MEASUREMENT NEWS

#8 - March 16, 1984

Measurement News is an unofficial newsletter that the Editor sendsout at irregular intervals, once he has had enough correspondence on various subjects to make up an issue. Nothing in it should be construed as the Party Line on any issue. For the official dope, read NRDC News or wait for a letter from Ted Corbitt. They are the official sources of information.

Outside the official channels, MN provides the Editor with an opportunity to seek out and disperse various items of general interest to the people who are responsible for seeing that courses are accurately and properly measured. Our methods vary slightly from area to area, and there are various tricks of the trade that we can share.

Although there are subjects on which I hold strong opinions, I don't think that MN is the place to argue at length. Several people, including myself, have been bombarding Ted and Ken and Allan and Tom B with reams of documents, all calculated to persuade them that the writers' positions are correct. On the subject of validations alone over 30 single-spaced pages of discourse and argumentation has been written. I try to keep MN separate from politics, and just stick to measurement techniques, but sometimes the temptation is too great and I jump on my white horse.

For those proofreaders and grammarians among you, I must apologize for the typos and occasional lapses into improper usage which you will find if you look. As I read through this I see them, but since I'm unwilling to retype you will have to live with them. I do know better, but as I regard MN as simply a letter to each of you I don't feel a strong obligation to be absolutely correct in my use of the language. My apologies to those who mind.

As always, correspondence on any measurement-related subject is welcome. Send your letters to:

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614-451-5617 (home, not after 10)
424-4009 (work, 8 to 4:30)

This little space is left over, so I'll use it to fill you in on solid tires. Bob Baumel got himself some "Eliminator" tubes (plastic tubing inside the tire) like mine, but he said that he had had a devil of a time mounting his tires, in spite of being very careful about gauging his tire with the little measuring gizmo they send you. I don't know whether he finally has overcome his difficulties.

I remain in love with mine. As Bob Letson predicted, mine has finally squashed down to a stable size, and my riding constant has leveled off to about 15185 counts per mile. Typical daily variation is now about 2 to 4 counts, which is lots less than I used to get with inflated tires. Needless to say, I have not had a flat. Now I just ride right through those glass fragments. Solid tubes make you fearless, and reduce your calibration variation.

I wish Bob good luck in getting his tubes mounted. I'll let you know how it comes out.

FAILURE TO RIDE THE SPR
a Perplexing Problem

I recently had occasion to measure a race course that contained a stretch of heavily-traveled two-lane highway. The stretch contained a reverse s-bend that forced the measurement route to cross the trafficky road twice. Because it was simply impossible to get away from the edge of the road and into the traffic (without getting killed) I measured along the right-hand side. I judged that missing the SPR as I did cost me about 4 or 5 meters on a 10 k measurement. I base this judgement on examination of some maps and geometrical calculations that I made.

I am going to advise the race director to add another 20 feet to the course, based on this estimate. I am not happy about this, because I would prefer that the course be measured, not estimated. However, under the circumstances traffic control of that major road was impossible, and I had to do the best I could. I am sure that I am not the only one of us who has dark secrets like this buried in his bosom.

If the course should ever be validated, I suspect that the validator will face the same problem that I had. He simply will not have access to the SPR, and will have to do the best he can.In that case, I could simply not worry about it, figuring that the course is still over 10 k and is a good one. However, as I measured it, I figure that the course is only about 5 meters oversize, and if the validator should somehow find a way to beat that traffic he may well be able to shoot down the course.

What could I have done? On this measurement I was far from Columbus and had limited time at my disposal. I was not hurried, but I did not have time to spend on techniques that might have produced a better measurement. Some of my options were:

1) Measure on the right and force the race director to provide a mile of cones and monitors to keep the runners on the extreme right side of the road. The race is a big one, and this would leave the runners with inadequate running room. They fill the road on race day.

2) Risk my life. I was too scared to do this.

3) Demand traffic control and get it, or refuse to measure at all. Since I was unaware of the problem until we reached that road, I didn't have time for this.

4)Try to do the measurement at night. I didn't have time, and the help I had available was only available on the day of measurement. Besides, there are cars on that road at night too, and it is hard to see road hazards and follow the proper route at night.

I think that estimating what I was unable to get, and adding it to the course, was my only reasonable choice. Still, I am not happy with that as a measurement technique. I'm asking any of you who have faced a similar problem to suggest what we might do when a problem like this arises.

Suppose I had been a validator? The aspects of this sort of problem arising on a validation measurement are certainly interesting. Would a validator be justified in subtracting an estimated 4 or 5 meters from his measurement, and thus perhaps using that number to shoot down the course? Interesting problem.

CHANGE OF CALIBRATION CONSTANT WITH TEMPERATURE

A warm tire is larger than the same tire when cold. Because of this size change, calibration runs are made before and after each measurement, the goal being to minimize the error that arises from calibration drift.

In the usual measurement the measurer goes out in the morning, when it is cool, and calibrates. He then goes to the course and measures it, and the measurement temperature is generally higher than the precalibration temperature. When he finishes measuring the course he returns to the calibration course and recalibrates. Recalibration temperature may, because it is late in the day, be lower than the temperature at which the course was measured.

The above scenario may not be exact, but it is fair to say that a normal daytime measurement takes place at a temperature that is somewhat higher than the average calibration temperature. How much difference does this make in terms of course accuracy?

Using the data of 12 of the Olympic measurers, it was found that the average pneumatic tire changed by:

$$\text{Change} = .077 \pm .016 \ \frac{\text{M/Km}}{\text{Degree F}} \ \text{or} \ \frac{\text{Counts/1000 Counts}}{\text{Degree F}}$$

[The 13th measurer used a solid tire]

In other words, a rider who calibrated at 50 F in the morning, and obtained a constant of 9400 counts/km (15128 counts/mile) would find that in the afternoon, when he recalibrated at 70 F, his calibration constant had declined by 14 counts/km to a value of 9386 (15105 counts/mile).

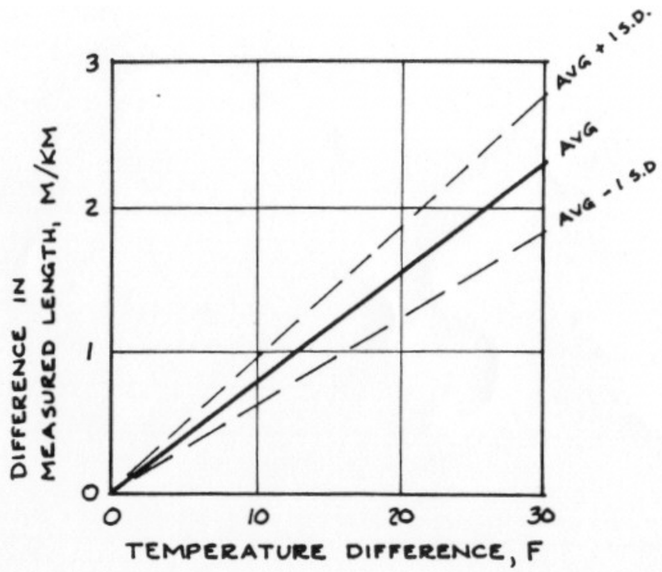
So long as measurement takes place at a temperature close to the average calibration temperature, no great error occurs. However, what if calibration and recalibration were done at 50 F, and measurement at 70 F?

In this case the course, as measured, would be <u>long</u> by about 1.6 meters per kilometer.

As long as temperatures during calibration and measurement follow the normal pattern (cool calibration, warm measurement) courses will tend to be laid out slightly long. However, if the same temperature pattern occurs during the <u>checking</u> of a course (as in a validation measurement), the measurement of a perfectly good course may show it to be short. A 10 k course laid out to be 10 meters oversize (on a day when temperature did not vary) would be found to be about 5 meters short if the foregoing 20 F temperature variation occurred on the validation ride.

This is a serious problem, and it points out the need to obtain accurate temperature information throughout the course of a measurement, so that the amount of error due to temperature change can be estimated.

When temperature variation is likely to be excessive, it is desirable to recalibrate frequently, so as to accurately track the drift of the constant. If this is not possible, it is desirable to obtain calibration information at two widely-separated temperatures, so that the actual constant during the measurement can be estimated.



This figure shows the effect on measurement of varying temperature, based on data from the Olympic measurement. The solid line shows average change, while the dotted lines indicate a total spread of two standard deviations.

While this information is probably fairly typical of the behavior of pneumatic tires, each measurer will find that his own tires behave in a unique pattern, and truly accurate determination of the effect of temperature on tire size should come from calibration and temperature data obtained by the individual measurer on the same day he measures.

As an example of the use of the graph, a course in which measurement took place at 73 F, while average calibration temperature was 60 F, would be found to be about one meter per kilometer shorter than its true length (as determined under invariant temperature conditions).

It would be easier for us if this information could be ignored, because it does complicate the process of measurement evaluation. But there it is, and the potential errors are large enough so that the 0.1 percent short course prevention factor may not be enough, in some cases, to overcome the effects of temperature on tire size.

For normal daytime measurements the effect can probably be ignored, because of the tendency toward long courses under normal daytime calibration and measurement practices. If a measurer sends in data without temperature information, the course is probably "safe".

It is validation measurements in which this is likely to be a problem. We, as potential validators, must exercise every effort to see that we take this temperature effect into account, so as not to unjustly find a good course short.

Pete Riegel 12-29-83

VALIDATIONS

When a record is set on a course, a skilled rider (perhaps you) is sent to the course to remeasure it, to see whether it is the proper length. The last MN discussed this somewhat, and Ken Young, in the January 1984 NRDC News, expounded on the view taken by him as TAC recordkeeper. Some of his views aroused interest in the measurement community, and both Bob Baumel and Alan Jones took the trouble to prepare erudite treatises on the statistics involved in formulating a correct Short Course Prevention Factor (SCPF) - that's the 0.1 percent we add to courses.

The reasoning in Ken's article, and in the two replies from Baumel and Jones, was sound, and based mostly on the observed differences between measurers on the Olympic measurement and elsewhere. All three concluded that the SCPF used must depend on the variation encountered in the original measurement and in the measurements likely to be done in a validation.

Because Ken's article implied that the SCPF might be increased if we find that too many courses are rejected for shortness, I begged him to consider the effect on the measurement community if we are asked to add 0.2 percent (or whatever), after taking all the trouble to educate measurers to add 0.1 percent. I think such a change would cause great disruption. So far it has not been proposed. That's where things stand right now on validations.

As of this writing (March 12) I don't have the next NRDC News. Maybe something will appear there to supplement the above. This is an interesting subject, and a potentially controversial one. Think about it and let me and Ken know what you think.

Jim Lewis proposes a sliding scale for validations, as follows (for 10 k):

10004 or more - declare the course accurate

9995 - 10004 - declare course accurate but add distance to get 10010 meters

less than 9995 - declare the course inaccurate

He then says "None of the numbers are sacred". This is the course that I (Editor) think should be taken on validations as well.

Lewis also says "I hope that all good measurers are also worried about making courses unnecessarily long".

Bob Letson says he "views as tragic the possibility that a perfectly accurate race course could be invalidated by an imperfect measurement", and adds "All valid tools should be OK for measurement, and validation should take into account the error in the measurement method".

Letson and Riegel advocate decertification only if the remeasurement proves, beyond reasonable doubt, that the course is shorter than the nominal distance.

THE "LARGER" CONSTANT

Bob Baumel has come through with a proposal that makes so much sense that it should be passed on. Disturbed by the potentially large errors that can occur due to temperature change and other effects, he sought a simple way to remedy the problem. He found one.

He proposes that the measurer use his larger constant as the official one. If the morning (pre-measurement) constant is larger than the afternoon (post-measurement) constant, the morning constant is used as the "constant for the day".

This has two large benefits. First, it subtly adds a very small extra amount to the course, since the larger constant will somewhat exceed the average of precal and postcal. Second, in most cases it makes any post-measurement adjustments unnecessary, since in almost every case it is warmer in the afternoon than in the morning, and postcal constants are almost always lower that precal constants.

The effect on those who use solid tires, or those who calibrate frequently, will not be large, since little calibration change will occur. However, for those who come up with amazing changes in constant, extra distance will automatically be added to their courses in proportion to the difference in their constants.

When you get a measurement to review in which the constant varies by 25 counts in a mile, or 20 counts in a kilometer, you wonder just where in tha span the actual course measurement occurred. It's unlikely that the measuremen happened at the average. Using the larger constant, a safety factor is applied that adds more to courses with sloppy calibration and hardly affects those with good calibration.

Using the larger constant is something I will urge all my measurers to do. They will find it easier, because they will not, in general, have to return to the course to make final adjustments. And their courses will be safer against validation.

The Monster Wheel of Al Phillips

Wishing to investigate the effect of tire growth on measurement, Al Phillips did a mathematical treatment of a measurement in which the wheel grew at a constant rate as the measurement progressed. The rate he chose was large, as was his wheel. He looked at a wheel 1 mile in circumference at the start, which grew 0.2 mile with each mile covered during a pair of 5 mile measurements. Not surprisingly, considerable measurement error resulted. But it was amusing to see his diagram, full of wheels of ever-increasing size, and diagrams of the course measurement. It is too large to reproduce here, but those of you who are math freaks may wish to fiddle with it. (changed my mind - see the diagram next page)

Al also likes the idea of using only one set of marks. He, like Baumel and I, has some trouble educating old-timers in the technique, but once they get the hang of it, all the data appears on paper, instead of out on the road somewhere to be washed away by the weather.

EXAGERATED GRAPHIC COMPARISON OF A THEORETICAL BICYLE WHEEL 1 MILE IN CIRCUMFERENCE THAT EXPANDS AT A RATE OF .2 MI. IN CIR. EVERY MILE AT A VELOCITY OF 10 M.P.H.

DIAGRAMS ASSUME NO TEMP. CHANGE AT TIME OF CALIBRATION INITIALLY OR AT RECAL. TO SIMPLIFY CALCULATIONS. ALSO ASSUMES 2ND. RIDE TURNS AROUND AT FINISH OF 1ST. RIDE & RIDES BACK TO START. 2ND. RIDE IS PLOTTED AS THOUGH IT STARTED BACK AT START FOR COMPARISON. CALIBRATION RUN IS ASSUMED TO BE 1ST. MILE OF RACE SO AT END OF 2ND. RIDE RIDER TURNS AROUND AGAIN + IMMEDIATELY RIDES RECAL.

1ST RIDE - $\pi D = C$, C = 1 MI. AT START ∴ D AT START = $\frac{1 MI.}{\pi}$ OR .3183091 MI. (.3 MI) → (.3)

AT END OF 1ST. RIDE C. = 2 MI., ∴ D AT END = $\frac{2 MI}{\pi}$ OR .6366182 MI. (.64 MI.) → (.64)

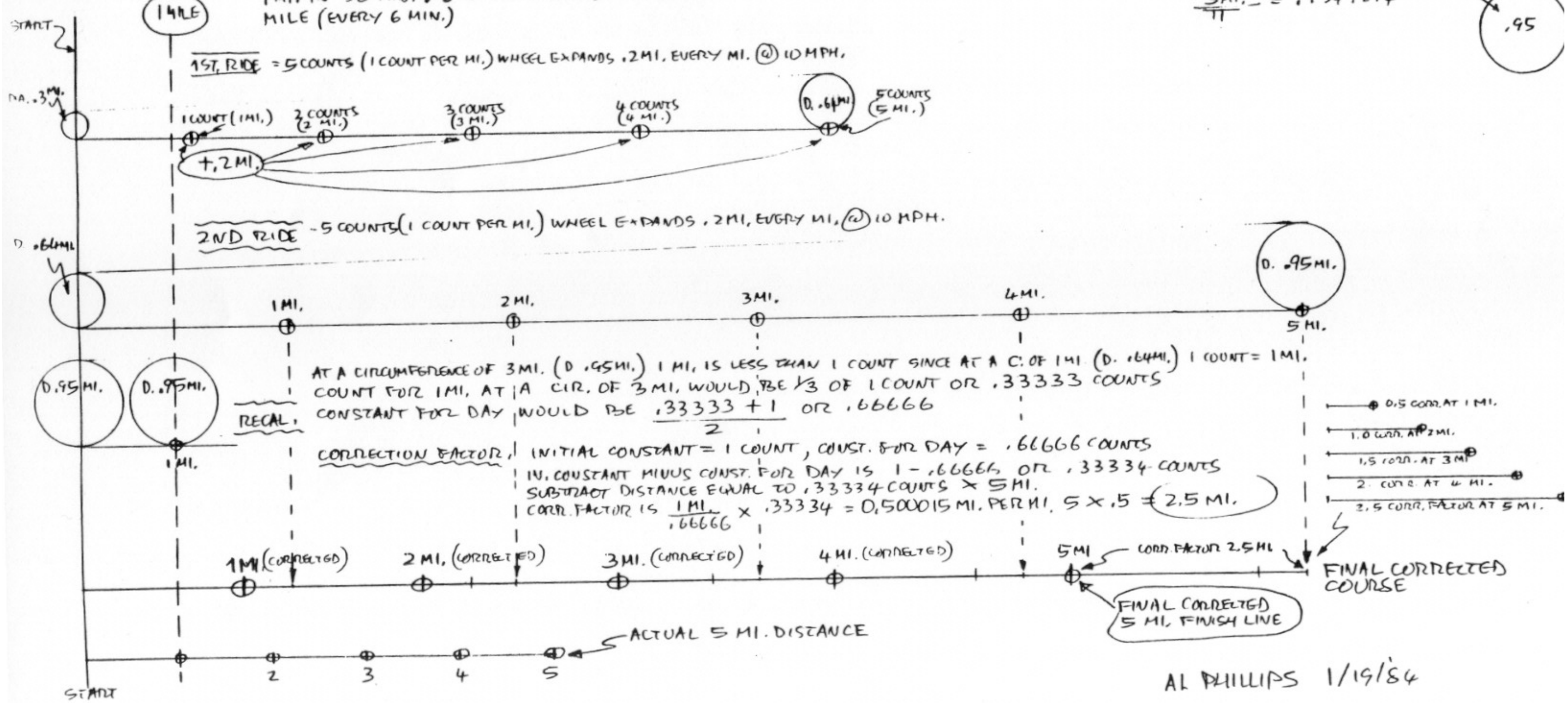
2ND. RIDE - TURN AROUND IMMEDIATELY & RIDE BACK 5 MI. TO START @ 10 MPH

CIRCUMFERENCE AT START OF 2ND. RIDE = 2 MI., DIA = .64 MI. (.64)

CIRCUMFERENCE AT END OF 2ND. RIDE = 3 MI., DIA. = .95 MI. $\frac{3 MI.}{\pi}$ = .9549274 (.95)

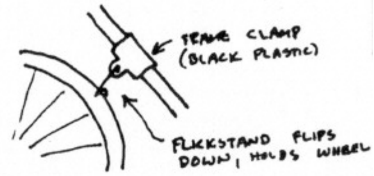
5 MI. @ 10 MPH. = 30 MIN. ∴ 1 MI. TAKES 6 MIN. CIRCUMFERENCE OF WHEEL IS ASSUMED TO EXPAND 1 MI. IN 30 MIN. ∴ WHEEL EXPANDS .2 MI. EVERY MILE (EVERY 6 MIN.)

SCALE 1/4" = .25 MI.



AL PHILLIPS 1/19/84

A Useful Gimmick for the Measurer - When my son got his new bike, he bought one accessory that is a big help to me as a measurer. It's called a Flickstand, and it really helps me do things better. It is simply a piece of bent wire mounted on a clamp which fastens to the frame of the bike just behind the front wheel. When you want to lean your bike, or put down the kickstand, you first reach down with one hand, flip out the Flickstand, and roll the bike backwards about 3 inches. The bent wire locks onto the tire and keeps the front wheel from turning sideways when the bike is leaned on the kickstand or against something. You will have to try it to see how much easier it makes things, when you have to stop the bike when calibrating, or at a point where you want to lay out an intermediate point. It's a big help not having that front wheel get sideways, screwing up the count. You'll find a picture of the Flickstand, as well as the address of Bike Nashbar, on this page. BN is a great place to buy stuff by mail. They ship fast, and they have a huge stock of all sorts of good bike accessories. No, I don't own any stock.



(I was going to put a picture from the catalog here, but it has a dark background and is unxeroxable. Flickstand costs $3.89. Get catalog from Bike Nashbar, 215 Main Street, Middletown, OH 44442. (216)542-3671)

Short Calibration Courses - The idea of using a quarter-mile, 1000 foot, 300 meter or whatever calibration course has been discussed in past issues. Initially it seemed to be an idea whose time had come. Since it was originally proposed by Bob Letson, he and Bob Baumel have expressed some second thoughts and misgivings, with which I agree.

We seem to be in agreement that a skilled, experienced measurer can use a short calibration course without serious loss of accuracy. However, we are agreed that the novice can find ways to abuse it that lead to horrendous inaccuracies. Failure to take the slack out of the counter is a big potential error. Inability to understand the importance of locking the wheel with the hand brake is another. All things considered, we seem to be in agreement that the short calibration course is not for the novice.

I don't feel at ease with the idea of a double standard. While it would be easier on us if we could use short cal courses, I don't like the idea that our method of measurement should be different from that used by the less-skilled.

Throughout the discussions of short cal courses Ted Corbitt has maintained a position of silence on the matter, aside from recommending at one meeting that the time was not yet right for them. In retrospect it appears that his benign neglect was the wise course. He allowed us to think it through a bit more and come to conclusions that we had not reached earlier.

Short calibration courses would be easier for us, it's true. But the easy way isn't always the one to take. I'm now more at ease with our standard half-mile or 800 meters as a minimum, even though it does take more time to lay out. The potential for abuse of a short cal course is too great for us to risk our measurement system, which works OK, for an easier way that may not work as well.

Surface	Measured Distance By Bob Letson	By Ken Loveless	
Pavement	1000	1000	
Firm Dirt..................	999.3		
Pine Needles...............	995.3		
Grass......................	987.3	992.5	
Firm Sand (damp)...........	996.7		
Loose Sand.................	968	1056	Glitch!!!
Firm Gravel................		999.1	
"Swale" alongside road.....		993.2	

Measuring on Dirt and Sand

Information has come to light regarding what happens when you use a bike to measure on dirt and sand. Bob Letson did some work in 1976, which he wrote up in 1980. Also, just a few months ago Ken Loveless, in Florida, did some similar work. Results are shown in the table above.

Except for the discrepancy concerning loose sand, both are in agreement that if you calibrate your bike on pavement, you will tend to lay out a longer-than-nominal course on a softer surface. If you are measuring an existing course, you will tend to find it short.

Therefore, it seems that we are on the safe side if we use our bikes to measure those occasional stretches of dirt roads. Nothing to worry about, except that our courses will tend to be somewhat on the long side.

Validators, however, face a different situation. Suppose the course is a straight 1000 meters, on the grass right next to a steel-taped 1000 meter cal course. The bike ride will find the grass course to be 987 to 993 meters, assuming that the bike is calibrated on the pavement. This is probably nothing to worry about, since few records are likely to be set on courses with significant portions of dirt and grass.

The discrepancy in the "loose sand" data remains unexplained. One easy explanation is that either Letson or Loveless made a mistake in taping, but this is only an obvious assumption. Loveless' sand was so loose it was over his rims. Letson's was unknown to me. The discrepancy does not worry me, since the great preponderance of data shows the same thing - it is safe to use a bike to lay out a course on dirt and sand, if you don't mind it being a bit more oversize than 0.1 percent (which should still be added, in my opinion).

The data are not precise enough at this point to establish any mathematical guidelines. It is merely clear that softer surfaces produce longer laid-out courses.

So if your course goes across a hundred meters of grass, and finishes with a lap of a cinder track, just go ahead and use the bike to lay it out. The mistakes that can be made with a steel tape, when trying to marry it up with a bike measurement, are horrendous. Bob Baumel concludes the same thing, based on some taping he did in the course of laying out a course on a road that had a near-unrideable hill.

Both Bob and Ken used similar techniques. Each laid out a known stretch on the pavement next to the softer surface, and each then rode the pavement to calibrate and then measured the grass or whatever.

As an extra bit of information, Letson has concluded from experimentation on pavement alone that a 130 count discrepancy exists between walking and riding. For instance, when riding Bob gets 15000 counts for a given stretch of road. If he walks his bike over the same stretch, he gets 14870 counts. If you calibrated the bike while riding it, and then laid out a 1000 meter course, the course you laid out would be 1009 meters long, if your "walking factor" was the same as Letson's. So if you walk your bike on some portions of the measurement (while trying to get that last 137 counts coming up on the mark) don't worry about it. The walking you do is only a tiny fraction of course length, and the error is in the direction of a longer course. Validators - watch out. You conceivably could walk your way to finding an OK course short!

The following is an exerpt from a letter from Bob Baumel, describing the trials and tribulations of steel-taping parts of the course. It's worth reading:

"• • • • This particular course doesn't have any unpaved sections, but it does have a rather steep hill (about 10% grade -- downhill in the running direction, but uphill in the measuring direction) which we decided to tape for a stretch of 250 meters. Actually, if I'd been measuring by myself, I probably wouldn't have bothered with this taping, and would have just "toughed it out" up the hill (macho). But we knew that this hill would be more of a problem for my wife.

In retrospect, that taping caused more trouble than it was worth. And after analyzing the data, I concluded that the taping was by no means necessary (even though it's true that my wife couldn't have pedaled her bike all the way up the hill). It would have been perfectly legitimate to simply dismount and walk the bikes up any hill that was too steep to ride. And if we had done that, then this course would just have come out longer by about 2 meters.

The first problem due to the taping was simply the amount of time eaten up by the taping itself (which we did on the morning of the measurement day). When combined with various other delays during the day, we just barely finished the race course measurement by sundown, and then after the 10-15 minute drive back to the calibration course, it was already getting pretty dark as we re-calibrated! Furthermore, we couldn't accomplish as much as I'd planned in the course measurement (I'd originally intended to mark every kilometer, but once we arrived on the course to start the bike measurement, it was obvious we wouldn't have time for that).

The second problem due to the taping was the calculation error described in the write-up. Fortunately, I caught the mistake rather quickly, due mainly to my intimate familiarity with this particular course (which I often train on). But note that if I hadn't caught it, then I would have finished the measurement, and have laid out a course that was long by 250 meters (i.e. the length of the taped stretch). The starting line and all the splits in the first half of the course would have been off by 250 m. Chances are that I would have eventually realized the mistake when checking my calculations, but by then, it would have been a real pain to correct (especially since all the required 250 m adjustments would have involved measuring around curves). In fact, I probably would have chosen to re-do the whole measurement, rather than try to make those 250 m adjustments.

The scariest thing about this whole calculation-error episode is that it's the sort of mistake that I think just about any measurer is likely to make, whenever a portion of a course has been taped! So far, I've received only one application from measurers who had taped a portion of their course (not counting the standard final taped corrections, of course). This was actually another example that I mentioned to you on the phone, as it was a case where the measurers either ignored or didn't understand the instructions on my worksheets, and used two sets of marks. Anyway, they were measuring a 15 km course which included a graveled area in the middle. During the measurement, when they came to the start of the gravel area, they taped it and found it to be 192'3" (or 58.6 m in "real" units). Then they carried their bikes across the gravel with wheels frozen. After resuming their bike riding on the other side of the gravel, they continued until they had ridden the full number of counts for a 15 km course. This means that their course was actually long by the length of the gravel stretch. Finally, they shortened the course at the starting line by 192'3" using steel tape. It should be understood that in this particular case, no splits at all had been marked during the measurement, so they didn't have to worry about adjusting any splits

Returning to the Groundhog Run measurement, the best thing to come out of this whole taping affair was some good data on bike walking vs. riding (though actually, it seems pretty paltry in comparison with what Letson has done). In any case, the results are in excellent agreement with Letson's data. In the Olympic report, BL stated that a Riding Constant would exceed a Walking Constant by about 135 counts/mile (or 84 counts/km in real* units). The actual riding-walking differences observed during the Groundhog Run measurement were about 84 counts/km for myself, and 73 counts/km for Marcia. It should be mentioned that Marcia was using the same front wheel and tire (a relatively thin, high pressure one) that I had used in the Olympic measurement. I used a different front wheel with a fatter, lower pressure tire. Note that although the lower pressure tire showed (as you would expect) the larger riding-walking difference, it nevertheless performed better in terms of the difference between cal and recal!

From the observed riding-walking differences, we can calculate the result mentioned earlier, namely that if we had simply measured the whole course by bike, dismounting and walking the bikes when necessary, then the course would have come out 2 meters longer than the course that we actually laid out with all our effort at taping that hill.

The moral of all this is that measurers should be encouraged to measure the whole course by bike, rather than to tape portions of the course. This applies to both steep hills and unpaved stretches. In both cases, the measurer may dismount and walk the bike for short stretches if the surface or terrain is too difficult to ride. By avoiding the taping of intermediate sections, we make the measuring process easier, and eliminate a big opportunity for numerical error. And whenever you walk your bike during a race course measurement, you're safe because the course will just come out a little bit longer. Of course, you should never walk when calibrating the bike, since that would make the race course come out short.

As for Validation measurements, it is obviously impractical for the validator to do very many tape measurements. So, in practice, all or most of the course will be measured by bike. But the validator should try to ride (rather than walk) the whole thing, to decrease the risk of unfairly finding the course short. Presumably, the validator is in good physical shape and can ride up the hills. In any case, records are rarely set on courses with steep hills. (I certainly don't expect any records on the present Groundhog Run course). "

* I know you'll say that feet, inches and miles are just as "real" as meters and kilometers. I think the meter is more "real" because it's a more primary standard -- defined in terms of basic physical processes, and used in all countries on this planet. Feet and inches are defined in terms of the meter, and are used in only a small (decreasing) number of countries.