.00
Cost per output power: $0.70/W - $0.79/Wout

DC charger w/Power Supply:
180W Hitec X1 Pro/ePowerbox 17 Combo $79.99
Cost per output power: $0.44/Wout

250W The Starter (iCharger 106B & PRC350) $144.99
Cost per output power: $0.58/Wout

February 2018 Midwest Meeting

Ken Myers, vice-president, called on the officers for their reports.

Lynn Morgan, club secretary, reminded the members that their 2018 dues are due NO LATER THAN the March 7 meeting. After that date their is an additional late fee of $25. Why? The AMA club charter, including current the current membership roster, is due at AMA headquarters in March. People who sign up late require a resubmission of the roster and more work for our secretary.

Dave Stacer, club secretary, noted that the fertilizer bill has been paid for 2018. Paying early saves the club a substantial sum.

Show and Tell

Mel Berent presented his scratch built Angry Bird. The airframe is constructed Model Plane Foam (MPF).
http://www.modelplanefoam.com/index.php/foam1/

Mel purchased his MPF at FlightLine Hobby in Lake Orion.

http://www.flightlinehobby.com/

The plans are found online.

http://rc-plans.com/catalog/item11.html

He used a small 2600K_v outrunner, 3S LiPo battery and 6x4 prop. Being a 'prop through a hole' type design, it has quite a 'scream' and can certainly sound like an angry bird!

He noted that it only took about an hour to build it, but it took the better part of two hours to paint it.

He has been flying it at both the Ultimate Soccer Arenas, in Pontiac, and Legacy Center, in Brighton.

Denny Sumner shared his scratch built, Mark Rittinger design, Pharaoh sport plane.

It has a foam core wing with balsa and plywood construction for the rest of the airframe.

Denny's build thread is found on RC Groups.
https://www.rcgroups.com/forums/showthread.php?3000450-Another-Mark-Rittinger-Pharaoh

Specifications for Mark's prototype:
Ready to Fly Wt.: 72 oz.
Wing Area: 3.68 sq.ft. (~530 sq.in.)
Wing Area Loading: 19.56 oz. sq./ft
Wing Cube Loading Factor: 10.2
Power: 750W at 48A
Watts in: 166.66W/lb.
CG at 25% with no nose weight.
https://www.rcgroups.com/forums/showpost.php?p=33279810&postcount=109

Denny's version is immaculately covered with red and white World Models Toughlon covering with MonoKote checker boarding.

It uses a Cobra 3520/12 and a Cobra 60 Amp ESC turning a 12x8E prop on 4S LiPo battery.

To change your email address contact Ken Myers at kmyersefo@mac.com

The 2018 membership application is available at the club Web site, http://www.midwestrcsociety.org, for downloading with the link on the homepage.

Upcoming Events:

Tuesdays, Indoor flying at the Ultimate Soccer Arenas, 10 a.m. - 1 p.m., Oct. 24 - April 10 (details in this issue)

Wednesdays, Indoor flying at the Legacy Center, 9299 Goble Dr., Brighton, MI 48116. Flying time: 12:30 p.m. to 2:30 p.m., The cost is $10 per drop-in session or $150 for a seasonal membership.

March 7, Wednesday, Monthly Midwest RC Society meeting, EAA building, Canton-Plymouth Mettetal Airport, 8550 N. Lilley Rd., Canton, MI 48187
7:00 p.m. Aviation related video
7:30 Meeting - Guest Speaker TBD

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April 6, 7 & 8, Friday, Saturday & Sunday, 64th Annual Toledo Weak Signals RC Exposition, Seagate Center, 401 Jefferson Ave., Toledo, OH, admission $10

http://www.toledoshow.com

Denny's Pharaoh Continued

He used JR NES-321 servos for the rudder and elevator and Hitec HS-80s on ailerons.

We can't wait to see this one take to the air when the weather finally breaks for this year!

Please Get Your 2018 Membership Application, copy of Your AMA Card and Check for $100 to Lynn Morgan, club secretary
ASAP. This is the last month to rejoin with out the $25 fee added.

The Next Meeting:
Date: Wednesday, March 7, 2018
Time: 7 p.m. aviation video(s) - 7:30 meeting
Place: EAA building, Mettetal Airport, Plymouth, MI