IAAF SEMINAR FOR ROAD RACE COURSE MEASUREMENT

Seoul, Korea December 1-4, 1986

Report to IAAF Technical Committee
IAAF Cross Country and Road Running Committee

IAAF Bureau, February 10th, 1987

Introduction

In February 1986, the IAAF Council decided to establish a Road Running Sub-Commission to study certain key problems that had arisen in Road Running. The Road Running Sub-Commission recommended to the IAAF Council that a standardised method of Road Race Course Measurement should be found which could be adopted as the official IAAF Method of Measurement. This recommendation was accepted by the IAAF Council.

A seminar was therefore organised in Seoul, Korea from December 1st-4th, 1986, which assembled many of the worlds leading experts in the field to give a final test to the AIMS approved method of measurement.

Firstly, there is a presentation of the standardised method now practised by AIMS approved measurers as used as a basis for the practical sessions in Seoul. The practical outcome of the Seoul Seminar was the clear evidence that the method demonstrated was simple, reasonably cheap and reliable. It consistantly produced results which ensured accuracy within the tolerances defined in the IAAF rules.

This report also includes an account of the proceedings in Seoul, detailed analysis of the results of a practical measurement session, and several discussion documents by participants on the course, and a consensus from the seminar.

This is followed by a discussion of the considerations for:-
1) The certification and validation of courses
2) IAAF Panel of Road Race Course Surveyors
3) Future Seminars.

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Contents

SEVERAL PAGES WERE
FOUND MISSING IN
THIS COPY OF THE
REPORT, AS RECEIVED

PAGE 3 - MISSING

8. ROAD MARKING MATERIALS

Special wax crayons are available which will mark on wet surfaces.
Spray paint cans are convenient for marking - best used with a template cut from cardboard.

9. MASONRY NAILS, WASHERS and HAMMER

For marking vital definitive sections such as the Calibration Course.

10. SAFETY EQUIPMENT

Bright safety vest. Bicycle lights. Reflective front and rear strips and wheel reflectors.

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c) Ride the bicycle over the course, taking care to follow the **shortest possible route** as it will be available to the runner on race day. take note when riding of sections of the course where a cone or marshall will be required to prevent runners from taking a route inside this line. Record Jones Counter readings at marked salient points or the calculated 5 km, 10 km etc positions..

Note: IAAF Rule 145 reads:- "In events over roads, the course shall be measured along the ideal line of running or walking, i.e. the shortest possible path, in the section of the road permitted for the runners or walkers." The practical interpretation of "the shortest possible path" has been to take the words at their face value and to measure with a bicycle as close to the limit of the available road surface as it is possible to ride. This would produce a similar discipline for the rider as will be applied to the runner, that is, both wheel and foot can come within a centimetre or two of a line, twenty centimetres or so from significant kerbs and perhaps nearly a metre from a wall. In short, the bicycle wheel follows the "shortest possible path" that a runner can achieve.

d) When you reach the tentative finish line, record the Jones Counter reading. The tentative finish line can be also established by an approximate measurement using a map or other technique or by using the "working constant" to calculate the expected reading on the Jones Counter at the finish line. When the counter reaches this number, dismount and paint a line level with the front axle.

e) Repeat the procedure.

Note:(If mile or kilometre splits are to be laid out, then calculate using the "working constant" the expected reading on the Jones Counter at 1km, 5km, 10km etc as required. Make a list of these readings and as you ride keep a check on the Jones Counter until you reach the first of these readings. Dismount the bicycle and paint a short line and reference marking on the ground. A flickstand is useful to freeze the position of the front wheel. Continue along the shortest possible route. On the second measurement, you do not need to make any calculations before riding to figure out where to stop your bicycle. You simply stop at each of the marks you've painted on the road during your first measurement. At each mark, record exactly what your counter reads when the front axle is directly over the previously painted mark.)

4. RE-CALIBRATE THE BICYCLE

Immediately following the course measurement(s), the bicycle must be recalibrated. Again, **at least 4 rides** over the course are necessary.

Determine the "finish constant" by dividing the average post measurement figures by the length of the calibration course in kilometres and multiplying by 1.001.

Determine the **"constant for the day"**, which will be either the "working constant" or the "finish constant", whichever is the **larger** figure.

5. DETERMINE THE PROPER MEASURED COURSE LENGTH

Recalculate the measured distance using the "constant for the day".

The **"proper measured course length"** will be the smaller value. eg. If you measure between the same start and finish points twice and obtain figures of 10,003m and 10,009m, then the "proper measured length" is 10,003m. If you only measure twice, the two measurements may not differ by more than 0.07%, otherwise you must take a third measurement. If more than two measurements are made, always take the shortest measurement.

6. MAKE FINAL ADJUSTMENTS TO THE COURSE LENGTH

If the "proper measured length" differs from the desired course length, you will need to adjust either your start or finish point (or turnaround point for an out and back course). These adjustments may be made with a steel tape. Once all the measurements have been completed, the proper set of marks should be made permanent and all working marks should be erased.

2. IAAF Rules Relevant to Road Race Course Measurement

If the Jones counter/bicycle technique of measurement is to be accepted as the official IAAF Method, then Rule 145.4 will need to be revised.

The rule currently reads:-

> 4.—In events over roads, the course shall be measured along the ideal line of running or walking, i.e. the shortest possible path, in the section of the road permitted for the runners or walkers. In all meetings under Rule 12, paragraph 1(a), (b) and (c), the course must not measure less than the official distance for the event, and the variation in the measurements must not exceed 0.1% (i.e. 42 metres for the Marathon.
>
> *See also Rules 165 (Road Running) and 191 (Walking).*
>
> NOTE 1.—*For measuring road courses, a calibrated wheel of normal diameter which indicates the number of revolutions on a revolution counter is recommended. When measuring, this wheel should not travel faster than 5km per hour. The revolution counter must be checked before being used. This checking is best done by measuring with a steel or fibre glass tape a flat distance of 1000m paved in asphalt. The wheel is then taken along this measured distance of 1000m, once in each direction. The exact distance of the course may then be determined.*
>
> *For the purpose of verification by the technical Delegate or Chief Technical Official appointed by the Federation, the calibrated wheel must be available on the day of the competition.*
>
> *2.—The actual measurement of the distance will determine the start and finish points. Each kilometre is to be denoted by marking on the road side. On an asphalt surface, this point should be denoted in white, where possible, with the number of the kilometre.*
>
> *In the official measurement document, each notable, invariable point (house, street corner, cross roads, sign etc) is to be described with its distance from the start.*

The key points for consideration are:-

1. Recognition of the official method of measurement. Deletion of all references to the calibrated wheel and fibre class tape.

2. Definition of "shortest possible route" - should the current wording be clarified? i.e. Should the following words in parentheses be deleted?

   "In events over roads, the course shall be measured along the ideal line of running or walking, i.e. the shortest possible path, in the section of the road permitted for the runners or walkers."

3. Definition of "short course prevention factor"
   - should this be included in the rules or in the method?
   - should this be 0.1% or 0.05%?

These matters are discussed in Appendix 1 by A Lennart Julin, Technical Officer of the Swedish Athletics Federation, in a paper to IAAF Bureau after the Seoul Seminar.

3. Implications of Adopting the Bicycle technique of measurement

Approval of the bicycle technique of measurement as the official IAAF method is an essential first step in the standardisation of measurement procedures. It is a necessary condition if in the future records are introduced, on courses which have been certificated..

Therefore road races in meets under Rule 12, paragraph 1(a), (b) and (c) as well as races included in the IAAF Road Race Calendar, must have the length of their course certified in accordance with IAAF procedures.

This means that the IAAF will need to adopt a procedure for certification and/or validation.

These procedures will need to cover:-

1. Official Measurement Recording Form/Data Sheet
2. Official Certificate to signed by Measurer (from another country?)
3. System of selecting Measurer
4. System of validation that the course run was the same as the certificated course. (The validation to be made by the certificator?)
5. Procedure for adding Measurers to IAAF Panel of Road Race Course Surveyors. [eg. An interim period may be necessary during which the IAAF need to take responsibility for setting the standards of approved measurers by organising seminars and testing sessions until such a time that national approved measurers will be acceptable for IAAF Record purposes.]

Note This subject is also covered in Lennart Julin's Paper to the IAAF Bureau. See Appendix 2.

IAAF Seminar for Road Race Course Measurement

Seoul, Korea - December 1st-4th, 1986

Programme

Monday December 1st

Delegates arrive in Seoul during the afternoon.

19.30 hours (Cascade Cafe) * DINNER *

21.00 (Acacia Room) Introduction of IAAF's activities relevant to Road Race Course Measurment by IAAF Course administrator.

Introduction and explantion of Programme.
Report on IAAF/AIMS discussions on Road Course Certification and Measurement - John Disley (European Co-ordinator of AIMS Measurers).

General discussion on Implication of the 'new-rules".

Tuesday December 2nd

08.30	Lecture/Discussion	- "The cycle - Jones Counter technique of measurement"
	Practical Session (at hotel)	- Fitting Jones Counters to cycles.
	Lecture	- Calibration of Cycle - methods available.
	Practical Session (near hotel)	- Setting up a Calibration Course - a) Steel-tape b) Electronic Distance Measurer
	* LUNCH *	
13.30	Lecture - Discussion	- "The Shortest Possible Route" - Robert Letson (USA).
	Practical Session	- Riding the "S.P.R" on local roads.
	Visit by bus	- Seoul Olympic Marathon Course.
	* DINNER *	
Evening	Lecture	- "Course Maps" - Robert Letson
		- "Short Course Prevention Factor" - John Disley.

Preparation for Measuring Olympic Course Session.

Wednesday 3rd December

03.00	Practical Session	- Measuring the Seoul Olympic Marathon Course.
		- Post Mortum and discussion of results of Measuring.
	* LUNCH *	
pm	Lecture	- Road Course Certification - International Acceptance of Criteria.
		- Final Discussion and Drafting of Report on Seminar for IAAF/AIMS.
18.00	DINNER OFFERED BY KAAF	

Thursday 4th December - DISPERSAL

IAAF Marketing & Information Department
19 November 1986

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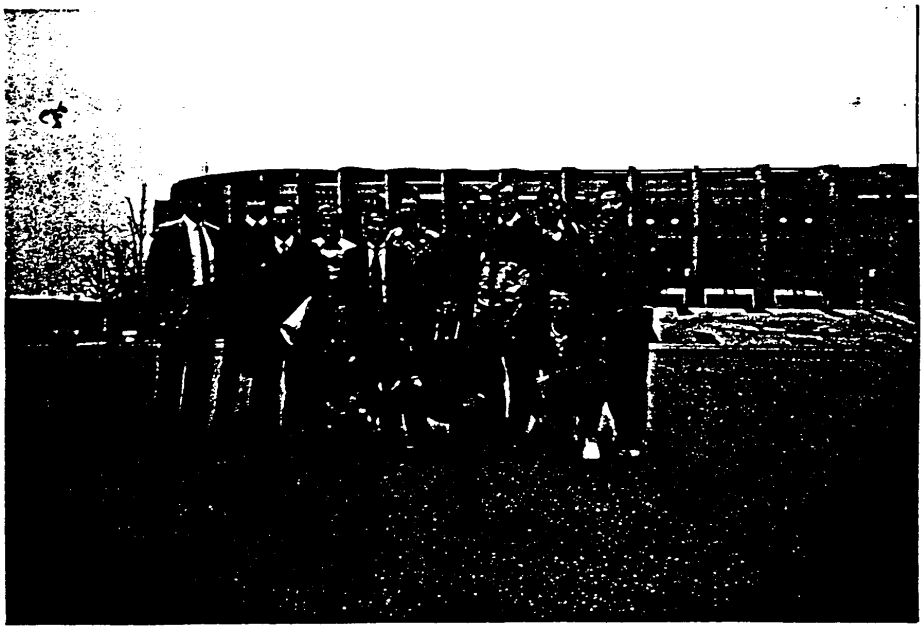
List of Participants

John Disley (GBR)	Chairman of Seminar IAAF/AIMS Measuring co-ordinator for Europe Course Director for London Marathon
Lennart Julin (SWE)	IAAF/AIMS Approved Measurer Technical Officer, Swedish Athletics Federation
Robert Read (NZL)	IAAF/AIMS Approved Measurer Course Director, Hamilton Marathon
Robert Letson (USA)	IAAF/AIMS Approved Measurer Co-ordinator, Los Angeles 1984 Olympic Marathon course measurement
Robert Thurston (USA)	AIMS/TAC Approved Measurer
Shin Shimazu (JAP)	Chief of Equipment Division, JAAF
Shoichi Iizuka (JAP)	Assistant Chief of Equipment Division, JAAF
Yukata Sasai (JAP)	Interpreter
Kim Young Duck (KOR)	Equipment Director, Korea AAF
Kang Sung Ku (KOR)	Korea AAF
Tae Hwa Yoon (KOR)	Interpreter
Paul Bristow (IAAF)	Administrator of Seminar



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A key point from this list of criteria is to reach a standardised, IAAF approved method of course measurement, which is also essential to include in any criteria drawn up for the introduction of World Records for road races.

The Road Running Sub-Commission therefore proposed to Council that a Method of Road Race Course Measurement be found which could be adopted as the official IAAF Method of Measurement. They suggested that a final test should be given to the AIMS approved measurement method in Seoul and that if found acceptable would become the standard IAAF Method of Measurement.

Outline of Programme

Mr Robert Letson outlined the general programme for the seminar and gave a general introuction to the Jones Counter/Bicycle technique of measuring. There was a general discussion on the practicalities of the bicycle method.

DAY 2 - Tuesday 2nd December

08.30

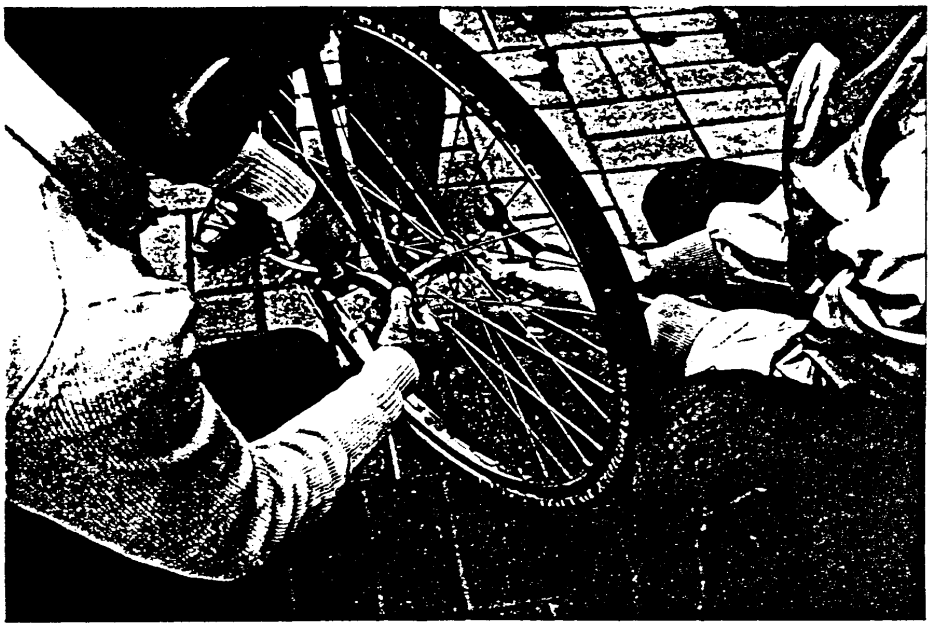
The Jones Counter Technique of Measurement

John Disley explained the mechanics of the Jones Counter Method of measurement. It had been invented by an American runner called Clain Jones from New York to enable a bicycle to be used effectively as a measuring tool.
The steel-tape method of measuring road race courses although accurate is a very expensive and time consuming operation and there are many locations where steel-taping is totally impractical because of traffic conditions. Likewise, the surveyors wheel is a slow method of measurement and is also suspect with regards to accuracy. The combination of the Jones Counter (which records a count change for about every 10 centimetres) and a 27" or near wheel bicycle, has proved to be a very accurate method of measuring and has been acccepted by the IAAF and included in the IAAF Development Programme Book 4 Guidelines for the conduct of Road Racing. (see Appendix 3 for details of Jones Counter, cost and availability).

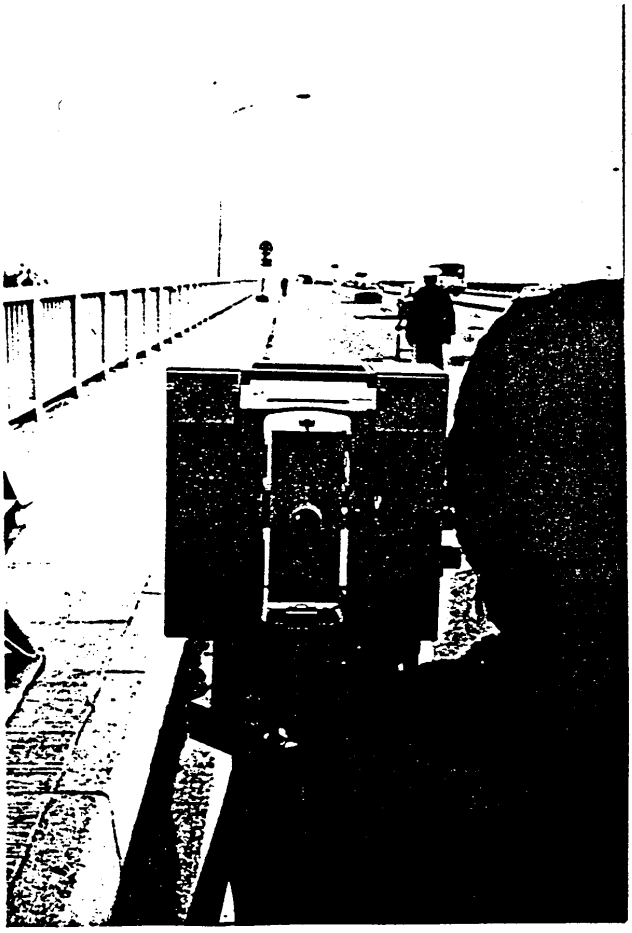
Calibration

The Jones Counter does not provide a read out of actual metres, it provides a "count-figure" for a certain distance.
The Jones counter can only be "calibrated" by riding the bicycle (with Jones Counter attached) over an accurately suveyed stretch of road - which needs to be flat, straight, and over 500 metres long preferably 1,000m.
This calibration course can be measured by steel tape, or with an Electronic Distance Measurer (EDM) machine. The ends of the course must be precisely marked with a steel nail set in the centre of an easily visible line. As the course will be ridden in a straight line and without interuption it should be set out on a relatively traffic free road.
The pre-calibration of the bicycle/counter should take place just before the route measurement starts.
At least four rides are made over the calibration course and the Jones Counter readings are carefully noted. Any ride that is interrupted or effected by other problems from being a good ride should be disregarded from the results and another ride taken. The average of these rides is taken and will become the pre-measurement count. Divide this count by the length of the calibration course in metres or yards and multiply by 1,000 or 1,760 to obtain the figure for a kilometre or a mile.

Jones Counters were fitted to the front wheels.



The Calibration Course



After measuring the route a post measurement calibration must be made to ensure that the calibration figure has not substantially changed due to a slow air loss from the wheel. Differences in temperature from the pre to the post measurements can also produce significant changes in the calibration figure. For this reason it is preferable to do the whole measurement procedure at a time of day when there is little change in the temperature expected, eg. on a dull day, early in the morning, or through the night.

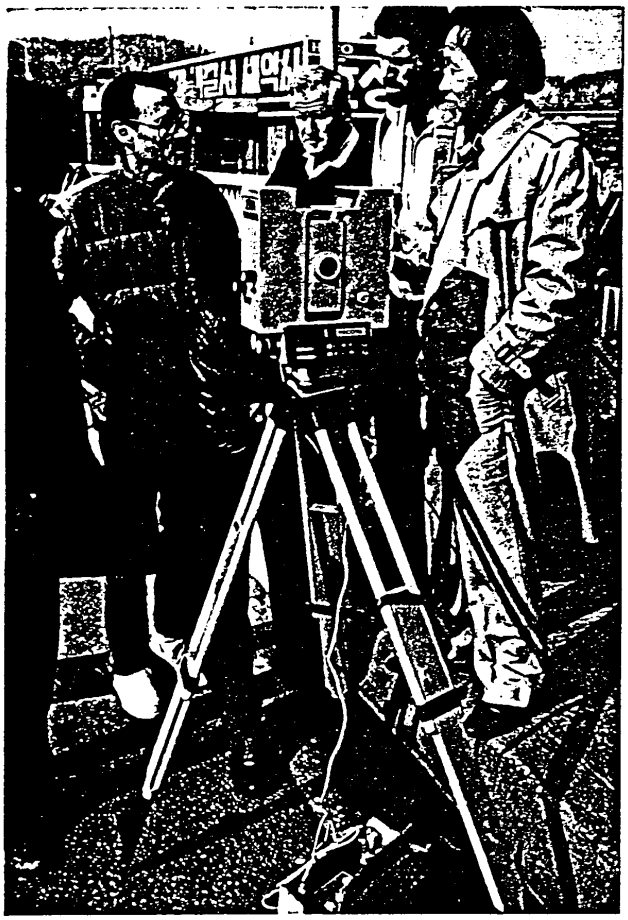
10.00

Practical Session - "Riding a Calibration Course"

15 bicycles had been supplied by the KAAF and they were adjusted to suit each rider.

(It should be noted that these bicycles were not the ideal type for course measurement, and that a "tourist" type bicycle is preferable to the "racing" type dropped handlebar style used here. A measurer should ride the bicycle in an upright position to have the best possible view of the route and other traffic. It is important also that the rider maintains a consistent posture on the bicycle and with the "racing" type bicycle it is often necessary to move ones position in order to brake for example.)

A lane of the Ch'onhodaegyo Bridge was measured with an Electronic Distance Measurer by officials from the Seoul Surveyors Office the previous day and was witnessed by those seminar participants who had arrived early (RL,RR,RT,PB,KAAF Int Affairs Dept). It can be seen that this was a straight, flat stretch of road, it was however a very busy road and it needed police protection for the participants to be able to ride the calibration course.



Unfortunately, Mr Shimazu suffered a minor accident on the steep descent from the hotel to the calibration course, which precluded his further ability to join the practical session.

All participants practised riding a calibration course and were instructed in the skill of straight riding, consistent posture and careful recording of figures.

It was encouraging to note that those who were inexperienced with the Jones Counter Technique rapidly gained confidence and were soon recording figures that were identical or varied just one or two counts (9cm).

Shortest Possible Route

John Disley explained that in 1981 the IAAF had abandoned the "1 metre rule", where road courses were measured one metre from the edge of the running surface and replaced this recommendation with the recommendation that courses must be measured following the shortest possible path.

Note: IAAF Rule 145 now reads:-

In events over roads, the course shall be measured along the ideal line of running or walking, i.e. the shortest possible path, in the section of the road permitted for the runners or walkers. In all meetings under Rule 12, paragraph 1(a), (b) and (c), the course must not measure less than the official distance for the event, and the variation in the measurements must not exceed 0.1% (i.e. 42 metres for the Marathon)

See also Rules 165 (Road Running) and 191 (Walking)
NOTE 1.- For measuring road courses, a calibrated wheel of normal diameter which indicates the number of revolutions on a revolution counter is recommended. When measuring, this wheel should not travel faster than 5km per hour. The revolution counter must be checked before being used. This checking is best done by measuring with a steel or fibre glass tape a flat distance of 1000m paved in asphalt. The wheel is then taken along this measured distance of 1000m, once in each direction. The exact distance of the course may then be determined.

For the purpose of verification by the technical Delegate or Chief Technical Official appointed by the Federation, the calibrated wheel must be available on the day of the competition.

2.-The actual measurement of the distance will determine the start and finish points. Each kilometre is to be denoted by marking on the road side. On an asphalt surface, this point should be denoted in white, where possible, with the number of the kilometre.

In the official measurement document, each notable, invariable point (house, street corner, cross roads, sign etc) is to be described with its distance from the start.

It was unanimously agreed that the above NOTE was unclear and that current practice made it erroneous.

Robert Letson made the point that TAC applied the same criteria for measurement as are applied in track layout. eg. a 400m track is correct when measured 30cm from the inside kerb and 20cm from the lane lines. Consequently, TAC measurers measure 30cm from the road kerb and 20cm from the edge when the running surface is a marked line or a change in the surface. eg. tarmac to gravel.

Lennart Julin however argued strongly that the existing IAAF Rule 145 was much safer as it allowed the course measurer to use a line that paralleled the exact shortest possible route that could be used by the runner. He pointed out that there were many situations where the usable running surface was some distance from the kerb. eg. continuous metal gratings often bordered the kerb which because of their configuration made running extremely dangerous. There were also other situations where the height of the kerb is just one or two centimetres and this would certainly allow a runner to put his feet nearer to it than the 30cm allowed by the TAC recommendations. He believed that there would be much less confusion if the IAAF retained the present wording in the rule.

Robert Letson gave a diagrammatic talk on the shortest possible route and its application to various situations eg. winding roads, turning points, restricted roads etc. (See Appendix 4)

2.15 Tour of the Olympic Marathon Course by bus

The KAAF had supplied participants with copies of their Marathon Course Study and Measurement Document (224 pages of detailed figures, drawings and explanations in English). This document was based on the Los Angeles Measurement report for the 1984 Olympics.

The participants were very impressed by the information supplied and the practical demonstration of the route measured by the continuous blue line painted on the road which had been prepared for the Asian Games.

The course starts and finishes in the Olympic Stadium and although not totally without gradients is generally an open, fast route on a good surface (2 hours 09 21 secs - winner of Asian Games 1986, Kadima (JAP))

4.30 Arrangements for Measuring Session of Olympic Course

Although it would have been possible for a small group of experienced measurers (2-3) to complete the circuit of the full course in the 3 hours of police protection, it was more appropriate for all the seminar participants to all experience a practical measuring session.
Arrangements were made for the calibration to take place between the marks at 3.30am and a subsequent measuring to be carried out on the first 10km section of the course. It was also agreed that it would be illuminating to return back to the calibration section by reriding these first 10km in the reverse direction. It would then be possible for the measurers to compare their figures and note how consistent the recordings were on the return measurement.

Arrangements were made to check Jones Counter readings at 6 intermediate points.

Day 3 - Wednesday 3rd December

3.30 a.m. Calibration

A stretch between "3km" and R32 of the Olympic Marathon Course was chosen, 504.036m in length according to the figures given in the official report. (After the measurement sessions the calibration course was checked by steel-tape measurement in pouring rain. The length measured was 504.015m which was in good agreement with the official length).

In view of the rather short (but not necessarily too short) calibration course, it would have been advisable for everyone to have made as many rides as Robert Thurston in both calibration sets.

For undisturbed calibration rides the spread should not be more than one count within each set. The conditions were however not ideal since there were so many riders, so a somewhat larger spread of 2-3 counts is reasonable.

Some of the more experienced riders would not have accepted their calibration rides here for a "serious" measurement as the large number of riders forced them to deviate slightly from the intended straight line to avoid collisions with other measurers. This means that the "true" calibration "constants" were perhaps one count lower than those recorded in Appendix 3. This would have made the measured course slightly longer.

4.00 a.m. Course Measurement

The police protection outnumbered the riders making the measurement and it was possible to take the exact running line on the bikes even although these often required the rider to be exposed to other traffic on very long diagonals from corner to corner.

The complication of a closed gate across the shortest possible route at the entrance to the stadium produced some problems, but also provided a good example of how evasive action could be compensated for in the measurements.

Robert Letson did not ride the route but supervised the Jones Counter readings at the 14 points on the out and back course that was measured.

Key Points from the Practical Session

1. The consistency of Jones Counter recordings by all the riders.

   Several measurers had identical figures for the out and back sections.

2. That although the inexperienced riders were obtaining figures for the straight sections of road that were very close to the readings made by the "experts", their ability to ride corners on the "shortest possible route" running line was not so good. The "experts" were usually recording a metre or two less for the winding sections. This was to be expected and practice would eliminate this fault.

3. It was encouraging to note that even by the return journey the novices were riding with more confidence and were recording reduced distances on the section that contained corners eg R6-R7, Appendix 3.

4. Even with 9 riders and many stopping points some 23 kilometres were measured in less than 2 hours, a distance, which it was agreed, would have been impossible to measure by steel tape method, in that short time. Several participants said that they had measured full marathon courses in under 4 hours.

   There was a total agreement that mass measurement sessions are inappropriate for accurate course certification and that the ideal number of measurers was 2 with a lead rider 50 m ahead to give an indication of the shortest possible route.

5. The figures produced by the experienced riders in particular show that the Jones Counter readings matched closely the recorded intervals which had been steel taped in the original measurement by Professor Dr Chul-Ho Ahn, of Seoul National University.

6. However, some sections were measured shorter because the riders had been able to take a route inside the blue line. This does not imply that the Olympic Course is incorrectly measured because on race day, cones are placed on these corners which would preclude the runner being able to put his foot over the blue line.

7. The seminar agreed that detailed information is always necessary on the positioning of race day barriers and cones particularly on corners and turning points, before accurate measurements can be made.

A final discussion took place on "short course prevention factors" and the certification and validation of courses.

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APPENDIX 1.

RULES FOR MEASUREMENT OF ROAD RACES COURSES

In the IAAF Handbook (latest edition 1985/86) the regulations concerning measurement of road races courses are found in Rule 145. The wording is as follows:

"In events over roads, the course shall be measured along the ideal line of running or walking, i e the shortest possible path, in the section of the road permitted for the runners or walkers. In all meetings under Rule 12, paragraph 1(a), (b) and (c), the course must not measure less than the official distance for the event, and the variation in the measurements must not exceed 0.1 % (i e 42 metres for the Marathon)."

This rule has been in effect since 1 April 1981 following a decision by the 1980 IAAF Congress after a proposal from the Swedish AA. The previous wording was as follows:

"In events over roads, the course shall be measured one metre from the verge of the road and in the direction of the race. A certificate of correctness shall be furnished by the official surveyor. It is recommended that a wheel of exact circumference which will record on a counter the number of revolutions be used. The speed of operation of the wheel should not exceed 5000 metres per hour and the counter must be checked against a stretch of road - not running track - not less than one kilometre in length accurately measured by a surveyor's chain, steel tape or fibre glass tape."

The major changes - each of them important - were:
1. Deletion of the concept "one metre from the verge of the road" and instead introduction of a definition of the course ("the section of the road permitted for the runners") and the concept of "the shortest possible path". The reasons behind these changes were that "the verge" is not defined clearly enough and that on meandering roads a runner could run considerably less than the distance measured.
2. An undeniable calling of attention to the concept that a course never shall be allowed to be shorter than the prescribed distance for the event!
3. Introduction of a realistic tolerance based on measuring experience. (When originally proposed the rule basically only concerned marathons so the tolerance was listed as 50m for a full marathon.)
4. Deletion from the rule of any mentioning of the measuring technique to be used. (Rules should in principle only give the conditions and the limits. Any recommendations on how to achieve them should be given in Notes or in other publications. As for the method described in the previous wording there were several highly questionable points - "fibre-glass tape", "not exceed 5000m per hour", "exact circumference" - which made it even more important to get it out of the rules as quickly as possible!)

However the current wording of the second sentence is - for some reasons not known to me - slightly modified when you compare it with the original proposal that read approximately (I don't have the original text available at the moment but I was the original author) as follows:

"The length of the course must not be less than the official distance of the event, and the uncertainty in the measurements must not exceed 0.1 % in meetings under Rule 12, paragraph 1(a), (b) and (c)."

The basic idea behind this wording is that EXACT measurement of a road course is impossible and that we thus never will know the "true" length of the course. There will always be some uncertainty - which is a combination of errors (systematic and random) - in the measurement of the calibration course, in the calibration and in the measurement of the competition course. These errors could - based on experience - be controlled by a careful measurer in such a way that the total uncertainty will be possible to keep within the 0.1 % limit.

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does anyone really believe that such tables give sufficiently accurate values for these purposes? No mention of EDM as an alternative.
7. The calibration consists of only two trips over the calibration course. Hardly satisfactory - especially as nothing is said about what variation between these two trips that should be acceptable.
8. It should also be noted that the wheel only counts full revolutions which means that using a normal bicycle wheel each revolution is similar to approximately 2 metres! The disastrous effects a 2 metre uncertainty per 1000m calibration can have are obvious. (You could reduce it by counting spokes but nothing is said about this in the text!)
9. Why should the wheel be available to the Technical Delegate on race day? What kind of "verification" could really be done then? Including calibrations he/she would need some 10 hours to measure the course with the wheel and that amount of time is not at hand on race-day! Also - the Technical Delegate does not have to have any personal practical experience in course measurement.

Thus it is obvious that this note should be deleted as quickly as possible from the rule-book as it is detrimental to the promotion of practical, reliable and accurate course measurement! If there should be any recommendation concerning measuring technique in the Handbook it should be a reference to the calibrated bicycle method. As it is not possible to describe that method (or any other method) fully in just a short note I suggest that the method is just mentioned by name together with a reference to a source where it is described in detail.

According to what was reported at the seminar in Seoul two new changes to the current rule will be proposed to the 1987 Congress. These changes would be
1. That the "shortest possible path" is defined by 30 cm from the kerb and 20 cm from lines or comparable delimitations.
2. That a "short course prevention factor" of 0.05% should be brought into the measurements.

I would like to comment on these proposal as I am not at all certain that they will be advantageous - instead they could have a detrimental effect on measurement quality!

When the concept of "SHORTEST POSSIBLE PATH" was introduced in 1980 it was because it was obvious that the "1 metre from the verge of the road" didn't create courses with similar lengths regardless of the number of turns on the road. This - as said above - first because runners could run shorter and secondly because the concept "the verge of the road" was not clearly enough defined when marathons left the traditional type of country roads and were brought into city streets with all kinds of delimitations to the section of the street allowed for the runners.

By introducing "30cm from kerbs and 20 cm from lines" we will once more get into similar situations where different persons will have different ideas of from where the 30cm/20cm should be measured.

The parallell to track racing is also with little relevance. On track you ONLY have LEFT hand turns and the WHOLE course is delimited on the left hand side by a kerb with standardised height. This is an artically created permanent arrangement that is identical in all relevant aspects for every arena in the whole world.

This means that even if "the 30cm from the kerb"-rule doesn't measure the true minimal running distance for a competitor it doesn't matter because it is the same for everyone else competing anywhere else.

As for the "20 cm from the line" it should be noted that this applies only to very few events (races up to 400m plus the first bend of the 800m) all lasting considerably less than 1 minute. For these short time periods the meet organiser have a large number of judges on the bends to supervise that runners in lane 2 and outwards keep in their lanes. (These judges - as well as all other observant persons - also know that runners are putting their feet down on the track much closer to the line than 20 cm!)

The track reality is definitely something differing in several important aspect to the road reality. Kerbs are not standardised, you

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2im probably have less effect on the finishing times than a change in the air temperature of 2 degrees Celsius! Also it must always be realised that world records not necessarily are the best efforts ever but rather the best marks registred in meets carried out in full accordance with the IAAF rules. (E g in my personaly opinion Carlos Lopes 2:09 in the 1984 OG - and not his 2:07 in Rotterdam - is the greatest marathon effort ever!)

- If a SCPF should be brought into the rules this should definitely NOT be as a new paragraph but in the form of a recommendation in a note. That note could read something like this:

"To prevent a course to turn up short on a future remeasurement it is recommended that a "short course prevention factor" of 0.1 % is added to the measured length when the course layout is decided. This means that each km along the course should have a measured length of 1001 metres.".

These reflections concerning the rules have become fairly long but as everything else we are doing will be based on the rules I find it necessary that the wording in the Handbook is precise and without contradictions or anything that could create misunderstanings of any kind. Hopefully this can achieved in a proposal to the IAAF Congress 1987!

A. Lennart Julin
6 December 1986

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their courses certified by an independent IAAF measurer from another country.

2. There are two categories of races that definitely must be certified: the major international championships and cups as well as the road races incorporated in the IAAF Road Race Calender. Thus a new paragraph of Rule 145 should be introduced:

"Road races in meets under Rule 12, paragraph 1(a), (b) and (c), as well as races included in the IAAF Road Race Calender must have the length of their course certified in advance by an IAAF approved measurer from another country."

By making certification mandatory (every race in the categories listed have to be independently certified) without any chance for exemptions we are avoiding the risk of making this a matter of questioned ability for some organisers. They should instead be so proud of their own measurement efforts that they would be happy to show them to people from other countries.

Of course also organisers of other international road races should be strongly recommended and encouraged to have their courses certified in the same way.

3. A group of IAAF approved measurers - basically those previously approved by AIMS - have already been established. With few exceptions the persons in this group have had the opportunity in the last two years to measure together with someone of the others on some course. The experience has been most encouraging as the results have been highly similar. This shows that the measurement techniques and methods used are as far as possible non-subjective.

The group currently consists of 21 persons from 7 nations. It should not be expanded too much or too quickly. It is absolutely essential that the quality is kept at the current very high level. I therefore suggest the following regulations:
A. A maximum age (55 or 60 years?) is introduced. Measurement requires quite a lot physically (good bike riding ability, endurance, good eye-sight etc). A measurer that reaches the age limit will still have an inspiring and important mission in educating and training the next generation of measurers!
B. An aspiring new measurer must first prove his ability to measure correctly by getting results very similar to the ones achieved by an already approved measurer on a race course. A practical way is to measure a course together with an approved measurer.

It should NEVER be possible to be approved just by recommendation or without any practical demonstrations! To be an IAAF measurer is an honor but that is not the same as that it can be acquired like a mark of distinction. Like an athlete you should instead have to earn the "honor" by proving your skill in a competitive situation!

The expansion of the group of approved measurers should in the next couple of years be concentrated on adding persons from areas not yet represented (foremost Asia and Africa).

4. The only method to use for certification measurement is the bicycle method with a Jones counter. Other methods can produce as accurate results but is too time and energy consuming to be practical for certification purposes.

5. A certification has to be performed personally - i e that the IAAF measurer has to ride the bike HIMSELF along what HE views as the shortest possible path. He should also carry out is own calculations. A mere supervision of someone else measuring is NOT sufficient for a reliable certification.

6. For major championship/cup races there should be two IAAF measurers doing the certification. I think this is necessary considering the importance of the race. Suppose that there is only one measurer and that his result shows that the course is incorrect - what should be done then? Perhaps he has made a mistake - will there be time enough (and

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whatever compilations of certified courses that will be published by the IAAF in bulletins, magazines or otherwise. Such compilations should contain name of race, site, certifier and date of certification measurement. Such lists - constantly revised - should be published with regular intervals.

It is absolutely essential that certifiers are viewed as individuals with a personal responsibility and that the announcement of certifications is established as a natural and regular procedure. Everyone who is interested should have the chance to know what courses that are certified and by whom. Otherwise the whole thing will be a failure. It is not acceptable like it has been during the first year of AIMS certifications where not even I - who is a member of the (fictional?) AIMS Standards Committee - know anything about what has been certified and by whom - except for what I have done myself!

If the "anonymous" system is kept in the future this will ruin the idea of certification because the meaning of "certification" is not defined in a way than can be controlled. A race can (unintentionally?) erroneously claim to be IAAF certified when they perhaps really mean that the course has been measured by themselves according to IAAF rules or that the course has been certified nationally. This can only be avoided by announcing the certifiers name and the date of the certification. If the name is on the IAAF list it means that the certification is real and of a undisputable quality! If there is no name all claims of certification should be strongly doubted!

13. A certification is valid as long as the course remains unchanged. (This means that races carried out on the same course doesn't have to be re-certified every year!).

14. For major races it should be strongly recommended that the measurer responsible for the certification should be able to follow the race from a lead vehicle to make certain that the course run is the the course measured. Especially whenever there is a noticeable chance for an important record run the certifier should be there. If this is not possible the documentation of the measurement (See 10.H. above!) should be available for some other neutral observer.

A. Lennart Julin
6 December 1986

PS
Concerning the IAAF/AIMS approved measurers there are errors in the addresses for both me and the other Swedish measurer in the lists in the "AIMS Marathon Yearbook 1987" as well as in the "AIMS Newsletter No 27 (September 1986)". These errors are very unfortunate as they will make it very hard for anyone that might like to contact us. We would therefore be grateful if those addresses where corrected to read as below in future publications (e g next issue of AIMS Newsletter).

Lennart Bresky
Krångedevägen 19
S-115 43 STOCKHOLM
Ph: 8-61 08 07

A. Lennart Julin
Gästrikegatan 14
S-113 34 STOCKHOLM
Ph: 8-30 13 33

CONCERNING POSSIBLE FUTURE IAAF SEMINARS ON COURSE MEASUREMENT

In my opinion the best way to learn a technique like the bicycle method for measuring road race courses is to practice together with experienced and skilful measurers. By just reading books and instructions you might miss several important details that are of crucial importance for the quality of the measurement.

There is currently a great need to spread knowledge about the bicycle method around the growing world of road running. This need should be met by seminars where beginners would meet and work together with "established" IAAF approved measurers.

To make effective use of the limited time available for a seminar it is important with detailed planning and sufficient arrangements for the practice sessions. Although the seminar in Seoul was very fruitful for all of us (we all learned a lot by meeting, discussing and exchanging experiences and views) it was also obvious that the time available could have been used in an even more rewarding way. E g did we have to spend quite a lot of time discussing how we best should use the 3 hours of police protection when it was obvious that it would not allow us to measure the whole course.

Also we discovered too late that the bicycles that we were to use in several aspects diverged from the ideal for these measurement purposes.

Based on these and previous experiences I would like to suggest the following "points" of importance for the optimal success of future seminars:

1. The IAAF measurer responsible for the seminar should go to the site a couple of days in advance to make certain that all practical details are as wanted. Among those details are:
- suitable calibration course (500-1000m long) in a place without traffic (preferably bicycle path) available at 24 hours of the day
- good bikes ("tourist type" with non-drop handle bars, 3-5 gears, light (battery powered), good brakes, etc)
- a "good" practice course of 12-15 km
- police protection for measurement session on the course
- conference material (overhead projector, copier, etc)

2. At the seminar there should preferably be at least 3-4 experienced bicycle method measurers, 8-15 "pupils" who should be persons capable of and interested in performing measurements personally. (These requirements should be stressed when inviting to the seminar to avoid getting people there that are not suited for practical measurement that demands riding for several hours a bicycle with a Jones Counter mounted on the front wheel.)

3. A time schedule for the seminar could look like this:
- DAY 1: EVENING: Lecture on rules and the principles of the bicycle method.
- DAY 2: MORNING: Checking an EDM-measured calibration course with a steel tape. Mount Jones counters on bikes and perform numerous rides over the calibration course. (Practical instructions on riding technique to the beginners from the experienced measurers.) AFTERNOON: Lecture and discussion on calibration courses (length, levelness, etc), on bike riding techniques and on calibration performances (consistency, acceptable variations). Discussion on equipment needed besides the bike and the Jones counter
- DAY 3: NIGHT: A measurement session consisting of pre-calibration, riding a "decisive" course of 12-15 km (at least 6 check-points) in both directions (or twice in one direction) and post-calibration. This should be performed by all beginners and 2-3 experienced measurers. At least one experienced measurer should act as supervisor noting what mistakes and what good things the measurers made. (Every measurer should also be encouraged to make notes of all "strange" things - e g obstacles like

INSTALLATION INSTRUCTIONS FOR JONES COURSE MEASURING DEVICE

IMPORTANT: *As you sit on your bicycle, in riding position, device is installed on LEFT SIDE of front wheel, between fork and front wheel.*

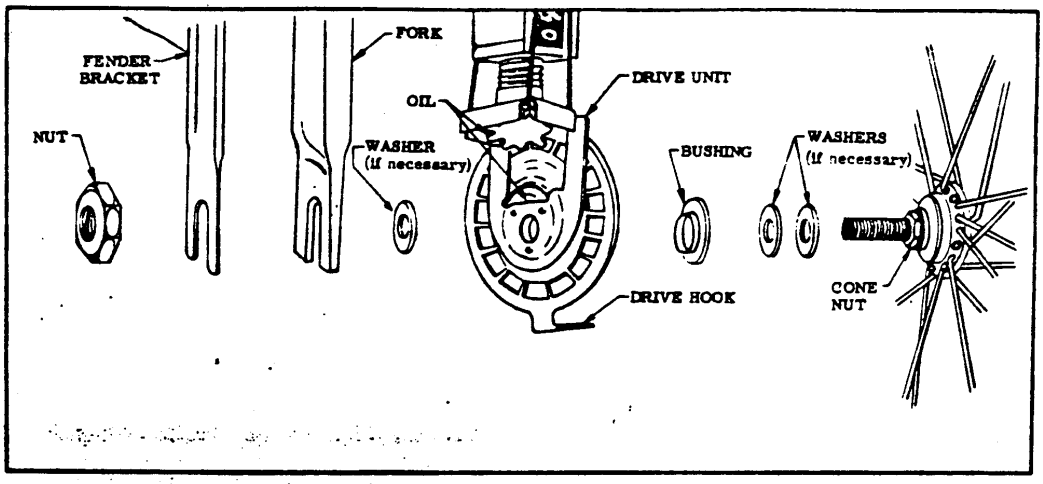


FIGURE 1

Step 1. Turn bicycle upside down and remove front wheel. Use a proper size wrench (not pliers) to remove the wheel nuts.

Step 2. Slide washers onto axle to prevent device from touching spokes when placed on axle.

Step 3. Slide unit onto axle and insert drive hook between any two spokes. If clearance between spokes and drive gear face is greater than 1/32" (width of a penny), remove one washer at a time until 1/32" distance between spokes and drive gear is obtained. See Figures 1 and 2.

Step 4. Insert washer between unit and fork if necessary to give clearance and keep device vertical. Place front wheel with device into fork. It may be necessary to spread the fork slightly to make room for the unit.

Step 5. Replace front wheel nuts removed in Step 1 and tighten.

Step 6. Make sure wheel turns freely. If not, it may be necessary to add a washer as shown.

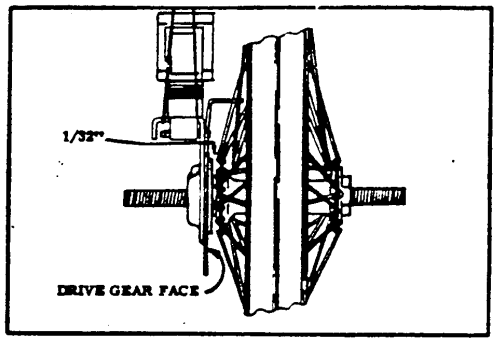


FIGURE 2

NOTES: Attach counter in such a position that the numbers can be seen while riding.

The counter is not designed for continual use in wet weather. If bike is to be used a great deal for other than measuring, it is recommended that the counter be removed and only mounted while measuring courses.

INSTRUCTIONS FOR USE OF JONES COURSE MEASURING DEVICE

For course measurement, refer to Ted Corbitt's booklet, "Measuring Road Running Courses." This is available from:

Mr. Ted Corbitt, Chairman
RRCA/TAC Standards Committee
150 W. 225th Street
Apt. 8H Sect. 4
New York, NY 10463

The price of the booklet is $2.00.

To calibrate the counter, measure a half mile or one kilometer course using a steel tape with 10 lb. (4.5 kg) tension. See Ted Corbitt's pamphlet for details. Record the reading of the Course Measuring Device at the beginning and end of the course. Only read when the bike is advancing to the mark. If you overshoot by a few inches, back up behind the mark so that the counter is advancing as you come again to the mark. This will eliminate "backlash". Ride over the course at least twice. Record the results as shown in the example:

	Run 1	Run 2
STOP	86590	94449
START	78735	86592
Difference	7855	7857

Subtract and take the average. If a half-mile course, multiply by two for counts per mile. If a mile or kilometer course use the average. For this example we get (if from a half-mile course):

counts per mile = 15712 (9763 per km)

Then we use this to figure the number of counts for the desired distance. For example, for a 10 mile course it would be 157120 counts. Since the counter only records 5 digits, note that it will "turn over" about every 6.4 miles (10.2 km).

For a 20 kilometer course (12.4274. . . miles) it would be 12.427424 x 15712 = 195260 counts or 20 x 9763 = 195260 counts. (We recommend the use of a calculator to aid in these computations.) When measuring the actual course, read the counter as the bike is set at the starting point and add the desired counts to get the number to obtain at the finish. You may want to compute the count for each mile (or kilometer) mark. Then each mile can be marked for use by the runners during the race.

If you measure an existing course and want to find its length, determine the total number of counts and divide by the counts per mile. For example, using the counts per mile from above, if the total counts for the course was 166734 this would be:

166734/15712 = 10.6119 miles = 10 miles 1077 yds.
or 166734/9763 = 17.0782 km = 17 km 78 Meters

. . . . . .

For your convenience, the following conversion factors are given:

1 mile	= 1.609344km(exact)
1 kilometer	= 0.62137119 miles
5 kilometers	= 3.106856 miles
10 kilometers	= 6.213711 miles
15 kilometers	= 9.320568 miles
20 kilometers	= 12.427424 miles
25 kilometers	= 15.534280 miles
Marathon	= 42195 meters
	= 42.195 kilometers
	= 26 miles 385 yards
	= 26.21875 miles

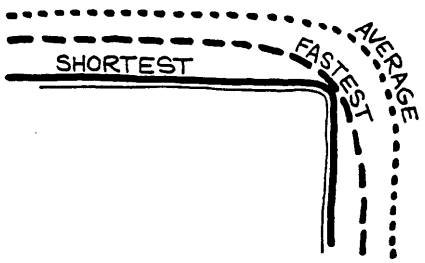
The Jones Course Measuring Device is available from:

New York Road Runners Club
P.O. Box 881, FDR Station
New York, New York 10150
Attn: Bill Noel
(212) 860-4455

Lecture notes on the SHORTEST POSSIBLE ROUTE by Robert Letson

SHORTEST POSSIBLE ROUTE (SPR)

The Shortest Possible Route (SPR) is best defined by comparing it with other routes that are commonly measured:

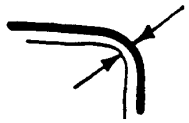


•• ·••• AVERAGE ROUTE: The "average" route is the average path taken by all of the runners on a race course. The length of the average route is good for appraising average performance, and is therefore good for fun runs. However, the average route is not where elite runners run, and is not accepted for setting records because runners can legally run distances less than the length of the average route.

— — FASTEST ROUTE: The "fastest" route is the ideal path for achieving the fastest time. The winner of a race probably travels along the fastest route. The length of the fastest route is excellent for appraising elite performance. However, measurements of the fastest route are not accepted for setting records because runners can legally run distances less than the length of the fastest route.

——— SHORTEST POSSIBLE ROUTE (SPR): The SPR is the shortest route that a runner can possibly take without cutting the course. The length of the SPR is not as good as the FASTEST ROUTE for appraising elite performance. However, measurements of the SPR are accepted for setting records. Consequently, if records are sought, the course must be measured along the SPR.

OFFSET OF SPR FROM CURB/LINE/WALL:



The precise definition of the offset of the SPR from curb/line/wall is contraversial. The Japanese measure one meter from curb/line/wall. Most measurers in USA and New Zealand measure "within 30 centimeters" of curb/line/wall. Sweden measures the "shortest possible route" without defining a specific offset. The 1984 and 1988 Olympic Marathons were measured with track rules: 30 centimeters from curb, and 20 centimeters from line. The Seoul Marathon also measured 61 centimeters from a wall. This issue is left as a question because, although track rules were adopted for road races to establish "world road records", road races have very unusual circumstances not found on tracks (i.e., taller curbs, smaller radii, and hazards on the road).

In 1981 the IAAF officially replaced the "one meter from verge of road" rule with the "shortest possible route" rule.

In 1982 the USA officially adopted the "within 12 inches of curb" rule. All road race courses measured by the "one meter from verge of road" rule were decertified. All certified road race courses in USA are now measured within 30 centimeters of the curb at turns.

All USA/AIMS measurers currently measure within 30 centimeters of curb/line.

If a 30-centimeters-from-curb remeasurement determined that a one-meter-from-curb course is "short", and if the remeasurements were contested in a court of law, the court would refer to the IAAF rule book for guidance. The court would be forced to acknowledge that the rule does not explicitly prohibit measuring one meter from the curb. In fact, the one meter offset more closely approximates where the winner of a race runs. For example, the video tapes of Alberto Salazar's 1981 2:08:13 performance reveales that Salazar ran an average of 2.0 meters from curb at turns. The "shortest possible route" for 12 miles per hour runners is often more than 30 centimeters from curb at small radius turns. Defenders of the 30-centimeter-from-curb rule would not have an easy time convincing the court that one-meter-from-curb is not an appropriate measure of the "shortest possible route"! However, the court would also acknowledge that all of the USA/AIMS approved measurers follow the 30-centimeters-from-curb rule. The decision of the court could fall either way, but would probably be most influenced by those in highest authority in the sport (i.e., the IAAF/AIMS measurers).

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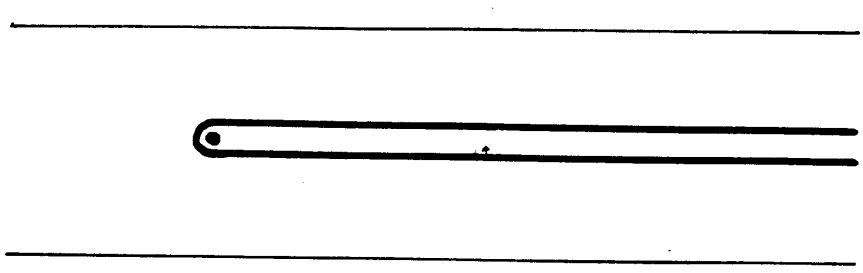
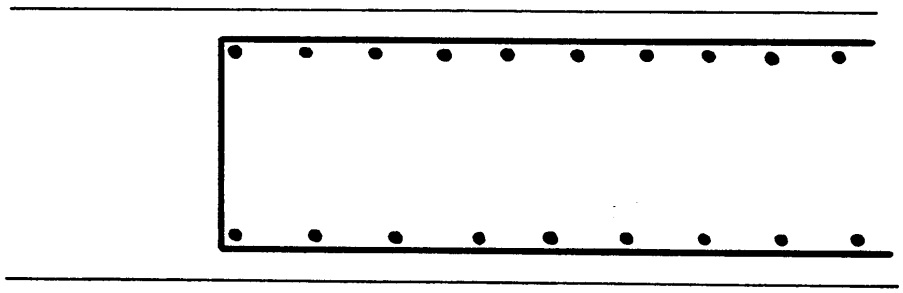
SPR FOR A U-TURN:

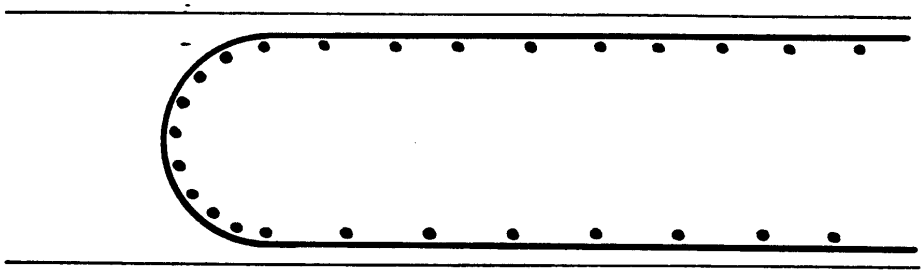
The next set of drawings show the SPR for a 180 degree turnaround. The simplest case shows the SPR when one cone marks the turnaround point, as follows:



If runners are restrained by cones, the SPR is the shortest route defined by the cones, as follows:

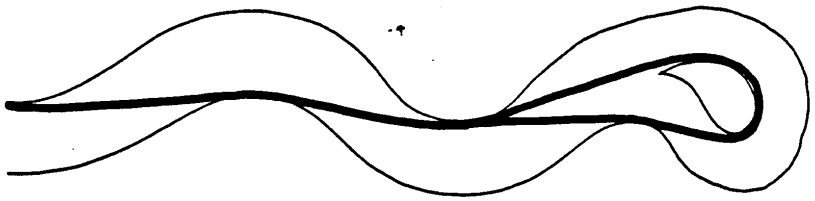


The fastest course is created by defining a circular arc and marking it with cones, as follows:

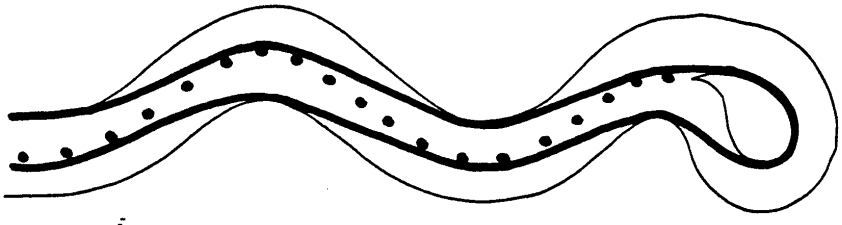


SPR FOR AN OUT-BACK LOOP:

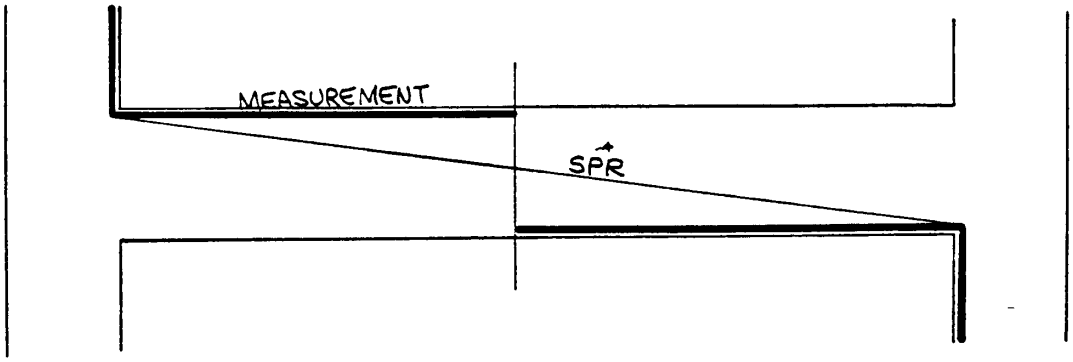
The SPR for incomming runners may be identical to the SPR for outgoing runners, as in the following example. Both SPRs share the exact same line. The incomming runner may be given the best route by considerate outgoing runners. It is therefore possible for a runner to travel the same line both ways.



The fastest way to define an out-back route is to separate outgoing runners from incomming runners, as in the following example. This way two separate SPRs are defined, and runners will not interfere with each others progress.

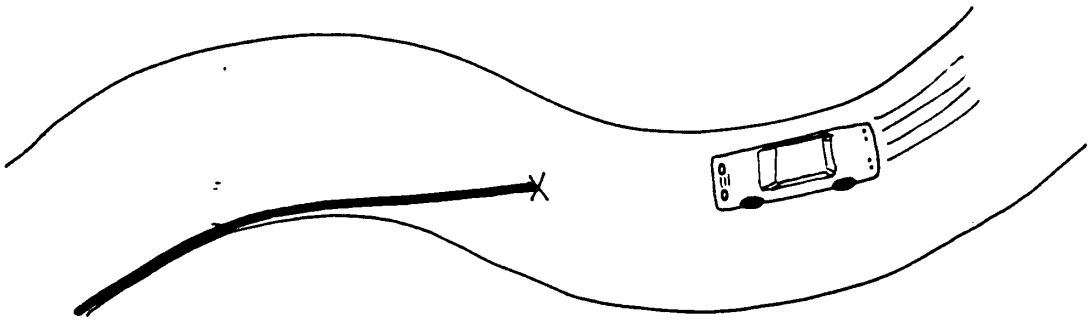


Measuring can be hazardous to health, especially if a 1000 kilogram automobile collides with a 50 kilogram measurer. To avoid hazards, the SPR may be measured indirectly. For example, the length of a diagnol SPR on a long straight road may be approximated by measuring along one side of the road, as follows:



The SPR diagnol length may be computed from the lengths of the side and width of the road. Or, if the road is very long, the length of the side may be assumed to be the length of the diagnol: in this case the error makes the course oversized, and this is a good error because oversized courses are acceptable.

The following diagram illustrates what could happen if the measurement is interrupted by a hazard. Two choices may be made: 1) stop and wait, or 2) mark the spot and move off the road. Choice 2 requires that the spot be marked (e.g., with a penny, or chalk) and that the measuring device be set so that the measurement may resume at the interruption point.



SUMMARY:

1. Measurement of the "shortest possible route" is required for setting records.

2. The exact offset of the SPR from curb is controversial, but is commonly accepted to be within about 30 centimeters of curbs at turns. The 1984 and 1988 Olympic Marathons and Race Walks use track rules: exactly 30 centimeters from curbs at turns, and exactly 20 centimeters from lines at turns.

3. A fast course can be designed by defining and coning circular arcs at turns, and by physically separating outgoing runners from incomming runners.

APPENDIX 5.

TRIAL MEASUREMENTS OF THE SEOUL MARATHON

Attendies of the December 1-3 seminar performed nine bicycle measurements of eleven kilometers of a marathon course that is excellently documented in the "MARATHON/RACE WALKS COURSES, Study and Measurement" report produced on July 26, 1986, for the Seoul Olympic Organizing Committee by the Korean Society of Geodesy, Photogrammetry & Cartography.

The goals of the December 3 measurements are:

1. To examine the calibrated bicycle method as a tool for measuring the length of a road race course.

2. To prove the efficiency of the calibrated bicycle method by a tool comparison with the steel taped measurements of the Seoul Course.

The entire marathon course was viewed by all seminar attendies on December 2. All attendies noticed that the shortest possible route (SPR) was conveyed by a professionally painted blue line throughout the entire course. This line was unbroken, and correctly followed all tangents between turns. The offset of this line from curbs at turns was approximately 30 centimeters, although at times it was slightly more. This was probably due to the limitations of the paint spraying machine.

Cyclists were assigned two letter codes for ease of recording. The measurement occured from 4am to 6:30am on December 3, 1986, with ten police motorcycles in excort. The temperature was estimated (by wristwatch and alcohol thermometers) to be about 4 degrees Celsius at 4 am, and about 2 degrees Celsius at 6:30 am. Jones counter readings were taken at the following reference points:

-3km located 22.92m south of R31 (between R31 and R32)
R32
R1
R2
R3
R4
R6
R7

The locations of R31, R32, R1, R2, R3, R4, R6, and R7 are described in the "MARATHON/RACE WALKS COURSES" report. These intervals had already been measured numerous times by expert bicyclists and civil engineers. Our goal was to test our ability on an already accurate course, and verify the correctness of the established course.

Results of this study are presented in the following pages.

M E A S U R E R S

BT Bob Thurston, AIMS/TAC measurer
2135 Newport Place NW, Washington DC, 20037, USA

JD John Disley, IAAF/AIMS measuring coordinator for Europe
Hampton House, Upper Sunbury Road, Hampton, Middlesex
TW12 2DW, England

KS Kang Sung Ku, teacher

KY Kim Young Duck, Director of KAAF
5, 2KA, Namdaemoon-R0, Chung-ku, Seoul, Korea

LJ Lennart Julin, IAAF/AIMS measurer, Stockholm Marathon
Gastrikegater 14, S-11334, Stockholm, Sweden

PB Paul Bristow, Administrator of Seoul Seminar
Hampton House, Upper Sunbury Road, Hampton, Middlesex
TW12 2DW, England

RR Robert Read, IAAF/AIMS measurer, Hamilton Marathon
81 Comries Road, Hamilton, New Zealand

SI Shoichi Iizuka, Assistant Chief of Equipment, JAAF

YT Yoon Tae Hwa, Korean interpreter

R A W J O N E S C O U N T S

2-4 degrees Celsius, 4-6 a.m., December 3, 1986

	BT	JD	KS	KY	LJ	BP	RR	SI	YT
-3km	37793	54890	60001	89900	98000	70000	35444	62000	32001
R32		59878	64983	94850	02970	75008	40418	66956	36991
-3km	47701	64865	69965	99802	07940	80012	45393	71913	41976
R32	52656	69855	74952	04754	12910	85018	50368	76871	46958
-3km	57610	74844	79934	09705	17880	90023	55342	81827	51940
R32	62564		84917	14656		95029	60318	86785	56924
-3km	67517		89899	19607		00033	65296	91744	61906
-3km	77470	74895	89907	19894	18000	00213	65384	91700	61931
R1	00826	98422	13416	43263	41428	23817	88839	15093	85427
R1	00826	98422	13416	43263	41520	23817	88839	15093	85427
R2	13028	10704	25697	55462	53755	36141	01088	27308	97700
R3	24642	22396	37368	67065	65401	47873	12743	38930	09375
R4	54986	52935	67914	97403	95844	78519	43208	69304	39906
R6	70997	69053	84012	13404	11904	94693	59280	85333	56005
R7	85061	83210	98193	27485	26010	08898	73396	99421	70145
R6	99122	97408	12355	41545	40118	23101	87522	13498	84282
R4	15133	13530	28458	57547	56177	39274	03593	29525	00367
R3	45466	44051	59016	87875	86619	69912	34055	59904	30884
R2	57079	55738	70693	99477	98266	81639	45709	71520	42564
R1	69280	68018	82978	11676	10507	93963	57958	83745	54841
R32		86541	01502	30074	28968	12553	76449	02176	73364
-3km	92637	91525	06489	35027	33940	17556	81425	07138	78342
R32	97593	96518	11473	39978	38911	22559	86401	12095	83323
-3km	02550	01506	16456	44932	43882	27562	91377	17059	88309
R32	07506	06498	21443	49885	48853	32566	96352	22019	93290
-3km	12462	11488	26426	54835	53823	37570	01327	26978	98270

R31, -3km, R32, R1, R2, R3, R4, R6, R7 are reference points marked with bronze monuments, with locations described in the "MARATHON/RACE WALKS COURSES, Study and Measurement" book produced July 26, 1986, for the Seoul Olympic Organizing Committee by the Korean Society of Geodesy, Photogrammetry & Cartography.

The following intervals were measured with electronic instruments:

(-3km - R32) = (526.956 - 22.92) meters = 504.03 meters
(R2 - R3) = 1181.164 meters
(R4 - R6) = (1628.700 + .13) meters = 1628.83 meters

-3km is at a bronze monument between R31 and R32. The 22.92m difference between R31 and -3km was reported by Kim Young Duc and was confirmed by Bob Thurston via steel tape remeasurement on December 3, 1986.

The measurement between -3km to R1 was interrupted by a double metal gate: all cyclists measured to the gate, carried bikes around the gate, and resumed measuring from the gate, omitting 1.6 meters (estimated by 5.5 of Bob Letson's 29.5cm tennis shoes).

COUNTS PER INTERVAL

	BT	JD	KS	KY	LJ	BP	RR	SI	YT
-3km to R32	4954	4988	4982	4950	4970	5008	4974	4956	4990
R32 to -3km	4954	4987	4982	4952	4970	5004	4975	4957	4985
-3km to R32	4955	4990	4987	4952	4970	5006	4975	4958	4982
R32 to -3km	4954	4989	4982	4951	4970	5005	4974	4956	4982
-3km to R32	4954		4983	4951		5006	4976	4958	4984
R32 to -3km	4953		4982	4951		5004	4978	4959	4982
-3km to R1	23356	23527	23509	23369	23428	23604	23455	23393	23496
R1 to R2	12202	12282	12281	12199	12235	12324	12249	12215	12273
R2 to R3	11614	11692	11671	11603	11646	11732	11655	11622	11675
R3 to R4	30344	30539	30546	30338	30443	30646	30465	30374	30531
R4 to R6	16011	16118	16098	16001	16060	16174	16072	16029	16099
R6 to R7	14064	14157	14181	14081	14106	14205	14116	14088	14140
R7 to R6	14061	14198	14162	14060	14108	14203	14126	14077	14137
R6 to R4	16011	16122	16103	16002	16059	16173	16071	16027	16085
R4 to R3	30333	30521	30558	30328	30442	30638	30462	30379	30517
R3 to R2	11613	11687	11677	11602	11647	11727	11654	11616	11680
R2 to R1	12201	12280	12285	12199	12241	12324	12249	12225	12277
R1 to -3km	23357	23507	23511	23351	23433	23593	23467	23393	23501
R32 to -3km		4984	4987	4953	4972	5003	4976	4962	4978
-3km to R32	4956	4993	4984	4951	4971	5003	4976	4957	4981
R32 to -3km	4957	4988	4983	4954	4971	5003	4976	4964	4986
-3km to R32	4956	4992	4987	4953	4971	5004	4975	4960	4981
R32 to -3km	4956	4990	4983	4950	4970	5004	4975	4959	4980

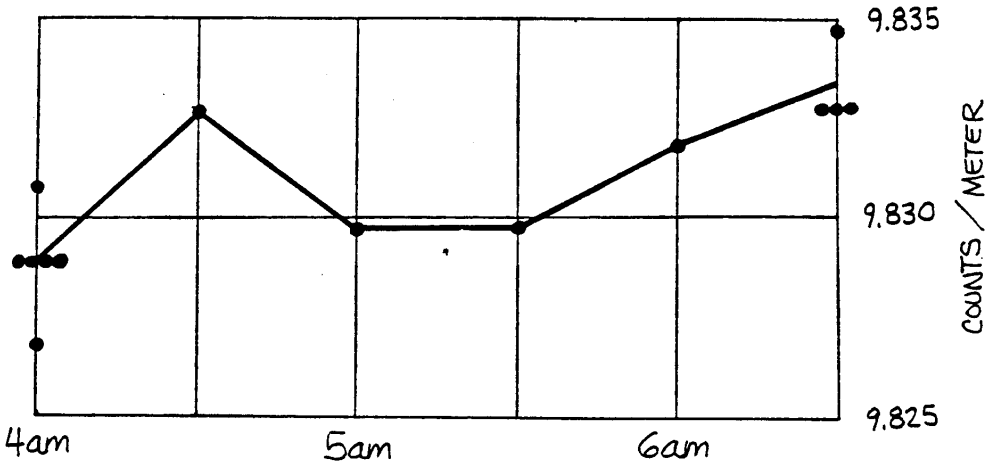
COUNTS PER METER

	BT	JD	KS	KY	LJ	BP	RR	SI	YT
504.03m	9.8288	9.8962	9.8843	9.8208	9.8605	9.9359	9.8685	9.8327	9.9002
504.03m	9.8288	9.8943	9.8843	9.8248	9.8605	9.9280	9.8704	9.8347	9.8903
504.03m	9.8308	9.9002	9.8943	9.8248	9.8605	9.9319	9.8704	9.8367	9.8843
504.03m	9.8288	9.8982	9.8843	9.8228	9.8605	9.9300	9.8685	9.8327	9.8843
504.03m	9.8288		9.8863	9.8228		9.9319	9.8724	9.8367	9.8883
504.03m	9.8268		9.8843	9.8228		9.9280	9.8764	9.8387	9.8843
mean	9.8288	9.8972	9.8863	9.8232	9.8605	9.9310	9.8710	9.8353	9.8887
1181.16m	9.8327	9.8987	9.8809	9.8234	9.8598	9.9326	9.8674	9.8394	9.8843
1628.83m	9.8298	9.8955	9.8832	9.8237	9.8599	9.9299	9.8673	9.8409	9.8838
1628.83m	9.8298	9.8980	9.8863	9.8243	9.8593	9.9293	9.8667	9.8396	9.8752
1181.16m	9.8318	9.8945	9.8860	9.8225	9.8606	9.9283	9.8665	9.8344	9.8886
504.03m		9.8883	9.8943	9.8268	9.8645	9.9260	9.8724	9.8447	9.8764
504.03m	9.8327	9.9062	9.8883	9.8228	9.8625	9.9260	9.8724	9.8347	9.8823
504.03m	9.8347	9.8962	9.8863	9.8288	9.8625	9.9260	9.8724	9.8486	9.8923
504.03m	9.8327	9.9042	9.8943	9.8268	9.8625	9.9280	9.8704	9.8407	9.8823
504.03m	9.8327	9.9002	9.8863	9.8208	9.8605	9.9280	9.8704	9.8387	9.8804
mean	9.8333	9.8990	9.8899	9.8252	9.8625	9.9268	9.8716	9.8415	9.8827
MEANmean	9.8310	9.8972	9.8854	9.8237	9.8604	9.9297	9.8684	9.8385	9.8839

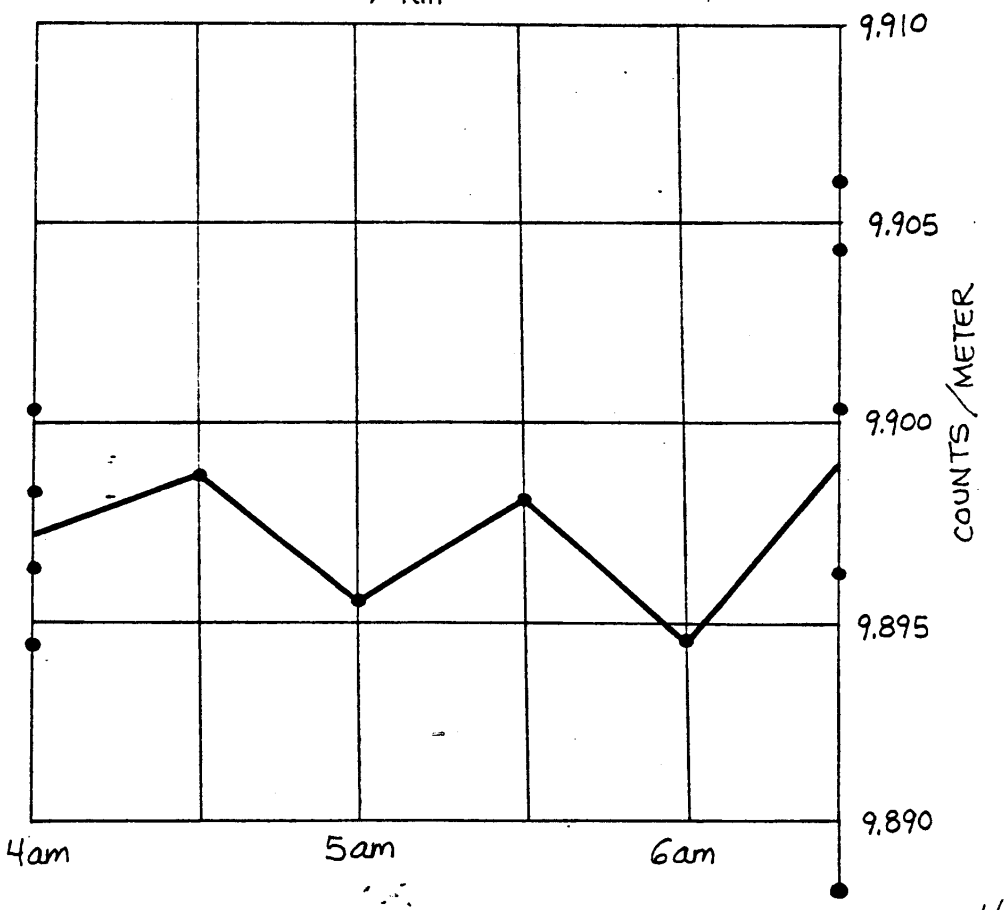
MEANmean is the mean of the means, computed from the mean counts/meter for each baseline.

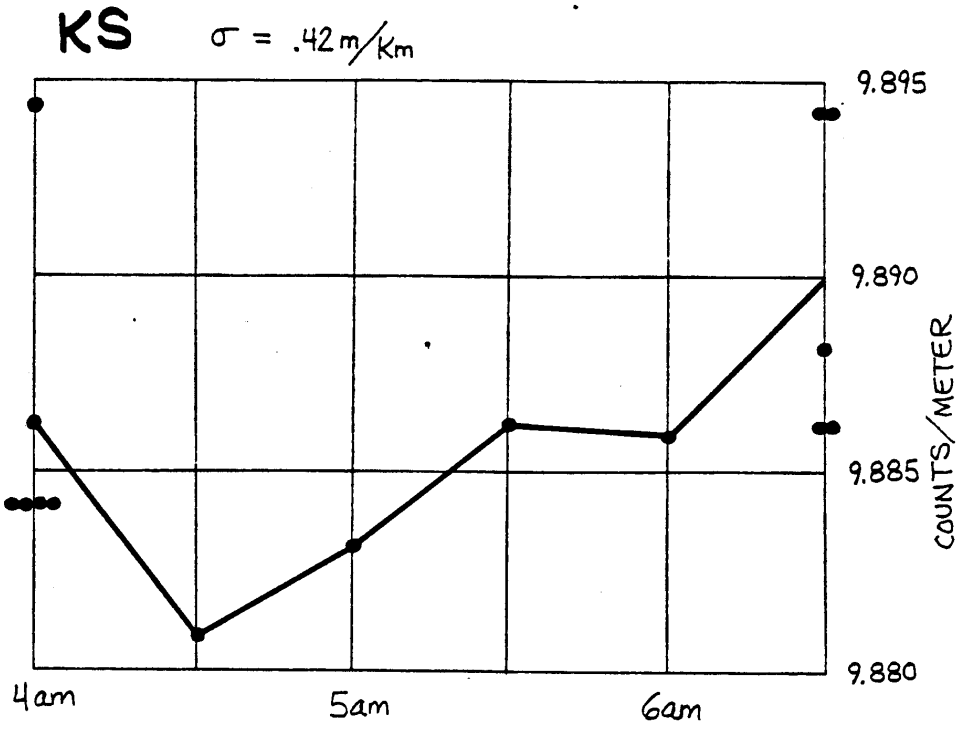
Cyclists rode the 504.03m baseline in both directions simultaneously, causing interference which slightly increased the counts/meter for most cyclists on this interval.

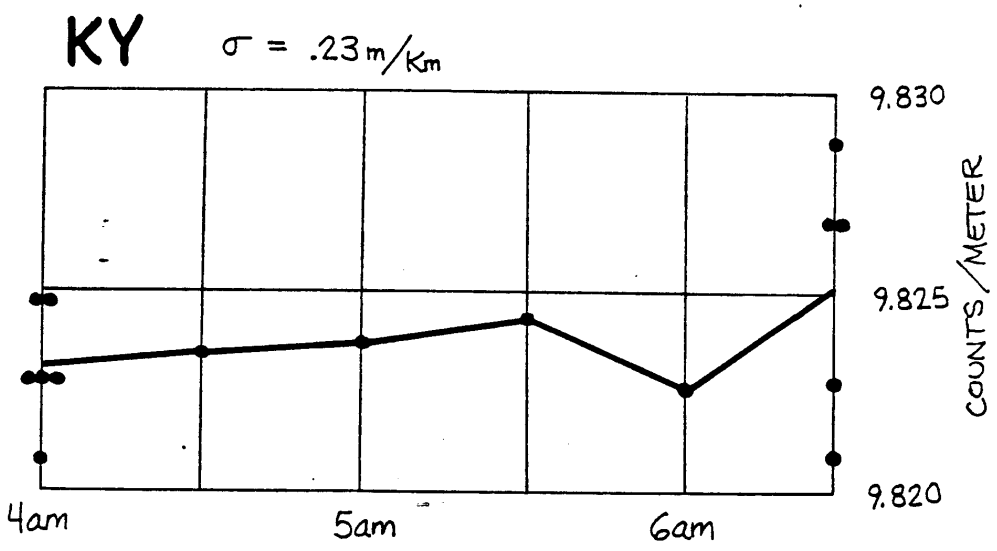
BT σ = .22 m/Km



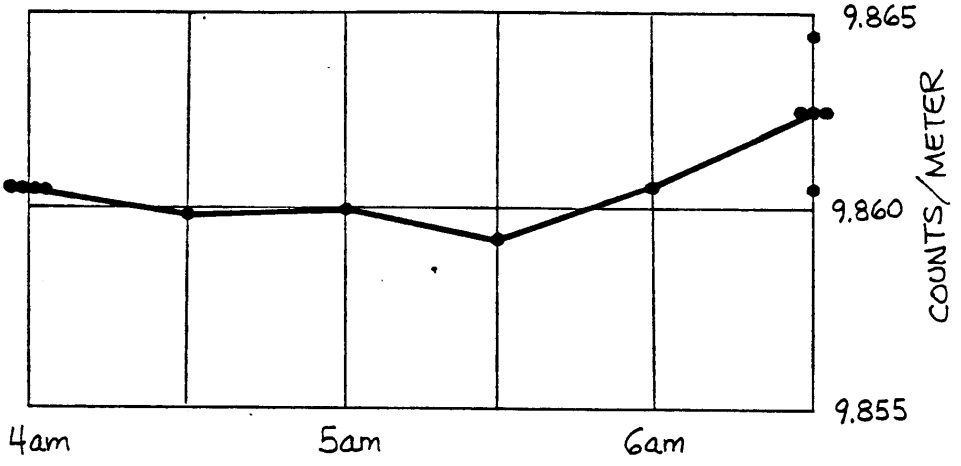
JD σ = .45 m/Km



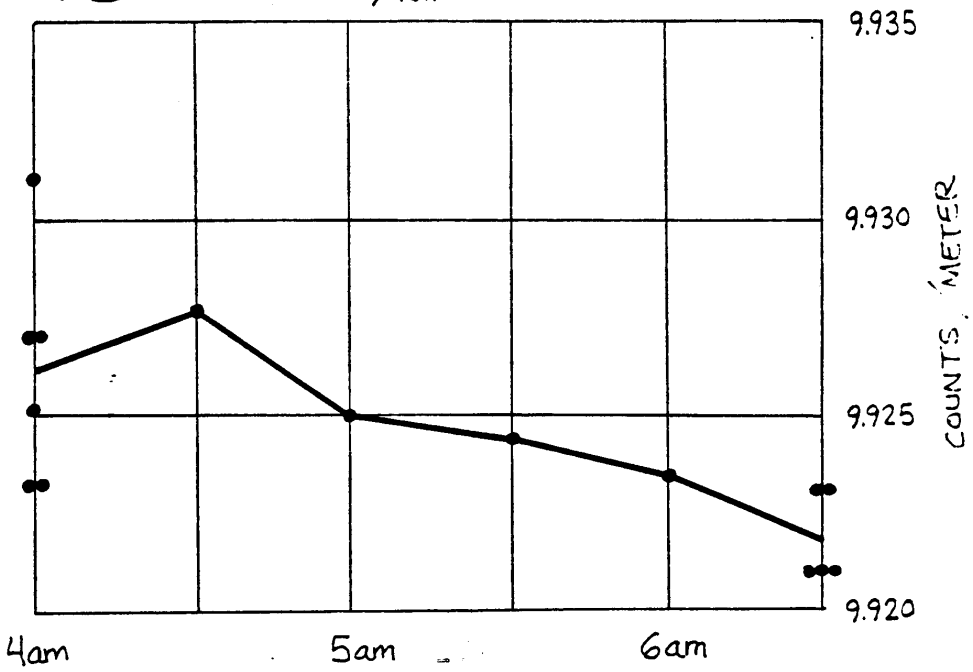

KS
σ = .42 m/Km
9.895
9.890
9.885
9.880
COUNTS/METER
4am
5am
6am

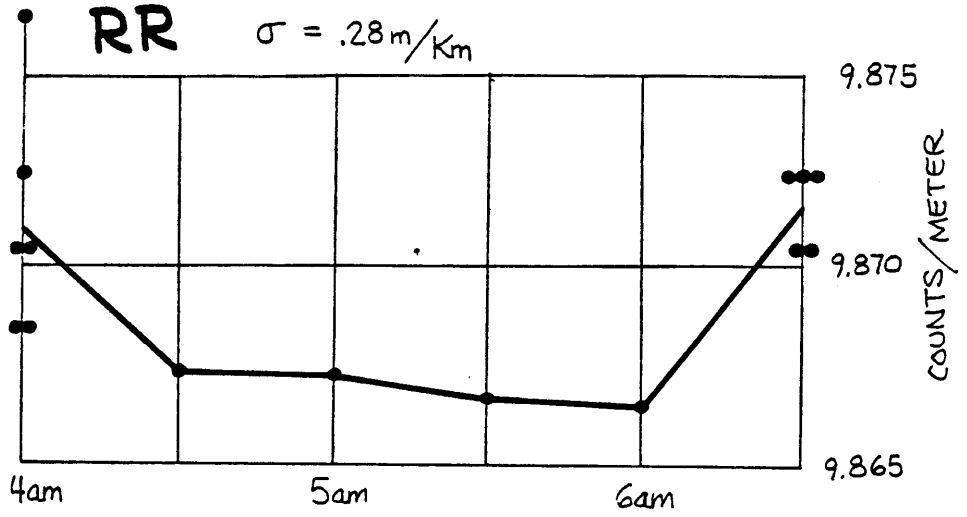

KY
σ = .23 m/Km
9.830
9.825
9.820
COUNTS/METER
4am
5am
6am

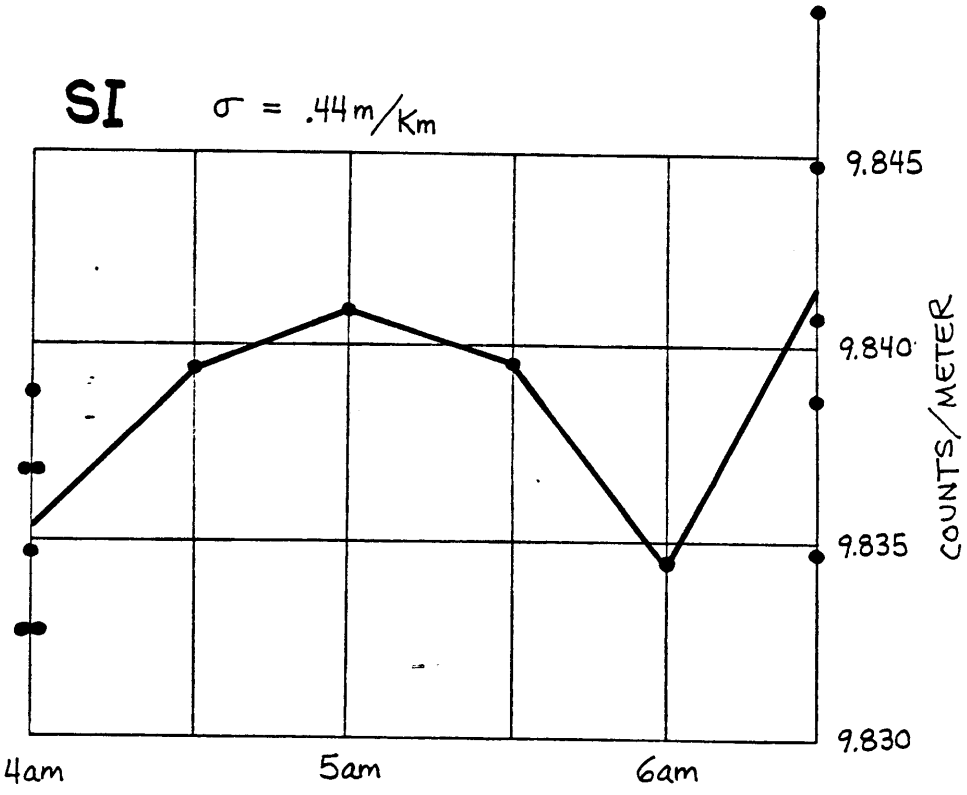
LJ σ = .15 m/Km

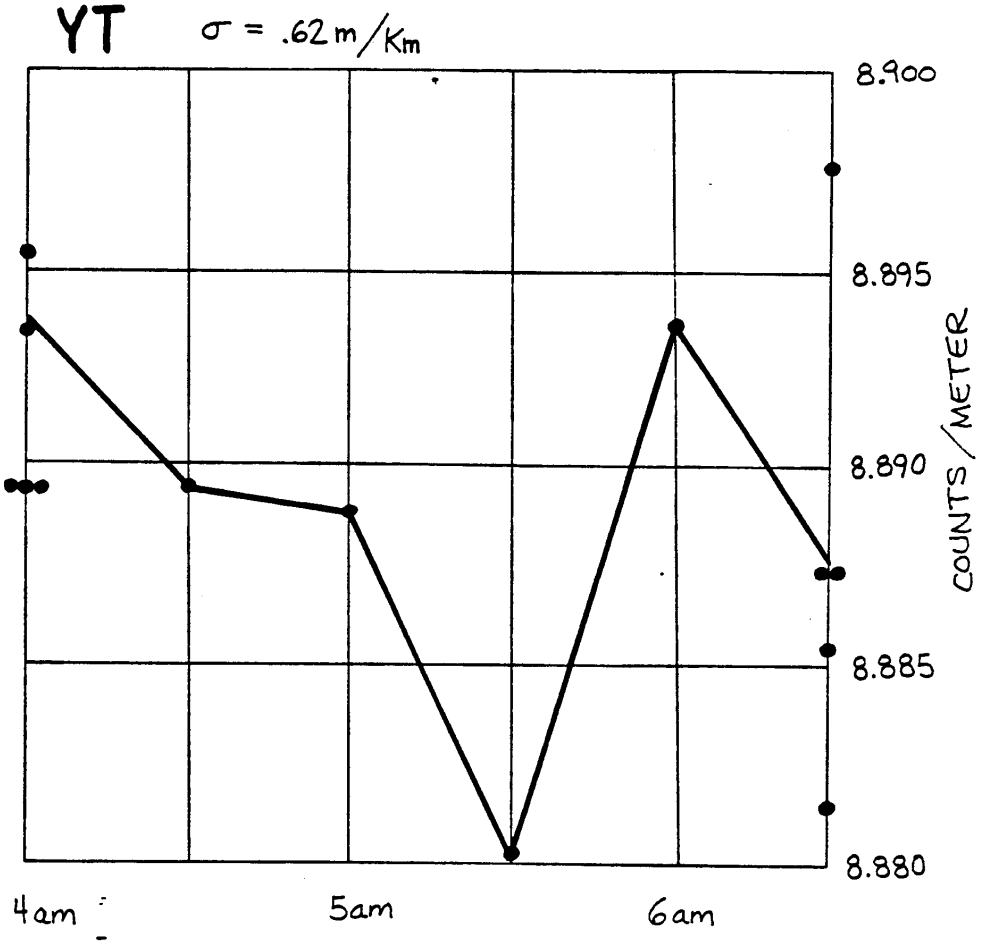


PB σ = .28 m/Km




RR
σ = .28 m/Km
9.875
9.870
9.865
COUNTS/METER
4am
5am
6am


SI
σ = .44 m/Km
9.845
9.840
9.835
9.830
COUNTS/METER
4am
5am
6am


YT
σ = .62 m/Km
8.900
8.895
8.890
8.885
8.880
COUNTS/METER
4am
5am
6am

M E A S U R E D L E N G T H S (meters)

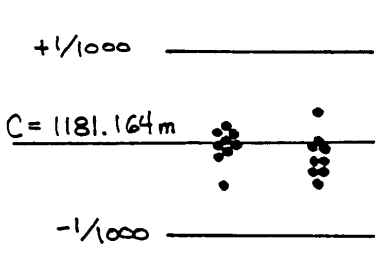
INTERVALS:
A = -3km to R1
B = R1 to R2
C = R2 to R3 = 1181.164 meters
D = R3 to R4
E = R4 to R6 = 1628.83 meters
F = R6 to R7

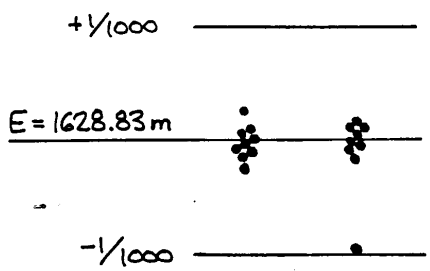
	BT	JD	KS	KY	LJ	BP	RR	SI	YT
A	2375.8	2377.1	2378.2	2378.8	2376.0	2377.1	2376.8	2377.7	2377.2
B	1241.2	1241.0	1242.3	1241.8	1240.8	1241.1	1241.2	1241.6	1241.7
C	1181.37	1181.34	1180.63	1181.12	1181.09	1181.51	1181.04	1181.28	1181.2
D	3086.6	3085.6	3090.0	3088.2	3087.4	3086.3	3087.1	3087.3	3089.0
E	1628.62	1628.54	1628.46	1628.82	1628.74	1628.85	1628.63	1629.21	1628.8
F	1430.6	1430.4	1434.5	1433.4	1430.6	1430.6	1430.4	1431.9	1430.6
F	1430.3	1434.5	1432.6	1431.2	1430.8	1430.4	1431.4	1430.8	1430.3
E	1628.62	1628.95	1628.97	1628.92	1628.64	1628.75	1628.53	1629.01	1627.4
D	3085.4	3083.8	3091.2	3087.2	3087.3	3085.5	3086.8	3087.8	3087.5
C	1181.26	1180.84	1181.24	1181.02	1181.19	1181.00	1180.94	1180.67	1181.7
B	1241.1	1240.8	1242.7	1241.8	1241.4	1241.1	1241.2	1242.6	1242.1
A	2375.9	2375.1	2378.4	2377.0	2376.5	2376.0	2378.0	2377.7	2377.7

MEANmean was used to compute the above lengths.
To test ability of MEANmean for estimating lengths, the following study is performed: MEANmean is used to compute bicycle measurements of the length of the electronically measured base lines that were cycled (C and E). The differences between the bicycle and electronic measurements are listed below:

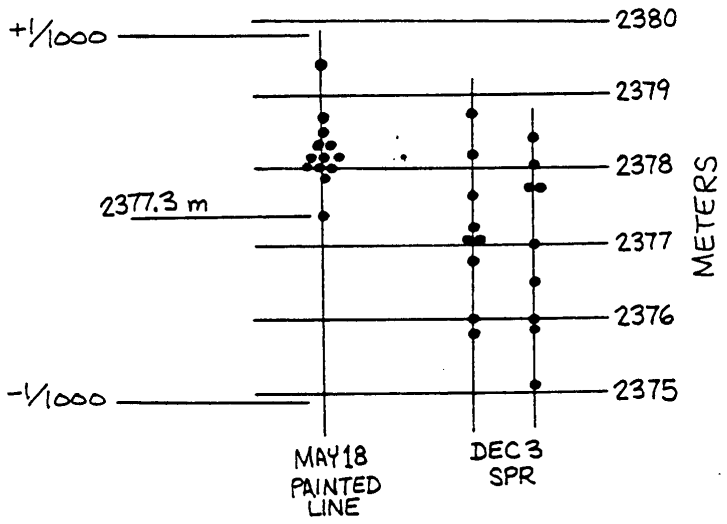
	BT	JD	KS	KY	LJ	BP	RR	SI	YT
C	.21	.18	-.53	-.04	-.07	.35	-.12	.12	.04
E	-.21	-.29	-.37	-.01	-.09	.02	-.20	.38	-.03
E	-.21	.12	.14	.09	-.19	-.08	-.30	.18	-1.43
F	.10	-.32	.08	-.14	.03	-.16	-.22	-.49	.54

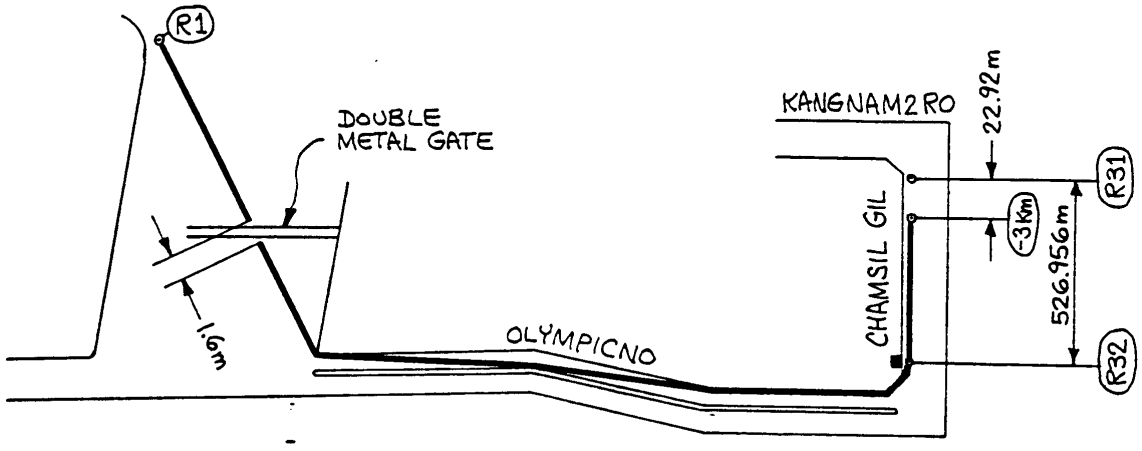
This data demonstrates that MEANmean is an acceptably accurate estimate of counts/meter for computing the length of intervals measured on December 3, 1986. This data also demonstrates that the cyclists are capable of obtaining very accurate measurements of straight intervals.





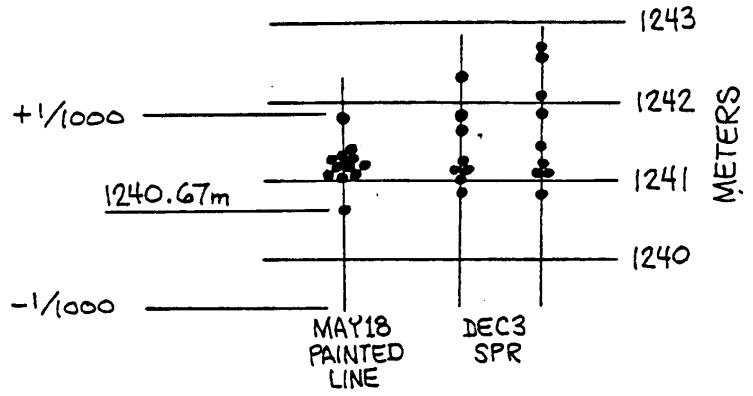
-3KM to R1



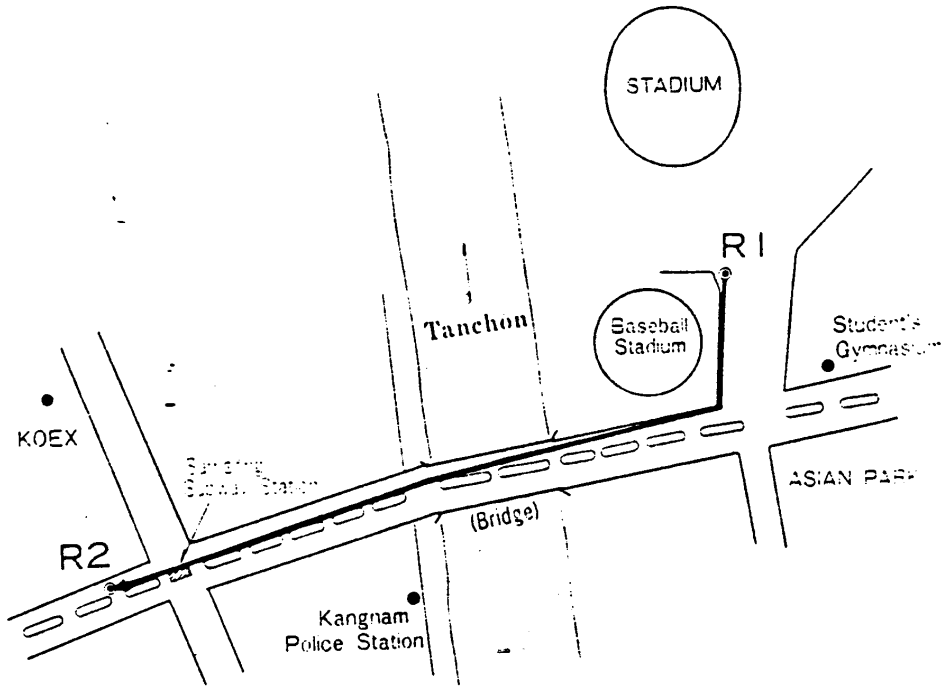


EVALUATION: ALL DEC3 MEASUREMENTS FALL WITHIN THE REGION OF DOUBT AROUND 2377.3 ± 2.38 METERS. THIS INTERVAL IS THEREFORE "ACCURATE". IT IS POSSIBLE THAT SOLITARY BICYCLE MEASUREMENTS WILL INDICATE SHORTNESS OF 2 METERS.

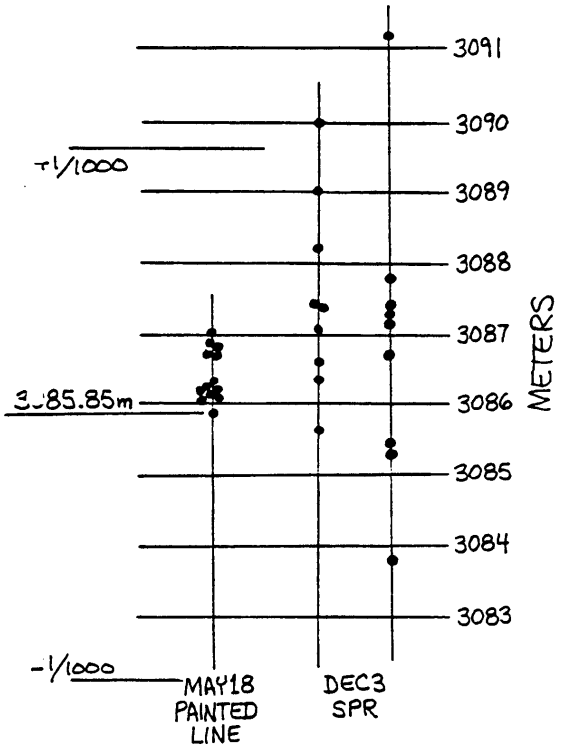
R1 to R2



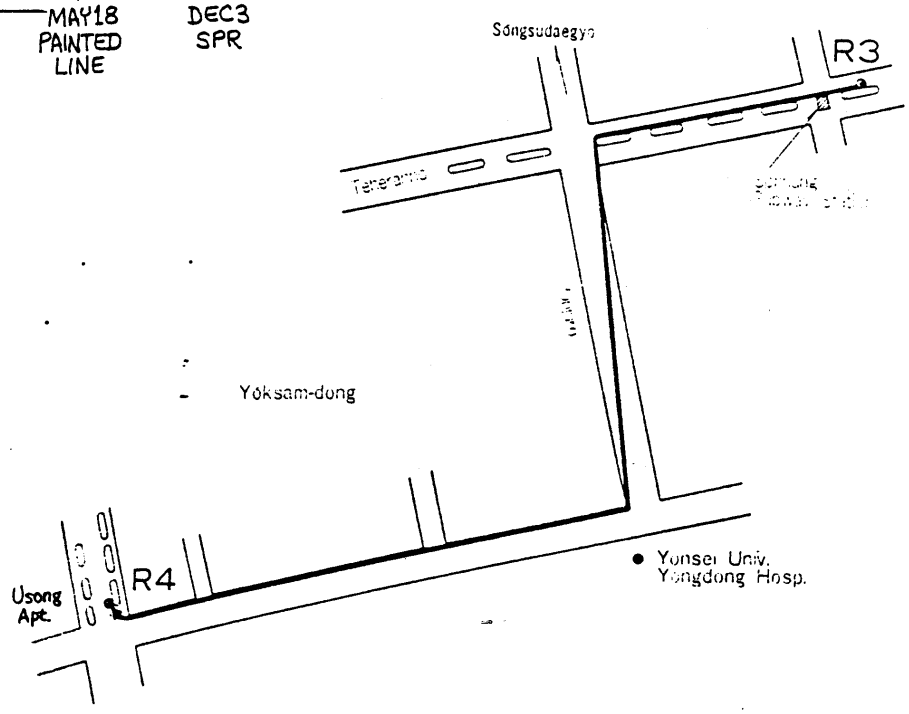
EVALUATION: THIS INTERVAL IS "ACCURATE"



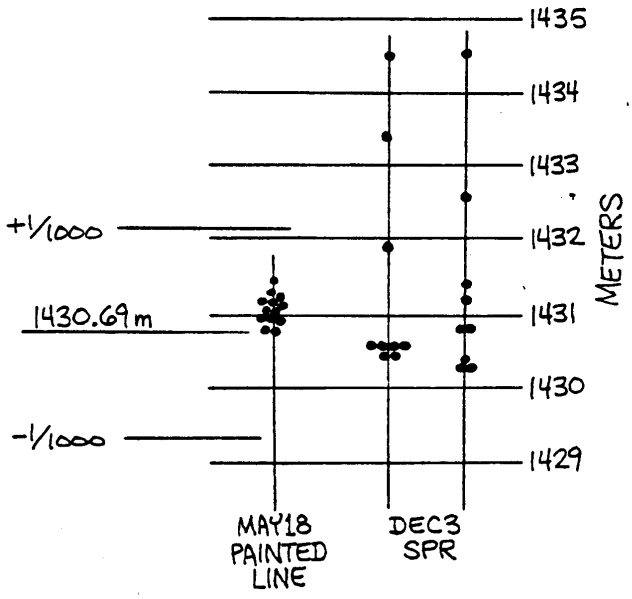
R3 to R4



EVALUATION: THIS INTERVAL IS "ACCURATE". THE DEC3 MEASUREMENTS ARE DISPURSED, BUT LIE WITHIN A RANGE OF ±1/1000 (SPREAD = 1/500). THE MAY18 MEASUREMENTS FORM A TIGHT GROUP, INDICATING EXCELLENCE IN CYCLING ABILITY. THE WHITE LINE (PREDECESSOR OF THE BLUE LINE) WAS CAREFULLY MEASURED ON MAY18.

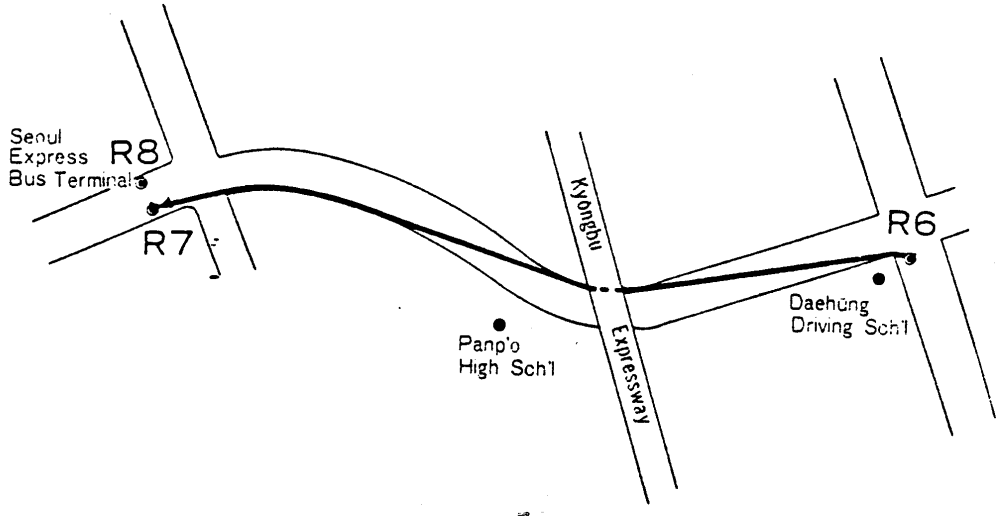


R6 to R7



EVALUATION:

THIS INTERVAL IS "ACCURATE." MAY18 CYCLISTS ARE SUPERIOR BICYCLE RIDERS. HOWEVER, DEC3 CYCLISTS ATTEMPT TO RIDE AN INVISIBLE, THEORETICAL SPR, "WITHIN 30cm of CURB" (BOB THURSTON), OR SIMPLY THE "SHORTEST ROUTE" (LENNART JULIN).



SUM OF ALL MEASUREMENTS

The sum of the lowest measurements for each cyclist, for all bicycle measured intervals (excluding the electronic baselines), is presented in the following table:

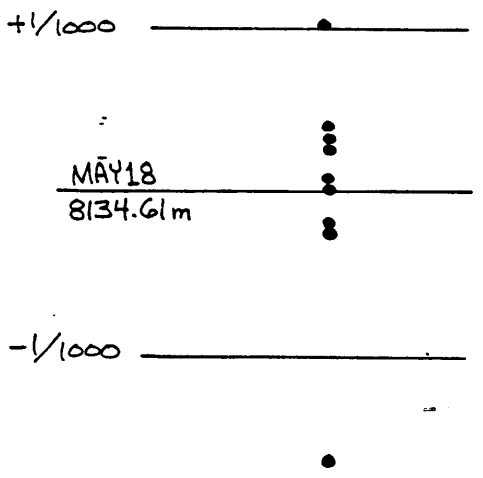
INTERVALS:
- A = -3km to R1
- B = R1 to R2
- D = R3 to R4
- F = R6 to R7

	BT	JD	KS	KY	LJ	BP	RR	SI	YT	May18
A	2375.8	2375.1	2378.2	2377.0	2376.0	2376.0	2376.8	2377.7	2377.2	2377.4
B	1241.1	1240.8	1242.3	1241.8	1240.8	1241.1	1241.2	1241.6	1241.7	1240.67
D	3085.4	3083.8	3090.0	3087.2	3087.3	3085.5	3086.8	3087.3	3087.5	3085.85
F	1430.3	1430.3	1432.6	1431.2	1430.6	1430.4	1430.4	1430.8	1430.3	1430.69
TOTALS:	8132.6	8120.0	8143.1	8137.2	8134.7	8133.0	8135.2	8137.9	8136.7	8134.61
ERRORS:	-2.0	-14.6	8.5	2.6	.1	-1.6	.6	3.3	2.1	

Accuracy of pneumatic bicycle is 1/1000, or 8/8135. The overall May18 measurement for intervals A+B+D+F is judged as follows by the Dec3 measurement:

ACCURATE:	7 bicycles
SHORT:	1 bicycle
LONG:	1 bicycle

This judgement remains the same if an accuracy level of 1/2000 is applied. Therefore, the Dec3 judgement is that the overall measurement for intervals A+B+D+F is "accurate".



C O N C L U S I O N S

The following conclusions are based upon the December 3 sample measurements of the Seoul marathon:

1. Accuracy for the December 3 bicycle measurements appears to about 1/1000 (1/500 spread). This indicates average cycling ability, and measurement of independent lines (i.e., the SPR as judged by each cyclist).

2. Accuracy for the May 18 bicycle measurements appears to be about 1/2000 (1/1000 spread). This indicates superior cycling ability, and measurement of the same line (i.e., a painted white line).

3. Assuming that the accuracy level is 1/1000, the December 3 measurements judge the May 18 measurements of intervals R31-R32-R1-R2-R3-R4-R6-R7 to be "accurate".

4. Accuracy of bicycle measurements seems to be greater for straight routes (1/2000) than curved routes (1/1000).

5. Accuracy of bicycle measurements seems to be greater for experienced bicycle riders than for inexperienced bicycle riders. The May 18 cyclists were highly skilled and had an apparent accuracy of 1/2000. The December 3 cyclists were less skilled and had an apparent accuracy of 1/1000.

6. Painting of the SPR is an excellent technique for several reasons:
   a. Cyclists need not be experienced measurers. Instead, all they need to do is follow the line.
   b. Runners may follow the line to run the shortest distance (i.e., fastest time).
   c. Officials can see the optimum running route without guessing where it should be.

7. If the SPR is improperly painted, conclusion #6 is invalid.

8. The accuracy of courses measured with pneumatic bicycles is not greater than 1/1000, or 42 meters for a marathon, or 8 seconds for 2:08.