



NIMBUS DESIGN

Specialist Framebuilders for Road, Track & Time-Trial
Columbus Tubing

**DESIGN OF LOW
PROFILE FRAMES
(Jim Cook MCEI)**

The major change in design of a typical Lo-Pro frame is the steep angle of the seat tube, it looks like a **funny** bike because we are conditioned to the look of a typical road frame with a 73 degree head angle with a 72 degree seat tube. The dedicated low-pro frame is a completely different animal, it is almost a different discipline to conventional cycling.

The penny drops when we see a rider on a dedicated frame, rider and bike move as one smooth unit, it is immediately apparent that the pedalling has a more fluid action. On the modified road frame the rider appears to be sat on top of the bike fighting it all round the course with a position that is made worse by the addition of Tri-Bars. As a direct consequence the rider suffers back pain and assumes that if it hurts he must be going faster.

The rider on the dedicated Low-Pro returns an improvement in performance of 4—9 sec per mile over a tri-bar modified road frame. Of course good legs, heart and lungs help.

What follows is the result of 10 years designing and building dedicated Low-Pro frames, none of this would have been possible without the feed back from riders using dedicated frames. I would also include the work of Ian Garside BSc, at JM Liverpool, his work on the effect of seat tube angle and GME in a series of tests on nine riders in his research project endorsed my conclusions found by empirical methods.

Steeper seat angles are not a recent innovation, during the thirties continental track riders used seat angles of 76' degrees +. In 1937 a British frame builder and track rider (Dick Swann) on a visit to a Belgium track meeting asked a rider why he rode a bike with a steep seat angle, the answer was, it's *faster*.

We've all ridden on the rivet, all gone through the pain of the last mile of a '25'. On the rivet had moved our position forward by approx 6 cm. A rough guide is 1 degree on the seat angle = 1 cm on the saddle nose. They knew in 1937, we knew it was faster in 1950.

Then came Graeme Obree, with a stroke of Genius he changed the whole concept of riding position restricted by conventional frame design.

Two factors that contribute to faster times on two wheels were now obvious. **Reduced frontal area, (the tucked position)**. and *Greater Mechanical Efficiency*, Old faithful had an 85 degree effective seat angle this increases the output of the pedalling action (equal wattage at a lower pulse rate).

Design objectives.

- 1. Is the rider comfortable in the new position?
- 2. Has the pedalling efficiency improved? GME.
- 3. Is there a reduction in the frontal area profile to the air- flow?
- 4. Can the airflow escape the scoop effect between upper body and thigh?

- 5. Has the rider's output wattage increased for the same pulse rate?
- 6. Will the frame transmit the rider's output with the minimum of loss due to frame flexibility?
- 7. Is the tubing type matched to the rider's weight?
- 8. Will the finished frame give the rider pride of ownership?
- 9. Will it hold a steering line with the minimum input from the rider?

Design Procedure

The method I use to find the optimum position is by comparison and measurement of output. I mount the rider's current bike on a turbo trainer, preferably one with a magnetic resistance unit. Then transfer the key measurements to a dynamic simulator consisting of a base unit with 700c wheel and computer controlled resistance unit.

(COMPUTRAINER) The system highlights the change in pedalling action when the saddle nose is behind the B/Brkt C/Line and the increase in GME with the saddle nose forward of the centre line.

In other words steep seat angles increase the mechanical advantage; your legs are a simple system of levers and pivot points. The pedalling force is now more vertical to the B/Brkt centre. (as in a reciprocating engine configuration)

A top rail with slides carry the saddle and Tri-Bars, these are fully adjustable in the X& Y planes. With adjustments of 43--66 cm in seat tube and top tube length the simulator accommodates all road or low-profile frames.

The rider can compare the original position with the new simulated position under load; repeated changes between bike and rig highlight the effect of changes to the key measurements. In other words good old common sense prevails. Whenever possible the rider's saddle and Tri-bar set up is installed on the rig, this produces accurate measurements for the new frame.

Newton's third law of motion states that for every action there is an opposite and equal reaction, if your saddle is behind the b/bracket and you push hard on the pedals the opposite reaction is to pull on the bars. Trying to bend the bars will not increase your speed, only your pulse rate will go faster. That's why moving the saddle forward to a position that you **push down** on the pedals without pulling on the bars increases your GME. (Check your pulse rate) blood flow is restricted in muscles under tension, therefore return flow to the heart is reduced. (remember you only have one pump to power the whole hydraulic system , why misuse it)

A recent test on a top rated rider showed a reduction of 7 bpm when the effective seat angle was increased to 81 degrees from 72 degrees. There seems to be a relationship between pulse rate reduction and seconds per mile, i.e., 6 sec = 6 BP. It may sound too

glib but it has been noted during debriefing sessions on numerous occasions to be a simple coincidence.

The final part of the whole process is to look at the frontal area to the induced airflow; “**DRAG IS THE SQUARE OF THE SPEED**” “we are all well aware of a head wind and a tail wind so we are not talking rocket science. About 75% of the rider’s output is used to overcome the effect of drag when riding on a flat road. The obsession of getting as low as possible is not the answer; it has the same detrimental effect as being too high. Is your Aero Helmet blending with your back shape or working as an **AIR BRAKE**, To prove this try a simple roll down test, you can relate either time / distance to check the effect of your position. . The position of a high diver at the time of entry into water is a perfect example of reduced frontal area. (*The SUPERMAN POSITION.*) Arms should be extended in a straight line to reduce frontal area, don’t clench your fists it increases the area, if you think this is nonsense drive at 30 mph put your arm out of the window and feel the effect OK! The forward saddle position also increases the separation between the natural scoop effect of leg and chest; this gives the airflow an escape route reducing form drag. Quite a number of riders have remarked that they cannot feel the wind on their back or chest, a secondary effect is their breathing is unrestricted due to the free movement of the diaphragm. In the normal folded position the thigh comes into contact with the abdomen.

- **ONLY THE RIDER CAN DESIGN THE LOW –PROFILE FRAME, ONLY HE KNOWS EXACTLY WHEN HIS POSITION IS CORRECT. IT IS IMPOSSIBLE TO FIGHT THE BICYCLE AND TO PERFORM TO YOUR MAXIMUM POTENTIAL.**

Measuring method with rider on diagnostic rig and normal bike on turbo. (It takes about 2-3 hours) beware of the five minute fitting, it produces a standard frame.

- 1. The top tube with Tri-bars will be shorter by approx. 35 mm than the rider’s normal road frame.
- 2. Saddle height to B/B centre is normally 3-6 mm higher, this follows the rule, back and DOWN forward and UP. ie, the saddle height is a radius from the bottom bracket centre.
- 3. Now the fine-tuning can start. Height of the Tri-Bar pads will determine head and top tube height. This is critical, can the rider look up. .
- 4. Saddle and Tri-bars are adjusted fore and aft along the top rail fine tuning the saddle nose to bottom bracket centre line position. An 80 degree seat angle is the most common ie, nose of the saddle approx. 6 cm ahead of B/Brkt C/Line. (weight is transferred to the forearms)
- 5. The upper body is now supported by the arms; this reduces pressure on the lumber area. (many riders report that back problems during racing have been eliminated with a steeper seat angle) there is a secondary effect in the rotation of the pelvic area, numbness can result therefore saddle quality is a vital part of the design.

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- 6. Break for a short period of say 15 mins in the measuring procedure, the rider should take a ten-minute ride on his normal framed bike on the road. It is essential to have this pause to remove the confusion in body and mind caused by the change in riding position.
- **7. The guiding principle is to relax the muscles not directly involved in propulsion of the bicycle. Pulling on the bars turns T/T cycling into a wheeled version of Nordic skiing. (check the riders pulse rate)**

A frame I designed for Sean Yates in 1997 followed this design route. The starting point was his Track bike, which had a seat angle of 76 degrees, this was his best position up to that time, his body found that an 80 degree seat angle was more efficient and comfortable. This moved the saddle nose forward by 13 cm compared with the standard stock 71 degree T/T frame he was riding at the time.

General notes on frame design.

The idea of using a curved seat post on a road frame to move the saddle forward places the rider's weight further over the front wheel; the result is an unstable position. A steeper seat angle effectively moves the B/Brkt backward, this maintains stability.

The Head angle will be 72 or 73 degrees with a fork offset of 50/46 mm to produce a trail of 56--55 mm with 700c wheels. Steep head angles transmit more road shocks to the rider. These transmitted micro vibrations contribute to rider fatigue. For a smoother ride get your self a set of "Columbus Muscle" carbon forks they are light at 360g and the best thing since sliced bread, the ride quality is superb without side deflection. The fork offset of 43 mm is compatible with 73-74 head angles.

A stem length of 100 mm places the Tri-Bar mass in a fairly neutral position, steering in a straight line hands off is the norm with this head geometry and Tri-Bar configuration. A shorter stem will be twitchy; a longer stem slows it down.

It is quite noticeable that frames with road seat angles are subject to PIO's (pilot induced oscillations) when used with a Tri-bar set up and a trail that is not matched to the head angle. With the saddle nose about 70 mm behind the B/B centre line the rider is basically trying to push the cranks forward, he counteracts this by pulling on the bars, the induced oscillation generated is magnified by the wrong fork trail setting. The trail works as a feedback control system that is quite sensitive to over correction from the mean steering track, **result, a steering oscillation in time with the pedalling cadence.** YOU ALSO RIDE A GREATER DISTANCE.

Wider Tri-Bar armrests will improve the steering control and straight-line stability, they also reduce strain on the neck muscles, one of the main causes of neck pain, the rest is plain common sense. Listening to the rider is a vital part of the design process, making suggestions but not transplanting your Ideas into a willing victim.

The final stage is to produce a full size drawing of the frame so the rider can comment on the finer points to produce his dream frame, I still believe that the look of a frame has an effect on the riders performance.

Remember that the riders body shape designs the frame. Not the builder. They would rather supply a standard frame; it takes less time to build.

Summary of changes to rider's position and education.

It is sometimes difficult to get the rider to accept major changes to his position, because he, like the vast majority have been fed a diet of garbage by the cycling press and amateur coaches, who in the words of one of the best "could not teach frogs to jump".

- 1. Move rider forward over the B/Brkt this will increase GME by approx. 2%-3%.
- 2. Position Tri-Bar pad height and width to eliminate neck and shoulder problems. (the rider usually wants to ride as low as Chris Boardman, remind him that he is not Chris) too low is as bad as too high, (this is pretty hard for the rider to grasp)
- 3. Explain that pulling on the bars only increases pulse rate not linear speed.
- 4. Again the principle of muscles not engaged in propulsion should be in a relaxed state. Modern swimming techniques in the American crawl has the legs in almost a passive role, the major groups for propulsion are the arms.
- 5. Reduce frontal area, show rider video shots from the side and front of new and old positions. The upper body and arms should now be almost parallel to the induced airflow.
- 6. Get the rider to conduct his own roll down tests, (it lays the aerodynamic crap to rest) now is a good time to test the scoop effect of his old position. He can also measure the over stated effect of various components.
- 7. Introduce the rider to breathing control. (see Breathplay Web site)
- 8. Remind him that riding a 100 T/T one week is not speed training for a 10 P/B the next week. When was the last time Linford Christie run a marathon in training for the 100 yards?

Tubing and Construction of Low Profile Frames.

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I must confess a preference for Columbus NIVACROM steel Tubing, As the design calls for seat angles of 78—85 degrees the frames are fillet brazed using 9% Nickel Bronze. (Lugs and bottom bracket shells are produced for standard 73 degree angles) The fillet size through the throat should be 3-4 times the thickness of the parent material with a leg length of times 7 to give 100% joint efficiency. I prefer to use the type” L “ 50X32 Megatube as the down tube, it’s a good aero shape, also the D/T is main structural member in the front triangle, this gives the frame its inherent stiffness.

The front triangle is completed in the multi jig, by this method as opposed to only tack brazing in the jig, perfect alignment is maintained. Cold setting of the finished frame is eliminated resulting in a stress free structure.

Setting of the rear triangle is with a true dished wheel and fore/aft jig rails. Rear vertical dropouts are polished investment cast stainless steel, they are stronger than the normal steel types and less prone to stripped threads on the gear hanger. After painting I treat the frame internally with a rust inhibitor. The whole process from start to finish takes about 60-70 hours.

The mechanical characteristics of the Nivacrom tubing are retained following the brazing process; this is achieved by the addition of Vanadium and Niobium. These elements prevent the formation of chromium carbides and refine the grain structure in the parent material. This prevents brittle fracture in the heat-affected zone and increases fatigue life of the finished frame.

The tubing material is designed specifically for bike frames and the various welding /brazing processes applied to frame manufacture. In the Welding Industry, weld procedures are developed to produce mechanical properties equal to the parent material, the real clever bit is to design an alloy steel (Nivacrom) that after the joining process the original mechanical properties are retained without further thermal treatment. The chemical composition has a minimal effect on the actual performance of the frame, tube diameter, tube length and wall thickness are the determining factors in frame rigidity. Again the cycling scribes write some utter nonsense about tube types and aerodynamics, but their description of welding and brazing methods are hilarious, they must be extracts from their favourite comic book.

Steel still the best material

A low alloy steel tube frame built correctly with lugs or fillet brazed is technically and aesthetically superior. The latest steel tube sets are equal in weight to their aluminium competitors. They also have the advantage of having a longer fatigue life, and a superior ride quality.(micro vibration damping) Thin wall tubular structures that are subject to continuous reversals of load require a material with a high fatigue life. Aluminium is not the material for that environment. According to recent reports the American market is moving back to Cr, Mo alloy steel for frames, I doubt that it is just a fashion statement.

TIG welded alloy steel frames should not be viewed as a technically advanced product. Yet again the cycling pundits express their opinion on the merits of TIG welded frames,

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what they should be considering is why the manufacturer chose the process for frame fabrication. Taiwan factories can now produce complete aluminium frames in less than 3 man-hours.

TIG process advantages on main frame joints.

- 1. It can be automated, reduction of man-hours per unit.
- 2. Machine operators can be employed on production.
- 3. Skilled frame builders not required.
- 4. Reduction of high cost frame components.
- 5. Less finishing time on weld areas.
- 6. Ideal high volume production method.
- 7. Lower unit costs = more profit.

TIG welded steel frames should be purged internally with Argon at ambient pressure as a vital part of the welding procedure, without purge the weld quality is highly suspect due to internal oxidation (burning) of the weld area.

Why have I written this about frame design and building.? I'd like to think that if you have got this far in my rants, like me you like bikes, and you would love to go faster or ride in comfort to your maximum potential without backache and neck pains, neither of these contribute to your performance. . I hope this brief outline on design and construction will give you a guide to some of points you should discuss with your frame designer/builder and the specification of the next frame you ride.

J Cook. . MCEI M.A.W.T.E NIMBUS DESIGN. FEB 2002

Hon Chairman. Cycle Engineers Institute (now retired)