Gurney Flaps & T-strips for Model Airplanes-rev 3

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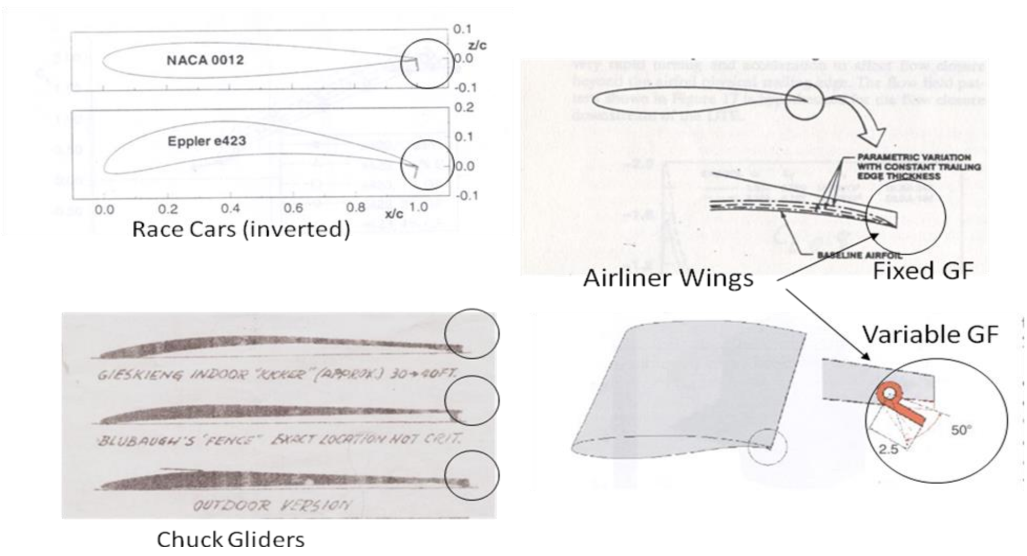
INTRODUCTION

This paper is about Gurney Flaps and T-strips and how they might improve the flight characteristics of model airplanes. I was an aeronautical engineer and aero-modeller and I found these small devices to be useful on full-sized aircraft and am surprised not to see them used more widely on models.

The GF was 'invented' by the Dan Gurney racing car team as a 'bit of bent tin' that increased wing down-force that was robust but easily adjustable. The simplicity and small size of this device caused a minor revolution in those aeronautical circles that had always preached that sharp trailing edges were best! Over the next few years GF-type devices were researched theoretically and experimentally, initially at low speeds and then at the higher speeds relevant to jet airliners.

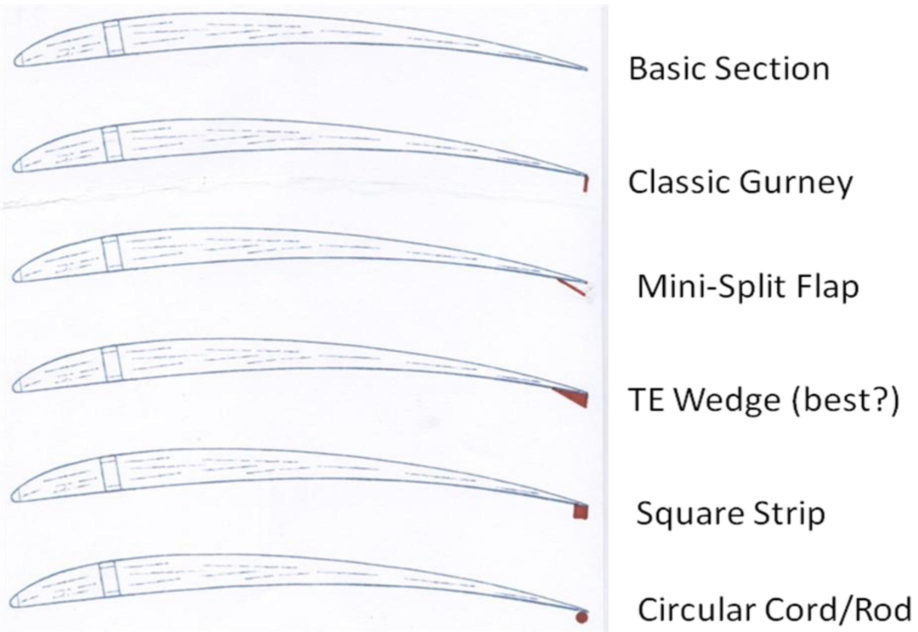


Gurney Flaps and similar devices are now in widespread use on racing cars and have been flown on sailplanes and jet transport aircraft.

In retrospect, it is clear that several devices similar to the GF had been used on aircraft from the 1920s onwards. Any close examination of old aircraft preserved in museums will show a wide variety of such devices used primarily as 'fixes' to improve stability and/or control when flight-testing showed the basic designs to be deficient. They were also used to trim any asymmetries caused by those inevitable build errors. In these earlier manifestations they were given various names such as L-strip (as on the GF), T-strip (GF on both sides), kicker, tab etc.

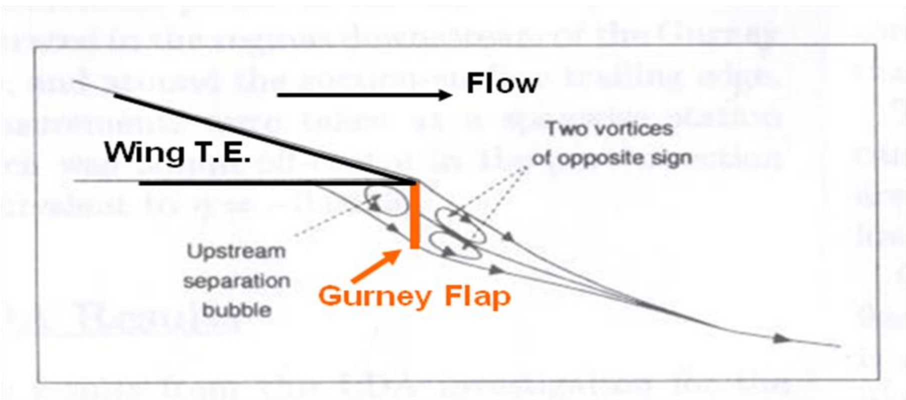
TYPICAL GF CONFIGURATIONS FOR MODEL PLANES

PLANES When we look at how we might incorporate GFs onto our model aircraft there are several ways to do it, but the solid triangular wedge is probably the simplest and most robust. The exact shape is not important and a 2:1 wedge is about right. Remember that the key parameter of any GF device is its 'height' at the trailing edge.



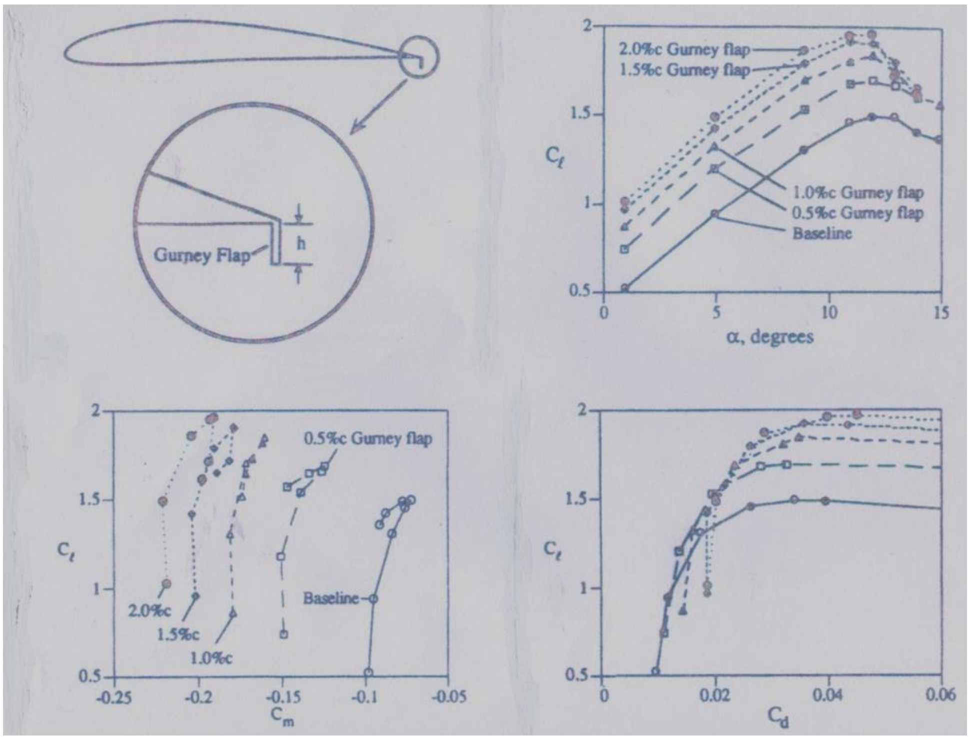
HOW A GF DOES ITS JOB

The GF works by preventing the upper and lower surface flows meeting and affecting each other at the trailing edge. It does this by deliberately creating a small well-formed wake, thus the upper surface flow develops its optimum lift and extra lift is added to the lower surface.



A BRIEF HISTORY OF GF DEVELOPMENT TESTING

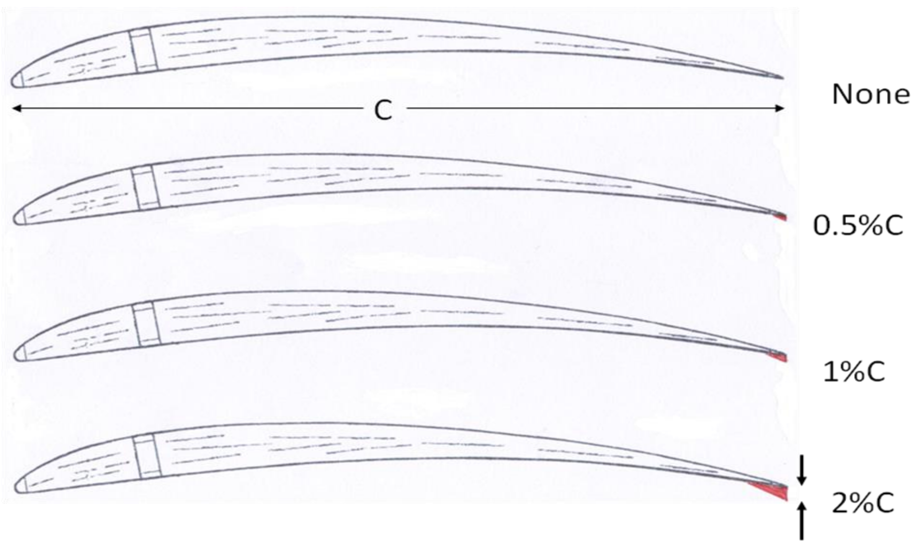
There is a lot of published data on GF wind tunnel testing. An example of the available data is shown for a wing section tested with various sizes of GF. It is remarkable how such small devices can have such significant effects.



Over the years I have gathered GF data from over 20 sources and found that the GF has similar effects over a wide range of Reynolds Numbers, Mach Numbers and over a wide variety of aerofoil shapes; just the thing for our models! It is also of interest that GF data at sizes from 0.5% chord to 5% chord can be merged with the vast library of historical data for Split Flaps from 10% chord to 40% chord, thus 'proving' that the GF is really just a tiny Split Flap.

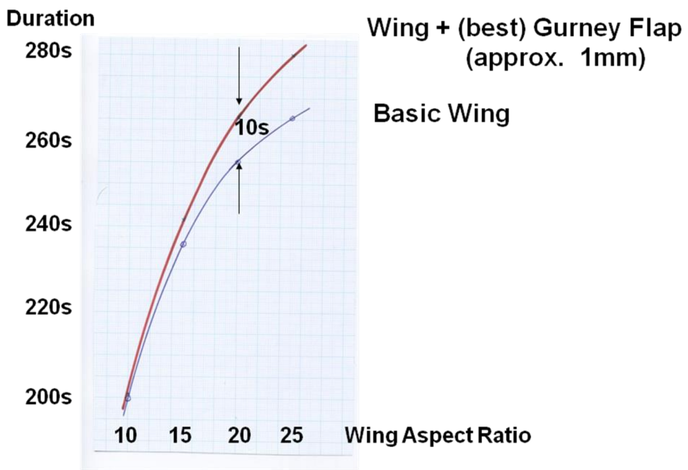
THE REWARDS OF WING GF'S - INCREASED DURATION

The GF size offering best results for competition models is shown later to be around 1% of the wing chord. When drawn to scale on a typical model glider wing section the GF looks really quite tiny.

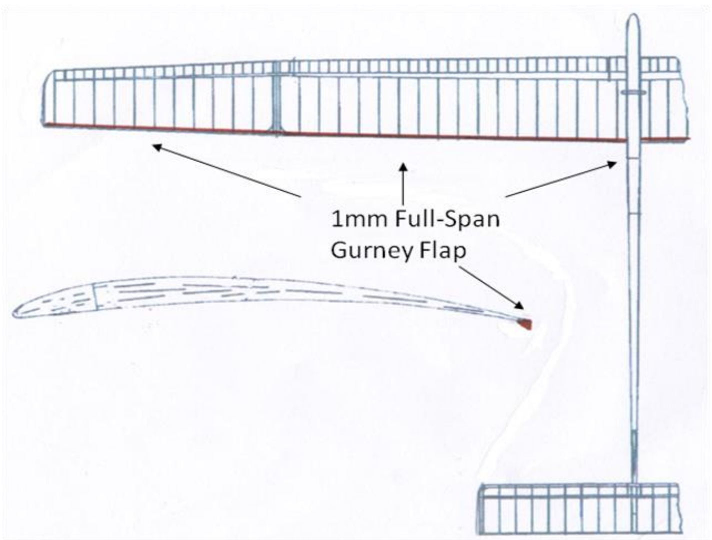


After reviewing the history of the GF and gathering data, we can at last, get round to calculating how much benefit a GF might confer on a competition model aircraft. For simplicity I have concentrated on the effects of GFs on gliders. Championship quality glider are built to the limit of the competition rules and have all the best aerodynamic features of good wing section (properly turbulated), high aspect ratio and with some span-wise taper.

A lifetime collection of model flight data, wind tunnel data and CFD calculations, was analysed. and the effects of different sizes of GF on the key parameters of CDo and CLmax were included. The calculations were made over a wide range of wing aspect ratios and indicated that a championship model without GF might have a duration in still air of about 4 minutes. The 'best size' of GF was calculated to increase duration of a typical existing championship model by about 10 seconds. Lower aspect ratio models would gain less and high aspect ratio models would gain more. 10 seconds is not much, but is just significant, and there is more to come later!



The 'best size' of GF was seen to vary for different wing aspect ratios, but it is also clear that if the GF is made too big then the performance gain is lost. A rough 'rule of thumb' might be that the full-span GF should be about 1mm high on a championship quality model.



Same Aspect Ratio

+

Same Span-loading

+

More CLmax & CDo

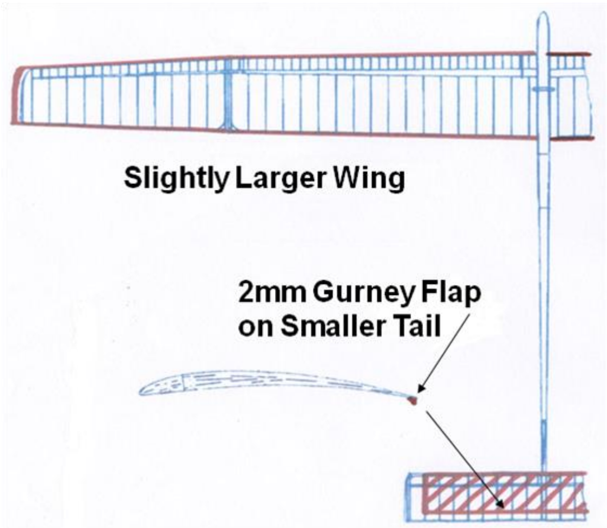
Overall effect:

Extra 10s duration

TWO MORE GF TRICKS CAN GET YOU ANOTHER 15 SECONDS!

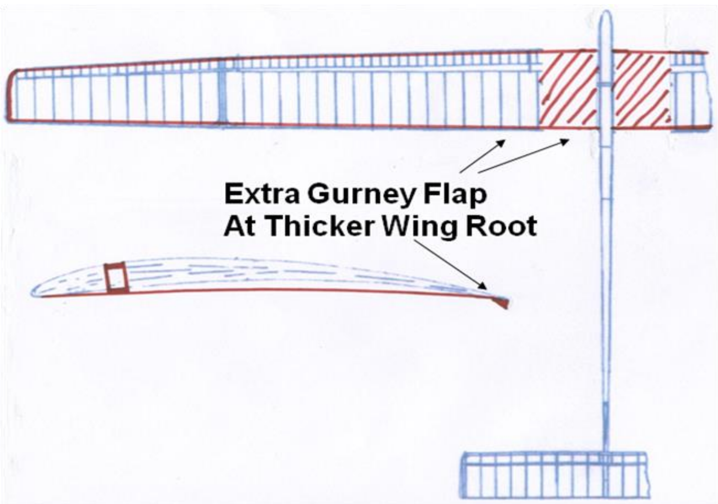
Further improvements can be obtained by designing new models to take maximum advantage of the benefits that a GF can bring. In the case of a new-build championship model there are two extra 'tricks' to be played.

The first 'trick' is to use a GF on the tail to improve its trimming capability. This would allow the tail to be made about 25% smaller for the same effectiveness, and the wing can then be made a little larger within the total area rule. The effect of the slightly larger wing is to give about another 5 seconds duration.



Gurney increases Tail Lift
so that
Tail Area can be reduced
& Wing Area increased
=
Extra 5s duration

The second 'trick' is to make use of the ability of a GF to help regain the good maximum lift characteristics of a thin section if we require a thicker wing section at the wing root region for extra bending strength. If this is done then the wing aspect ratio can be increased significantly and this might give perhaps another 10 seconds duration.



Thicker Wing Root
with GF allows
Increased Span
=
Increased AR
=
Extra 10s duration

SUMMING UP-INCREASED DURATION AND OTHER PERFORMANCE BENEFITS OF GF'S

Summarising the various benefits that GFs can bring to F1A gliders it is seen that a new-build championship model might gain about 25 seconds and this is about 10%.

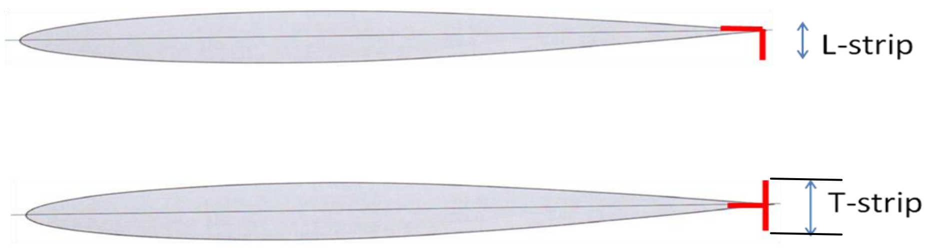
We have to consider the effect of GFs on the trimming of models. When GFs are applied to improve wing section performance, it will be necessary to add a small amount of 'up-elevator' trim correction (extra decalage) to the tail. Another possibility with GFs is to use them part-span, temporarily or permanently, to modify the twist of the wing from that designed or built-in.

Many other classes of competition model may benefit from the use of GFs. Other glider classes will have similar gains as F1A, but the 'power' classes may have a reduced gain since the drag of the GF during the high-speed power-on phase will slow the climb slightly.

For modellers of 'real airplanes', GFs can improve flight characteristics of scale models. Many scale models would benefit from GFs to improve stalling speeds since true-scale wing sections do not always work well at model scale.

A FINAL WEAPON: TAIL FEATHER T-STRIPS

There are many famous airplanes which had handling issues due to having under-sized tail units, and these problems tend to get worse at model scales. This is where the T-strip, a double-sided variant of the Gurney Flap, can help when applied to the trailing edge of an aerofoil. The key advantage of the T-strip is that it is effective in increasing both the lift slope and the maximum lift aerofoils at both positive and negative angles of attack. This is just what is needed to improve the stability and control of true-scale tail units.

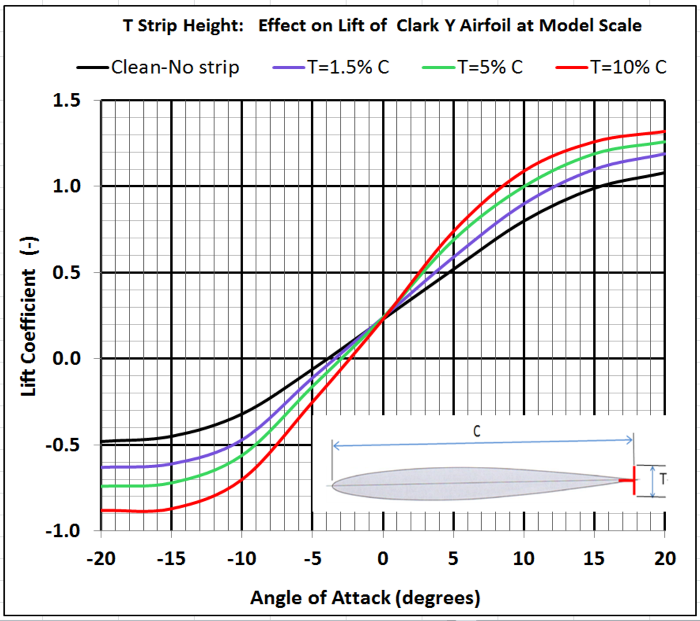


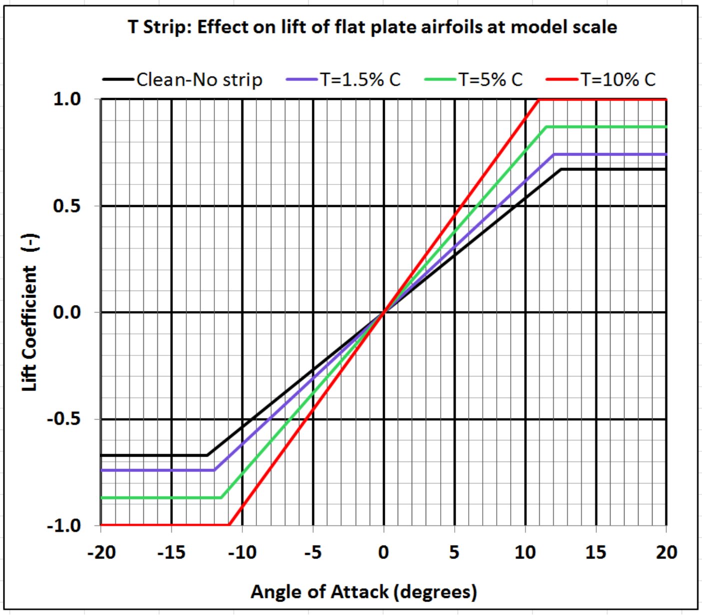
* Lots of data on L-strip/GF.........but little on T-strips

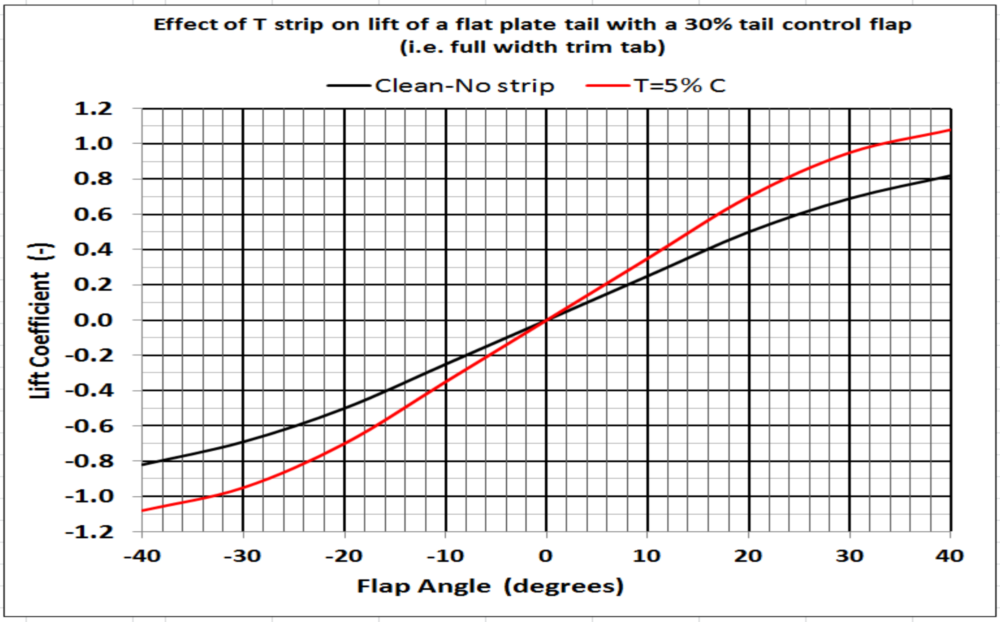
A visit to any aircraft museum shows that various sizes of T-strip have been used on many older aircraft. Sometimes they are large metal strips, other times fabric-covered 'cording'. Although they are seldom described in technical documents, it is known that these T-strips were applied as 'economy fixes' to correct some problems of stability, control power or handling qualities identified during flight testing. The inevitable small drag penalty was presumably accepted in exchange for a speedy and simple solution to a more serious stability or control problem.   T-strips of various sizes are still being fitted to the tails of some new aircraft of the business and general aviation types.

In general, the T-strip was not 'designed in' to these older aircraft and very little effectiveness data exists in the aeronautical literature.   There is only one report having a comprehensive set of wind tunnel tests of both T-strips and L-strip / GFs, and in this case on a non-symmetric aerofoil.   However, there are similarities to T-strips in the nautical world with 'staukeils' and Schilling rudders which feature wedge-shaped, blunt trailing edges on symmetric underwater sections.

The very limited amount of published T-strip data encouraged me to make additional low-speed wind tunnel tests with T-strips mounted on several cambered and symmetric aerofoils and also on flapped control surfaces.   These test results (shown below) confirmed that T-strips can be effective on flat-plates, curved-plates, symmetric aerofoils and also on flapped control surfaces, and at model scales.







A correlation of all available T-strip test data has been attempted and the major data trends have been identified, in particular a key finding is that, as the T-strip size is reduced, the drag penalty reduces more quickly than the lift benefit, similar trends to that of the Gurney flap. These results are similar to published data.

GF'S AND T-STRIPS ON SCALE MODELS-MORE GOLD TO BE MINED

The combination of GFs on the wing and T-strips on the tails could make a significant difference to the stalling speed and handling characteristics of scale model airplanes such as on a Spitfire as shown below.