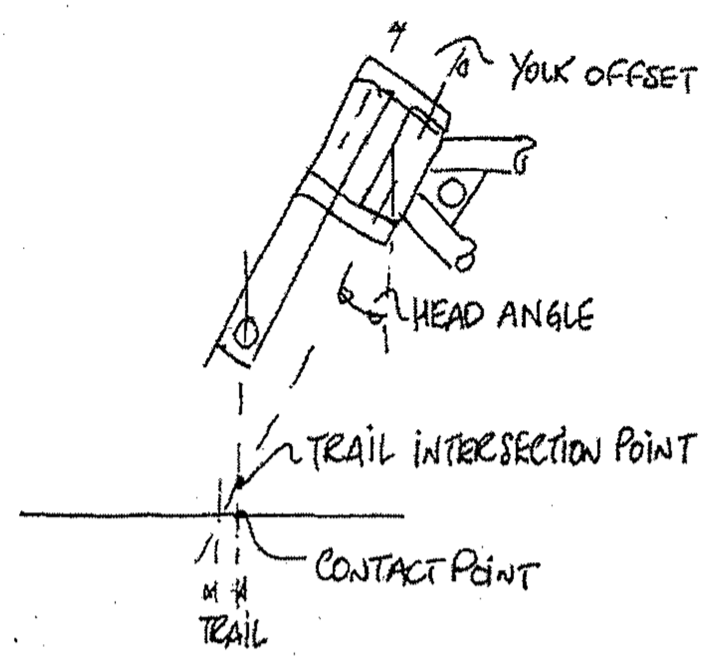
WHEEL LEAD FORMULA

by Peter Smith

Here's a few notes on the formula I use to determine the correct amount of wheel lead when installing any bike to any sidecar. This applies to conventional set ups, i.e. telescopic forks, non steerable sidecar wheel and non-articulating connections.

The following points are covered in detail, in hopes of trying to show the effects of variations and how they are interconnected to combine handling situations approaching "as good as its going to get."



1. Trail intersection point. 2. Rolling radius. 3. Differential rise. 4. Contact Point 5. Resultant steering arc. 6. Lineal offset. 7. Lateral scrub factor 8. Lateral/Longitudinal center of gravity. 9. Vertical center of gravity. 10. Overview of all of these values and effects.

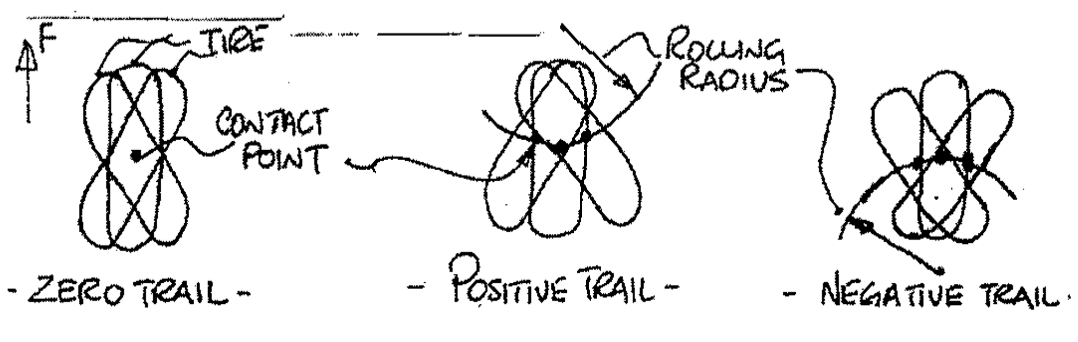
Most importantly when setting up a rig, after establishing the track width, the wheel lead is the very foundation to base any correct amount of 'toe-in' on. The minimum toe-in can only be obtained after the correct wheel lead is found. I have endeavored throughout this information to simplify the many hard to understand points of importance concerning wheel lead. I hope this will be of value to readers, probably not as new information, but more of an explanation of reasons why I highly recommend this data.

So let's start with the first item which is trail intersection point.

TRAIL INTERSECTION POINT

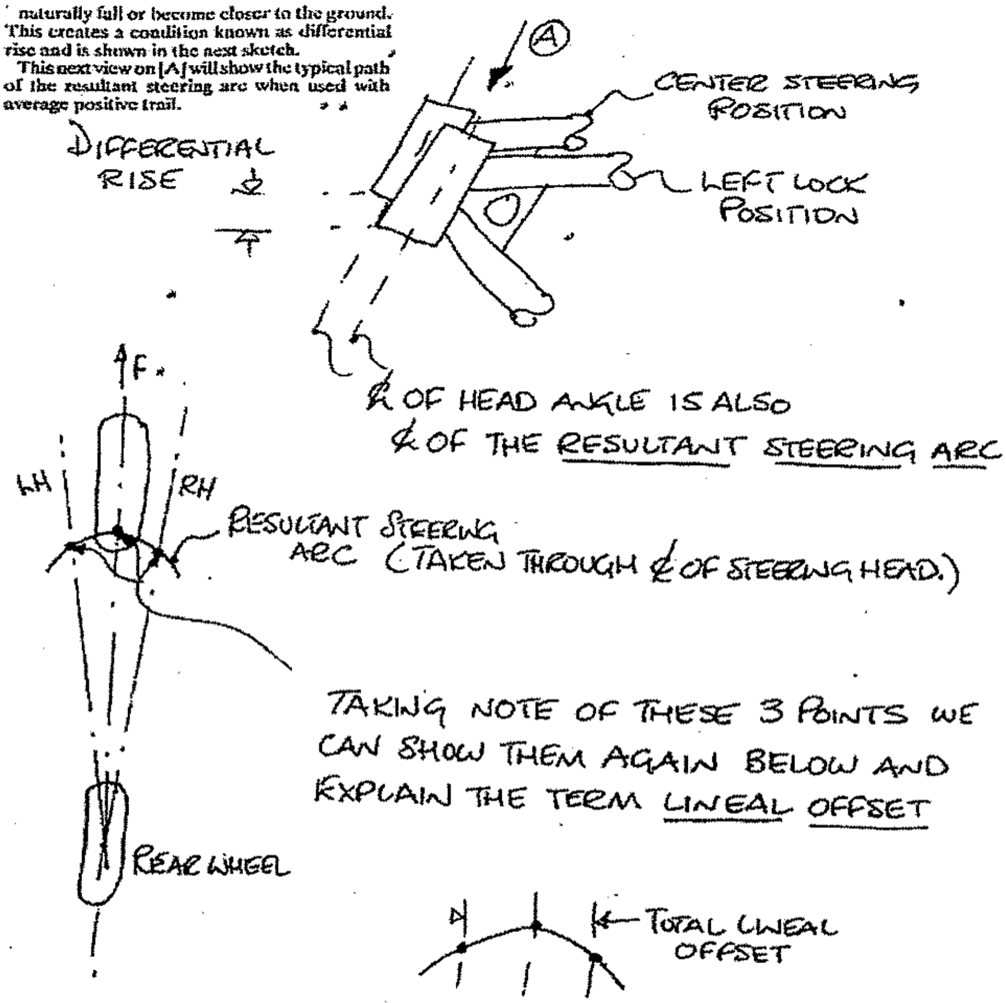
This point is determined and affected by head angle, yoke offset, wheel diameter and suspension position. The contact point of the tire is relative to this intersection point and when the steering is turned the contact point moves along a line known as the rolling radius. The following shows the changes in rolling radius using different values of trail. All views are drawn looking down, with left, straight and right locks.

For clarity reasons the corrected contact point has been omitted. It moves from center of the tire when turning left or right due to the steering head angle (if the head angle was 90 degrees there would be no variation). As a result of positive trail and head angles in the 30 degree area, when the steering is turned from center to left lock, for example, the sprung components (frame, fork legs, engine, etc.) will

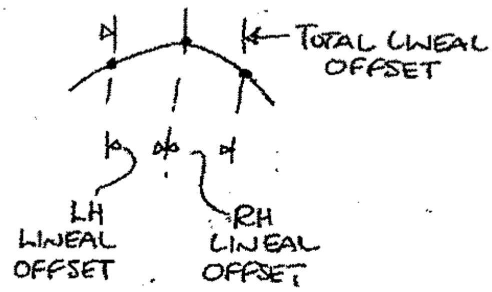


naturally fall or become closer to the ground. This creates a condition known as differential rise and is shown in the next sketch.

This next view on [A] will show the typical path of the resultant steering arc when used with average positive trail.

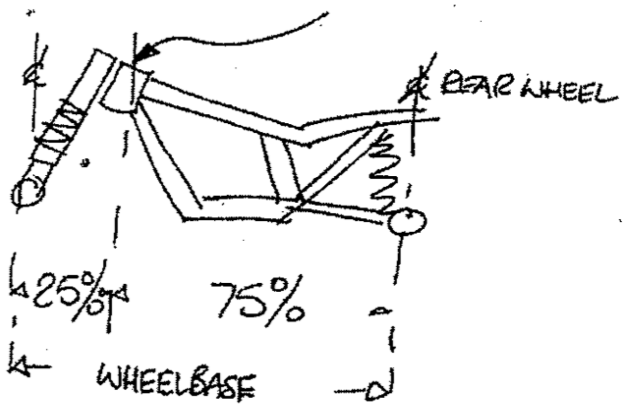


TAKING NOTE OF THESE 3 POINTS WE CAN SHOW THEM AGAIN BELOW AND EXPLAIN THE TERM LINEAL OFFSET

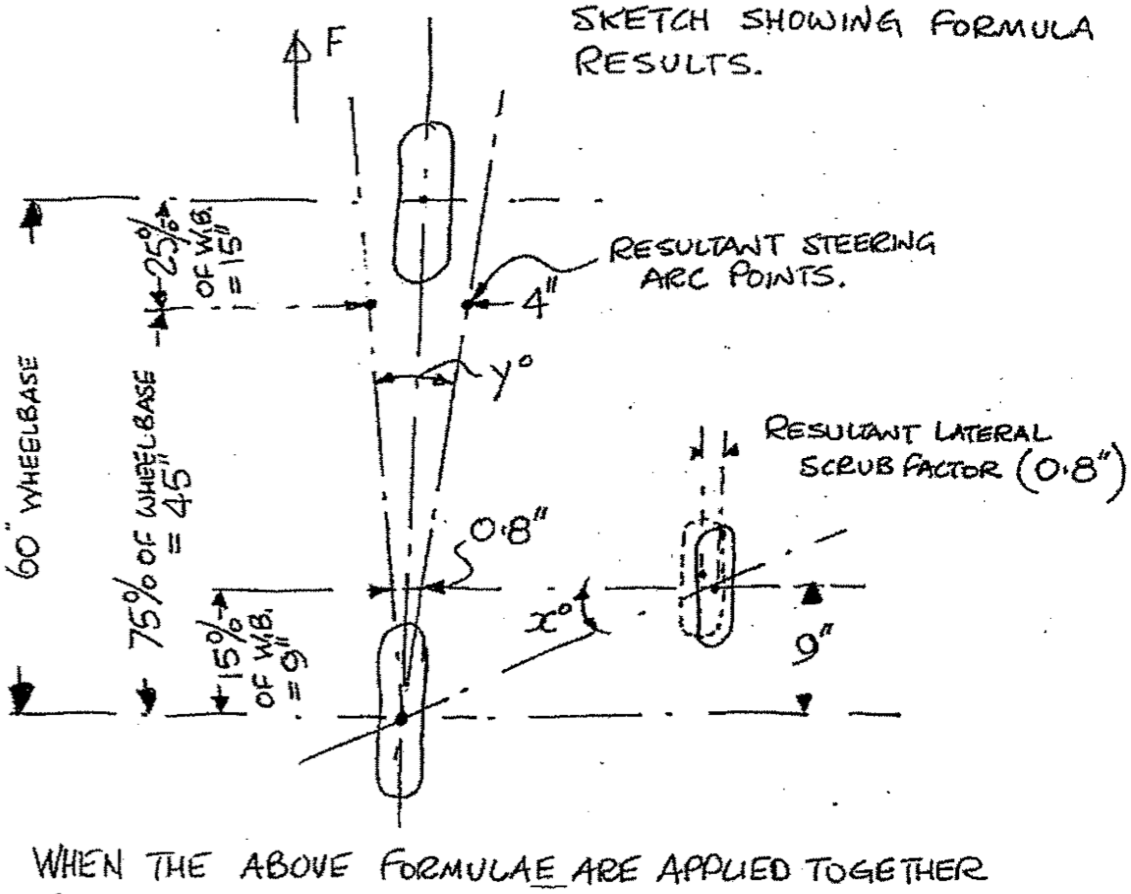


The lineal offset and resultant steering arc are typically located about 1/4 of the way along the wheelbase as shown. We adjust the wheelbase by this amount when using the formula to determine allowable wheel lead.

The following sketches illustrate how the Lateral Scrub Factor "Affects and Determines" the wheel lead. The negative-lead sketch is included (though not practical for street use) to show how the scrub factor is reversed, actually creating a servo force at the steering. This advantage is purely singular, of course, due to unacceptable support of center of gravity, tire wear and over all length. This system can, and has been used to the good for land speed record attempts where the above criteria can be adjusted or for the most part ignored.

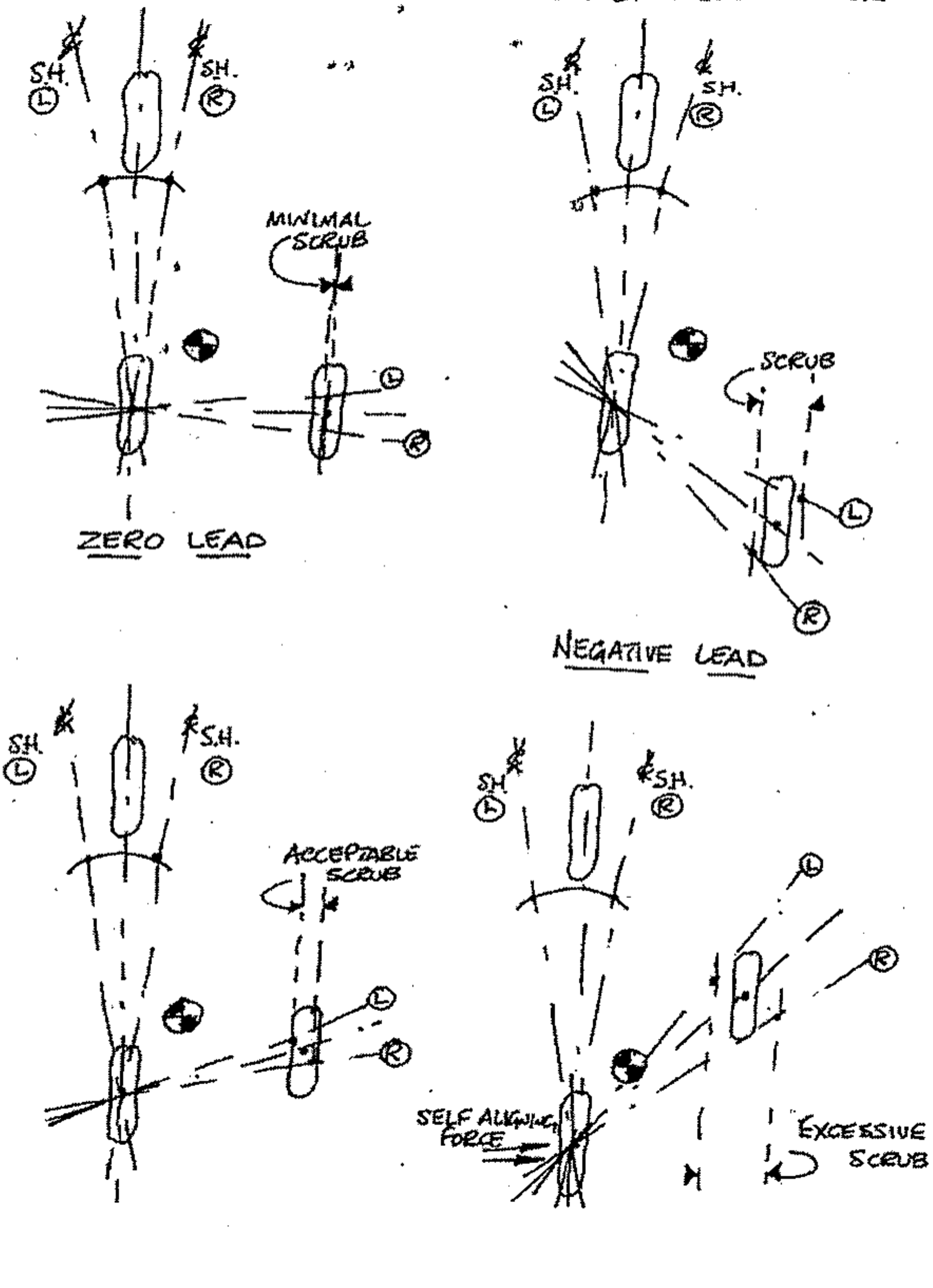


The terms ℄S.H. L and ℄S.H. R refer to the center line of the steering head on left and right locks lines drawn through these points intersect at the contact point of the rear wheel. The dot on the sidecar wheel depicts the movement of the contact point during left and right turns. The line (resultant steering arc) is also shown. The lateral/longitudinal center of gravity is shown only for reference further in the text.



WHEN THE ABOVE FORMULAE ARE APPLIED TOGETHER WITH CORRECT STRUT ANGLES, GOOD RESULTS ARE OBTAINED IN THE AREAS OF HANDLING, FRAME-FLEX AND ABOVE ALL, SAFETY.

– SKETCHES SHOWING LATERAL SCRUB FACTOR –



The lateral and longitudinal center of gravity is poorly supported in the negative-lead situation, but steering effort is minimal. These same center of gravities are very well supported in the excessive-lead situation, but steering effort and the associated problems that go with it, are at their maximums, at best, but typically are very unacceptable in the areas of safety levels and operational comfort. Of note is the constant self aligning force at the rear wheel, trying to maintain a medium between the front and sidecar wheel thus in itself creating excessive tire wear. With excessive lead the sidecar wheel becomes similar to a non steerable wheel located at the front of the sidecar.

As can be seen, positioning the center of gravity, then determining wheel lead to support this can be detrimental to the handling of the outfit. We unfortunately have to compromise the ideal support of the center of gravity. (Unless we steer the sidecar wheel), in favour of more acceptable wheel lead. The effects of incorrect wheel lead far outweigh the theoretical ideal placement of the long/lat. center of gravity. We do not ignore the center of gravity. On the contrary, it is highly present during the design of the frame, ballast location, seat position, auxiliary fuel tanks, trunk capacity, etc.

We must not forget the vertical center of gravity, also during the design stages, to ensure it be kept to a minimum.

The goal for the sidecar designer in this area is to achieve the maximum wheel-lead for support of variable long/lat. center of gravities, without creating excessive scrub which causes countersteering of the front wheel. If there is excessive scrub an increase in the amount of direct steer force is required at the handlebar. When this situation exists, the differential rise is constantly changing, helped by static load carried on the front wheel. This in turn causes...the steering to generate a wobble due to the positive trailed wheel being pulled by the steering head along the rolling radius.

This may occur at slower speeds because of insufficient gyro effect from the front wheel. The steering damper comes into play during this situation and is highly recommended to maintain maximum control at all speeds.

Armed with the preceding information the following formulae and sketches are presented as a guide to design the ideal wheel-lead for any given change in the motorcycle. It should be noted that any change in O.E.M. steering geometry (i.e. the alteration of yoke lead to reduce trail, the conversion to leading link fork, etc.) would improve the overall handling. However, these formulae are intended for original forks/spring/wheels etc.

For this example we have assumed a wheelbase of 60" and a total lineal offset of 4".

2 basic rules apply here and are used in the example:

1. Sidecar wheel lead as a percentage of wheelbase. Minimum...10% Maximum...20%

2. Overriding factor in this formula is that the lateral scrub factor should be no more than 20% of lineal offset.

Refer to the next sketch to see that we have pre-adjusted this % figure to allow for the angle X° which lessens the actual amount of lateral scrub.

Wheel lead must be corrected within the...10% - 20% range by using the resultant lateral scrub factor.

i.e. This factor of 0.80" computes to 9" wheel lead using the triangle of Y degrees.

Using Basic Rule #1 and a 60" wheelbase the maximum wheel lead would be:

Lead = 20% X Wheelbase
L = 20% X 60"
L = 12"

Minimum wheel lead would be:

Lead = 10% X Wheelbase
L = 10% X 60"
L = 6"

Using Basic Rule #2 and a total lineal offset of 4" the maximum lateral scrub factor would be:

L.S. = Lineal Offset x 20%
L.S. = 4" x 20%
L.S. = 0.8"

This value is the resultant lateral scrub factor and as shown in the sketch would result in a corrected wheel lead of 9".

This wheel lead can be shown as A % of wheelbase.

i.e.

$$L = 100 \div \frac{WB}{L}$$

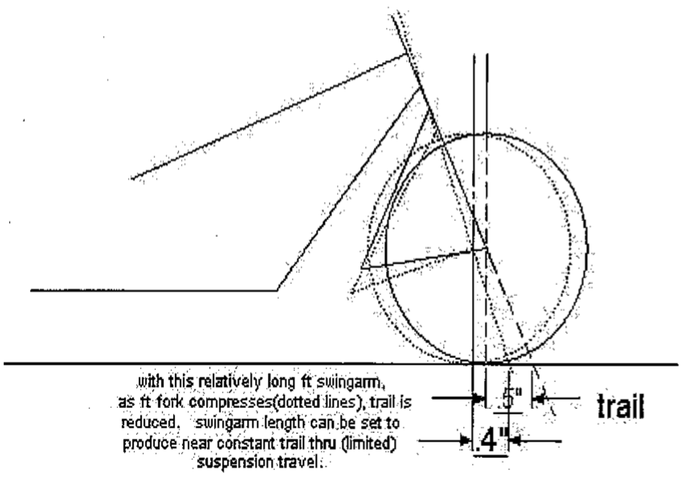
$$L = 100 \div \frac{60}{9}$$

$$L = 100 \div 6.66$$

L = 15% which falls between the maximum and minimum values allowable.

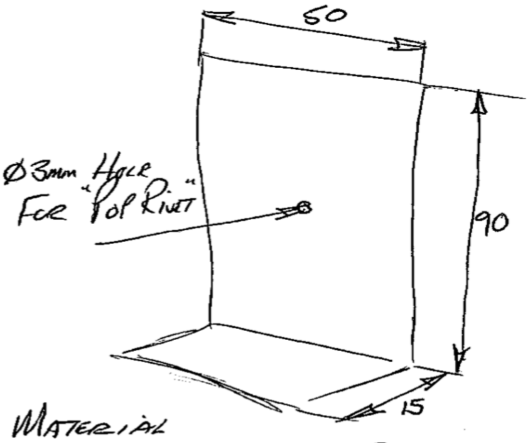
Hi Roger,
I have been thinking!
Sidecar steering trail angles.
Head rake angles 22 to 26 degrees
Positive trail .5 to .75 of an inch(10 to 15mm). Contact patch of the wheel on the road to be behind the headstock angle line where it contacts the road.
Perhaps turning the existing fork unit backwards may give the right dimensions.
Sidecar wheel toe in = 0
Vertical lean of the bike into the sidecar = 1.0 -2.0degrees

Info and diagram on trail on www.race-uscra.com/sidecar.html.



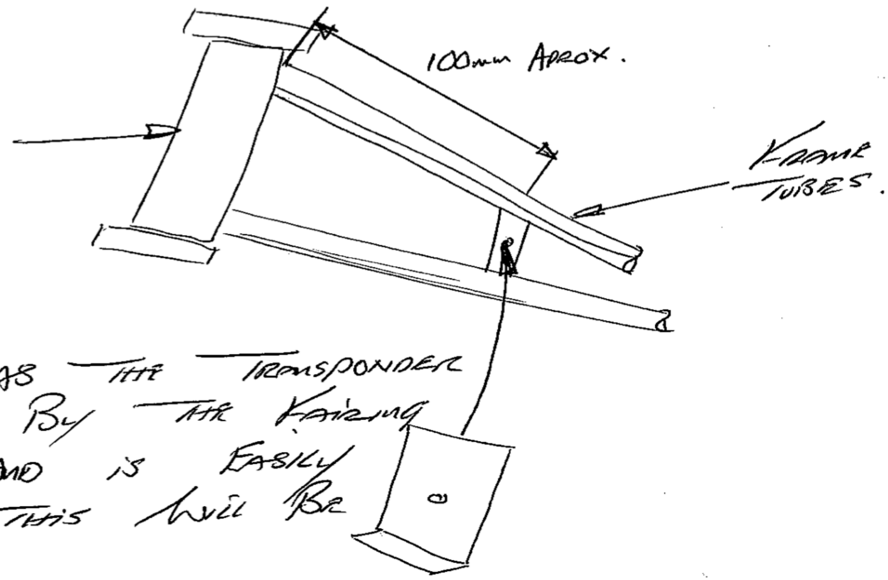
Cheers
Robert H

TRANSPONDER BRACKET.



MATERIAL
0.4mm GALVO STEEL

TRANSPONDER FITTING



NOTE

AS LONG AS THE TRANSPONDER IS PROTECTED BY THE FAIRING OR SIMILAR AND IS EASILY ACCESSABLE THIS WILL BE OK.