Model aircraft noise reduction

1. Throttle Travel

As noise level increases with increased throttle travel, one way over reducing a model's noise is if it overpowered is to reduce the throttle travel on the transmitter (end point adjustment / travel limit etc.) in the programming. This can also be achieved mechanically by adjusting the servo arm or linkage. However, the travel limit on the transmitter would be simpler to set up as it can be carried out live whilst the noise meter is being used to measure the plane, requiring less trial and error tweaks and being more precise. If this method is used, then you need to keep this limit and if asked for a retest in the future you will need to submit again.

2. Exhaust Noise

Glow engines should not normally be an issue.

However, older 2-stroke glow engines may have very small or unbaffled silencers and can give rise to unacceptable noise levels. Therefore, an older glow engine will benefit from the installation of one of the newer longer, baffled silencers that produce a marked reduction in emitted noise. Another option is to install a secondary silencer which is connected to the outlet of the main silencer with high temperature silicone tube or flexible metal tube.

Older short silencer

Quiet longer silencer

Super quiet very long silencer

Secondary silencer

The same can be true for older 4-stroke glow engines, some of which are fitted with simple outlet pipes without a silencer or a very small muffler. In these cases, a modern 4-stroke silencer could be retrofitted, or a secondary silencer fitted. The current range of OS 4-stroke engines are fitted with silencers very similar to those used on 2-stroke engines, providing much better noise reduction. With the use of standard threaded bosses these may be able to be retrofitted to older engines.

Basic 4-stroke glow exhaust

Modern 4-stroke exhaust

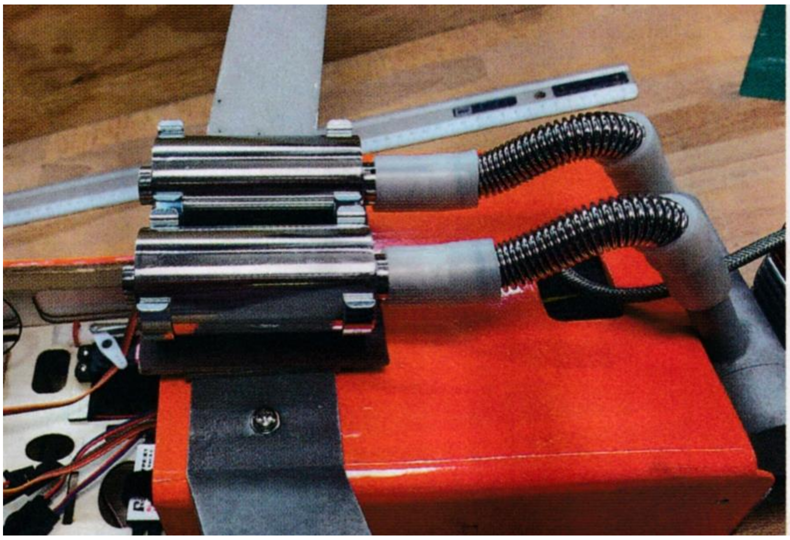
Glow powered helicopters can be readily silenced by using one of the larger canister silencers with plenty of volume and internal baffling.

Helicopter silencer.

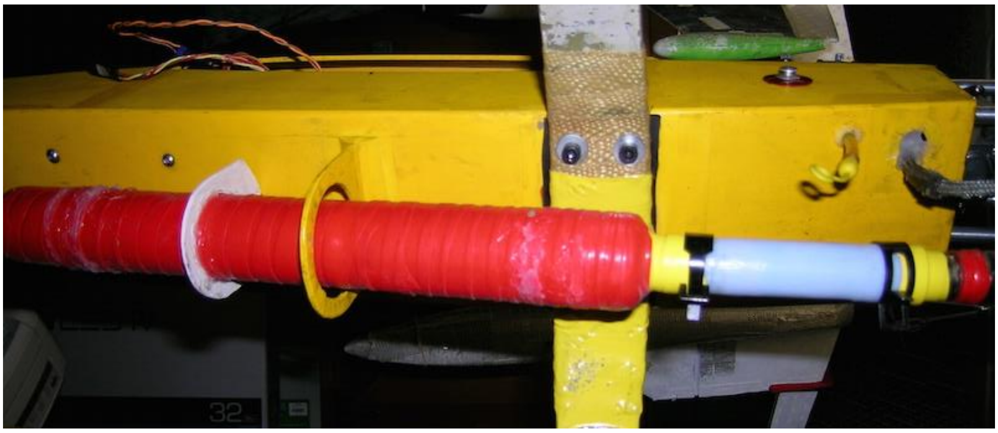
Large two-stroke petrol engines have become quite popular in recent years. However: they are not quiet and the silencers supplied with them often emit an unpleasant bark which can cause problems on some flying sites. The main point to make is that the silencer supplied with most petrol engines is not suitable and if you want to run larger petrol engine models then you should include an aftermarket silencer in your plans. The larger can silencers are well known for their effectiveness in reducing the harsh exhaust sound of these engines.

Petrol canister exhaust system

A recent article in RCM&E (September 2019, “The Art of Noise”) described how the addition of a secondary stainless steel silencer was found to dramatically reduce noise levels. These can be found on ebay, search “stainless steel muffler” in the Toys and Games category and have been successfully used on 25 to 35cc engines with noise levels of 82dB(A) or less with the correct propeller choice.


Secondary silencer system

There was an article in RCME many years ago which advocated wrapping the exhaust with high temperature silicone tape, or silicone rubber, possibly with fibreglass matting underneath. Recent experience by a couple of club members is that the use of self-amalgamating / self-fusing silicone rescue tape will withstand exhaust heat and can be wrapped around the manifolds, headers, pipes and cans with good effect and this reduces the “tinny” sound emitted from these thin walled objects.


Petrol engine exhaust can wrapped with silicone rescue tape.

You can also buy pepper pot type outlets that fit into a small section of silicon tube on the outlet stub of the exhaust and can be purchased for 20 or 30cc size engines, or two can be used on a 60cc twin, or if you have a 55cc engine with twin outlets from the exhaust. Forums and product reviews suggest that these do work and have a minor effect on top end rpm, perhaps 200rpm lower. They are also stated to reduce the harsh tinny / bark that these engines make on the standard silencer. A search for DLE20 muffler, DLE silencer or DLE pepper pot will give seller on line including HobbyKing and some ebay shops amongst others.

Exhaust outlet insert installed

Exhaust outlet insert installed

An additional measure that can be taken for any engine include the use of a silicone rubber exhaust extension / deflector.

Silicone rubber exhaust deflector

Finally, equally applicable to all engine types is the rpm that the engine runs at. Reducing the engine rpm will result in a reduction in the amount of noise generated by the engine. This is often achieved by increasing the loading of the propeller by increasing diameter or pitch. This is discussed more under propeller noise below.

3. Induction Noise

Induction noise is the noise emitted by the carburettor as it sucks in air and is an issue on larger models, especially petrol-powered ones. The exhaust, propeller and airframe noise should be tackled first and if the model remains noisier than required, then attention can be focussed on this area.

Most engines can be fitted with an air filter to reduce noise levels. It is also possible to fit a pipe onto the carburettor inlet, or fit an extension between the carburettor and engine and draw the air from within the aircraft fuselage. This can muffle the induction noise as the air intake is no longer open to the atmosphere.

However, this needs to be tempered if the fuselage is large and open with thin or film covered sides, in which case resonance can occur. See vibration and airframe noise below.

Zenoah engine with carburettor extension elbow drawing air from the fuselage to reduce induction noise

4. Propeller Noise

The noise generated by the propeller can be significant, especially on larger aeroplanes and is equally applicable to electric motor driven propellers as glow and petrol engine driven ones. On an IC powered model, once the exhaust noise has been reduced as far as practicable, the propeller will be the next highest source of noise, and on electric motor driven aircraft, the propeller will be the main source of noise.

Before considering propeller type and size, it is imperative that the propeller is balanced and so is the spinner if fitted. If the propeller is driven by an electric motor, the motor shaft must be straight and the aluminium propeller driver must also be straight. On electric motors, it can be easy to bend the motor shaft and propeller driver from nose overs if these are manufactured from metals that are too soft. The propeller must also be free from damage, especially tip damage as nicks or chips, especially at the tips can increase the air turbulence and noise generated by the propeller.

Another significant issue affects pusher type aircraft where the propeller is very close to the trailing edge of the wing / fuselage. In this case, unlike a normal tractor propeller, the air supply to the propeller is not open and uniform and the turbulence generated by the trailing edge increases the noise of the propeller. This can create a very harsh noise in the case of electric models with small diameter high rpm propellers. In these cases, the motor will need to be set further back away from the trailing edge if the noise level is not acceptable.

The main factors affecting propeller noise are tip speed and tip shape with the material of construction having a lesser impact.

A propeller with a well rounded or raked tip will normally produce much less noise than a blunt or square tipped propeller. If the model is generating a lot of propeller noise, then a change to one with a better shape may reduce this noise. Some propellers such as Master Airscrew have squared off tips and these can be replaced with for example, APC with a raked tip or a Master Airscrew or Graupner with a rounded tip. However, changing the propeller sometimes improves the situation and sometimes doesn't, there is no universal solution. Experimentation here is the key, try a different one and test again.


Square
Poor


Raked
Good


Rounded
Good


Tapered / rounded
Good

The choice of propeller material can also have an impact on the noise generated, but as with the discussion on tip shape, there is no universal rule. Softer flexible nylon propellers will generally make more noise than stiffer propellers because the flexing of the propeller can generate additional mechanical noise, plus extra air turbulence. The best normal materials are glass filled nylon and wood, with claims that some of the better wooden propellers are quieter than the glass filled nylon, although this is not universally accepted. The quietist propellers are probably the very stiff carbon fibre reinforced epoxy propellers, although these tend to be very expensive and are really only considered for larger models.

The propeller tip speed is the second factor that can be easily altered to reduce the noise generated by the model. Many tests over the years have shown that for an acceptable level of noise with a well designed propeller, the tip speed should be no more than 400mph, and every reduction of 50mph below this reduces the noise by 2dB(A).

The propeller tip speed is a function of the propeller diameter and the propeller rpm. A simple way of calculating this is by multiplying the propeller diameter in inches times the rpm in thousands of rpm and multiplying the answer by 3. An example is an 18” propeller, operating at 8,000rpm.

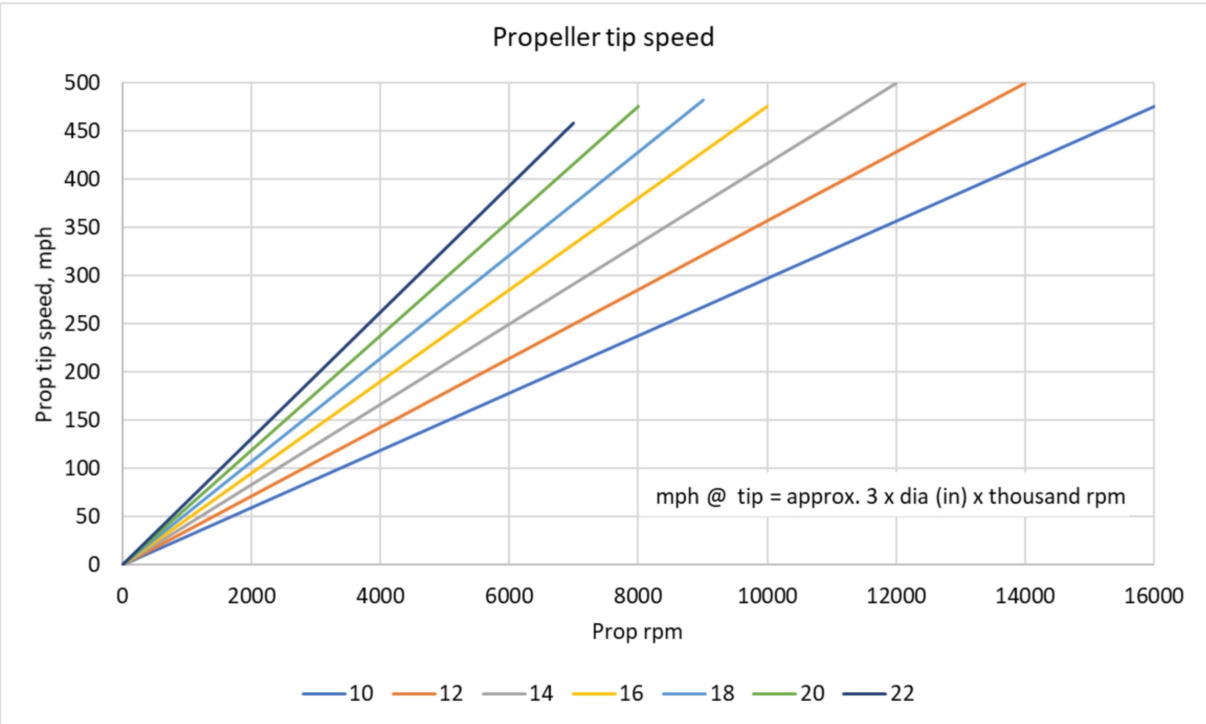
Tip speed, mph = 18 x 8 x 3 = 432mph.

The precise calculation is only 1% different, hence it is very easy to use the simple version with acceptable accuracy, especially if you are comparing different propellers and rpm values.

Tip speed, mph = 18 x 8 x 2.975 = 428mph

The graph and table below give some guidance on tip speed as a function of propeller diameter and rpm, however, given the simple calculation method, this should be the favoured route for any calculations.

Propeller diameter, inches	Propeller rpm @ 350mph tip speed	Propeller rpm @ 400mph tip speed	Propeller rpm @ 450mph tip speed
8	14706	16807	18908
9	13072	14939	16807
10	11765	13445	15126
11	10695	12223	13751
12	9804	11205	12605
13	9050	10343	11635
14	8403	9604	10804
15	7843	8964	10084
16	7353	8403	9454
17	6920	7909	8898
18	6536	7470	8403
19	6192	7077	7961
20	5882	6723	7563
21	5602	6403	7203
22	5348	6112	6875
23	5115	5846	6577
24	4902	5602	6303



On an IC engine, the tip speed is reduced by changing the propeller pitch and/or diameter. Reducing the diameter on its own will increase the rpm, offsetting the desired reduction in tip speed. There are several permutations that are possible.

a. Increase the pitch and retain the diameter. In this case the rpm will fall which reduces the tip speed and has the side benefit of reducing exhaust noise at the same time. The increased pitch offsets the reduced rpm, hence flying speed is maintained. Static thrust will also remain relatively unchanged.

b. Increase the pitch and reduce the diameter to give the same propeller loading. In this case the rpm will remain constant and the tip speed reduction is via the smaller diameter propeller. In this case, the flying speed may be increased and the static thrust reduced, which may or may not be a problem.
c. Increase the pitch and the diameter. In this case there will be a marked reduction in engine rpm and the reduced rpm will more than offset the increased diameter, giving a reduced tip speed and a reduced exhaust noise. In this case, if the new propeller is chosen wisely, the static thrust and flying speed can remain the same because although the engine is producing a lower power rating, the larger slow propeller is more efficient.

An example of case c is a 70 size 2 stroke engine using an 11″x7″ propeller turning at 13,500rpm, which has a tip velocity of 442mph. Changing the propeller to a 12″x8″ will reduce the rpm to around 11,000rpm with a corresponding reduction of tip speed to around 393mph This is almost a 50mph reduction in tip speed and therefore a reduction of around 2dB(A) in noise level. Both of these propellers will generate nearly the same static thrust and flying speed even though the engine is turning almost 20% slower.

An example of this with a 26cc petrol engine was given in the September 2019 issue of RCM&E referenced above. The model was being run at 9,000rpm with a 16x8 Master Airscrew propeller and standard silencer giving a tip speed of 428mph and a sound reading of 92dB(A). a secondary silencer was added and the propeller changed to an 18x6 APC wood propeller which ran at 7,400rpm. This gave a tip speed of 396mph, a small reduction. However, in this case, this illustrates the whole system approach as the secondary silencer will have made some reduction, the lower rpm will have also reduced the exhaust noise, the propeller tip speed will have reduced the noise by a small amount and the change from the Master Airscrew to APC most likely also had an impact.

For larger aircraft which are struggling to keep the propeller speed low enough, a change to 3 bladed or even 4 bladed propellers can be used to have the same effect as noted above. The larger IMAC style models are tending to run 3 bladed propellers for this very reason.

For electric motor models, propeller noise is unlikely to become an issue until power levels in excess of 2kW (25cc -30cc equivalent) are being used. The same guidelines of 400mph maximum tip speed is equally applicable to electric motor driven propellers. However, if a tip speed reduction is required, then a different strategy is required because an electric motor is a fixed speed device, and increasing the propeller loading by for example increasing the pitch will not reduce the rpm, it will increase the current and risk burning out the motor or ESC. The permutations possible are different to IC engines and include the following.

d. Reduce the number of battery cells driving the motor. If the aircraft is over powered and a reduction in performance can be accepted, then reducing say a 6S battery to a 5S battery will result in an approximate 16% reduction in rpm and hence tip speed and noise. It may be possible to combine this with say an increase in diameter or pitch if the current rating of the ESC and motor allow this to regain some of the lost performance.
e. Reduce the propeller diameter. If the aircraft is over powered at full throttle and flies mostly at say half throttle a reduction in full throttle performance may be acceptable. Reducing the propeller diameter will reduce the tip speed and noise. However, the static thrust will be reduced as may the flying speed at full throttle and a higher throttle setting will be required for normal flight.
f. Reduce the propeller diameter and increase the pitch. In the case where a reduction in performance can not be accepted, the propeller diameter is reduced to reduce the tip speed and noise, but the pitch is increased to offset the reduced diameter and maintain the same power output from the motor at full throttle. In this case there will

be some small reduction in static thrust and an increase in flying speed as the two changes balance out.

An example of case f is a 25cc equivalent electric motor running an 18”x8” propeller at 8,000rpm with a tip speed of 428mph. Changing the propeller to a 17″x10″ will maintain the same power draw and 8,000rpm, with a reduction in tip speed to around 405mph This is almost a 25mph reduction in tip speed and therefore a reduction of around 1dB(A) in noise level. Both of these propellers will generate nearly the same static thrust and the second will have a higher flying speed even. This does show that reducing tip speed is more difficult with electric motors with their fixed speed characteristics.

As with larger IC engine models, 3 bladed propellers may be used to reduce the tip speed of larger electric powered models. In this case, care needs to be taken to choose a 3 bladed propeller with the same load characteristic as the original 2 bladed propeller to avoid overloading the motor and burning it out.

Taking the example above, if the 18”x8” 2 bladed propeller running at 8,000rpm with a tip speed of 428mph is replaced with a 3 blade 16 x 10 running at 8,000rpm, the tip speed will be reduced to 381mph. This is almost a 50mph reduction in tip speed and therefore a reduction of around 2dB(A) in noise level. Both of these propellers will generate nearly the same static thrust but the 3 bladed one will have a higher flying speed.

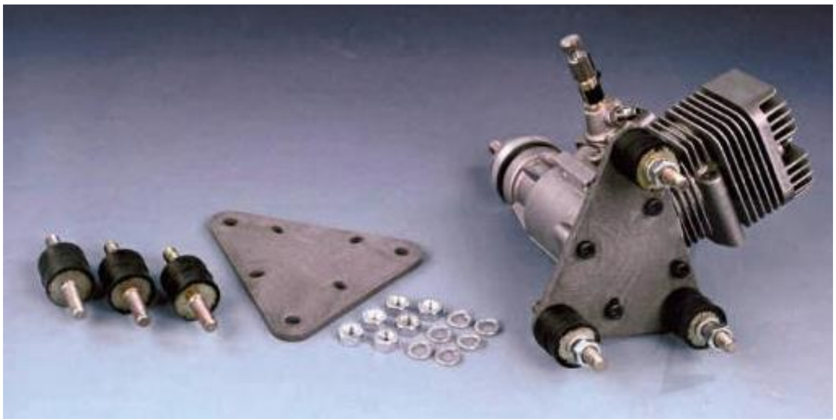
5. Vibration and Airframe Noise

Any hollow space will act like an amplifier for sound and a wooden hollow air-frame is excellent for just this purpose, acting much like a drum. Any vibration transmitted from the engine to the airframe can resonate within the airframe, creating additional noise.

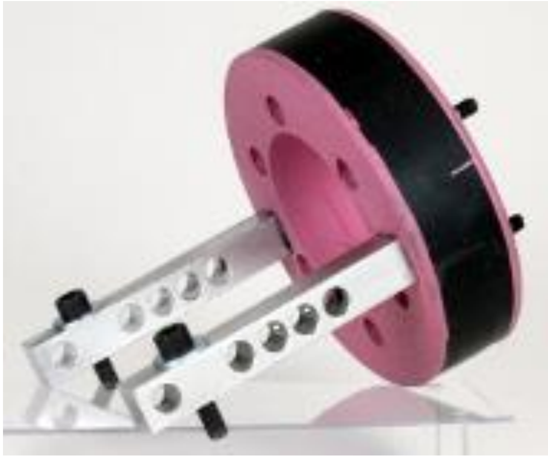
The airframe should be inspected for items that can rattle such as power leads, pushrods, snakes, control surfaces, hatches and cowls. Items should either be fastened down with tie wraps, or foam / rubber cushioning placed between them and the airframe and slop should be removed from control surfaces. In the case of large aircraft that have an open structure with large areas of heat shrink film covering, extra support strips for the covering, from hard balsa strip may reduce the amount of drumming produced. Alternatively, strips of lightweight foam can be glued to the inside of the covering as a damper / sound absorbing material.

Rubber isolation mounts or soft mounts can be used to reduce the amount of vibration transmitted from the engine / motor to the airframe to reduce any resonant noise. Depending upon the quality of the mount system used and the size of the air-frame, a reduction of up to 3dB(A) can be achieved. Two types can be used, soft mounts or isolation mounts.

Soft mounts are where the engine / motor is separated from the bulkhead by a rubber block / bobbins with no through bolting. These are the most effective at reducing vibration related noise, but care needs to be taken in choosing an appropriate type for the size of motor / engine and must not be too soft, otherwise the motor can move about too much.



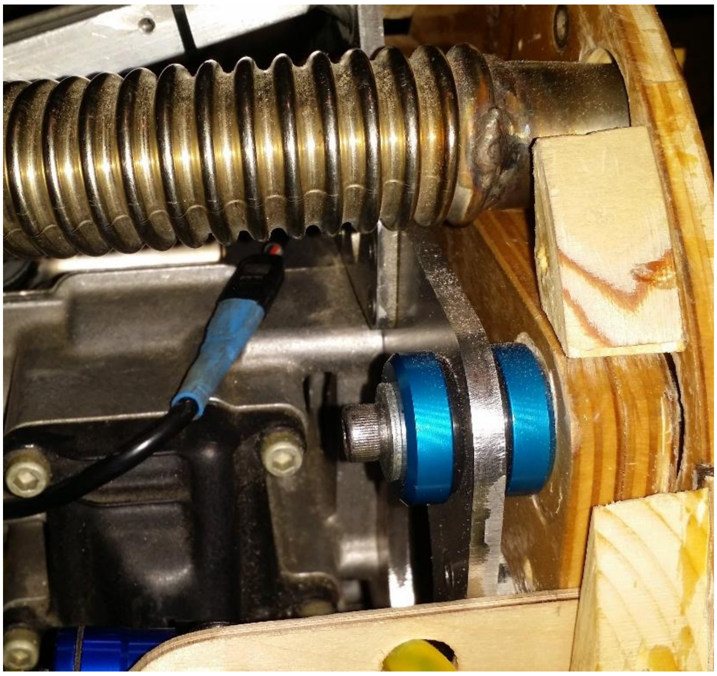
JP soft mount with mounting plate and rubber bobbins



Hyde soft mount with single rubber pad

Isolation mounts are where the engine remains bolted through to the firewall, with rubber washers either side of the firewall or mount and a rubber bush passing through the hole in the firewall. Therefore, there is no direct contact from the mount or firewall to the bolts and some flexibility is available. These systems provide less damping of vibration than the soft mounts, but prevent excessive engine movement that can be associated with true soft mounts. It is important when fitting an engine / motor with these mounts not to tighten them up too much, otherwise the rubber washers are compressed and the arrangement becomes rigid, defeating the purpose. This type of mount is available from many sources such as such as Dubro, Secraft, Just Engines etc.

Dubro engine isolation mount Just Engines rubber isolation bushings



Secraft floating mounts in situ, individual components and an assembled mount

It is possible to use isolation mounts with large electric motors with silicone rubber, tube and large metal washers. A model with a large fuselage and large areas of film covering at our field has been reduced by 5dB(A) using this method, which illustrates how much the induced noise from fuselage vibration can add to the total noise.

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