



Los Angeles Olympic Organizing Committee

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21 December 1983



Theodore Corbitt Allan Steinfeld Aldo Scandurra

Gentlemen,

At last, after seven months of extensive analysis, we are prepared to present the first of two reports for certification of the 1984 Olympic Marathon. This initial report is most critical because it establishes the length for 98% of the course. The next report will define the locations for the start, finish, and kilometer points.

Enclosed are three copies of the initial report, one for each of you to review and keep. Although the report is lengthy, please note that a summary is contained in the last three pages. Dr. Bob Baumel, Peter Riegel, and I will be happy to answer any questions you may have (see page 12 for addresses and phone numbers). Any edits or ammendments to the report should be addressed to Bob Letson.

When you have completed your review, and approve, please place your signatures on all three copies of the report and on all five cover sheets that have been enclosed with these reports. When all three of you have signed all five cover sheets, please mail them back to me so that I can place them on the reports that will be sent to the three authors (Bob Baumel, Peter Riegel, Bob Letson) and the Los Angeles Olympic Organizing Committee (Bill Bedford and John Brennand).

Your careful consideration is appreciated.

Respectfully submitted,

labert a. Letson

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final review copy

1984 OLYMPIC MARATHON REFERENCE POINTS

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ACKNOWLEDGMENTS

Wally Rick, of Rick Engineering in San Diego, generously donated the HP3810A tachymeter used by Ron Scardera and Bob Letson to establish two 1000m baselines on January 23, 1983.

Lewis and Lewis of Ventura generously provided the Lietz/Sokkisha Model SDM3E tachymeter and bronze monuments used by John Brennand to establish six enroute baselines on March 13, 1983.

John Brennand coordinated the bicycle measurements performed on April 24, 1983, which required the cooperative effort of police from three cities, the California Highway Patrol, two recording teams, and thirteen bicycle measurers.

Dr. Alan Jones, his son Clain, and Bill Noel of New York, deserve our thanks for making available the best bicycle measuring device we know, the "Clain Jones assembly".

AVON financed the lodging and meal expenses for the certifiers who performed the bicycle measurements on April 24, 1983.

Fourteen expert certifiers donated their time and financed their own travel expenses for the bicycle measurements performed on April 24, 1983: Allan Steinfeld, Dr. Bob Baumel, Bob Letson, Carl Wisser, David Katz, Jim Delaney, Paul Christensen, Peter Riegel, Pete Shandera, Ron Scardera, Tom Benjamin, Tom Duranti, Dr. Tom Knight, and Dr. Will Rasmussen.

Peter Riegel and Dr. Bob Baumel devoted hundreds of hours to the analysis of the bicycle measurements performed on April 24, 1983. Peter contributed reams of reports and computer listings which were more comprehensive than anyone expected. And Peter's volumes were ably met by "Baumelian broadsides", fearless incisive reviews that forced us to correct our errors and seek new interpretations. Dr. Baumel's statistical analysis was especially helpful in understanding the significance of the limited number of measurements taken on April 24.

The format and emphasis of this report is attributed to Bob Letson, its primary author.

FREFACE

The 1984 Olympic Marathon measurements, gathered on April 24, 1983, have been viewed from many different perspectives in order to enhance our knowledge, confirm our results, and provide the most accurate course possible that fulfills international standards.

Previous Olympic Marathons were created with a moderate philosophy, based on measuring the probable running route one meter from curbs, and using the average of all good measurements.

The 1984 Olympic Marathon is being created with a new philosophy, borrowed from track and field, which is intolerant of short courses. IAAF Rule 145.5 says that "a Marathon course must be between 42195 and 42245 metres". New TAC rules require that the shortest possible route be measured "12 inches from curbs, or 8 inches from lines", and that a "short course prevention factor" be added to insure against the possibility of a short course.

The short course prevention factor for certification in the United States is 1/1000 of the total length. The concept of short course prevention is analyzed in this report, and statistical methods are presented that attempt to compute an appropriate short course prevention factor for the April 24, 1983, measurements.

The exact location of the start, finish, and kilometer points will be determined after this report has been reviewed, and official lengths have been certified for the intervals measured on April 24, 1983.

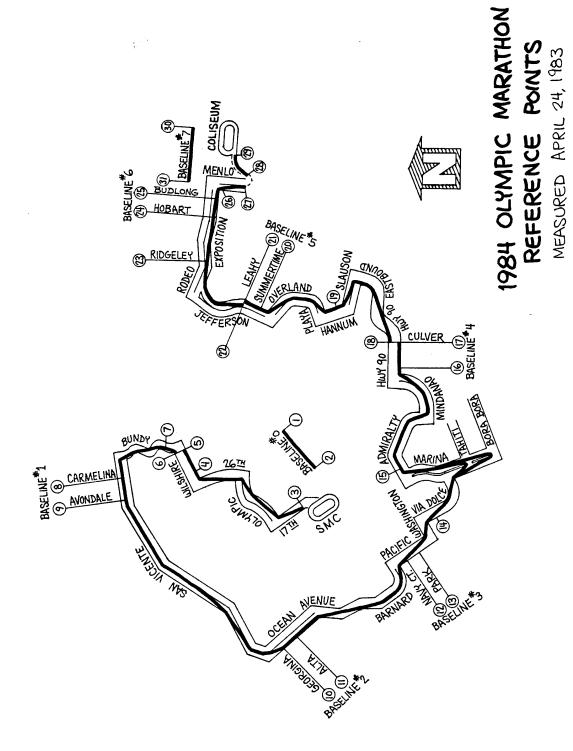
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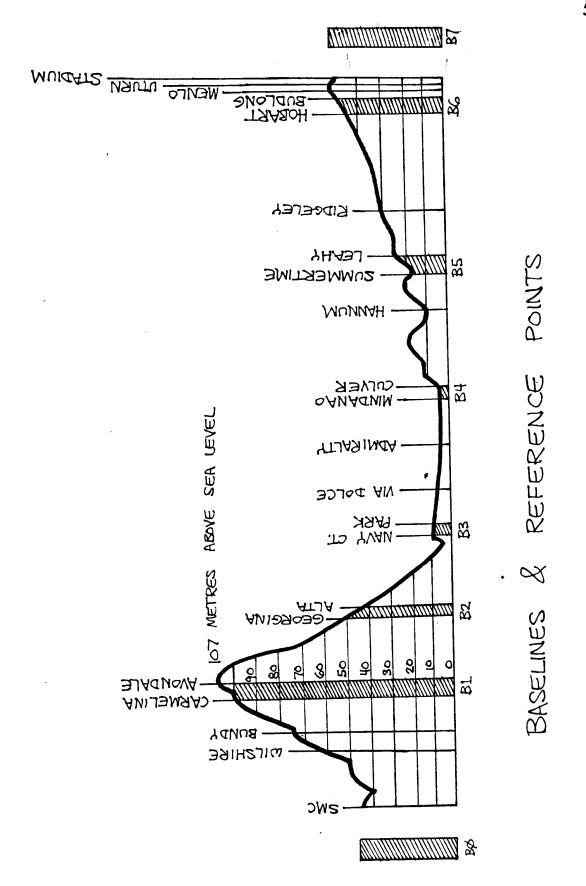
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NOTES

Santa Monica College is no longer a "city" college. All references to "Santa Monica City College" or "SMCC" in this report should be interpreted as "Santa Monica College" or "SMC".

All references to "Stadium" in this report imply the Coliseum.





APRIL 24, 1983

Course Design

The 1984 Olympic Marathon route, measured on April 24, 1983, was merely the final version of several possible routes that had been researched by John Brennand over the previous year. By February, 1983, the final route had been approved by the IAAF, LACOC, Los Angeles County, CALTRANS, and the three cities in which the course was located. John Brennand performed detailed reviews of the final course to determine the exact running route. This final course was again reviewed on April 23, 1983, by the majority of the fourteen expert certifiers who came to Los Angeles at their own expense to measure the Olympic Marathon. All decisions concerning the exact route to measure were resolved the day before the measurement, including the decision to paint dotted lines along wide arcs around two sharp U-turns (to be coned) to allow runners to run them without loss of speed. The exact route measured on April 24, 1983, is defined by maps located in the "Maps and Measurements" section of this report, and is identical to the shortest possible running route within 30 centimeters (12 inches) of curbs and 20 centimeters (8 inches) of lines at turns.

Baselines

Eight baselines were used for the April 24, 1983, measurements. Each of these baselines is located on a straight, flat, paved surface. The detailed measurements and maps for each of these eight baselines is contained in the "Maps and Measurements" section of this report. The length and location of each baseline is listed below:

<u>BASELINE</u>	LENGTH	LOCATION
BO	1000.178m	near the start
B1	955.978m	start + 6km
B2	379.007m	start + 10km
B3	601.258m	start + 14km
B4	768.575m	start + 20km
B5	974.693m	start + 26km
B6	1000.030m	start + 34km
B7	1000.000m	near the finish

Baselines O and 7 were surveyed by Ron Scardera and Bob Letson on January 23, 1983, using an HP3810A tachymeter donated by Rick Engineering of San Diego. The accuracy of the HP3810A was verified by measuring an established 2874.216 ft. baseline on January 24, 1983, which resulted in a difference of five millimeters. Baseline O is slightly oversized because it was originally measured using steel tape. The end points of these baselines are marked with white paint. Both baselines were nationally certified by Ted Corbitt prior to April 24, 1983.

Baselines 1 through 6 are located directly on the marathon route. All of these six baselines were surveyed by John Brennand on March 13, 1983, using a Lietz/Sokkisha SDM3E tachymeter donated by Lewis and Lewis of Ventura. The accuracy of the SDM3E was verified by Lewis and Lewis, and also by measuring the 880 yard marks on baseline 0, which resulted in a difference of one centimeter (0.03 foot) from the length previously measured by the Scardera/Letson HP3810A. The end points for each of the six enroute baselines are marked with bronze monuments, one inch in diameter, epoxied into the asphalt.

Reference Points

Thirty-one reference points were used for the April 24, 1983 measurements. Four of these mark the end points for baselines 0 and 7, and the remaining twenty-seven are located on the marathon course. Thirteen reference points are marked by bronze monuments: one at the first reference point at Santa Monica College (SMC), and one at each end of the six enroute baselines. Four reference points were used to relocate bicycles directly across busy streets (exactly 90 degrees from the direction of the street) at three locations: across Wilshire near Bundy, across the Marina Freeway at the end of baseline 4 near Culver, and across Jefferson at the end of baseline 5. Twenty-three enroute reference points were used as recording points, at which Jones counters were read. All thirty-one reference points are mapped in the "Measurements and Maps" section of this report, and are briefly listed on the following page.

REFERENCE POINTS

R1 R2	NAME	MARK paint paint	GENERAL LOCATION baseline 0, east end baseline 0, west end	(baseline (baseline	
R3 R4 R5	SMC Wilshire	bronze paint	Santa Monica College Wilshire, near 26th Street Wilshire, near Bundy		
R6 R7	Bundy	crosswalk paint	Wilshire, across street from Bundy, near Wilshire	R5	
R8	Carmelina	bronze	San Vicente, near Carmelina	(baseline	1)
R9	Avondale	bronze	San Vicente, near Avondale	(baseline	1)
R10	Georgina	bronze	Ocean, near Georgina	(baseline	2)
R11	Alta	bronze	Ocean, near Alta	(baseline	2)
R12	Navy	bronze	Pacific, near Navy Ct.	(baseline	3)
R13	Park	bronze	Pacific, near Park	(baseline	3)
R14	Via Dolce	paint	Via Dolce, near Washington		
R15	Admiralty	paint	Admiralty, near Marina Dr.		
R16	Mindanao	bronze	Hwy 90, near Mindanao	(baseline	4)
R17	Culver	bronze	Hwy 90, near Culver	(baseline	4)
R18	Culver	paint	Across street from R17		
R19	Hannum	paint	Hannum, near Slauson		
R20	Summertime	bronze	Jefferson, near Summertime	(baseline	5)
R21	Leahy	bronze	Jefferson, near Leahy	(baseline	5)
R22		paint	Across street from R21		
R23	Ridgeley	paint	Rodeo, near Ridgeley 🕡		
R24	Hobart	bronze	Exposition, near Hobart	(baseline	6)
R25	Budlong	bronze	Exposition, near Budlong	(baseline	6)
R26	Menlo	paint	Menlo, near Exposition		
R27	U-turn	paint	Menlo, begin U-turn		
R28	U-turn	paint	Menlo, end U-turn		
R29	Stadium	paint	Coliseum, begin track		
R30		paint	baseline 7, east end	(baseline	7)
R31		paint	baseline 7, west end	(baseline	7)

<u>Intervals</u>

Thirty-two intervals were used for the April 24, 1983, measurements. Detailed maps for all of these intervals are contained in the "Maps and Measurements" section of this report. The following list shows the location and usage of each interval:

INTERVALS

					JREME		BASELINE
	<u>NAME</u>	•	_OCATION	Steel		Bike	Rides/bike
1	411 7	(baseline 0)	R1-R2	2	8	_	4
2 3	Wilshire		R3-R4			9	
	Bundy		R4-R7			13	
4	Carmelina		R7-R8		_	13	
5	Avondale	(baseline 1)	R8-R9		3		1
6	Georgina		R9-R10		_	13	
7	Alta	(baseline 2)	R10-R11		5		1
8	Navy		R11-R12			13	
9	Park	(baseline 3)	R12-R13		4		1
10	Via Dolce		R13-R14			13	•
11		rn (Tahiti)	R14-R15			3	
12		rn (Bora Bora)				22002220	
13*		rn (NW Passage)				3	
14*		rn (Via Dolce)				2	
15*	Olympic tu	rn (Capt. Row)	R14-R15			2	
16*		(Marquesas)	R14-R15			3	
17*	AVON turn	(Tahiti)	R14-R15			5	
18*	AVON turn	(Bora Bora)	R14-R15			3	
19*	AVON turn	(Via Dolce)	R14-R15			2	
20	Mindanao		R15-R16			13	
21	Culver	(baseline 4)	R16-R17		6		1
22	Hannum		R18-R19			13	
23	Summertime		R19-R20			13	
24	Leahy	(baseline 5)	R20-R21		5		1
25	Ridgeley		R22-R23			13	
26	Hobart		R23-R24			13	
27	Budlong	(baseline 6)	R24-R25		8		1
28	Menlo		R25-R26			13	
29	U-turn		R26-R27			13	
30	U-turn arc	length	R27-R28	3		2	
31	Stadium	-	R28-R29			13	_
32		(baseline 7)	R30-R31		7		2

*NOTE: Intervals 11-19 are the "Marina intervals". The only candidates for the Olympic Marathon are intervals 11 and 12. Intervals 13-19 will not be used.

Measuring Instruments

"Jones assemblies" were used exclusively for the Olympic Marathon measurements performed on April 24, 1983. This device was invented by Alan Jones in 1971, was produced and distributed by his son, Clain, from 1973 to 1982, and is now produced and distributed for \$20/each by Bill Noel of the New York Road Running Club, Box 881, FDR Sta., NY, NY 10150. A "Jones assembly" is an industrial Veeder Root counter mounted on a bicycle odometer axle assembly. It has a direct gear drive, counts 20 digits per revolution, and is guaranteed to operate at 500 revolutions/minute for 100 million counts, which is equivalent to 40 miles/hour for 6700 miles when mounted on the front wheel of a bicycle. The best feature of the "Jones assembly" is its reliability. Because it has direct gear drive, the probability for a counter error is essentially zero. The Jones assembly is the best device we know for measuring road race courses.

Two different electronic distance meters (EDM, also known as "tachymeters") were used to establish all of the baselines used for the April 24, 1983, measurements. Rick Engineering donated one of them to establish baselines 0 and 7. Rick Engineering's HP3810A was verified by performing eight measurements of a 2874.216 foot baseline that had been established via 21 measurements by five other EDMs (two HP3800As and three DM60 Cubitapes) in 1973, which resulted in an average HP3810A measurement of 2874.230 feet (difference = 0.014 foot). Lewis and Lewis of Ventura donated the other tachymeter to establish the six enroute baselines. John Brennand verified this instrument by measuring the 880 yard marks on baseline 0, which resulted in a difference of 0.03 foot. Most of the 0.03 foot difference was probably due to ambiguity in the white lines, and crookedness of an expansion joint which marked the 880 yard points for baseline 0.

A commercial 15 foot steel tape, owned by Tom Knight, was used to measure the length of the U-turn arc near the Coliseum. This tape was compared to a surveyor's steel tape owned by Bob Letson. No difference was discernable between these two tapes.

A new 300 foot surveyor's steel tape, owned by John Brennand, was used to perform one measurement on the Coliseum track, from the last reference point used for bicycle measurements (R29, Stadium) 487.88 feet (148.71m) to the beginning of curve at the outside face of curb (marked by an "X" chiseled on top of the curb). The force gauge, wielded by David Katz, was used to maintain 20 pounds tension during this measurement.

Measurers

Thirteen expert certifiers performed the bicycle measurements on April 24, 1983. This elite group had been selected for their experience at successfully obtaining national certifications for road race courses. The collective experience of this group totals over 600 certifications nationwide. Present were three PhDs, three members of the national TAC LDR Standards Committee, six chairmen of certification committees covering seven states, and virtually all of California's best certifiers. The names and addresses of these thirteen certifiers are listed on the following page.

Each measurer was assigned a two-letter code that was used for quick identification at each reference point. The two-letter codes used on April 24, 1983, are as follows:

- BB Bob Baumel
- BL Bob Letson
- CW Carl Wisser
- DK David Katz
- JD Jim Delaney
- PC Paul Christensen
- PR Peter Riegel
- PS Pete Shandera
- RS Ron Scardera
- TB Tom Benjamin
- TD Tom Duranti
- TK Tom Knight
- WR Will Rasmussen

Recording Teams

Two recording teams, under the direction of John Brennand and Allan Steinfeld, were used to record the Jones counter readings on April 24, 1983. The teams performed in a leap-frog fashion: while one team was recording, the other team traveled to the next reference point. Each team had a van for transportation, a black notebook, and several people who shared in the records duties. Each cyclist announced his two-letter identity code upon arriving at each reference point, and the team captain recorded it. One assistant helped position the bicycle over the reference point and read the Jones counter aloud, then the team captain wrote the number in the notebook and repeated the number aloud. In addition to this, some bicyclists recorded their own counts on their own paper, and verified the number recorded by the team.

MEASURERS

- BB Dr. Bob Baumel, Certificates Chairman for OK-TAC 129 Warwick Rd.; Ponca City, OK 746Ø1 (4Ø5) 765-ØØ5Ø h 767-4655 w
- BL Bob Letson, Certificates Chairman for PSA-TAC 4369 Hamilton St. #4; San Diego, CA 92104 (619) 298-0924 h 225-8401 x249 w
- CW Carl Wisser, Certificates Chairman for PA-TAC 2608 Ninth St.; Berkeley, CA 94710 (415) 549-3687 w
- DK David Katz, Member, TAC LDR Standards Committee P. O. Box 822; Port Washington, NY 11050
- JD Jim Delaney, San Luis Obispo area certifier 128 Seacliff; Pismo Beach, CA 93449
- PC Paul Christensen, Portland area certifier 3715 NE 18th; Portland, OR 97212
- PR Peter Riegel, Certificates Chairman for OH,IN,KY,TN-TAC 3354 Kirkham Rd.; Columbus, OH 43221 (614) 424-4009 w 451-5617 h
- PS Pete Shandera, PA-TAC Certifier 40 Santa Fe; Pt. Richmond, CA 94801 (415) 234-8322
- RS Ron Scardera, Certificates Chairman for SPA-TAC 6907 Camrose Dr.; Los Angeles, CA 90068 (213) 874-6867 h
- TB Tom Benjamin, PA-TAC Certifier P. O. Box 8715; San Francisco, CA 94128
- TD Tom Duranti, Certificates Chairman for WA-TAC 9907 NE 124th St.; Kirkland, WA 98033
- TK Dr. Tom Knight, PA-TAC Certifier 724 Arastradero Rd. #107; Palo Alto, CA 94306 (415) 856-3349 h 854-3300 ×2065 w
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Lead Cyclist

Ron Scardera, the local certification chairman for the Los Angeles area, was lead bicyclist because he knew the course better than any of the out-of-town certifiers. With the records van up front, and Ron Scardera leading the way, the remaining cyclists had little doubt concerning the specific route to measure. Most measurers acted independently, using Ron Scardera merely as a general guide, and always following their own judgement concerning the shortest possible route along the course that had been reviewed the previous day.

Weather

The weather was less than ideal. Rain that had drizzled throughout the night continued into the first 15 kilometers of the measurement. Fortunately the wind was gentle (about 5-10 knots), and the temperature was fairly constant, around 65° F. But everyone and everything was drenched for the first few hours. The drizzle began to cease after baseline 3, and the road surface remained wet until reaching Via Dolce at about 18 kilometers. At Via Dolce we regrouped and spent about one hour planning and executing the measurements for nine separate intervals for the Avon Marathon and Olympic Marathon. Only one of these intervals would be selected for the final versions of each course, to optimize the locations for the start and finish. During this hour the sun appeared and dried the bicycles and road completely. The remainder of the day was dry and mostly sunny, with the temperature hovering around 72° F from Admiralty to the Coliseum.

Total Time

The measurements on April 24, 1983, were performed in a time span of seven hours, beginning at 6 AM and ending at 1 PM. The actual marathon course measurements were performed from 8:30 AM to noon.

Errors

In addition to expected random errors, there were some notable imperfections in the April 24, 1983, measurements. All of these imperfections were associated with a minority of the measurers, thereby causing minimum impact on the overall measurement. The majority of good measurements rendered these few imperfections insignificant.

- a. Bob Letson and Paul Christensen made an illegal course cut by failing to ride around the center-line of Ocean Ave., the agreed turning point for the left turn from San Vicente onto Ocean Ave.
- b. Ron Scardera made two overly wide left turns, from Bundy onto San Vicente, and from Highway 90 onto Slauson.
- c. Six cyclists rode past the end of baseline 6, and walked back about 40 meters to the reference point. One of the cyclists, WR, swerved significantly before stopping.
- d. Five cyclists walked an estimated average of 15 meters while approaching and departing reference points, with their weight removed from their bicycles while walking.
- Baseline 2 (B2) was ridden so slowly that many cyclists wobbled. Also, the south end of B2 is slightly curved.
- f. Baseline 7 had two hazards that tended to elevate the counts/km: a busy cross street at which everyone stopped, and some broken glass around which some cyclists rode.
- g. Parked cars seemed to block the shortest possible route on Bundy.

Remeasurement, 5 June 1983

Tom Knight performed a serious remeasurement of many of the the Olympic Marathon intervals while riding in front of the Avon Marathon race on June 5, 1983. Tom's measurements were superior at only one interval, on Bundy to Carmelina, where parked cars seemed to block the shortest route for the April 24 measurement. Except for one wrecked car, there were absolutely no parked cars on Bundy during Tom Knight's remeasurement. Tom's remeasurement was about Ø.2m less than the best measurement from April 24 for this 1593m interval.

Steel Tape Measurements

The following locations, mapped in the "Maps and Measure-ments" section of this report, were measured via steel tape:

- a. Wilshire & Bundy: A temporary plywood wall extends Ø.79 meters (2'7") from the curb onto Wilshire, measured by Ron Scardera, October 16, 1983.
- b. Via Marina turnarounds (Tahiti, Bora Bora): Wide arcs are painted for these 180° turns, to be coned, with a radius 3.66 meters (12°0"), and an apex 2.65 meters (8'8") south of the apex of the concrete center island, measured by Ron Scardera, October 16, 1983.
- c. U-turn at the Coliseum: A wide arc is painted for this 135° turn, to be coned, with a length of 15.76 meters, measured by Tom Knight and Bob Letson, June 4, 1983.
- d. First straightaway in the Coliseum: This interval, from R28 to the beginning of the SW curve (marked with an "x" chiseled on top of the curb), touching the curb, has a length of 148.71 meters (487.88'), measured by John Brennand, David Katz, and Bob Letson, April 24, 1983.

Reports

John Brennand mailed photocopies of all records taken on April 24, 1983, to each measurer within the week following the measurement. Included were photocopies of the electronic meter measurements for the six enroute baselines. The following pages contain all of the raw Jones counter readings from this initial report from John Brennand.

A few preliminary reports were generated from Peter Riegel, Bob Baumel, and Bob Letson in May, 1983, which presented a variety of interpretations of the April 24, 1983, measurements.

Peter Riegel, Bob Letson, and Bob Baumel spent the next seven months shooting "broadsides" at each others' work, which succeeded in eliminating many errors from our analysis of the April 24, 1983, measurements. More than forty computer programs written in Pascal and Basic were used to eliminate human error in performing the repetitive calculations for each of the thirteen measurers. Many methods of analysis were explored, all which served to double-check our results. This report embodies the lastest version of our work, which we now believe is adequate for determining the official lengths of the intervals measured on April 24, 1983.

RAW JONES COUNTS

	REFE	RENCE POINT	BB	BL	CM	DK
,	R2		561500	090000	082878	314000
ВО	R1		570902.5	099499	092517.5	323601
	R1		571000	099499	092517.5	323601
BO	R2		580404	108998.5	102162.5	333200
	R2		580500	113000	102162.5	333200
BO	R1		589902	122499	111804.5	342799
	R1		590000	122499	111804.5	342799
BO	R2		599403	131997	121450	352399
	R3	SMC	622000	162000		37500 0
	R4	Wilshire	650184	190477	278888	403777
	R7	Bundy	662347.5	202764	291354.5	416196
	R8	Carmelina	677329	217896	306718	431494
B1	R9	Avondale	686314	226973	315932	440667
	R10	Georgina	719898.5	260888	3 5 03 79	474968
B2	R11	Alta	723462	264488	354033	478606
	R12	Navy Ct.	763249	304696	394844.5	519230.5
ВZ	R13	Park	768900	310407	400637	524999
	R14	Via Dolce	786917.5	328618	419110	543391
	R15	Admiralty	819947	347586	450516.5	571678
	R15	Admiralty	844916	366816	485564.5	602894
	R16	Mindanao	868865	391041	510137	627358
B4		Culver	876080.5	398337	517537	6 34726
	R19	Hannum	916151	438867	558649	675666
	R20	Summertime	935242	458176	5 78234.5	695170
B5		Leahy	944388	467429	587617	704510
	R23	Ridgeley	970478	493812	614379	731164
	R24	Hobart	1020292	544187	665468.5	782038
B6	R25	Budlong	1029678	553679	675094.5	791628
	R26	Menlo	1035414	559479	680980.5	797487
		U-turn	1040818	564945	686524	803006
	R29	Stadium	1042403.5	566547	688148	804621
	Ŗ30		1063000	582720	714854	820400
B7	R31		1072385	592214	724482	829984
B7	R30		1081770.5	601707	734110	839569

*Jones counts for R18, R22, and R28 are identical to R17, R21, and R27 respectively.

R	A la	Ι	· n	N	F	5	~	Ω	11	N	T	

	REFE	RENCE POINT	JD	PC	PR	PS
	R2		062000	050000	364500	024366
во	R1		071601	059458	373848.5	033728
	R1		071600	059458	373848.5	033728
BO	R2		081199	068916	383198	043092
	R2		081200	068916	383198	043092
BO	R1		090 799	078374	392546	052456
	R1		090800	078374	392546	052456
во	R2		100401	087832	401898	061822
	R3	SMC	104000	110000	425000	
	R4	Wilshire	132783	138361	453028	513758
	R7	Bundy	145192	150600	465118	525883
	R8	Carmelina	160489	165670	480014	540802
B1	R9	Avondale	169661	174706	488948	549754
	R10	Georgina	203939	208476	522344	583212
B2	R11	Alta	207572	212061	525885	586763
	R12	Navy Ct.	248196	252086	565443	626405
B 3	R13	Park	253966	257772	571060	632036
	R14	Via Dolce	272361	275900	588975	649992
	R15	Admiralty	300654.5	294783	619428	677617
	R15	Admiralty	332595	312747	653539	708249
	R16	Mindanao	357053	336862	677360	732119
B4		Culver	364419	344121	684532	739310
	R19	Hannum	405335	384456	724383	779244
	R20	Summertime	424832	403672	743367	798269
B5	R21*	Leahy	434169	412875	752462	807383
	R23	Ridgeley	460809	439132	778411	833382
	R24	Hobart	511657.5	489262	827938	883008
B6	R25	Budlong	521244	498711	837268	892361
	R26	Menlo	527103	504483	842971	898077
	R27*	U-turn	532617	509921	848345	903463
	, R29	Stadium	534238	511512	849923	905038
	R30		562200	538277	876400	952706
B7	R31		571782	547722	885736	962059
B7	R30	•	581364	557169	895071	971411

^{*}Jones counts for R18, R22, and R28 are identical to R17, R21, and R27 respectively.

RAW JONES COUNTS

	REFERE	NCE POINT	RS	ТВ	ΤD	ΤK	WR
BO	R2 R1		132240 141638	058000 067427	021500 030843	015000 024293	027200 03 688 0
во	R1 R2		141638 151039	067427 076857	030843 040190	024293 033588	03 688 0 0 465 61
ВО	R2 R1		151140 160540	076857 086288	040190 049533	033588 042881	046600 056279
во	R1 R2		160540 169942	086288 095719	049533 058880	042881 052176	056279 065960
БU	R3 S	SMC	188900		085000		085000
	R7 B	Jilshire Bundy Carmelina	217093 229256 244263	138026 150222 165254	113036 125127 140020	093474 105497 120302	114026 126551.5 141972
B1 B2	R10 G	Avondale Georgina Alta	253248.5 286831 290393	174268 207956.5 211528	148955 182340 185878	129184 162392 165915	151220 185778 189444
B3	R12 N	lavy Ct. Park	330185.5 335835	251440.5 257109	225407 231023	205256 210843	230392 236208
		lia Dolce Admiralty	353845.5 386869	275184 293995.5	248931 273790	228657 253388	254751 280496
		Admiralty Mindanao	411724 435679	312704 33673 5	298229 322038	278803 302485	30587 9 330531
B4		Culver Hannum Gummertime	442894 482996.5	343971 384177 403328	329207 369037 388013	309618 349240 368117	337957 379213 398868
B5	R21* L R23 R	eahy Ridgeley	511226 537310	412501 438666	397101 423026	377162 402 95 7	408281 435137
B6	R25 B	Hobart Budlong Menlo	587105.5 596490 602223	488629 498044 503792	472511 481838 487535	452205 461483 467152	486386.5 496056 501960
	R27* U		607625 609201	509211 510799.5	492904 494472	472496 474062	507522 509151.5
F1 -7	R30		635400	547413 554887 5	521866 531193.5	518561 527841	534000 547//2 F
B7 B7	R31 R30		644779.5 654155	556823.5 566234.5	531193.5 540515	527841	543662.5 553322.5

 $\star J \text{ones}$ counts for R18, R22, and R28 are identical to R17, R21, and R27 respectively.

JUNE 5, 1983

The Avon Marathon, Sunday, June 5, 1983, provided a unique opportunity to ride bicycles ahead of the runners, with streets totally blocked by police, and with no parked cars on Bundy. Dr. Tom Knight (TK), Ron Scardera (RS), and Bob Letson (BL) seized this opportunity to review the Olympic Marathon course, and perform various remeasurements.

On Saturday, June 4, 1983, Tom Knight and Bob Letson reviewed the Olympic Marathon route to confirm the locations of all of the reference points used during the April 24 measurement, and to steel tape the U-turn arc at the coliseum.

On Sunday, June 5, 1983, Tom Knight, Ron Scardera, and Bob Letson performed calibrated bicycle measurements of many of the Olympic Marathon intervals while riding several hundred yards ahead of the Avon Marathon runners. Bob Letson was diverted from this task by repositioning cones, barriers, and spectators for optimal execution of the Avon Marathon. Tom Knight concentrated on remeasuring the Olympic Marathon intervals. Ron Scardera concentrated on measuring the Avon Marathon route as marked, for validation. Consequently, the best Olympic Marathon remeasurements were obtained by Tom Knight.

The map and data for the June 5, 1983, bicycle measurements are on the following pages. Note that Tom Knight rode one of the Olympic Marathon intervals incorrectly, from Admiralty to Mindanao, where the Olympic route should be on the right side of Mindanao. A summary of the Olympic Marathon intervals measured on June 5 is listed below. The "best" (lowest) measurement from April 24, 1983, is in the right column. (meters)

TERMINUS	RS	TK	BL	BEST ₄₋₂₄₋₆₃
Bundy	1296.2	1296.1	1298.5	(1292.96)
Carmelina	1594.8	1592.8	1594.2	(1592.96)
Georgina	3573.6	3573. <i>7</i>	3573.7	(3571.46)
Navy Ct.	4235.7	4234.6		(423Ø.94)
Via Dolce		1917.4		(1916.35)
Mindanao	2554.4			(2549.56)
Hannum	4271.2	4269.8	4271.3	(4267.21)
Summerti me	2034.6	2033.8		(2033.32)
Menlo	611.0	610.8		(610.65)

The "best" April 24 measurements were bettered only once, by Tom Knight, for the interval ending at Carmelina.

SUNDAY 6-5-83 AVON MARATHON

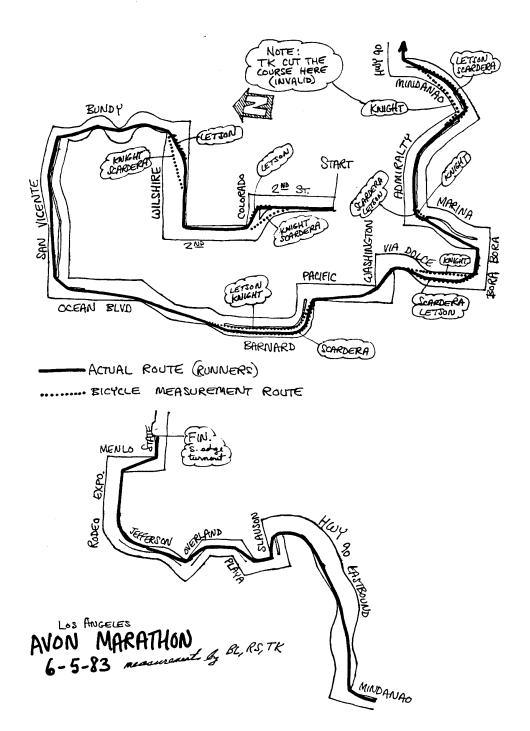
RON SCARDERA	Tom KNIGHT	BOB LETSON!
408610 3.	062000	12000 -
427424.5	085564	30999
436832.5	089845.5	49998 \$

SANTA MONICA 1000-178 METERS. 5:30 AM CALIBRATION

Г	110-222	126000	- 87000	AVON START (17'1" S. of "AVON")
1	483000	136000	087300	
L			118105	
4	522217 10.0		12701348	
-	534405,00	186707,26	139346	LINE ~50y N of WILSHIRE on BUNDY
	543708,0	195873,49		"4" MILES
-[54940164		154488	
\dashv	558389	210359	J63567 🖏	AVONDALE (B.M.)
4	59199035	2435 224	197510 351	51 GEORGINA (B.M.) } 1243.46'
-	595552.5			ALTA (B.M)
	Ţ	285411	240403,28	"10" MILES, BARNARD & PACIFIC
-	635379	286335\$		NAVY CT. (B.M.)
4	641032	291914		PARK (B.M.)
-[3097078		VIA DOLCE (LINE) S, SIDE MAILBOX
+	684537	334770		ADMIRALTY (LINE) LAMPOST 5/21
-	7085556	358241,48	315284	MINDANAO (B.M.) } 2521.57'
-	715782	365378		CULVER (B.M.)
Γ		3897085		"17" MILES
	,	, 404737 M	1	"18" MILES
-	755943	4050000	363153	HANNUM (UNE) GO, N of SLAUSON
4		423 873 g		3 SUMMERTIME (B.M.)
4	860269	507968	468546.0	HOBART (B.M.)
4	869667.5	517247	478044	BUDLONG (B.M.)
+	875413,19	522915 ₁₀		MENLO (LINE) 30,2 of EXPOSITION
	880052	527488 ₃ 9	488549,	AYON FIN. (W. EDGE PARKING TURNOUT)

			_
900300	535 <i>0</i> 00	09000	l
909699	544 278	18499	
919098	553558	27996	1
0,00	562837	œ	١
939	572114 &	676	
9402.7/km	9279.6/Km	9498/Km	_
15132 MILE	14934 MILE	15286/mile	

9:15 AM CALIBRATION COLESEUM 1000.00 METERS



INTERVALS MEASURED BY EDM & STEEL TAPE

The following portions of the Olympic Marathon were measured by electronic distance meters (EDM) or steel tape:

Baselines 1-6 Construction at Wilshire & Bundy Wide arcs for Marina intervals Wide arc for U-turn at coliseum First straightaway in coliseum

<u>Baselines 1-6</u>

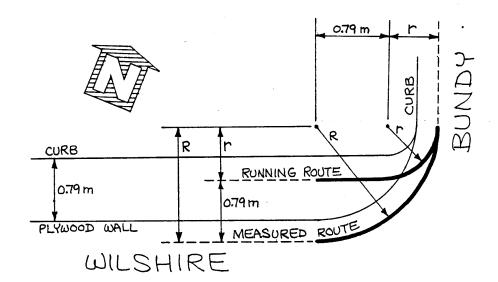
Each of the six enroute baselines has a minimum of four measurements via Lietz/Sokkisha Model SDM3E tachymeter. The length and "spread" (distance between the highest and lowest measurements) for each baseline are listed below: (meters)

BASELINE	LENGTH	SFREAD
1	955.978	0.006
2 3	379.ØØ7 6Ø1.258	0.003 0.009
4 5	768.575 974.693	0.003 0.00 9
6	1000.030	Ø.Ø12
TOTAL =	4679.541	Ø.Ø42

The SDM3E is an infrared EDM that has an advertised accuracy of (1cm + 1/100,000) per measurement. For the total length of all six baselines, this represents an accuracy of (0.047m + 0.06m), or about 11 centimeters. This means that the total length of all six baselines is not less than (4679.54m + 0.11m), or 4679.43m.

Construction at Wilshire & Bundy

All 13 measurers on April 24, 1983, were unable to measure 30cm from the curb while making the left turn from Wilshire to Bundy. Instead, all bicycles measured 30cm from a temporary plywood wall 0.79 meters (2°7") from the north curbline of Wilshire, measured via steel tape by Ron Scardera, October 16, 1983. This plywood wall has a large radius curve onto the top of the west curbline of Bundy, as shown on the following page. The difference between the measured route and official running route is computed below the diagram.



$$R = r + 0.79 \text{ m}$$

MEASURED ROUTE = $\frac{\pi}{2}R = \frac{\pi}{2}(r + 0.79 \text{ m})$

RUNNING ROUTE = $0.79 \text{ m} + \frac{\pi}{2}r$

DIFFERENCE = $0.79 \text{ m} \left(\frac{\pi}{2} - 1\right) = 0.45 \text{ m}$

The route measured on April 24, 1983, was 45 centimeters longer than the official running route. Consequently, 45 centimeters must be subtracted from the bicycle measurement from Wilshire to Bundy.

<u>Wide Arcs for Marina Intervals</u>

Wide arcs were painted with dashed white lines around each of the Marina interval turnarounds. Only one of these turns will be used for the final course. Cones or barriers must be placed on top of this painted arc to prevent the possibility of a shorter route during the Olympic race. The bicycle measurements were performed by riding within $2\emptyset$ centimeters of these lines. Each of these arcs has the same radius, $3.66m~(12^\circ9")$, with the center of arc exactly one meter north of the apex of the concrete center island. These dimensions were measured by Ron Scardera via steel tape on October 16, 1983.

Wide Arc for the U-turn at the Coliseum

A wide arc is painted with dashed white lines at the 135° U-turn from Menlo into the Coliseum. Cones or barriers must be placed on top of this painted arc to prevent the possibility of a shorter route during the Olympic race. The map and measurements for this U-turn arc are described in the "Maps and Measurements" section of this report. The length of this U-turn arc is 15.76 meters, measured on top of the painted line. The length of the running route 20 centimeters from the line is 16.25 meters.

First Straightaway in the Coliseum

The length from the last bicycle reference point, R28, to the beginning of the first curve (marked by an "x" on top of the curb) at the curb, was measured once by John Brennand (trailing end), David Katz (leading end), and Bob Letson (recorder) using a new 300° steel tape and force gage (20° lbs), yielding a result of 148.71 meters (487.88°). The map for this interval is in the "Maps and Measurements" section of this report.

INTERVALS MEASURED BY BICYCLES

The following portions of the Olympic Marathon were measured by bicycles on April 24, 1983:

```
Marina intervals ( 2 intervals, 3 measurements/interval) SMC to Wilshire ( 1 interval, 9 measurements/interval) Wilshire to Stadium (13 intervals, 13 measurements/interval)
```

Fresentation of the bicycle analysis is divided into two sections, as follows:

- 1. Standard Method
- 2. Short Course Prevention

The first section computes the length of all bicycle-measured intervals using established rules formally described by Ted Corbitt, January 13, 1983.

The second section analyzes the concept of short course prevention for bicycle measurements, and uses statistics to compute an appropriate short course prevention factor for the intervals with more than eight bicycle measurements.

Standard Method

TAC STANDARDS COMMITTEE -- NEW MEASUREMENT STANDARDS/RULES

1.COURSE MEASURING PATH: Study course by map and otherwise. Determine how much of road will be available to the runners: all, half, or one lane. Decide if there are local laws or police restrictions which define where runners will be allowed to race, such as with traffic or against traffic or at will.

MEASURE THE SHORTEST PATH possible on the race course, including all short cuts.

2. The old one meter rule is dead. Measure 12 inches from curbs, or 8 inches from edge of curbless roads or lines, where applicable.

3. The IAAF now says that a course cannot be less than the stated distance. It may be longer, e.g. 50 meters for the 42,195 meters marathon.

ADD AN EXTRA 1/1000th of race course distance to the standard length. This extra distance may be added en route, for instance measuring each kilometer one meter long, or each mile a bit long, or add extra distance at the start or finish, or turn around point.

4.All courses should be measured at least twice. <u>Use the longer</u> (MEDIAN) measurement. The two measurements should be reasonably close. If a 10,000 meters course measurements differ by more than 8 meters, or if marathon course measurements differ by more than 37 yards, take a third measurement.

5.In writing a report (application) of the course measurement, state the exact length of the course, plus the added distance, for instance: 26 miles 385 yards, plus 50 meters. You will still use 26 miles 385 yards on entry blanks and in press releases.

6. If an open American record, or a "world's best" time is made in a road race, it must be confirmed that the correct, measured course was the one raced, and an independent measurement of the race course will be made. If the course is found to be short of the stated distance, no record will be allowed.

ADDITIONAL POINTS: The Race Director, or someone delegated to make decisions as to course route, and the start and finish points, should be on hand during the course measurement.

Someone who has run the course and who knows the shortest path taken by the runners should guide the course measurer; or should operate the measuring device.

Measure the course when the traffic is light. In dangerous situations, try to get a police escort, or a municipal vehicle with flashing lights on the roof, to be driven along to alert motorists and so protect the course measurers.

Safety of the runners, traffic problems, safety of course measurers,

Safety of the runners, traffic problems, safety of course measurers, and other practical factors help to determine the course route and configuration.

After measuring a race course, verify the actual running route taken by the runners during the following race(s). Compare the actual route run, with the measured or certified route. In case of discrepancies, measure the actual running route, including all noted short cuts, and get the course re-certified.

Ted Corbitt, Chairman TAC Standards Committee, 1/13/83

STANDARD METHOD

The "Standard Method", as defined by Ted Corbitt, is basically a two-step process:

- Compute the accurate length of the interval for each measurement.
- Compute the lowest median (Md), and let the official length of the interval be (.999Md).

To accomplish this, and double-check our results, we have used six different methods. These methods are described in the following pages, and are listed below:

```
LR Linear Regression method
CR Cosine Regression method
TVC TVC method
STVC Smoothed TVC method
W Weighted Baselines method
WZ Weighted Zones method
```

There are 16 bicycle-measured intervals, grouped as follows:

```
Marina intervals ( 2 intervals, 3 measurements/interval) SMCC to Wilshire ( 1 interval, 9 measurements/interval) Wilshire to Stadium (13 intervals, 13 measurements/interval)
```

The Marina intervals have the following lengths (.999Md) for each method. The lowest length is underlined: (meters)

	Tahiti	Bora Bora
LR	1995.61	2660.23
CR	1995.60	2660.08
TVC	1995.55	266Ø.45
STVC	1995.26	2659.79

SMCC to Wilshire has the following length (.999Md) for each method. The lowest length is underlined: (meters)

```
SMCC to Wilshire
LR 2996.31
CR 2996.20
TVC 2996.38
STVC 2996.23
WZ 2996.38
```

The 13 intervals from Wilshire to Stadium, with 13 measurements per interval, have the following total length (sum of (.999Md)) for each method. The lowest length is underlined: (meters)

	Wilshire to Stadium
LR	3Ø878.2
CR	3Ø879.1
TVC	30880.5
STVC	3Ø878.5
W	3 <u>0877.2</u>
WZ	30878.8

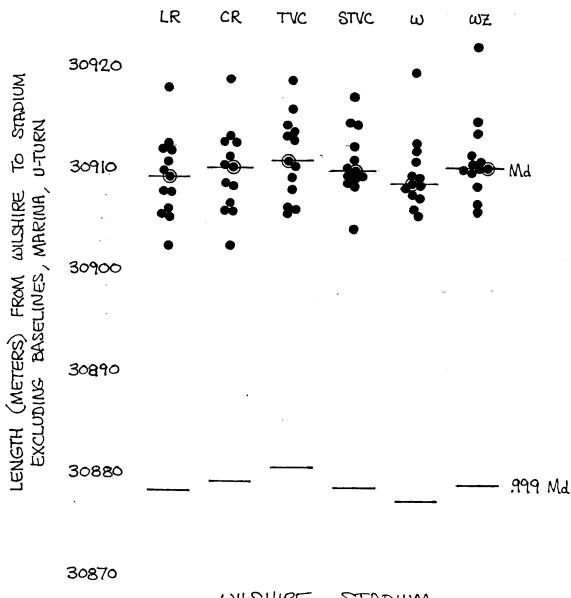
The lowest (.999Md) lengths of the 16 bicycle-measured intervals, using the Standard method, are summarized below: (meters)

Marina intervals:	Tahiti	1995.26
	Bora Bora	2659.79
SMCC to Wilshire		2996.20
Wilshire to Stadiu	m (13 intervals)	3Ø877.2

One of the intervals, from Wilshire to Bundy, requires an adjustment which is discussed in the "EDM and Steel Tape Measurements" section of this report.

The Wilshire to Stadium measurements are graphed on the following page to illustrate the relative position of each overall measurement in comparison to (.999Md). This graph shows an obvious gap between the actual measurements and (999Md), which suggests that the 1/1000 short course prevention factor is unnecessarily large.

The next section of this report analyzes short course prevention, and uses statistics to compute an appropriate short course prevention factor for intervals with more than eight measurements.



WILSHIRE — STADIUM (13 MEASUREMENTS-13 INTERVALS)

STANDARD METHOD

for computing an accurate length:

LINEAR REGRESSION METHOD

The "Linear Regression" method, as used in this report, has the following basic rules:

1. The counts/km for each measurer is assumed to vary linearly with elapsed Jones counts, and can therefore be computed by the following formula:

$$y = A + Bx$$

where y = counts/km
x = elapsed Jones counts

2. The coefficients A and B are computed as follows:

$$A = \frac{\sum y \sum x^2 - \sum x \sum xy}{n \sum x^2 - (\sum x)^2}$$

$$B = \frac{n\Sigma xy - \Sigma x\Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

where n = 8 baselines

x = elapsed Jones counts (from baseline 0)

y = average counts/km for each baseline

Linear Regression uses all baseline data to compute the best-fit straight line that most closely matches the actual counts/km $\,$ sampled at each baseline. Any erratic baseline data is smoothed, resulting in a simple general trend. If the actual trend is in fact a straight line, then linear regression is certainly the best method possible for estimating counts/km.

To establish how well the April 24 data fits the linear regressions, we can calculate the coefficient of determination (r^2) The coefficient of determination is a value between 0 (no fit) and 1 (perfect fit), calculated as follows:

$$r^{2} = \frac{\left[\Sigma(x-\overline{x})\cdot(y-\overline{y})\right]^{2}}{\left[\Sigma(x-\overline{x})\cdot^{2}\right]\left[\Sigma(y-\overline{y})^{2}\right]}$$

or its equivalent:

$$r^{2} = \frac{n\Sigma xy - \Sigma x\Sigma y}{n(n-1)\sigma_{X}\sigma_{Y}}$$

where n = 8 baselines

 σ_{x} = standard deviation for x

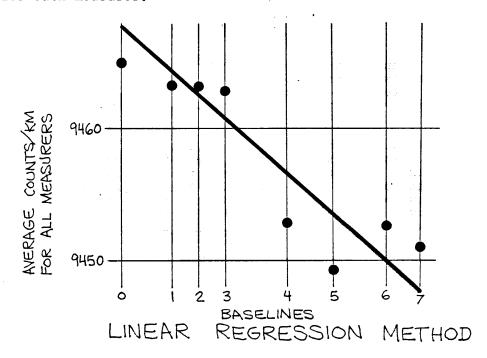
 σ_{y} = standard deviation for y

The coefficients of determination for each measurer's linear regression are listed below:

	r^2	meters			
BB	.83	30905.9			
\mathtt{BL}	.54	30905.5			
CW	.83	30910.6	- Md	=	30909.1
DK	.71	30911.9			
JD ·	.60	30909.7	$\overline{\mathbf{x}}$	=	30909.0
PC	.52	30907.7	s	_	4.0
PR	.77	30911.8	. -	_	4.0
PS	.66	30905.1	x -3s	=	30897.0
RS	.85	30917.9	.999ма	=	30878.2
TB	.80	30912.3	. 333Ma	_	30070.2
TD	.79	30909.1			
TK	.79	30907.7			
WR	.64	30902.3			

The average r^2 = .72 which is satisfactory, but not excellent. It is possible that another method could prove superior to Linear Regression, possibly a regression based on the cosine curve which tends to follow the rise and fall of temperature during the day.

There are thirteen bicycle-measured intervals between Wilshire and the Coliseum (excluding baselines, the Marina intervals, and the U-turn). Linear Regression was used to compute the counts/km at the mid-point of each interval. These counts/km for each interval were then used to compute the length of each interval for each measurer. The sum of the lengths of the thirteen intervals, as determined by Linear Regression, is listed above for each measurer.



COSINE REGRESSION METHOD

The "Cosine Regression" method, as used in this report, has the following basic rules:

 The counts/km for each measurer is assumed to vary sinusoidally (similar to temperature during the day), and can therefore be computed by the following formula:

$$y = A + B\cos\left[\pi \frac{x}{X}\right]$$

where x = elapsed counts (from baseline 0) X = total counts

2. The coefficients A and B are computed as follows:

$$B = \frac{\Sigma(z_{i} - \overline{z})(c_{i} - \overline{c})}{\Sigma(z_{i} - \overline{z})^{2}}$$

$$A = \overline{c} - B\overline{z}$$

where $z_i = \overline{\cos[\pi_X^x]}$ for baseline i

$$\frac{1}{z} = \frac{1}{n} \Sigma z_i$$

c_i = average counts/km for baseline i

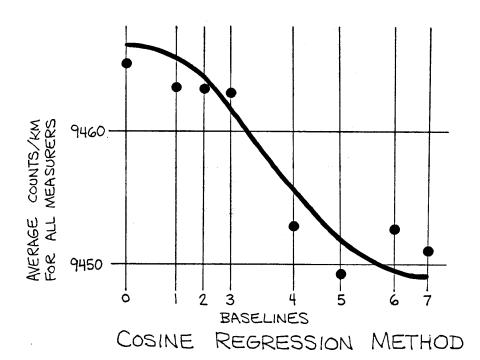
$$\overline{c} = \frac{1}{n} \Sigma c_i$$

This implementation of Cosine Regression utilizes a reasonably close-fit cosine curve to compute counts/km for each measurer. This was attempted only after inspection of the calibration data, which seemed to be closer to a cosine curve than to a straight line.

There are thirteen bicycle-measured intervals between Wilshire and the Coliseum (excluding baselines, the Marina intervals, and the U-turn). Cosine Regression was used to compute the counts/km at the mid-point of each interval. These counts/km for each interval were then used to compute the length of each interval for each measurer. The sum of the lengths of the thirteen intervals, as determined by Cosine Regression, is listed on the following page for each measurer.

	meters			
BB	30906.6			
BL	30,905.8			
CW	30911.2	ма	=	30910.0
DK	30912.4	 _		
JD	30910.2	$\overline{\mathbf{x}}$	=	30909.7
PC	30908.2	s	=	4.1
PR	30912.5			
PS	30905.8	\overline{x} -3s	=	30897.3
RS	30918.8	. 999ма	=	30879.1
TB	30913.0			300,3.1
TD	30910.0			
TK	30908.4			
WR	30902.8			

Cosine Regression is only one of many possible curvilinear approximations that could be used. The question arises: What is the actual shape of the counts/km for each measurer? We know that counts/km is affected by temperature, wind, hills, and consistency in riding the shortest possible route (SPR). These factors tend to vary during any measuring occasion, and consequently cause the actual counts/km to vary, wandering up or down with changes in wind, temperature, hills, etc. It is possible that the actual counts/km is most accurately approximated by a very curvilinear, even sawtoothed, line.



for computing an accurate length:

TVC METHOD

The letters "TVC" denote "time-varying constant" or "time-varying calibration." As such, it is not a unique identifier because almost every one of our methods tries to account for varying counts/km during the measurement. But this was our first attempt at incorporating all the calibration data, and the name has stuck. The basic rule of the TVC method is:

The counts/km for any interval of the course is taken to be the average of the counts/km obtained on the baselines immediately preceding and following the interval. For example, the average of the counts/km obtained on baselines 3 and 4 is used for calculating the lengths of all intervals contained between baselines 3 and 4.

For the thirteen bicycle-measured intervals between Wilshire and the Coliseum (excluding baselines, the Marina intervals, and the U-turn), the total measured distances, as calculated by three variations of the TVC method, are listed below for each measurer:

		Using All available Baseline data. (meters)	Omit B6 for the Overshooters.	Omit B6 for Overshooters. Omit B2 for Everybody.
BB BL CW DK JD PC PR PS RS TB TD TK WR		30907.8 30905.9 30913.0 30913.5 30912.5 30910.1 30915.8 30906.1 30918.4 30914.1 30911.4 30909.0 30905.5	(meters) 30907.8 30905.9 30913.0 30916.1 30914.7 30911.7 30915.8 30906.1 30921.8 30914.1 30912.5 30909.0 30909.4	(meters) 30909.3 30906.7 30914.9 30917.7 30910.7 30913.6 30915.3 30908.0 30921.9 30911.9 30908.8 30910.6 30909.0
Md x	#	30911.4 30911.0	30912.5 30912.1	30910.7
s	=	4.0	4.5	4.3
x-3s	=	30898.9	30898.6	30899.2
.999Md	=	30880.5	30881.6	30879.8

The first column is a TVC calculation using all the available calibration data, while the second and third columns represent attempts at greater accuracy by systematically eliminating certain items of faulty or questionable calibration data.

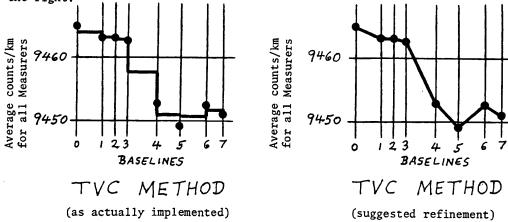
Six of the cyclists overshot the end of baseline 6 (in some cases, by 50 meters or more), and then walked their bikes backward to the mark. All the overshooters obtained significantly more counts/km on this baseline than on the neighboring baselines.

Baseline 2 was unusually short (379.007 m). To make matters worse, the cyclists were unable to ride it continuously, but had to stop midway while waiting for the police to regroup! The baseline 2 data was extremely erratic, with about half the riders seemingly getting significantly too many counts/km, while 3 of the remaining riders (JD, TD and TB) seem to have gotten far too few counts/km.

In the table (previous page), the second column is a TVC calculation omitting the baseline 6 data of the 6 overshooters. The third column omits the baseline 6 data of the 6 overshooters, as well as the baseline 2 data of $\underline{\text{all}}$ riders.

The third column is probably most accurate. Nevertheless, only the scheme represented by the first column (i.e. using all data from all baselines) has actually been implemented in a computer program. Thus, all the "TVC" interval distances in the "Maps and Measurements" section of this report were calculated as in the first column.

The counts/km used in the TVC method have a step-function graph as shown below on the left. One suggested refinement of the TVC method was to interpolate the counts/km between successive baselines, instead of just taking the average. This suggestion leads to a sawtooth graph as shown below on the right.



The difference between using the step-function and sawtooth graphs is probably negligible as far as the total measured distance is concerned, but can be significant for individual intervals -- especially between baselines 3 and 4.

Linear interpolation, based on elapsed Jones counts, has been included in the "Smoothed TVC" method (to be described next), but not in the "raw TVC" method. The Smoothed TVC method not only uses interpolated counts/km, but also includes walk-factor corrections, and incorporates many additional adjustments based on the personal artistic vision of Bob Letson.

SMOOTHED TVC METHOD

The "Smoothed TVC" method, as used in this report, has the following basic rules:

- TVC is assumed to be good if it contains no mistakes, no systematic errors, and no obvious irregularities.
- 2. Mistakes should be omitted.
- 3. Systematic errors should be compensated.
- 4. Obvious irregularities should be smoothed. This can be done arithmetically (by replacing adjacent extreme values with their mean), or artistically. (this is admittedly, subjective!)

Smoothed TVC attempts to correct specific errors that appear to exist for raw TVC. Distinctions are made for known blunders (mistakes), poor methodology (systematic errors), and large random errors of unknown origin (irregularities).

Three mistakes are recognized by individuals to whom they occurred:

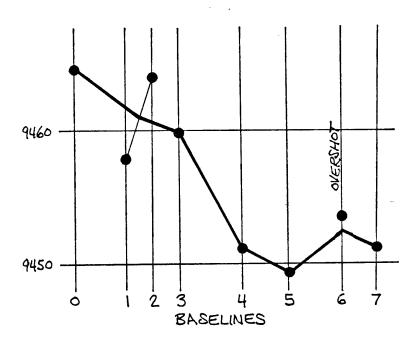
- a. BL (Bob Letson) is aware that he made an illegal shortcut from San Vicente left onto Ocean Blvd.
- b. RS (Ron Scardera), who was lead bicyclist, is aware that he rode two left turns too wide, departing from the shortest possible route (SPR) more than would be desired for a top quality measurement;
 - 1. From Bundy left onto San Vicente
 - 2. From Marina Freeway left onto Slauson

Two systematic errors are known:

- 1. Five cyclists walked their bicycles an average of 45 feet to/from each reference point (BL, CW, JD, PC, PR). This caused their counts/interval to be undersized by about one count/interval. It is appropriate to compensate for this error by adding one count/interval for each walker.
- 2. Six cyclists overshot the end of baseline 6 by about /50 feet, then walked their bicycles backward. This made their counts/km oversized by about one count/interval. It is appropriate to subtract one count/interval for baseline 6 for these overshooters.

One of the overshooters, Will Rasmussen, swerved much more than the other cyclists when stopping abruptly, which caused his counts/ k_1 to be higher than normal by an unknown amount. This could be classified as a "mistake" and omitted.

Several "sawtoothed" graphs of counts/km versus distance exist. These sawteeth, if excessively large, indicate abnormally large random errors that can be smoothed. Most of these "sawteeth" seemed to occur for baselines 2 and 3, which were shorter than normal. It is possible that this is caused by the magnification of normal random errors, such as "backlash" in the counter. Other sawteeth existed for baseline 6, for overshooters. All of these sawteeth can be smoothed graphically, by replacing adjacent extremes with their mean, as follows:



The sum of the lengths of the thirteen intervals measured by all thirteen bicycles, as determined by the Smoothed TVC method, are listed below for each measurer:

	meters	
BB	30908.3	
BL	30903.9	
CW	30909.9	
DK	30914.2	
JD	30909.5	
PC	30909.1	
PR	30912.1	
PS	30908.1	
RS	30916.9	
TB	30914.3	
TD	30909.2	
TK	30909.4	
WR	30910.6	

Md	=	30909.4
$\overline{\mathbf{x}}$	=	30910.4
S	=	3.3
\overline{x} -3s	=	30900.4
.999Md	=	30878.5

Walking Factor Analysis

David Katz expressed dismay at the way some of the measurers, including myself (Bob Letson), walked their bicycles to/from feference points on baselines. It is logical that the counts/km will decrease when weight is removed from the measuring wheel. To measure the amount of decrease, Bob Letson and Tom Benjamin thereafter reviewed old records and performed new tests that revealed a difference of 135 counts/mile between riding and walking. It is estimated that the amount of walking per baseline was about 45 feet, half the length of the bicycle queue. This amounts to about one count/baseline. Consequently, the Smoothed TVC method uses a compensation of one count/baseline for all walkers. (Tom Benjamin was not one of the walkers)

Peter Riegel realized that walking occurred not only on the baselines, but also on the measured intervals, and that these two effects would partially cancel each other. He was curious to see how much difference the walking really made, if this cancellation is taken into account. His calculations are shown on the following page. They reveal that, for a walk factor (WF) of one count/interval, the net effect of walking is to alter the calculated distance by about three meters for the entire bicycle measurement (30.9 km).

```
WALK EFFECT ESTIMATE
                              IMPROVED
           GIVEN
                       E Calibration distances =
                                                                             meters
                        E Measured courses
                                                                            counts/meter
                        Average constant
                        Walking factor = W counts/stretch
No. of cal courses = NI
                         No of measured stretches = N2
42.381 50 SHEFTS 5 SQUAR
42.382 100 SHEFTS 5 SQUAR
42.389 200 SHEFTS 5 SQUAR
                Total calibration counts =
                                                                             ORIGINAL
                Total
                            measured counts =
           After applying WF:
                         New cal counts = ac + WN1
                          New measured counts = bc + WNZ
                          New Constant = \frac{ac + WNi}{a} = c + \frac{WNi}{a}
                          New Measured Distance = bC + WNz
C+ WNi
               \frac{\text{Difference}, D = \frac{bc + wN_z}{c + \frac{wN_i}{a}} - b \frac{(c + \frac{w}{a}N_i)}{(c + \frac{w}{a}N_i)} = \frac{wN_z - w(\frac{b}{a})N_i}{c + \frac{w}{a}N_i}
                  Since C >>> \stackrel{\sim}{\simeq} N_1
D \cong \stackrel{\sim}{\simeq} (N_Z - \frac{b}{a} N_1)
Reduce proportionally depending on no. of "walkers"
 for N, =6, N2=13, W=1, C=9.467, a=4680, b=30900
                 D = \frac{1}{9.467} \left( 13 - \frac{30900}{4680} (6) \right) = -2.81
                           for W=2, D=-5.62
                                   w = 3, D = -8.43
              XC: LETSON, BAUMEL
```

WEIGHTED BASELINE METHOD

The "Weighted" Baseline method, as used in this report, has the following basic rules:

- 1. A "weight" is assigned to each calibration occasion, equal to the exact total distance traveled during that occasion, not to exceed 2 kilometers. For example, two rides on a 601.258 meters baseline yield a "weight" of 1.202516 Km. Four rides on this baseline yield a "weight" of 2.000000 Km.
- 2. Each measurer has a "total weight" for the day, equal to the sum of the weights for all of the calibration occasions for that measurer.
- 3. The counts/km for each measurer for the day is computed as follows:

Let w_i = weight for the ith calibration occasion

Let W = total weight for the day = $\sum_{i=1}^{\infty} w_i$ where n = number of calibration occasions

Let c_i = average counts/km for the ith calib. occasion

Let C = counts/km for the day, computed as follows: $C = \frac{1}{W} \sum_{i=1}^{\infty} (w_i)(c_i)$

The Weighted Baseline method directly addresses the problem of short baselines, which are less accurate than long baselines. This method assumes that the accuracy of a baseline is directly proportional to its length, and therefore assigns a "weight" that is equal to the length traveled during each calibration occasion. Theoretically, this reduces the effect of a short baseline error to the level that is experienced by a long baseline. Because the April 24, 1983, measurements experienced suspiciously erratic counts/km for short baseline#2, this method is desireable to minimize the effect of this baseline.

The weights used for the April 24, 1983, calibration occasions are as follows:

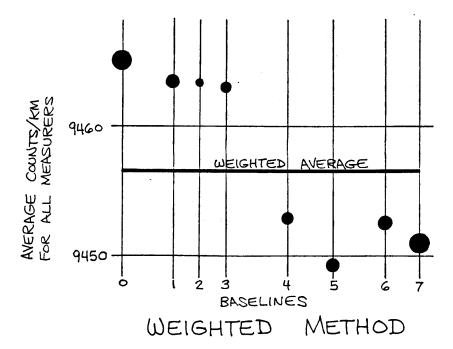
baseline 0: $w_0 = 2.000000$ baseline 4: $w_4 = .768575$ baseline 1: $w_1 = .955978$ baseline 5: $w_5 = .974693$ baseline 2: $w_2 = .379007$ baseline 6: $w_6 = 1.000030$ baseline 3: $w_3 = .601258$ baseline 7: $w_7 = 2.000000$

The total weight, W, equals 8.679541 kilometers.

The counts/km for the day for each measurer, and the length of all bicycle-measured intervals (excluding baselines and the U-turn) from Wilshire to the Coleseum, as determined by the "Weighted" Baseline method, are listed below:

	counts/km	meters			
BB	9392 . 19 9494 . 79	30905.9 30905.7			
BL CW	9632.72	30908.9	Md	=	30908.1
DK JD	9590.67 9588.65	30911.7 30907.0	$\overline{\mathbf{x}}$		30908.6
PC PR	9450.11 9338.71	30908.2 30908.1	s	=	4.3
PS	9357.83	30907.9	x -3s	=	30895.6
RS TB	9388.71 9419.41	30919.3 30912.3	.999Md	=	30877.2
TD	9333.29	30907.1			
TK	9285.13	30909.0			
WR	9668.43	30900.5			

Although this method accomodates short baselines satisfactorily, its use is biased if the weights for the various calibration occasions are not evenly distributed. The weights for the Olympic marathon calibration occasions on April 24 are slightly unevenly distributed, with short baselines in the first half of the course, and longer baselines in the last half of the course. It is therefore desireable to divide the measurements into zones, if possible, and compute the counts/km for each zone, in order to minimize the effect of the uneven distribution of baseline weights. Such a method exists, described on the following page, called the "Weighted Zones" method.



WEIGHTED ZONES METHOD

The "Weighted Zones" method, as used in this report, has the following basic rules:

- 1. Calibration occasions are grouped into the following categories:
 - a. Wet (SMC to Via Dolce)b. Dry (Admiralty to Stadium)
- 2. The Weighted Baseline method is used to compute the counts/km for each category. These constants can be used to compute the length of intervals that were measured within each category.
- 3. The counts/km for the day for each measurer is computed by using a weighted average of the counts/km for each category, where the weight for each category is equal to the total length of the bicycle-measured intervals within the category. This constant can be used to compute the total length of all bicycle-measured intervals for the day.

This method directly addresses the wet/dry conditions experienced on April 24, 1983, when we were totally drenched from SMCC to Via Dolce, and were dry and warm from Admiralty to the Coliseum after one hour of toying with Marina intervals. The graphs for counts/km strongly suggest the existence of these two zones, during which the counts/km was fairly stable, and between which a drastic change in counts/km occured.

Baselines 0 through 3 are within the Wet zone, with a total weight of 3.936243 Km. Baselines 4 through 7 are within the Dry zone, with a total weight of 4.743298 Km. The Wet zone measurements (from Wilshire to Via Dolce, minus baselines) totaled 12.613 Km. The Dry zone measurements (from Admiralty to the Coliseum, minus baselines and the U-turn) totaled 18.296 Km. Consequently, the following formulae apply:

$$C_{\text{wet}} = \frac{1}{3.936243} [2C_0 + (.955978)C_1 + (.379007)C_2 + (.601258)C_3]$$

$$C_{\text{dry}} = \frac{1}{4.743298} [(.768575)C_4 + (.974693)C_5 + (1.00003)C_6 + 2C_7]$$

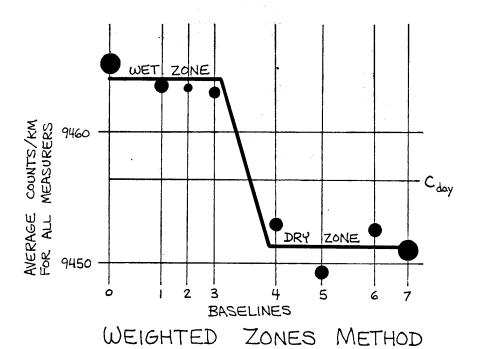
$$C_{\text{day}} = \frac{1}{30.909} [(12.613)C_{\text{wet}} + (18.296)C_{\text{dry}}]$$

The counts/km for each zone, the overall counts/km for the day, and the length of all bicycle-measured intervals from Wilshire to the Coliseum (excluding baselines and the U-turn and the Marina intervals), as computed by the Weighted Zones method, are listed below:

	Cwet	$^{\mathtt{C}}_{\mathtt{dry}}$	$^{\mathtt{C}}_{\mathtt{day}}$	meters		
BB	9400.30	9385.45	9391.51	30908.1		
BL	9496.97	9492.97	9494.60	30906.3		
CW	9639.42	9627.16	9632.16	30910.7	ſ	
DK	9596.87	9585.52	9590.15	30913.3	Md	30909.7
JD	9595.85	9582.68	9587.89	30909.0	$\overline{\mathbf{x}}$	30910.5
PC	9455.63	9445.54	9449.66	30909.7		
PR	9345.89	9332.75	9338.11	30910.1	S	4.5
PS	9363.92	9352.78	9357.33	30909.6	x -3s	30897.0
RS	9398.34	9380.77	9387.94	30921.8		•
TB	9427.81	9412.44	9418.71	30914.6	.999Md	30878.8
TD	9342.84	9325.37	9332.50	30909.7		
TK	9292.29	9279.20	9284.54	30911.0		
WR	9675.99	9662.16	9667.80	30902.5		

Will Rasmussen (WR) swerved abnormally and overshot baseline 6, which caused his counts/km to be abnormally high for this calibration occasion. If baseline 6 is omitted for WR, his constants are as follows:

	$^{ m C}$ wet	$^{\mathtt{C}}\mathtt{dry}$	$^{ extsf{C}}_{ extsf{day}}$	meters
WR	9675.99	9660.41	9666.77	30905.8



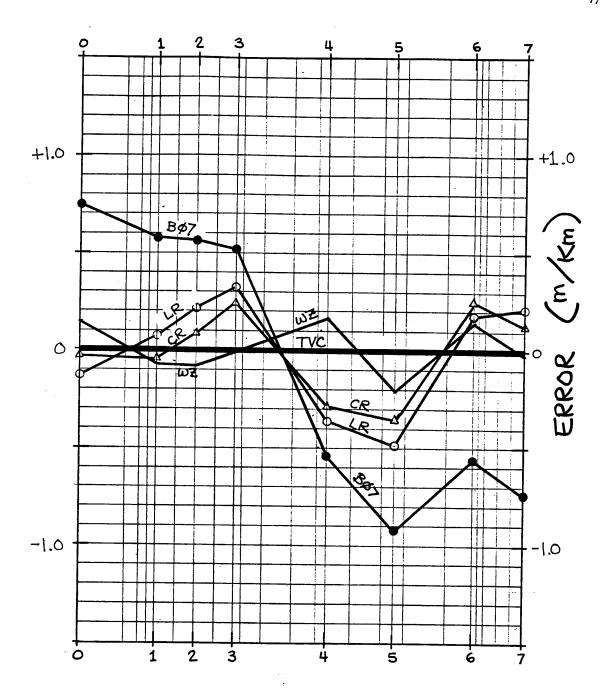
CLOSENESS OF FIT (Predictability Study #1)

Curiosity compels us to observe how well the various methods of computing counts/km fit the actual recorded counts/km for each baseline. Towards this end Peter Riegel developed a computer program (COS1) that computed the error made by each measurer for the eight baseline "measurements". Peter's computer printouts are on the following pages, and the average error for each method for each baseline is listed below. (meters/km)

	BØ7	LR	CR	WZ
ВØ	.742	13Ø	ø28	.148
B1	.578	.Ø72	Ø39	Ø68
B2	. 565	. 206	. Ø9Ø	084
B3	.516	.319	.241	007
B4	545	363	296	. 167
B5	919	488	354	207
B6	572	.18ø	. 251	. 141
B7	745	.210	.132	020
mean	Ø48	. ØØ4	.004	.061
s.d.	.7Ø5	. 296	. 227	.117

All of the above methods fell within 1/1000 of the actual counts/km. "B07" (the average of baselines 0 and 7 only), the method most commonly used in USA due to its convenience, appears to be more than twice as inaccurate as the other methods. The regression methods produce the closest overall length. And "WZ" is the least variable (i.e., most consistently accurate for intermediate intervals).

TVC is not included in this study because it uses, rather than computes, the counts/km for each baseline. This implies that TVC may be the most accurate method for estimating the actual counts/km during measuring. However, if random errors are significantly large, some form of smoothing (such as regression or smoothed TVC) may be superior to raw TVC for estimating actual counts/km during measuring.



CLOSENESS of FIT

			1			SI CHL Z IU FIR CHL	IN CHE 2
NAME	LIN REG	B#7	MZ	COS REG	. (NAME	LIN REG
DELANEY	4001.72	4004.11	4001.730	4002.19		DELANEY	378.754
KATZ	4000.37	4003.54	4001.200	4000.7	-	KATZ	379.173
RIFGEL	2444.83	4004.11	4661.846	4000.3		BAUMEL	379.192
LETSON	4000.36	4001.49	4000.802	40004		RIEGEL	379.029
DURANTI	3999.9	4004.75	4000.924	4000.48		THESON	379.098
CHRISTENSEN	4000.28	4002.89	4001.004	4000.51	****	CHRISTERSON	200.072
RASHUSSEN	4001.36	4004.23	4001.761	4001.79	, °	RASHISSEN	379.024
SCARDERA	3999.16	4005.2	4000.B13	3999.79	ŧξ	SCARDERA	379.119
BENCAMIN	3999.89	4004.34	4000.B22	4000.41		BENIDATA	378.944
WISSER Diskinst	4000.56	4003.47	4001.486	4000.97	(WISSER	379,176
UNANGERA	3998.59	4002.81	4000.035	3998.87		SHANDERA	379.267
11011	3,44,5	4003.59	4000.743	3999,94		KNIGHT	
1,000	212				C	8.66	
ACTUAL = 400 LIN	LIN REG	13467	ZM	COS REG		ACTURL" 31.	LIN REG
MEAN DIST =	4000.19	4003.68	4001.305	40004	(
STD DEV =		.953912	. 991	862825		HEAR DIST	080.875
RROR		2.968	593	- 110	. (TOOP I	9807011
ERROR ("/Km)	130	.742	.148	-,028	(ERROR (m/km)	20,00
ST CAL 1 TO E	TO END CAL 1	BASELINE	LINE 1			ST CAL 3 TO F	3 TO FIN CAL 3
NAME	LIN REG	B¢7	WZ	COS REG		NAKE	41
i					Ü		LIN NEU
DELANET	680.956	956.398	926.347	956.029		DELANEY	601.634
718	955.94	926.39	955.832	955.846	(KATZ	601.311
BAUREL	955.924	956.515	128.50	955.792		BAUMEL	601.442
TEGEL	706.103	926.36	435.45B	956.041		RIEGEL	601.345
DE SON	000.004	900.742	730.016	755.763	(LETSON	601.43
CHRISTENSEN	7.00	107.701	655. 621	100.401	•	DURANTI	601.516
RASHUSSEN	956.005	956.358	955.768	710.00		CHRISTENSER	601.55
SCARDERA	956.166	957,122	956.073	954.039	C	KASMUSSEN	601.407
BENCAMIN	956,283	956.947	956.108	956.168		SCARDERA	601.44
WISSER	956.003	956.34	955.867	668,526		BENCHILA	601.592
SHANDERA	955,996	956.674	956.010	955.874	(A D D D D D D D D D D D D D D D D D D D	601.182
KNIGHT	955.907	956.527	955.846	955.793		KNIGHT	10.100
455.97	۵				(OSTION INGTHIN	
ACTUAL" 1	LIN REG	847	MZ	COS REG		ACTURL - B	LIN REG
MEAN DIST =	956.047	115,530	955.910	055.041			
STD DEV =		.383581	.186	211202		MEAN DIST =	601.45
Rok		200	068	7,7117		510 DEV =	122216
ERROR (M.A.)		ore.	6	-,037	1.	17.00 17.00	7.7
		<=	000	-	-	13 10 11 11	

379.041 .151992 .034 .090

378.975 .187 -.032 -.084

379,221 ,186099 ,214 .565

BASELINE BA7

COS REG

ΣM

Bø7

601.593 601.272 601.385 601.417 601.457 601.457 601.353 601.355 601.375 601.375 601.375

661.102 661.081 661.151 661.013 661.013 661.013 661.013 661.073 661.073 661.073 661.073 661.253 661.253

601.403 .121247 .145 .241

601.254 .231 -.004

601.568 .186069 .310 .516

ZΜ

B¢7

378.723 379.136 379.139 379.083 379.083 378.806 378.914 378.914 378.914 378.914 378.914

378.826 379.303 379.359 379.054 379.054 379.11 379.11 379.419 379.419 379.402

BASELINE B47

ST CAL 4 TO FI	TO FIN CAL 4	BASELIN	LINE 4			ST CAL 6 TO F	6 TO FIN CAL 6			
NAME	LIN REG	B\$7	ZM	COS REG			, ,	DHACKING	שׁלַ בּי	010 000
DEI ANFY	748.324	748.08	768.763	748.342	-	1	2	/ds	7.86	בחם עבת
KATZ	768.304	768.198	768.659	768.36		DELANEY	1000.45	999.62	1000.175	1000.49
BAUMEL	768.317	768.139	768.796	768.391	(KATZ	1000.49	999.867	1000.467	1000.54
RIEGEL	768.147	767.743	/4.89/	768.21		BAUMEL	1000.11	999.204	1000.059	1000.19
LETSON	768.43	768,377	798.897	768.451		KIEGEL	777.847	998.751	507.666	956.656
DUKANII	768.23	768.059	7,00.70	768.301	<u>Ç.</u>	THEORY	004.444	240.644	1909.924	284.444
CHRISTENSEN	768.155	768.054	768.565	768.194	s T	TUDIOTENER	1000	777.237	1000.1/0	1000.34
KASHUSSEN	/68.16	/6/.741	140 127	168.209		DADKIDOUR DADKI	1000	1////	1000.000	1000.43
SCARDERA	768.529	768.531	748 770	768.605	(A DE	0007	777.670	1000.1000	10001
BENJAHIN	768.246	768.191	1,007	768.29		SCHOOL SECTION	74.0001	777.023	000000000000000000000000000000000000000	10001
WISSER	768.324	768.062	1,000,001	768.384		SENCOULA	1000.28	999.518	1000.272	1000.39
SHANDERA	768.434	768.481	798.897	768.483	(WISSER	999.982	999.103	999.828	1000.05
KNIGHT	768,243	768.172	/68./89/	768.287		SHANDERA	999.984	999.528	1900.024	10001
7(8.2						KNIGHT	88.666 0	999.173	999.871	1000
	:		781		(0.0001	L.			
- AC-2	LIN REG	26/	į	COS REG		ACTUAL 11	Z 1 -	7,94	M7	000
FO F G 77 U 7	0		768.703	7,0	~ {	<u>ن</u> ے		1	!	200
HERN DIGHT	06:540	901.89/	.171	100.04	ž.	MEAN LIST =	1000.21	900.458	1666.171	000
100000 m	070	1114111	128	/20411			.276004	477409	1000	772076
FORCE (m/km)	676		.167	177.		FRROR	200	05	. 141	00/67
LANCOUNT NO.	cac'_	- SH3		245		FRROR (m/km)	<u> </u>	2.0.	. 141	052.
						(m. /) Name	180	7,15,-	•	.250
ST CAL 5 TO F	5 TO FIN CAL 5	BASELINE	년 S			ST CAL 7 TO F	FIN CAL 7	4	l C	
T A A A	A REG	867	7M	009 869		!		BRSELINE		
!			!		{	NAME	LIN REG	BØ7	ZM	COS REG
DELANEY	974.132	973.603	974.546	974.23						
KATZ	974.145	973.802	4.	974.263		DELANEY	2000.32	1998.3	1999,858	2000.13
BAUMEL	974.171	973.654	4	974.335	T	KATZ	2000.11	1998.59	1999, 787	1999.98
RIEGEL	974.353	973,595	4	974.493		BAUMEL	2000.54	1998.3	1999,957	2000.37
LETSON	974.628	974.478	4	974.675		RIEGEL	2001.28	1998.68	2000.589	2001.12
DURANTI	974.197	973.653	974.546	974.371	•	LETSON	2000.24	1999.61	2000.112	20002
CHRISTENSEN	974.062	973,743	4.	974.173		DURANTI	2000.49	1997.98	1999.813	2000.27
RASHUSSEN	973,935	973.421	÷.	974.055		CHRISTENSEN	2000.37	1998.91	2000.098	2000.29
SCARDERA	974.026	973.686	÷.	974.205		KASAUSSEN	2000.27	1998.24	102.0002	2000.11
BENJAHIN	974.193	973.827	14.301	974.338		SCARUERA	1999.9	1997.75	1444.000	1999.65
WISSER	974.394	973.829	÷.	974.522		STENCHES IN	20007	61.861	1444.041	2000.08
SHANDERA	974.15	973.987	4/4.4/10	974.288	•	* CL0707.	20007	1998.62	- 1 - MAGO - 1 / 4	2000.59
KNIGHT	974.435	974.081	7/4./61	974.577		SHANDERA	2000.37	1998.95	1999.941	2000.28
6/17	~					ייייייייייייייייייייייייייייייייייייייי	80.000×	1778.36	164.4441	2000.4
14.01. A/4.01	1 N RFG	18.67	ZM	COS RFG		7.000.	1			
1		1				ACTURITY 1	LIN REG	B¢7	ZM.	COS REG
MEAN DIST =	974.217	973.797	974.491	974.348	_	* C * C * C * C * C * C * C * C * C * C				- :
SID DEV =	-	,267352	20.0	176366		CTO NHOU	24.0002	10.8441	1999.950	2000.27
ERROR		896 -	7.07	345		10000 = 1	357556	1/89/1	115.	.342413
ERROR (m/Km)	488	- 919	/07-	354		FREDR (M/A)	3 €	0.4. 1.4.	1 . 1 2 . 2 . 1	2.00
					•		22.	- 745	a - a -	. 35

SHORT COURSE PREVENTION

Length

Short course prevention must be addressed if we are to create the most accurate course possible for the 1984 Olympic Marathon. If the short course prevention factor is too small, remeasurement may find the course to be unacceptably short. However, if the short course prevention factor is too large, the course will be unnecessarily oversized. Ideally, the length should be as close to standard (i.e., 42195 meters/marathon) as possible without being short.

IAAF Rule 145.5 says that "a Marathon course must be between 42195 and 42245 metres". In other words, the course must be oversized, but not by more than 50 meters.

Validation Remeasurement

Ted Corbitt says that "a remeasurement should not find the course to be short". Remeasurement is therefore the criterion for judging whether a certified course should be rejected. The course should be rejected if a remeasurement determines that the course is not between 42195 and 42245 meters.

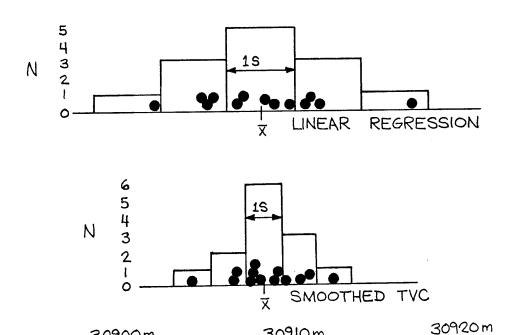
Short Course Prevention Factor (SCPF)

In order to provide a high probability that a course can pass a validation remeasurement, a short course prevention factor (SCPF) should be added to the length of the course. If we wish to protect the course against the most unforgiving remeasurement policy, then the SCPF should be sufficiently large as to encompass the regions of doubt of both the original measurement and the remeasurement.

The Standard Method's SCPF, 1/1000, is based on the personal experience of several seasoned certifiers. We have observed that inexperienced measurers create courses that are short by as much as 1/100 (e.g., 100 meters/100km). However, we also have observed that experienced measurers can always create courses that are within 1/1000 of remeasurements performed by highly skilled certifiers. The size of the SCPF therefore depends on the experience and skill of the measurer.

The April 24, 1983, measurements are fortunately endowed with numerous quality measurements by many experienced measurers. This leads us to believe that, for intervals with many measurements (e.g., more than eight measurements/interval), statistics can be used to calculate an the size of an SCPF that is large enough to provide reasonable assurance against shortness.

For simplicity, we may assume that the April 24, 1983, measurements have a Standard Normal Distribution (bell-shaped curve). This appears to be realistic, as seen in the following diagrams for the 13 intervals with 13 measurements/interval:



N = #MEASUREMENTS IN EACH BOX

X = MEAN

30900m

S = SAMPLE STANDARD DEVIATION (WIDTH OF EACH BOX)

30910m

If we assume that our distribution is normal, then it is possible to compute the probability that a remeasurement will find a limited number of measurements to be adequately long. Dr. Bob Baumel has derived this relationship (see letters from Dr. Baumel at the end of this section), and has provided the following table for computing a short course prevention factor (i.e., number of sample standard deviations below the mean), derived from the number of measurements (N), and desired confidence level (the desired probability for success):

CONFIDENCE LEVEL

N	<u>0.95</u>	<u>0.975</u>	<u>0.99</u>	<u>0.995</u>	<u>0.9995</u>
2 3	7.73 3.37	15.55 4.97	38.9 8.Ø4	78.Ø 11.45	78Ø 36.5
-	-	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
8	2.Ø2	2.50	3.18	3.71	5.73
9	1.96	2.43	3.06	3.54	5.31
1 Ø	1.92	2.37	2.96	3.41	5.Ø1
11	1.89	2.33	2.88	3.31	4.79
12	1.87	2.29	2.83	3.24	4.62
13	1.85	2.26	2.78	3.18	4.48
		_			
1000	1.64	1.96	2.33	2.58	3.29

For example, if we wish to have 99% confidence using 13 measurements, our short course prevention factor should be 2.78 sample standard deviations. If we wish to have 99% confidence using 9 measurements, the short course prevention factor should be 3.06 sample standard deviations.

Selecting a Confidence Level

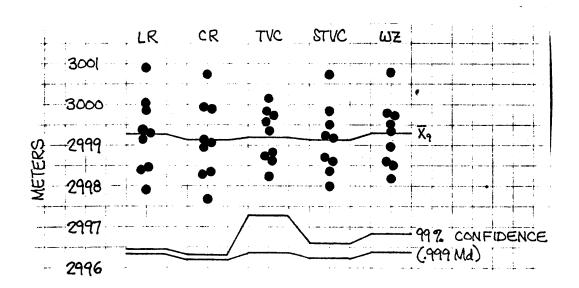
What confidence level is adequate for short course prevention? Cecilia Young, who has a masters degree in medical statistics, says that most of her studies use confidence levels in the range 90-95%. According to Cecilia, 99% provides virtual assurance that the desired event will occur. Bob Letson, who has a BA in mathematics, remembers his statistics professor, Dr. Bell, discussing 97% as a practical level commonly used by industry. We could assume that 97% is a practical value, and that it is unnecessary to have a confidence level larger than 99%.

99% Confidence for SMC-Wilshire (N=9)

The interval from SMC to Wilshire, with 9 measurements, has the following mean (\overline{X}_{Ψ}) , sample standard deviation (S_{Ψ}) , and 99% confidence length $(\overline{X}_{\Psi}-3.\emptyset6S_{\Psi})$ for each method of analysis. The lowest estimate is underlined. (meters)

	X ap	5.	99%
LR	2999.28	. 93	2996.45
CR	2999.14	.94	<u> 2996.28</u>
TVC	2999.23	. 64	2997.26
STVC	29 98.94	.62	2997.04
WZ	29 99.29	.81	2996.81

The following sketch shows the relative position of the 99% lengths with respect to each measurement and the Standard Method's (.999Md) for SMC-Wilshire:



In this case, the difference between the lowest lengths for 99% confidence and (.999Md) is insignificant.

99% Confidence for Wilshire-Stadium (N=13)

The <u>sum</u> of the 13 intervals from Wilshire to the Stadium, with 13 measurements per interval, has the following mean (\overline{X}_{13}) , sample standard deviation (S_{13}) , and 99% confidence length $(99\%(SUM) = \overline{X}_{13} - 2.78S_{13})$ for each method of analysis. Note that 99%(SUM) is about 1/2700 from the mean, which represents the probable accuracy for the April 24, 1983, bicycle measurements. The lowest estimate is underlined. (meters)

	X * 22	S _{3.35}	99% (SUM)
LR	3090 9. 0	4.0	30897.9
CR	30909 . 7	4.1	30898.3
TVC	3Ø91 1. Ø	4.Ø	30899.9
STVC	30910.4	3.3	30901.2
W	30908.6	4.3	30896.6
WZ	30910.5	4.5	30898.0

Each of the 13 intervals from Wilshire to the Stadium, with 13 measurements per interval, has the following 99% confidence length $(\overline{\chi}_{13} - 2.785_{13})$ for each method of analysis. The sum of these 99% lengths, SUM(99%), is also listed. The lowest SUM(99%) is underlined. (meters)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1292.79	1292.72	1292.48	1292.36	1292.62
Carmelina	1592.59	1592.43	1592.95	1592.71	1592.73
Georgina	3571.39	3571.06	3570.63	3571.73	357Ø.53
Navy Ct.	4232.62	4232.23	4230.44	4231.40	4230.61
Via Dolce	1916.87	1916.76	1917.29	1916.46	1915.71
Mindanao	2549.39	2549.51	2548.92	2550.12	2550.65
Hannum	4266.60	4267.03	4268.Ø8	4267.74	4268.28
Summertime	2033.06	2033.32	2033.49	2033.51	2033.59
Ridgeley	2778.24	2778.56	2778.71	2778.60	2778.85
Hobart	5303.60	5304.06	5303.76	5304.89	5303.90
Menlo	61Ø.56	610.62	610.51	610.58	610.54
U -turn	575.45	575.45	575.24	575.41	575.4Ø
Stadium	167.71	167.72	147.48	167.73	167.69
SUM (99%)	30890.87	30891.47	30890.18	30893.24	30891.10

SUM(99%) is 6.3 meters below 99%(SUM), and provides about 99.9% assurance against shortness for the total length.

Lowest Actual Measurements

Another approach to estimating a length that has a high probability of being adequate, for intervals with more than ten measurements, is to use only the "best" (lowest) actual measurement for each interval. If a single remeasurer's ability is equal to the ability of the average measurer on April 24, 1983, his chance of equaling the "best" measurement for a specific interval is less than 1/10, and his chance of equaling or bettering only half of the 13 "best" measurements is less than 1/10,000 (See letter from Bob Baumel, 11/26/83, in the next section). If the number of remeasurements is equal to the number of original measurements, the odds are increased to 50% that half of the "best" measurements will be bettered; however, conclusions for the remeasurement would be based on the median, not the "best" (lowest) values. Consequently, the probability is very low that a remeasurement would find the "best" of more than ten measurements to be short.

The "best" measurements for each interval, for each method of analysis, are listed below for the intervals with more than 100 measurements. The lowest value is underlined. (meters)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.35	1293.24	1293.10	1292.96	1293.16
Carmelina	1593.16	1592.96	1593.35	1592.8Ø	1593.24
Georgina	3572.Ø4	3571.68	<u>3571.46</u>	3572.51	3571.52
Navy Ct.	4233.37	4232.85	4231.92	4232.32	423Ø.94
Via Dolce	1917.26	1917.16	1917.68	1916.95	1916.35
Mindanao	2549.91	255ø.ø2	<u> 2549.56</u>	255Ø.64	2551.4Ø
Hannum	4267.21	4267.76	4269.26	4268.88	4269.48
Summertime	<u> 2033.32</u>	2Ø33.64	2034.01	2033.75	2034.03
Ridgeley	<u>2778.89</u>	2779.14	2779.25	2778.91	2779.21
Hobart	5303.74	5304.25	<u>5303.71</u>	5305.88	5304.14
Menlo	61Ø.71	61Ø.76	610.65	61Ø.74	610.68
U-turn	575.47	575.48	<u>575.33</u>	575.43	575.41
Stadium	168.Ø2	168.Ø3	148.ØØ	148.Ø4	<u>168.00</u>

SUM(BEST) 30896.4 30897.0 30897.3 30899.8 30897.6

SUM(BEST) = 30891.2 meters

The SUM(BEST) values are slightly lower than the 99%(SUM) values, and therefore provide more than 99% confidence against shortness.

 $\text{SUM}(\underline{\text{BEST}})$ is essentially equivalent to SUM(99%) , and provides about 99.8% confidence against shortness.

Limits

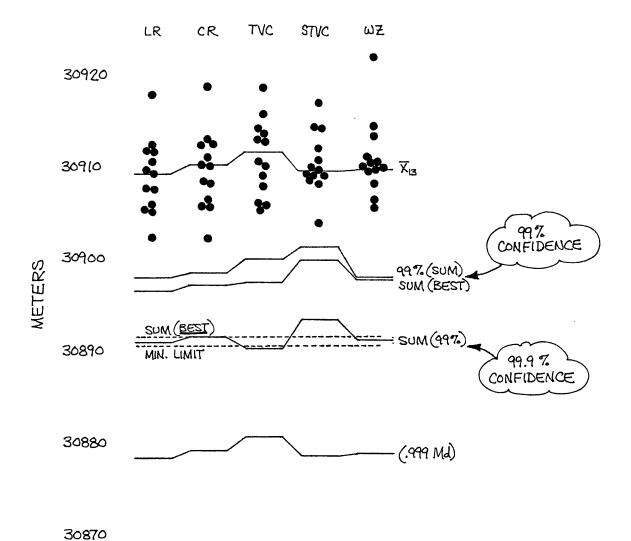
Yet another way to estimate a length that has a high probability of being adequate, when there are many enroute baseline samples and many measurements, is to use the largest counts/km from the nearest baselines before and after each interval. It is unlikely that the actual counts/km will be larger than the largest sample of counts/km before and after each interval. The risk is greatly reduced if there are many measurements with many enroute baselines. Use of the largest counts/km results in an estimate of the "minimum limit" length for each interval.

The minimum lengths for the bicycle-measured intervals are tabulated and plotted in the "Maps and Measurements" section of this report, and are listed below. Those intervals with less than 13 measurements are in italics. (meters)

TERMINUS	MIN. LIMIT		
Wilshire	2997.6	(9	measurements)
Bundy	1292.7		
Carmelina	1592.8		
Georgina	3571.1		•
Navy Ct.	4231.1		
Via Dolce	1916.5		
Tahiti	1995.3	(3	<i>measurements)</i>
Bora Bora	2661.4	(3	measurements)
Mindanao	2548.1		
Hannum	4268.1		
Summertime	2033.4		
Ridgeley	2778.8		
Hobart	5304.0		
Menlo	61Ø.5		
U-turn	575.2		
Stadium	167.9		

The total minimum length of the 13 intervals with 13 measurements per interval is $3\emptyset 89\emptyset.2$ meters, which is identical to the lowest value for SUM(99%). This means that the "minimum limit" lengths provide 99.9% confidence against shortness.

The graph on the following page shows the relative positions of the actual measured lengths, (.999Md), 99%(SUM), SUM(99%), SUM(BEST), SUM($\frac{BEST}{BEST}$), and the "minimum limit" length for the 13 intervals with 13 measurements per interval. All values below 99%(SUM) provide more than 99% confidence against shortness. Note that 99%(SUM) is lower than any of the actual measurements for the overall length.



WILSHIRE - STADIUM

13 INTERVALS
13 MEASUREMENTS/INTERVAL

SUM(BEST), THE SUM OF THE ALL-METHODS "BEST" (LOWEST) MEASUREMENT FOR INTERVALS WITH MORE THAN 10 BICYCLE MEASUREMENTS, PROVIDES ABOUT 99.8% CONFIDENCE THAT THE COMBINED LENGTH IS LONGER THAN SUM(BEST).

LETTERS

The following pages contain a selection of some of the many letters transferred between the authors of this report during the last six months. This selection zooms in on statistical analysis, and reveals some of our trains of thought. The ardent observer is invited to share our journey and, if so inspired, try to correct us if we are wrong, or enlighten us with better perspectives.

The following letters are contained herein:

DATE	AUTHOR	SUBJECT
8-23-83	BL	Relative error for N samples
8-31-83	BB	Probability of Shortness for a Remeasurement
9- 6-83	PR	Personal view
9-19-83	BB	Reply to PR. Explanation of 8-31-83 letter
1Ø- 6-83	BB	More probability theory
11-26-83	BB	Final review comments
10- 4-83	PR	Validation remeasurement theory
10-15-83	PR	Personal afterword

Bob Baumel's next-to-last letter (10-6-83) presents the table used to select a short course prevention factor given a set of "N" measurements and a desired confidence level.

Bob Baumel & Peter Riegel, RE: 99% CONFIDENCE FACTOR Here's a computation. Blease let me know if you find it wrong: BASIN: (from NATH. TABLES, Handbook of Chemistry & Bhysics)
"The probable error of a series of n measures a, az, az... an, the mean of which is m, is $C_n = \frac{0.6745}{\sqrt{(n-1)}} \sqrt{(m-a_1)^2 + (m-a_2)^2 + \dots + (m-a_n)^2}$ $RMS_n = \sqrt{\frac{1}{n}[(m-a_n)^2 + (m-a_n)^2 + \dots + (m-a_n)^2]}$ Therefore en= (0.6745) (RMS) 1/n-1 Relative error (my own name) = $\frac{C_n}{C_n} = \sqrt{\frac{n}{n-1}}$ 99% confidence (one tail) = 2.330 when n=0 99% confidence (one tail) = 2.330 / n-1 when n<0 Ithis is OK, they the 99% confidence lactors are: n=2 3.30 o 2.85 -2.69 0 5 2.61 0 10 2.46 0 15 Rob Letson 30 2.37 2.33

8-23-83

129 Warwick Road Ponca City, OK 74601 31 Aug 1983

Distinguished co-authors:

Concerning Letson's letter of 8-23-83: The "probable error" referred to in the CRC math tables simply refers to a range that ought to include half the observations; i.e. if you have a normally distributed random variable with mean μ and standard deviation σ , then there's a 1/2 probability of finding the variable in the interval from μ to μ to μ to μ where μ where μ 0.6745 σ .

Letson's derivation of the $\sqrt{n/(n-1)}$ factor is incorrect because the estimator that we've <u>already</u> been using for σ (in both Riegel's and Letson's programs) is

$$\hat{\sigma}_{n} = \sqrt{\frac{1}{n-1} \left[(a_{1}-m)^{2} + ... + (a_{n}-m)^{2} \right]}$$

rather than the RMS value,

$$RMS_m = \sqrt{\frac{1}{m} \left[(a_1 - m)^2 + \dots + (a_m - m)^2 \right]}$$

The main virtue of the estimator $\overset{\wedge}{\mathcal{O}_n}$ (as opposed to the RMS value) is that $\overset{\wedge}{\mathcal{O}_n}^2$ is an <u>unbiased</u> estimator of σ^2 .

Nevertheless, I have derived a result which correctly (I believe) obtains a $\sqrt{(n+l)/n}$ factor, based on specific assumptions about a validation remeasurement. Note: Letson's original language on page 101 is too loose in discussing the "confidence....that the interval is not short." Asking whether or not the course really is short raises the whole sticky question of defining what we mean by the "actual" length of a course (a question that Riegel made some attempt to deal with in early issues of "Measurement News", but has never really been answered satisfactorily). Fortunately, we don't need to define the "actual" length of a course in order to know whether a course is acceptable; we only need to know whether it will pass a validation measurement (and this should be made clear in the report).

Probability of Short Course in a Validation Measurement

<u>Problem</u>: Given N measurements $a_1, ..., a_N$ of a given race course, suppose the "official" length L is set at $L = \frac{a_1 + ... + a_N}{N} - S$

where S is some selected "safety factor" or "short course prevention factor." Suppose that one more measurement (i.e. a "validation remeasurement") is then made of the course, with the result $\,V_{\rm c}\,$ What is the probability that $\,V_{\rm c}\,$ will be less than the "official" length $\,L_{\rm c}\,$?

Statistical Assumptions: We assume a_1,\ldots,a_N are independent Gaussian random variables, which each have mean μ_o and standard deviation σ_o . We assume further that the remeasurement result V is also a Gaussian random variable, but with mean μ and standard deviation σ (not necessarily the same as μ_o and σ_o). We also assume the random variable V to be independent of the random variables a_1,\ldots,a_N .

Solution: We want the probability that $V < \frac{a_1 + \dots + a_N}{N} - S$, or equivalently, that $V - \frac{a_1 + \dots + a_N}{N} < -S$. Let us therefore

define the new random variable: $X = V - \frac{a_1 + \cdots + a_N}{N}$.

Now, since X is a linear combination of independent Gaussian random var

Now, since X is a linear combination of independent Gaussian random variables, it is itself a Gaussian random variable. It is easy to show that the probability distribution of X has the following mean and standard deviation.

$$\mu_{x} = \mu - \mu_{o}$$

$$\sigma_{x} = \sqrt{\sigma^{2} + \frac{\sigma_{o}^{2}}{N}}$$

It follows that

Prob
$$(X < -S) = \overline{\Phi} \left(\frac{-S - \mu_X}{\sigma_X} \right)$$

$$= \overline{\Phi} \left(-\left[\frac{S - (\mu_o - \mu)}{\sqrt{\sigma^2 + \sigma_o^2}} \right] \right)$$
(1)

where $\Phi(z)$ denotes the probability that a "standard" normally distributed random variable (of mean 0 and variance 1) has value less than z; thus $\Phi(z)$ is the standard "one-tailed" normal distribution tabulated in standard references

Table I.

6	0000	0014	6100	9200	9003	0048	0064	0084	0110	0143	0183	0233	0294	0367	0455	0559	1890	0823	9882	1170	1379	1611	1867	2148	2451	2776	3121	3483	3859	4247	4641
8	. 1000.	0014	0070	. 7200	. 7500	0049	9900	2800	0113	0146	0188	0238	0300	0375	. 0465	0220	. \$690	. 0838	1003	. 1190	1401	1635	1894	. 2177	2483	2810	3156	3520	3897	4286	4681
7	. 0001	. 0015	.0021	.0028	.0038	.0051	. 8900.	. 6800	.0116	.0150	.0192	.0244	.0307	.0384	.0475	.0582	.0708	.0853	1020	1210	.1423	1660	. 1922	.2206	.2514	.2843	.3192	.3557	3936	4325	.4721
9	.0002	.0015	.0021	.0029	.0039	.0052	6900	.009	0119	.0154	.0197	.0220	.0314	.0392	.0485	.0594	.0722	6980	. 1038	.1230	.1446	.1685	.1949	.2236	.2546	2877	.3228	.3594	3974	4364	4761
S	.0002	9100	.0022	.0030	.0040	.0054	.0071	.0094	.0122	.0158	.0202	.0256	.0322	.0401	.0495	9090	.0735	.0885	.1056	.1251	.1469	.1711	.1977	. 2266	.2578	.2912	.3264	.3632	.4013	4404	4801
4	.0003	0016	.0023	.0031	.0041	.0055	.0073	9600	.0126	.0162	.0207	.0262	.0329	.0409	.0505	.0618	.0749	.090	.1075	.1271	.1492	.1736	2002	.2297	.2611	2946	.3300	3669	.4052	4443	4840
3	.0005	.0017	.0023	.0032	.0043	.0057	.0075	6600	.0129	.0166	.0212	.0268	.0336	.0418	.0516	.0630	.0764	.0918	1093	1292	.1515	.1762	.2033	2327	2643	.2981	.3336	.3707	.4090	4483	4880
7	2000	.0017	.0024	.0033	.0044	.0059	.0078	.0102	.0132	.0170	.0217	.0274	.0344	.0427	.0526	.0643	.0778	.0934	.1112	.1314	.1539	1788	.2061	. 2358	.2676	.3015	.3372	3745	.4129	4522	.4920
1	.0010	.0018	.0025	.0034	.0045	0900	0800	.0104	.0136	.0174	.0222	.0281	.0352	.0436	.0537	.0655	.0793	.0951	.1131	. 1335	.1562	1814	.2090	.2389	.2709	.3050	.3409	.3783	.4168	.4562	.4960
0	.0013	.0019	.0026	.0035	.0047	.0062	.0082	.0107	.0139	.0179	.0228	.0287	.0359	.0446	. 0548	.0668	.0808	8960	.1151	.1357	.1587	. 1841	2119	. 2420	.2743	.3085	3446	.3821	.4207	4602	.5000
	-3.	-2.9	-2.8	-2.7	-2.6	-2.5	-2.4	-2.3	-2.2	-2.1	-2.0	-1.9	-1.8	-1.7	-1.6	-1.5	-1.4	-1.3	-1.2	-1.1	-1.0	e:	<u>ه</u>	7: -	9.	ا ئ	4.	ا ئ	<u>2</u>	T: 1	9. 1

Table I. Values of the Standard Normal Distribution Function (Continued)

5359	5753	6141	.6517	6829	.7224	.7549	. 7852	.8133	8389	.8621	.8830	.9015	.9177	.9319	.9441	.9545	.9633	9206	.9767	.9817	.9857	. 9890	9166	.9936	. 9952	.9964	9974	.998	9866	1.0000
319	714	103																								.9963	.9973	0866	9866	6666
٠	5675	6064	6443	· 8089	7157	7486	7794	8078	8340	. 8577	. 8790	8980	.9147	.9292	.9418	.9525	9196.	.9693	.9756	8086	.9850	.9884	.9911	.9932	.9949	.9962	.9972	9979	.9985	6666.
	5636	. 9209	. 9049	6772	7123	7454	7764	8051	. 8315	.8554	.8770	.8962	.9131	9278	.9406	.9515	8096	9896	.9750	.9803	.9846	.9881	6066	.9931	.9948	9961	.9971	9979	9985	8666.
5199	2596	5987	6368	6736	7088	7422	7734	.8023	8289	.8531	.8749	8944	.9115	.9265	.9394	.9505	.9599	8296.	.9744	9626	.9842	9878	9066	9929	.9946	.9960	.9970	.9978	.9984	.9998
5160	5557	5948	6331	0029	7054	7389	7703	. 7995	.8264	.8508	.8729	.8925	6606	.9251	.9382	.9495	.9591	1296	.9738	9793	.9838	.9874	9904	.9927	.9945	.9959	6966	7766	.9984	7666.
5120	5517	5910	6293	. 6664	7019	7357	7673	7967	.8238	.8485	8108	7068	.9082	.9236	.9370	9484	9582	9664	9732	9788	9834	.9871	1066.	.9925	.9943	9957				.9995
_																											1966	9266	.9982	9993
5040																									9940	9955	9966	9975	9982	0666
5000	5398		-							8413	8643	8849	9032	9192	0339	0459	0554	9641	0713	0770	1680	9861	9893	9018	9038	9053	9965	9074	9981	.9987
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Note 1: If a random variable X is not "standard," its values must be "standardized": $Z = (X - \mu)/\sigma$. That is, $P(X \le x) = N\left(\frac{x - \mu}{\sigma}\right)$.

Note 2: For "two-tail" probabilities, see Table Ib.

Note 3: For $z \ge 4$, N(z) = 1 to four decimal places; for $z \le -4$, N(z) = 0 to four decimal places.

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Table Ia. Percentiles of the Standard Normal Distribution

Z	
$P(Z \leq z)$	z
.001	-3.09
.005	-2.58
.01	-2.33
.02	-2.05
.03	-1.88
.04	-1.75
.05	-1.64
.10	-1.28
.15	-1.04
.20	84
.30	52
.40	- 25
.50	
.60	.25
.70	.52
.80	.84
.85	1.04
.90	1.28
.95	1.64
.96	1.75
.97	1.88
.98	2.05
.99	2.33
.995	2.58
.999	3.09
<u> </u>	

Table Ib. Two-Tail Probabilities for the Standard Normal Distribution

-K	K
K	P(171 > 10

K	P(Z >K)	
1.04	.30	
1.15	.25	
1.28	.20	
1.44	.15	
1.64	.10	
1.70	.09	
1.75	. 08	
1.81	.07	
1.88	.06	
1.96	.05	
2.05	.04	
2.17	.03	
2.33	.02	
2.58	.01	
2.81	. 005	
3.09	.002	
3.29	.001	

↑ 2[1-Φ(K)] = 2Φ(-K)

↑ Φ(≥)

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from B.W. Lindgren, STATISTICAL THEORY Macmillan, New York, 1962. Tab

		_
Degrees of Freedom	X.006	x
1 2 3 4 5 6 7 8 9 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 5 27 28 29 30 40 50 60	.000 .010 .072 .207 .412 .676 .676 .1.73 7 7 7 7 7 7 	.0 .1 .2

Note: For degre

percentile of the stand This table is adapte and H.O. Hartley, ori

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Let's try using Equation (1) to estimate the probability of finding the course short in a typical case where the original course measurers are not experts, and they use the standard short course prevention factor of 0.1%. We assume:

S = 0.1% $\sigma = 0.05\%$ $\sigma = 0.025\%$ $\mu - \mu = 0.05\%$

where I've expressed all distances as percentages of the total course distance. My estimates of σ and σ are educated guesses for the standard deviations of unskilled measurers and skilled measurers respectively. The $\mu_o - \mu$ estimate is a <u>pure</u> guess, and expresses the tendency of a more skilled measurer to find the course shorter, due to better riding of the shortest possible running route. The actual value of $\mu_o - \mu$ depends on the skill levels of the original measurers and the remeasurer, and on how tortuous the course is. You are free to repeat these calculations for other values of the parameters:

Number of original measurers	Probability of Short remeasurement		Confidence level	
2	Φ (-1.1547)	=	0.124	87.6 %
3	₫(-1.3093)	=	0.095	90.5 %
4	₫ (-1.4142)	=	0.079	92.1 %
10	$\Phi^{(-1.6903)}$	=	0.0455	95.45 %
∞	あ (-2)	=	0.0228	97.72 %

For the specific parameters used in this calculation, the 99 % confidence level cannot be attained by using a 0.1% safety factor, no matter how many measurers there are in the original measurement. Of course these calculations are extremely sensitive to the assumed value of μ_{\bullet} . In the case where μ_{\bullet} — μ exceeds the safety factor S, then the probability of a short remeasurement is greater than 1/2 (i.e., confidence level less than 50%).

The above calculations don't correspond to our actual measurement rules, since I've assumed that the <u>mean</u> measurement was used before applying the safety factor (See statement of problem -- top of page 2). Our actual rules for the case N=2 would have the safety factor applied to the <u>shorter</u> of the two measurements. Under these conditions, the probability of a <u>short remeasurement</u> is approximately*

$$\Phi\left(-\left[\frac{S-(\mu_{\circ}-\mu)+\frac{\sigma_{\circ}}{\sqrt{\pi}}}{\sqrt{\sigma^{2}+\left(\frac{\pi-1}{\pi}\right)\sigma_{\circ}^{2}}}\right]\right)$$
(2)

(I'll spare you the gory details, but they're available if you so desire). With the previously assumed values of the parameters, this works out to:

Short remeasurement probability =
$$\oint (-1.62)$$
 = 0.0526 (94.74 % confidence).

^{*} The approximation made in deriving equation (2) was to assume a normal distribution for a random variable that I know is not really normally distributed.

Note that for the particular parameters chosen in this calculation, we get as much confidence against a short course by taking 2 measurements and using the minimum, as by taking 8 measurements and using the mean!

If we have 3 measurements (or any other odd number of measurements), the rules say to use the median (before applying the safety factor). Clearly, our rules don't provide as much protection against short courses when we make an odd number of measurements, as when we make a similar even number of measurements! The following expression gives the probability of a short remeasurement when the original measurers used the median of a large, odd number of measurements:

$$\Phi\left(-\left[\frac{S-(\mu_o-\mu)}{\sqrt{\sigma^2+\frac{\pi\sigma_o^2}{2N}}}\right]\right).$$
(3)

With our assumed parameters from the top of page 3, with N=3, equation(3) yields:

$$\Phi$$
 (-1.137) = 0.128 \Longrightarrow 87.2 % confidence.

Now, equation (3), which was derived for large N, may not be very accurate for N=3, but the numbers seem to indicate that in this case, the median of three measurements provides only about as much confidence as the mean of 2 measurements, and much less confidence than the minimum of 2 measurements! It is certainly true that for any odd N>1, the median provides less confidence than the mean (although there is very little difference between equations (1) and (3) if N is large enough).

Let me hasten to add that this apparent superiority of the mean over the median is purely a consequence of our statistical assumptions about normal probability laws. There are cases where this assumption fails miserably (and in such cases, the median can be superior to the mean). From Jon Claerbout (Fundamentals of Geophysical Data Processing, McGraw Hill, 1976, page 87), "If in fact the data errors include blunders which arise from human errors or blunders from transient electronic equipment difficulties, then the gaussian assumption can be very wrong and can lead you into serious errors in geophysical interpretation. . . The median is insensitive to a data point, which by some blunder, is near infinity."

The moral is that if we use a method of analysis employing the mean (i.e. based on the Gaussian assumption), then any data points containing "blunders" (such as Ron Scardera's swerves on certain intervals of the Olympic course) must be edited out to avoid messing up the calculated mean. On the other hand, methods based on the median are robust enough to yield a reasonable answer in spite of the inclusion of a few data points way off the general trend. This robustness of the median is probably the reason for its inclusion in our official measurement rules (even though the median of a set of Gaussian random variables doesn't have as sharply peaked a probability distribution as the mean).

This discussion of median vs. mean should help resolve the ambiguity mentioned by Pete Riegel, of which portions of the course to take the medians on. Clearly, the median should be taken separately on every single interval, so as to most effectively recognize and eliminate the "blunders."

By the way, while a median-based method will enable us to avoid explicitly throwing away many of the "bad" data points (since taking the median throws those points away <u>automatically</u>), I think we must <u>still</u> throw out the baseline 6 calibration data of the cyclists who overshot the end of that baseline. That was a systematic error involving about half the measurers (rather than just 1 or 2 measurers), and retaining those erroneous calibrations would probably screw up even the median analysis. (The anomalous calibration rides on baseline 2 are probably less serious; whether we leave those points in is mainly a matter of what sort of philosophical statement we'd like to make about short calibration courses!).

Now let's return to equation (1). Let's invert it to calculate the safety factor S needed to obtain a given confidence level C. Note that confidence level C corresponds to a probability of 1 - C of a short remeasurement; thus:

$$1-C = \mathcal{F}\left(-\left[\frac{S-(\mu_0-\mu)}{\sqrt{\sigma^2+\frac{\sigma_0^2}{N}}}\right]\right)$$

$$C = \oint \left(\frac{S - (\mu_o - \mu)}{\sqrt{\sigma^2 + \frac{\sigma_o^2}{N}}} \right)$$

$$S = \mu_0 - \mu + \Phi^{-1}(C) \sqrt{\sigma^2 + \frac{\sigma_0^2}{N}}$$
 (4)

This equation tells us, for example, that if 3 measurers do a measurement, using the mean (as in procedure in problem statement on page 2), and if we assume the parameters listed on the top of page 3, then the safety factor needed for 99% confidence is

(except for the safety factor, of course)

$$0.05\% + 2.33\sqrt{(0.025\%)^2 + \frac{(0.05\%)^2}{3}} = 0.139\%$$

which is somewhat greater than the standard 0.1% safety factor.

Equation (4) is, of course, quite difficult to use in general, due to our lack of a priori knowledge of the correct value to use for $\mu_0 - \mu$. Nevertheless, in the particular case of our Olympic measurement, we can make a major simplifying assumption:

The people who measured this Olympic course are probably the best course measurers in the world. If a remeasurement ever needs to be made, the remeasurer will probably be drawn from the same population of measurers as was used for the original measurement. Under these conditions, it seems reasonable to assume that

$$\mu = \mu_0$$
, $\sigma = \sigma_0$

With these assumptions, equation (4) simplifies to:

$$S = \sigma \Phi^{-1}(C) \sqrt{1+\frac{1}{N}} . \tag{5}$$

This equation is very easy to apply: The $\Phi^{-1}(C)$ term is easily obtained from a table of the normal distribution (enclosed), and σ , which we assume to be the same as σ_{\bullet} , is easily estimated from the original measurers' data, using the estimator σ_{n} from page 1. As an example, if we want 99% confidence, and N=13, then

$$5 = 2.33 \, \sigma \sqrt{\frac{14}{13}} = 2.42 \, \sigma$$
.

Recall that equation (5) is derived from equation (1), which assumes the use of the mean in defining the course length. If medians are used instead of means, then we start with equation (3) instead of equation (1), and obtain the following equation for the safety factor:

$$S = \sigma \Phi^{-1}(C) \sqrt{1 + \frac{\pi}{2N}} . \tag{6}$$

For the special case of 99% confidence, with N=13, we then find:

$$S = 2.47 \sigma$$
.

Recommendations on Olympic course length

What is the purpose of our report? If all we're trying to do is make this particular race course acceptable, then we can use equation (5) or (6) to establish a course with a very high probability of not being found short. We can probably do this using a safety factor of only 0.05% or 0.06% of the measured distance.

On the other hand, I don't recommend such an approach if there's any chance of our report being taken as a precedent for future measurements -- especially for measurements where the assumptions leading to equation (5) or (6) may not apply. Note that the key assumption needed in reducing equation (4) to equation (5) was that the course was measured by the best measurers in the world! Clearly, the use of less than the full 0.1% safety factor depends on the skill of the measurers, rather than the sheer number of measurers.

If we decide to use a "confidence" method (providing less than the full 0.1% factor), then I prefer the mean-based method of equation (5) to the median-based method of equation (6), mainly because the former is easier to explain.

But recall that a mean-based method requires pre-editing of erroneous data points.

If we're concerned about our role as a precedent, then I suggest the full 0.1% factor, applied to the interval-by-interval medians (or to the "shorter" median for intervals with an even number of measurements) as required by our official rules.

Now, what method of calculation should be used before taking means or medians and applying the safety factor? Let me first say that it would be a big mistake not to use the intermediate calibration data in our primary calculation. For one thing, ignoring that data would be a slap in the face to John Brennand and the others who laid out those intermediate baselines for us! Also, thinking again of our possible role as a precedent, using the intermediate calibration data can insure accurate results in virtually any sort of weather/temperature pattern -- even in cases where the "standard" method would be way off. Thus, measurers of major marathons should be encouraged to set up and use intermediate calibration stretches along their courses.

It is now a choice between TVC and the various regression methods. TVC is the simplest extension of the standard method, to include the intermediate calibration data. There are more elaborate ways, but they really don't add any more accuracy. TVC is inherently more accurate (although not quite as precise) as the regression methods. TVC was implicitly the standard of accuracy against which all else was judged in Predictability Study #1 (and this should be made TVC does have a (very slight) precision problem since there more explicit). was only 1 ride over each intermediate baseline. But these are purely random errors and aren't worth worrying about since they average out in the final results. The regression methods try to improve precision, but at the cost of reduced accuracy, by forcing the calibration data through a curve of specified type. Regression can yield excellent results (just as good as TVC) if the curve type is well chosen. But none of the regression methods (including linear regression) can be properly applied without first seeing the data, so as to decide what type of curve to fit.

At this point, I'd like to discuss more topics (such as the "predictability studies"). But it's getting late, and I'd better get this letter typed up and in the mail before this weekend, when I leave for a two week trip. Good luck in your further deliberations. I suppose I'll find out your reactions in 2 weeks.

Best regards,

Boh

Note: one minor point...Don't forget to determine the adjustment for the construction site at Wilshire & Bundy. (I know there were several places on the course where we considered calculating adjustments, but this is probably the only one big enough to worry about).

September 6, 1983

Bob Letson

Dear Bob.

This will confirm some of the things we discussed in our conversation of last Saturday, in which I sold my soul to Ohio Bell.

I will cheerfully go along with a non-0.1 percent approach to defining course length. It is unimportant to me whether we use 2.42 SD's or, perhaps, the rounder 3. In order to accomplish this wonder of doublethink, I had to modify my previous adamant stance on the 0.1. I now reason as follows:

Course shortness may be prevented <u>either</u> by measuring twice using the standard method, <u>or</u> by using a measurement technique which convincingly demonstrates a low probability of course shortness.

We took the latter course, and I believe that we can demonstrate to any skeptic that the course is not short nor excessively long. We can use two methods to prove the point:

First, we can choose some level of confidence that we deem proper and use statistics to establish a course length. Even though our sample is small, our measurements, when plotted, have a fairly symmetrical, normal-distribution appearance, which is reassuring.

Second, we can show on the plot of how the measurement came out that the distance we picked was not found short by any measurer using any method.

If we had only two measurers, and the others were "checkers", none of the check rides could find the course short.

We thus have a blend of statistics and common sense, and they agree well with one another. I rest content that I will be able to sign off without further argument or obstinacy.

I am looking forward to getting the Baumellian broadside you mentioned that treats the statistics so elegantly.

here is the cleaned-up version of my COS 215 program. I've added some REM statements and resequenced it to make it pretty.

I'm looking forward to the FINAL report on this. Consult with me to whatever degree you wish, but rest assured that I will present no further obstruction to the final resolution of course length.

Best regards,

Pete Reiegl (whoops!)

xcBB

129 Warwick Road Ponca City, OK 74601 1983-09-19

Dear BL and PR,

It was nice to return from my 2 week business trip (1st week in Boston at an oil industry consortium at M.I.T., 2nd week in Las Vegas at Society of Exploration Geophysicists meeting) to find a stack of letters from Pete Riegel. Those letters contained some entertaining reading material, and some good observations (e.g. the potential errors in taking standard deviations with a calculator), along with some incorrect calculations (e.g. the probability of 2 measurements differing by more than 4σ), and possibly some misinterpretation of what I did in my letter of Aug 31.

My statistical calculations from Aug 31 had 3 main purposes:

- 1) I wanted to make it clear that Letson's "99% confidence method" applies only in the context of a "validation remeasurement." It considers the probability of finding the course short in a single repeat measurement. It is not concerned with the probability that the course is actually short (whatever that means).
- 2) I also wanted to make it very clear that the <u>only</u> real justification for using less than the full 0.1% safety factor is Letson's statement on page 103 "that all of the measurers were experts." If I had wished, I could have derived equation (5) quite directly, instead of going the more round-about route of first deriving more complicated equations which I then simplified to equation (5). But I wanted to bring out Letson's unstated assumption that the remeasurer is subject to the <u>same</u> probability distribution as the original measurers.

To that end, I first did several illustrative calculations for the "normal" situation where the remeasurer is more skilled (and thus has a different probability distribution) than the original measurers. In this "normal" case, it is not possible to calculate an appropriate safety factor using only the data from the original measurements. The only way I could obtain any numerical results for this case was by assuming ad hoc values for certain inherently unmeasurable parameters such as $\mu_0 - \mu$, the difference between the means of the probability distributions of the original measurers and the remeasurer. Recall that my calculated numbers indicated that in general, even the full 0.1% factor is not adequate to insure anything close to 99% confidence against finding the course short in a validation remeasurement!

My conclusion is that a statistical sort of method (such as \overline{x} - 3σ) is probably justified for the present Olympic measurement, precisely because we're just about the best measurers in the world (although it's rather difficult to come right out and say this in the report!). For this same reason, I think it would be a mistake to recommend anything less than the full 0.1% (at least for the bike-measured parts of the course) if there's any chance at all that our report will later be read and used by measurers less skilled than ourselves!

Please note that although relatively few people are likely to ever see our report, certain aspects of our procedure (e.g. whether we use the full 0.1%) are likely to leak out into the running magazines!

3) I wanted to take account of the finite number of measurers, and thus respond to the frequently leveled charge that statistical methods apply only to very large

numbers of measurements. It is true that <u>some</u> statistical methods are good only for large numbers of measurements, but it's also true that appropriate statistical reasoning can be of help in deriving valid conclusions from <u>any</u> amount of data.

Actually, I succeeded only about halfway in removing the large N restriction in this particular case. Let me explain. If the remeasurer has a normal probability distribution with mean μ and standard deviation σ , then it is quite correct to say that there's a 99% probability of the remeasurement finding the course no shorter than μ -2.33 σ . The main problem is that we don't know the correct values of μ and σ . But with the assumption that the remeasurer has the same probability distribution as the original measurers, we can estimate μ and σ by the sample mean and standard deviation, $\hat{\mu}_{N}$ and which we derive from the N original measurements of the course. But N must be large in order for $\hat{\mu}_{N}$ and $\hat{\sigma}_{N}$ to be good estimators of μ and σ . That's where the large N restriction comes from in BL's original 99% method.

In my calculations, I explicitly took account of the fact that $\hat{\mu}_N$ is not the same as \mathcal{L} . This difference led to the $\sqrt{(N+1)/N}$ factor in my equation (5). Unfortunately, I have still not accounted for the difference between $\hat{\sigma}_N$ and σ . Note that equation (5) involves σ , which is the (unknowable) standard deviation of the probability distribution. In practice, of course, you would use the estimator $\hat{\sigma}_N$ in place of σ in equation (5). But the equation is then no longer strictly correct (i.e. it no longer gives exactly the desired confidence level).

If you're really interested, I'm sure I can work out the correction to equation (5) to account for the use of $\widehat{\sigma_N}$ rather than σ (This correction would, of course, only be significant for small N). I don't know whether the numbers needed for such a correction can be found in standard statistical tables, or whether I'd have to do some integrals numerically on the computer. There is however some question as to whether this calculation is worth doing at all. For one thing, I'm not all that crazy about the idea of using a "statistical" method for defining our course length (I tend to prefer the full 0.1% factor as described in the previous section). If we do choose a "statistical" method, then I have no doubt that $\widehat{x} - 3\sigma$ would be perfectly adequate for all the intervals that had 8 or more measurers. Thus, the calculation in question would be of interest only to see how small a safety factor we could get away with for the Via Marina intervals which had only 2 or 3 measurers. But the result of such a calculation would differ only trivially from just using the standard 0.1% factor for that interval, as already proposed by BL.

Another subject investigated (at least approximately) in my statistical calculations was the difference between means, medians and minima. One interesting observation is that by following our standard rules, you get less protection against a short course when you make 3 measurements than when you make only 2 measurements! With just 2 measurements, you pick the minimum, thereby providing a definite bias toward a longer race course. But with 3 measurements, you pick the one in the middle, and there is no such bias.

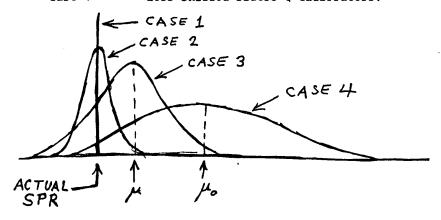
If the data is normally distributed, and you make any odd number of measurements, then both the sample mean and the sample median are unbiased estimates of the mean of the probability distribution. But it turns out that the sample mean is slightly superior to the sample median as an estimator of the distribution mean. On the other hand, the median becomes superior to the mean when the data contains some "blunders" causing departures from the normal probability law. This is described by saying that the median is a more robust statistic than the mean. And this robustness should make PR happy by allowing us to leave in all the "swerves" and "illegal shortcuts" that BL originally edited out.

On the subject of editing out bad data points, I don't like PR's suggested criterion of throwing out only those points which differ from the average by more than 3.29 \(\sigma \) (whose effect is not to throw out any points!). This criterion is certainly rather arbitrary. But PR's real fallacy is the idea that the criterion should be based entirely on numerical examination of the data itself, with no thought given to the question of how the data was obtained. For example, from merely examining the data on the Avondale-Georgina interval, it's not very obvious that anything is wrong with BL's data (it just looks like the best measurement). But I know that BL took an illegal shortcut -- he was right in front of me, and I saw him do it! This particular measurement was invalid because the measurer's path differed distinctly from the previously agreed upon path. (And this was a definite mistake, as opposed to the normal small variations that always afflict us in our attempts to ride the SPR). I do however think we must be very careful about rejecting these examples of "erroneous riding." For example, Ron Scardera's swerves should be rejected only if Ron himself agrees that he swerved off the intended course on those segments. Of course, none of these erroneously ridden intervals really need to be edited out if we use the more robust type of analysis provided by using the median instead of the mean.

As for baseline 6, PR's calculations are interesting, but still don't convince me that we ought to use the calibration data of the overshooters. Even if throwing out baseline 6 has a negligible effect on the overall course distance, it still has a more significant effect on the adjacent intervals (especially by TVC). I am not surprised that omitting the baseline 6 data had such a small effect on the total course distance as calculated by most of the methods. I am surprised that the cos reg distance changed about 4 times as much as any of the other calculated distances. I am even more surprised that the change in cosine regression distance was opposite in sign to the changes in the other methods. This may indicate lack of robustness in the cos reg method. More likely, it may indicate that there is still a bug in the cos reg program.

Another item I found very interesting in PR's letters was his sketches of probability distributions for 4 classes of riders. I'd like to offer my own version of this. Consider:

Case 1 Perfect calibrators, Perfect riders.
Case 2 Calibrators like us, Perfect riders.
Case 3 Calibrators like us, Riders like us.
Case 4 Less skilled riders & calibrators.



SPR = SHORTEST POSSIBLE ROUTE)

Notes:

- 0) I assume no temperature changes in any of the 4 cases. Temperature changes are a totally separate issue from riding ability. Furthermore, the effects of temperature changes can be handled quite well by TVC (and to a lesser extent by the regression methods).
- 1) The "perfect" riders of cases 1 and 2 are assumed to ride the mathematically idealized SPR; i.e. 30 cm from curbs, 20 cm from curbless road edges or lines, perfectly straight tangent lines. Thus the spike in case 1 represents the actual SPR.
- 2) In drawing the curve for case 2, I assumed the calibration errors to be completely random -- just as likely positive as negative. This is strictly speaking not true, as there are systematic errors in calibrating, including:
 - a) warm-up effects.
 - b) improper use of counter (e.g. backlash error).
 - c) The "calibration-wobble" effect -- tendency to get too high counts/km because of start-up wobble (which can occur several times if you have to make intermediate stops along the calibration course).
 - d) The "walk-factor" effect -- tendency to get too low counts/km due to taking weight off bike near endpoints.

As PR observed, it's debatable whether any warm-up effect can be demonstrated. Furthermore, I doubt that error (b) applies to any of the measurers in our group. Errors (c) and (d) act in opposite directions to each other. Also, both these effects tend to partially cancel between the calibration course and the race course -- but the cancellation is not complete since the calibration course tends to be shorter than the non-stop ridden portions of the race course.

In any case, I've ignored all the systematic calibration effects when drawing the curve for case 2.

- 3) For case 3, representing actual skilled measurers like ourselves, there is no reason whatever why the mean of this distribution (which I denote μ) should match the actual SPR of the course. I strongly suspect that μ is somewhat greater than the actual SPR. I have long maintained that a bicycle is not physically capable of riding with its front wheel as close as 30 cm to the curb when rounding a street corner. You can come this close by using the scooter technique, but relatively few of the measurers actually used the scooter method during the Olympic measurement.
- 4) For case 4, representing less skilled measurers, the curve is shifted to the right and is somewhat broader than in case 3. I've denoted the mean in this case by $\mu_{\mathbf{e}}$ to conform with the notation in my letter of Aug 31.
- 5) It's not clear whether the distributions in cases 3 and 4 should be symmetrical or skewed. In my letter of May 27 (where I first presented TVC results), I claimed to see some skewness in the TVC distances (i.e. some clustering of the data at the short end of the distance range -- which I found intuitively appealing). But I've since decided that there's no convincing evidence of skewness in our data (and in any case, our sample of 13 measurements is too small to tell), and the most reasonable choice seems to be the simplest possible description: a nice symmetrical, normal curve.

As for the less skilled measurers (case 4), this will forever be a matter of speculation. Any systematic experiment to determine the statistics of "unskilled measurers would be futile, since the subjects would inevitably be a lot more

skilled by the end of the experiment than they were at the beginning! The only incontrovertible facts are that the curve representing unskilled measurers ought to have its mean and peak values farther to the right than the curve representing skilled measurers.

6) In the specific case of the '84 Olympic course, I'm not sure whether the concept of the "actual SPR" (represented by the peaks of curves 1 and 2) has any real meaning. I say this mainly because of all the reflector buttons on the road (often about 30 cm from the curb), playing havoc with our official rules on where to measure. Each cyclist had to use his own judgment as to where to measure: Should he ride to the inside or the outside of the row of reflectors? Should he ride 30 cm from the reflectors (thinking of them as raised obstacles similar to a curb), or 20 cm from the reflectors (thinking of them as analogous to a line painted on the road), or maybe only 10 cm from the reflectors (which is possible if your riding is very steady, as the reflectors are low enough that you needn't worry about striking them with your pedals). It is theoretically possible that a runner could run directly on the row of reflectors (even though a bike can't ride there) since the runner can time his footsteps so as to always land between adjacent reflectors. Most tired marathoners wouldn't do this for any length of time, but they might do it briefly when rounding a street corner.

By the way, in addition to the problems with reflector buttons, we should also recall the arbitrary decision not to measure on the freeway shoulder (and this should be clearly indicated on the appropriate map!).

The moral is that in many cases (such as this one), our rules are not adequate to unambiguously define the "actual SPR" even in an idealized mathematical sense. In that case, it becomes totally pointless to even think about cases 1 and 2 of the curves drawn on page 3. We are then left with only cases 3 and 4, which it will be noted, represent the statistical assumptions behind the analysis from my letter of Aug 31.

Of course, there are courses which are simple enough that the SPR can be unambiguously defined, and could presumably be measured extremely accurately by careful surveying techniques (given enough time to do the surveying). The simplest such example would be a perfectly straight point-to-point course. There are also courses that have curves but are still straightforward enough to be so surveyed. Some requirements for such a course are that it be smoothly paved and curbed in its entirety (since uncurbed roads tend to have irregular edges), and it shouldn't have any reflector buttons or similar obstructions along the running path.

It would be very interesting to lay out a short test course of this type (e.g. under a kilometer in length) and survey it very carefully (just as one would survey a track to determine its length 30 cm from the curb). In fact, I suppose that a track itself could be used as the test course. Then measure it by the calibrated bicycle method, and see how close you can come to the actual SPR.

Best regards,

129 Warwick Road Ponca City, OK 74601 6 Oct 1983

Dear BL and PR:

PART I: SOME MORE PROBABILITY THEORY

PR's problem about 2 measurements differeng by more than 4 σ :

Problem Statement: Let A and B be independent random variables each of which has normal distribution with mean μ and standard deviation σ . What is the probability of A and B differing by more than 40?

PR's solution: PR correctly calculated that

Prob
$$\{(A < -2\sigma \text{ and } B > 2\sigma) \text{ or } (B < -2\sigma \text{ and } A > 2\sigma)\}$$

$$= 2 (0.0228)^2 = 0.00104$$
(1)

However, the possibilities considered in Equation (1) clearly do not encompass all possible ways in which A and B can differ by more than 4σ . Thus the probability calculated in equation (1) is definitely less than the desired probability:

Prof & 1A-B1 > 40} (2)

Correct Solution: We use the same trick as in my letter of 31 Aug. Define the new random variable

$$X = A - B \tag{3}$$

which (it is easy to show) has a normal distribution with mean and standard deviation:

$$\mu_{X} = 0$$

$$\sigma_{X} = \sqrt{2} \sigma \tag{4}$$

Note that:

$$\frac{4\sigma}{\sigma_{X}} = \frac{4\sigma}{\sqrt{2}\sigma} = 2\sqrt{2} = 2.8284\cdots$$
Therefore, using a standard table of the normal distribution,

Prob
$$\{|X| > 4\sigma\}$$
 = Prob $\{|X| > 2.8284 \sigma_X\}$ = 0.0047 which is about $4\frac{1}{2}$ times as large as PR's incorrect answer (1).

Generalization of Problem: Let A_1 , . . . , A_N be independent random variables, each of which has normal distribution with mean μ and standard deviation σ . What is the probability that some pair of the A's differs by more than $4\,\sigma$ (or some other specified amount)?

Solution: Use the table on page 2, giving the distribution of the "standardized range" (Note: the term "range" refers to the interval between the smallest and largest measurement). For example, if N=8, then the probability is 60% that the range will be no more than 3 or (or in other words, there's a 40% chance that the range will exceed 3 or).

ion

4 30 235 6260

9.5 99.5 5.6 26.5 3.9 13.8 47 9.38 47 9.38 31 7.23 07 5.99 28 5.20 73 4.65 33 4.25 02 3.94 78 3.70 19 3.51 18 3.10 8 3.00 0 2.92 2 2.84 2.78 2.72 5 2.67) 2.62 j 2.58

2.54 2.39 2.20 2.03 sians,

Table V. Distribution of the Standardized Range $W=R/\sigma$ (Assuming a Normal Population)

					_			,			
		Sample Size									
	2	3	4	5	6	7	8	9	10	12	15
$E(W)$ $\sigma_{\overline{w}}$	1.128 .853	1.693 .888	2.059	2.326	2.534 .848	2.704	2.847	2.970	3.078	3.258 .778	3.472 .755
W.008 W.01	.01	. 13	.34	. 55	. 75 . 87	.92 1.05	1.08	1.21	1.33	1.55	1.80
$W_{.025} \ W_{.05}$.04	.30	.59 .76	.85 1.03	1.06 1.25	1.05 1.25 1.44	1.20 1.41 1.60	1.34 1.55 1.74	1.47 1.67 1.86	1.68 1.88 2.07	1.93 2.14 2.32
W., W., W.,	.18	.62 .90	.98 1.29	1.26 1.57	1.49 1.80	1.68 1.99	1.83 2.14	1.97 2.28	2.09 2.39	2.30 2.59	2.54 2.83
W. W .	. 55 . 74 . 95	1.14 1.36 1.59	1.53 1.76 1.98	1.82 2.04 2.26	2.04 2.26 2.47	2.22 2.44 2.65	2.38	2.51	2.62 2.83	2.82 3.01	3.04 3.23
$W_{.4}$ $W_{.7}$	1.20 1.47	1.83	2.21 2.47	2.48 2.73	2.69	2.86 3.10	2.79 3.00 3.24	2.92 3.12 3.35	3.02 3.23 3.46	3.21 3.41 3.63	3.42 3.62 3.83
W.a W.s W.ss	1.81 2.33 2.77	2.42	2.78 3.24	3.04 3.48	3.23 3.66	3.39 3.81	3.52 3.93	3.63 4.04	3.73 4.13	3.90 4.29	4.09 4.47
W.975 W.99	3.17 3.64	3.31 3.68 4.12	3.63 3.98 4.40	3.86 4.20 4.60	4.03 4.36 4.76	4.17 4.49 4.88	4.29	4.39	4.47	4.62 4.92	4.80 5.09
W. 995	3.97	4.42	4.69	4.89	5.03	5.15	4.99 5.26	5.08 5. 3 4	5.16 5.42	5.29 5.54	5.45 5.70

This table is adapted from Tables XX and XXII in Biometrika Tables for Statisticians, Vol. I, 1954, by E. S. Pearson and H. O. Hartley, with the kind permission of the editor of Biometrika.

Exercise for reader: Show that in the special case of N=2, you get the same answer by using the table on page 2, as by using the trick of equations (3) and (4) along with a table of the normal distribution. Note that the trick of Equation (3) doesn't work when N is greater than 2.

 Removal of large N restriction from 99% confidence method (stated as a goal in letter of 19 Sept):

Problem Statement: Let A_1,\ldots,A_N be independent random variables, each of which has normal distribution with mean μ and standard deviation σ . (Note: we assume that the experimenters don't know the true values of μ and σ). Let V (representing the result of a "validation measurement") be another random variable, which is normally distributed and independent of the A's, and which has the same (unknown) mean and standard deviation μ and σ .

Let \overline{A} and $\widehat{\sigma}$ denote the sample mean and sample standard deviation of the A's:

$$\overline{A} = \frac{A_1 + \cdots + A_N}{N}$$

$$\widehat{\sigma} = \sqrt{\frac{(A_1 - \overline{A})^2 + \cdots + (A_N - \overline{A})^2}{N - I}}$$
(5)

We would like to define an "official length" L by the formula

$$\mathbf{L} = \overline{\mathbf{A}} - \mathbf{K} \, \mathbf{\hat{\sigma}} \, . \tag{6}$$

What value of $\, K \,$ must be chosen in order to attain a given probability $\, P \,$ that $\, V \,$ is not less than $\, L \,$?

Solution: Recall that in my letter of 31 Aug, I defined the new random variable

$$X = V - \overline{A} \tag{7}$$

which has the virtue of having a normal distribution that doesn't depend on the unknown parameter μ . Unfortunately, the distribution of X still does depend on the unknown parameter σ .

To solve the more complete problem, we define the new random variable

$$T = \sqrt{\frac{N}{N+1}} \left(\frac{V - \overline{A}}{\widehat{\sigma}} \right) \tag{8}$$

which has the virtue that its probability distribution is totally independent of both unknown parameters μ and σ . Unfortunately, the distribution of T is not normal. But fortunately, it is a standard tabulated distribution: As you may have guessed from its name, T has a standard t distribution (with N-1 degrees of freedom). It follows that the correct value of K to use in equation (6) is:

 $K = \sqrt{\frac{N+1}{N}} t_p^{(N-1)}$ (9)

where $t_p^{(N-1)}$ denotes the (P)th percentile of the t distribution with N - 1 degrees of freedom.

Table III. Percentiles of the t Distribution



Degrees of Freedom	t. 65 t. 60 t. 65 t. 70 t. 75 t. 80 tes too tes too too to	999:
1	.158 .325 .510 .727 1.00 1.38 1.96 3.08 6.31 12.7 31.8 63.7 63	_
2	.142 .289 .445 .617 .816 1.06 1.39 1.89 2.92 4.30 6.96 9.92 31	57
3	137 .277 .424 .584 .765 .978 1.25 1.64 2.35 3.18 4.54 5.84 12	0
4	.134 .271 .414 .569 .741 .941 1.19 1.53 2.13 2.78 3.75 4.60 8.	y
5	.132 .267 .408 .559 .727 .920 1.16 1.48 2.01 2.57 3.36 4.03 6.	07
6	.131 .265 .404 .553 .718 .906 1.13 1.44 1.94 2.45 3.14 3.71 5.	00
7	130 .263 .402 .549 .711 .896 1.12 1.42 1.90 2.36 3.00 3.50 5.	40 40
8	130 .262 .399 .546 .706 .889 1.11 1.40 1.86 2.31 2.90 3.36 5.4	41 U M 1
9	129 .261 .398 .543 .703 .883 1.10 1.38 1.83 2.26 2.82 3.25 4.3	70
10	129 .260 .397 .542 .700 .879 1.09 1.37 1.81 2.23 2.76 3.17 4.5	50
11	129 260 396 540 697 876 1.09 1.36 1.80 2.20 2.72 3.11 4.4	11
12	1 .120 .239 .395 .539 .695 .873 1.08 1.36 1.78 2 18 2 68 3 06 4 9	22
13	1 . 128 . 259 . 394 . 538 . 694 . 870 1 . 08 1 . 35 1 . 77 2 . 16 2 65 3 01 4 2	22
14	1 120 238 393 537 692 868 1.08 1.34 1.76 2.14 2.62 2.98 4 1	14
15	120 238 393 536 691 866 1.07 1.34 1.75 2.13 2.60 2.95 4.0	17
16	. 120 . 238 . 392 . 535 . 690 . 865 1.07 1.34 1.75 2.12 2.58 2 92 4 0	12
17	128 .257 .392 .534 .689 .863 1.07 1.33 1.74 2.11 2.57 2.90 3 9	16
18	.127 .257 .392 .534 .688 .862 1.07 1.33 1.73 2.10 2.55 2 88 3 9	2
19	.127 .257 .391 .533 .688 .861 1.07 1.33 1.73 2.09 2 54 2 86 3 8	Ω
20	.127 .237 .391 .533 .687 .860 1.06 1.32 1.72 2.09 2.53 2.84 3.8	5
21	.127 257 391 532 686 859 1.06 1.32 1.72 2.08 2.52 2.83 3.8	2
22	.127 .256 .390 .532 .686 .858 1.06 1.32 1.72 2.07 2.51 2.82 3.79	õ
23	.127 .250 .390 .532 .685 .858 1.06 1.32 1.71 2.07 2.50 2.81 3 7	7
24	.127 .230 .390 .531 .685 .857 1.06 1.32 1.71 2.06 2.49 2.80 3 7	4
25	. 127 . 230 . 390 . 531 . 684 . 856 1 . 06 1 . 32 1 . 71 2 . 06 2 . 48 2 . 79 3 75	2
	.127 .230 .390 .531 .684 .856 1.06 1.32 1.71 2.06 2.48 2.78 3 71	1
	.127 .230 .389 .531 .684 .855 1.06 1.31 1.70 2.05 2.47 2.77 3 69	Q
. 1	.127 .230 .389 .530 .683 .855 1.06 1.31 1.70 2.05 2.47 2.76 3 67	7
	.124 .250 .389 .530 .683 .854 1.05 1.31 1.70 2.04 2.46 2.76 3.66	5
	107 056 000 500	-
	.127 .256 .389 .530 .683 .854 1.05 1.31 1.70 2.04 2.46 2.75 3.65 .126 .253 .385 .524 .674 .842 1.04 1.28 1.64 1.96 2.33 2.58 3.29	•

Note 1: For the lower percentiles, use the relation $t_{\alpha} = -t_{1-\alpha}$. In particular, $t_{.50} = -t_{.50} = 0$. For example, for 6 degrees of freedom, $t_{.15} = -t_{.65} = -.404$. Note 2: For two-tail probabilities, see Table IV. This table is abridged from Table II of Fisher and Yates, Slatistical Tables for Biological, Agricultural, and Medical Research (5th ed.)/Fisher, Slatistical Methods for Research Workers, published by Oliver and Boyd, Ltd., Edinburgh, by permission of the authors and publishers.

 \mathbf{T}_i

This tab Vol. I, 1954 ton and C.

60

In equation (9), the $\sqrt{(N+1)/N}$ term accounts for the fact that we don't know the true population mean μ , while the use of the t_p term (as opposed to the corresponding percentile of the normal distribution) accounts for our lack of knowledge of the true population standard deviation σ . Equation (9) has now fully accounted for the finiteness of N.

As an example of Equation (9), we use the table on page 4 to find that if N=13, and we want 99% confidence, then the correct value of $\,$ K $\,$ is:

$$K = \sqrt{\frac{14}{13}} \times t_{0.99}^{(12)} = \sqrt{\frac{14}{13}} \times 2.68 = 2.78$$
.

Thus, the safety factor needed for 99% confidence when we have 13 measurers is 2.78 $\hat{\sigma}$. More generally, we construct the following table:

K values to use in equation (6)

			co	nfidence	leve1	
		0.95	0.975	0.99	0.995	0.9995
rs	2	7.73	15.55	38.9	78.0	780
measurers	3	3.37	4.97	8.04	11.45	36.5
sn		-	-	-	-	-
ea	8	2.02	2.50	3.18	3.71	5.73
	9	1.96	2.43	3.06	3.54	5.31
o£	10	1.92	2.37	2.96	3,41	5.01
H	11	1.89	2.33	2.88	3.31	4.79
þe	12	1.87	2.29	2.83	3.24	4.62
number	13	1.85	2.26	2.78	3.18	4.48
=		-	_	-	-	-
	∞	1.64	1.96	2.33	2.58	3.29

Note that if N = 9 or 10, and we want 99%, we must choose K equal to about 3. On the other hand, if N=13, and we choose exactly K=3, then we're getting a confidence level of about 99.3%. (Also, $\frac{1}{1} = \frac{1}{1} = \frac{1}{1}$, and we choose K=2.5, then we get a confidence level of about 98.2%).

One observation is that for N = ∞ , we recover our elementary criterion based on the normal distribution. That's because: (a) the $\sqrt{(N+1)/N}$ term becomes 1 as N $\rightarrow \infty$, and (b) the t distribution becomes a normal distribution when N $\rightarrow \infty$ (see bottom line of t table on page 4).

Another observation is that for \underline{small} N, the required K values are extremely large. This comes from the tp term, rather than the $\sqrt{(N+1)/N}$ term. It represents the fact that when N is \underline{small} , $\hat{\sigma}$ is a rather poor estimator of σ . For example, if we have only 2 measurements, then there's a significant probability that the 2 measurements will be extremely close to each other, so that $\hat{\sigma}$ will be considerably smaller than σ .

 $\,$ At the top of page 6 are some calculations for the Via Marina intervals:

VIA MARINA INTERVALS

Safety Factor for 99% Confidence (based on PR's raw TVC)

Interval	N	\overline{A}	ć	K	κ∂ (Safety factor)
Tahiti Way	3	1997.43	0.67	8.04	5.4
Bora Bora	3	2663.13	0.12	8.04	0.96
Northwest Passage	3	2950.30	0.80	8.04	6.4
next break	2	3261.28	0.46	38.9	17.9
Captain's Row	2	3516.22 meters	0.035 meters	38.9	1.36 meters

Note that for Captain's Row, the calculated safety factor is quite small (less than 0.1%) in spite of the very large value of K. That's because of the extremely small $\hat{\sigma}$, due to the remarkable coincidence of BB's and RS's measurements on that interval (at least by raw TVC).

On the other hand, for all but the Bora Bora and Captain's Row intervals, the calculated safety factors are considerably larger than 0.1%.

I think this shows that when we have only 2 or 3 measurements, the scheme based on equations (6) and (9) is not a good one, as it yields a very erratic safety factor. It often gives us a very much larger safety factor than we really need, in order that it won't give too small a safety factor in those (rather frequent) cases, such as BB and RS on Captain's Row, where $\hat{\sigma}$ is much less than σ .

The conclusion is that for N equal to 2 or 3, we're better off using the standard 0.1% safety factor, rather than a statistical scheme. But if we have 8 or more measurers, then the statistical approach using equations (6) and (9) is perfectly reasonable.

PART II: DISCUSSION OF OLYMPIC RECOMMENDATIONS

For nearly 6 months, we've been quibbling about a few meters one way or the other. The final choice of what number to adopt seems quite arbitrary. I don't think the decision can be made by purely scientific reasoning using only the data from the measurement. The final choice will certainly be influenced by political considerations and general philosophical principles. For example, one principle enunciated by PR (and I can say it's an idea I agree with) is that our final number should be calculable by a reasonably simple procedure. Relevant political considerations include the certification and validation rules (as we perceive them), and the reactions of, or effects upon, various groups of people. There are at least 5 groups of people we might consider:

- 1) The Runners. The 15-20 meters we're agonizing over are only worth about three or four seconds, and I don't think we need to worry about that. In any case, all recently certified marathons in this country do include the full 0.1% safety factor, so what we must decide is whether to give the runners a gift by making the course slightly shorter.
- 2) <u>Certification authorities in this country</u>. From the beginning, PR maintained that the "standard" method, including the full 0.1%, would be most readily accepted. That reasoning received a severe blow with TC's statement that there's nothing sacred about the 0.1%. Furthermore, Bob Hersh has now provided a good rationale for using less than the full 0.1%.

3) Athletic officials in other countries. Here I see a danger that we'll get complaints that the course is too long! For one thing, measurers in most other countries are probably still using the 1 meter rule. We might not really have measured exactly 30 cm (or even 30.48 cm) from the curbs (especially considering ambiguities due to reflector buttons, etc.), but even so, our course is probably at least 30 or 40 meters longer than if we had measured 1 meter from curbs!

A second point is that nobody outside the United States routinely tries to measure courses long by a factor of 1.001. The closest thing is probably the certification standard for an AIMS marathon, which says to aim for a measurement somewhere between the nominal distance and 1.001 x nominal distance (thus, they in effect use a safety factor of about 1.0005). If we use the full 0.1% factor, in addition to measuring by our 30 cm / 20 cm rule, I can really see some of these people shouting that the course is long!

- 4) The ordinary measurers who send us certification applications. Most of these will never see our report, but they'll probably still find out whether we included the full 0.1%. As PR has pointed out, we'll probably get less trouble from these people if we do use the full 0.1%. On the other hand, we might be able to explain that it would be overkill to use the full 0.1%. After all, the reason why novice measurers need the 0.1% is so that the course won't be found short when a more skilled measurer (such as ourselves) comes along to check the course. It therefore seems silly to still use the 0.1% when 13 of ourselves get together to measure a course, since we're the same people who would be doing the checking! (I wonder, though, whether in the future, somebody will build a course measuring robot that can do a better job than any human at measuring the SPR).
- 5) Measurers of other Major Marathons (e.g. AIMS events and future Olympics). One thing we should probably be doing in this report is promoting the tough U.S. standards for trying to prevent short road race courses; e.g. the 0.1% factor and the 30 cm / 20 cm rule. This becomes more difficult to do if we use less than the full 0.1% for the present course. But as BL has pointed out, we can set things up so that measurers can get away with less than the full 0.1%, provided they take enough other steps, such as having ten or more expert measurers (I know that Hersh referred to 'more than a dozen' measurers, but I wrote "ten" because I like metric).

I have this fear that some day the Olympics will be held in a country where the running boom has not yet caught on, but even so, the local officials will try to duplicate our procedure by gathering 13 people to measure the course on bicycles. The only problem is that none of those 13 people will have ever measured a race course before! We should therefore emphasize that we had 13 expert measurers, each of whom had done many course certifications, and thoroughly understood the concept of measuring the shortest possible running path.

Thus, an obvious prerequisite for measuring a course of this magnitude is that only experienced measurers be used. But perhaps even more important than experience is the attitude of the measurers, in trying their utmost to avoid a short race course. This is an attitude which has only recently been adopted by certification officials in this country, and may not yet have taken hold anywhere else in the world. But we were all imbued with that spirit during our measurement this past April, and we jokingly referred to it as a contest to see which measurer could obtain the best measurement by getting the shortest measured distance. (Fortunately, the results of that contest were inconclusive, due to all the different calculation methods). But perhaps we will do a valuable service if we can get some of that spirit across in the report!

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Now let's get down to the nitty gritty. What length should we recommend? I suppose that the "Hersh" number of 30892.8 m is a reasonable one (for that set of 13 intervals). Its derivation is quite straightforward (For each interval, pick the smallest measurement from any measurer, by any calculation method). Furthermore, I can give an a posteriori justification for the number in terms of my statistical approach. Let's suppose that a remeasurement is made, and the result calculated by raw TVC (which is one of the most valid methods). From Letson's recent graph, we see that the Hersh number is 4.49 standard deviations below the mean of raw TVC (where I'm talking about standard deviations for measurements of the full 30.9 km distance). Now, from my table on page 5 of this letter, we see that for 13 measurers, a K value of 4.49 corresponds to a confidence level of almost exactly 99.95 %.

The main element of arbitrariness in Letson's "Hersh" number is the choice of calculation methods from which it is derived. For example, if the "standard" method were included, then the number would be lower. But I agree with BL in omitting the "standard" method which, as I see it, is significantly less valid than the TVC methods (which I regard as most accurate). It so happened that in our particular measurement on 24 April 1983, the "standard" method gave a smaller answer than TVC. But that certainly doesn't mean that "standard" will always give a smaller answer (and thus result in a longer race course) than TVC! It's very likely that if the measurement were repeated on a different day, with a different temperature pattern, then the "standard" result would be higher than TVC. In the meantime, the TVC result would probably be quite reproducible on a different day with different weather.

As for the regression methods, I regard them as intermediate between standard and TVC. In fact, I suspect that regression (as implemented by PR) will generally give an answer intermediate between standard and TVC (I can even give a fairly rigorous mathematical proof of this assertion for the special case of equally spaced baselines and linear regression).

In terms of order of magnitude, I can accept either the 30892 m or 30888 m figure. However, I do think that BL's derivation of the 30888 m number is extremely arbitrary.

In any case, if we accept such a slim safety factor, there is still another danger that hasn't been mentioned yet. I'm not really worried that somebody will come along and find the course short, as long as they measure exactly the same course as we measured. It is therefore absolutely imperative that our written documentation provide an extremely accurate description of our measured path.

Actually, there are at least 4 points where the diagrams in BL's "Maps & Measurements" section describe what I think is a shorter path than what we actually measured. (Note: I've already mentioned 2 of these cases in previous letters):

- 1) Wilshire & Bundy: The map should clearly indicate the construction site at this corner, and, if possible, a course correction to account for that construction.
- 2) Via Marina turning points: I don't think BL's diagram of the turning circle is correct. My recollection is that the lines we painted on the road extended considerably farther south than just 12" from the point of the curb. The exact turning center and radius should be checked. There is also a question as to whether the lines we painted represented the measuring line or the pylon positions (My understanding was that our lines denoted the pylon positions, so that the measuring line was 30 cm farther out).

- 3) Marina Freeway: The map should make it clear that we measured only on the roadway proper -- not on the paved shoulders which contained debris that could cut bicycle tires.
- 4) Stadium Tunnel: I don't know whether we really measured 12" from the storm drains shown on BL's diagram. In fact, I don't remember ever seeing those storm drains. All I remember were those big barrels (or garbage cans) that were placed along the wall. (And those barrels aren't shown on BL's diagram at all!). I also recall that John Brennand issued verbal instructions to stay some rather large distance (maybe 6 ft, although I'm not sure I remember exactly) from the tunnel wall. It turned out that our measurements displayed a larger coefficient of variation on this interval than on any other interval of the course. I know that I tried to follow Brennand's instructions literally. I suspect that some of the other measurers ignored Brennand's instructions and simply squeezed as close as they could get to the barrels.

In the above cases (especially cases 2 and 4), BL should try to recover the original field notes from John Brennand, or whoever else might have them.

Best regards,

Note from BOB (ETSON:

After receipt of this letter of phoned Ron Scardera and asked him to

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remembers riding Ris brains in the stadium temme! Bot letter, remembers

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observing Ron Franchera dother, and confirm that RS roots less than

12" from the drains.

Rabutal- Letter,

11-19-83

November 18, 1983

Bob Baumel

Dear Bob,

Just got your reply to BL's report. Glad you think it's nice too. I think that your description of TVC is probably a little better than BL's was, but they both seem to do the job. Of special interest to me was your graphs of how TVC really worked. What we did was use TVC to calculate a constant for each interval between cal courses and then use the same out process constant for each of the intervals.

I did do a computer run in which I interpolated the two constants within the range, using a slightly different constant for each interval, if two or more were between cal courses. I may have sent you a printout - I know I sent one to BL. The difference between true interpolation and ordinary TVC was so tiny as not to justify using it. It is so much more complex and hard to explain.

Actually we used stair-step constant graphs on all our methods, even the regression ones. Each interval has its own constant. I think it would only confuse the readre if we got into those stairsteps. Maybe not. But is there any point in it, besides our own obsession with trying to be perfect?

As far as I am concerned, the report is perfect enough for me, and although there are still areas that fall short of perfection at think we should roll it up and mail it.

Like you, I found BL's foravs into the realm of STVC a bit more arcane than I would like, but I can't say I'm too disturbed about it. We have to be more flexible than we would like sometimes. Besides, I don't think that any serious incursions into inaccuracy were made, although I found the many adjustments and explanations to be awfully laborious just to improve our "accuracy" by such a trifling amount.

I think we would have been OK with only the straight standard method, but we would not have had nearly the fun, nor would the report be the classy job it's turning out to be. For the life of me I can't see why I got so obsessed by this, but I suppose that's why we do this stuff at all.

As for RETRODICTED, Good God. Please seek professional help. How about "derived counts" or something less overblown? If we need to do anything about that section at all. Personally I don't see the real point of that whole section, but it's a little more analysis that fust might help. I often find later that when I've thought you and EL to be in left field, reconsideration modifies my view. That section is all's baby, and I have no personal involvement with it at all. Just like

my views on STVC and adjusting data. I've had my say, and in these sections BL is having his.

Better put your erroneous objection to my Afterword back in. I think BL's going to ude it (edited, to escape my error concerning the non-uniqueness of our measurement due to its enroute courses. BL has used them before.)

I will leave you and BL to thrash out the remainder of your differences without my aid. I am happy with the present state of the report, and believe that further errors are all of such a minor nature that course accuracy is not seriously compromised.

I guess I wrote this letter all because of RETRODICTED. I absolutely couldn't believe it. Wonderful! I must find somewhere to use that word. Sounds like something from the Pentagon. (sorry, improper usage)

If I had to retrodict/the results of another similar measurement, I would say that we were handicapped by the speed with which we had to work. We did the best we could, but with all of us in that caravan, each of us had to let some things go in order to keep up with the others. Maybe two people who knew the course well could have done better, but probably not a hell of a lot.

I am still chuckling and giggling over that damn word. I'm sorry if I'm offending you, but I wan't help myself. If I don't stop I will get the hiccups.

Your commentary was good, Bob, and I think you're on the mark in the things you've said, so you and BL settle your differences. BL and I have ours settled already, I think.

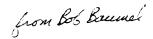
ر المحالية ا

Have a good Thanksgiving.

Best Perds,

Pete Riegel

XCBL



129 Warwick Road Ponca City, OK 74601 1983-11-26

Dear BL,

I've made numerous corrections and small changes, which you may act on as you wish. They're all marked in BLUE ink, and each page with changes has a \checkmark mark at the top.

I've also written 3 more items (on the enclosed 4 sheets of paper) which I would like to see added to the report in the appropriate places. They are:

- 1) I disagree with your interpretation of "region of doubt" as described in your "Validation Remeasurement" section on page 50. Rather than change what you have written in this case, I would like to add my own interpretation (2 typed pages, enclosed). Perhaps this should be inserted between pages 51 and 52. This disagreement in interpretation is also the reason for many of my proposed changes on page 179.
- 2) You had some incorrect probability calculations on page 55 in connection with the Lowest Actual Measurements method (this is a case where the binomial distribution, of which PR has been so enamored, should have been used). I have therefore written up a sheet of correct calculations. Actually, while these calculations are interesting, they may not be all that important to the report. Then again, you might consider them very important since the Lowest Actual Measurements method is the one used for defining most of our recommended lengths. Anyway, you can decide whether you want to include my calculations, or correct or eliminate your own erroneous calculations.
- 3) I have reworked the stadium U-Turn calculations from page 144. One thing I realized is that you overlooked a very small distance of 1.8 cm (which I denoted "w" on page 144). I've also done a thorough error analysis (on enclosed sheet) using partial derivatives to calculate how much the uncertainties in each of the three taped distances propagate through to the final calculated result for the length of the running path. One thing I realized is that the possible errors in each of the 3 taped distances are considerably larger than one might hope from a steel tape measurement under optimal conditions. That's because each taped distance was stated as a whole number of inches. In other words, the distances had been rounded to the nearest whole inch before we ever looked at them. Thus, each has a possible error of \pm 1/2 inch (or \pm 1.27 cm). This propagates through to a possible error of \pm 5 cm in the calculated result for the running path, which can be expressed as: 16.25 ± 0.05 meters.

On the list of proposed lengths (page 180), I've made basically just 2 changes:

- 1. My opinion is that the 45 cm construction adjustment for Wilshire-Bundy should be included in the average median distance, rather than the short-course prevention factor, since this is an actual change in available path, as opposed to a result of our short-course prevention analysis. In any case, this is an unimportant change, since I haven't changed the all-important final column "proposed" distance (since you already included the construction adjustment in that final column). I have added a footnote so as to eliminate any possible confusion on the part of the reader as to whether the construction adjustment has been included.
- 2. I've replaced the U-turn arc distance with my calculated result (3) above. This has the effect of returning the "proposed" distance for this interval to

16.20 m, which was your original printed version (before you made your change in red). In fact, my changes would return the entire final column of "proposed" lengths to the original printed version. However, the columns headed $\overline{\rm Md}$ and SCPF will be slightly different if my changes are accepted (and even if my changes aren't used, it should be noted that the sums at the bottom of those columns contained slight errors, as they hadn't been corrected to account for some slight revisions since the previous version of the report)

There is one other change listed on page 180, concerning the possibility of a remeasurement result out of tolerance. But this was perhaps more a semantic problem than a mathematical one.

I have one other request, Bob. When you send out copies of the final report, would you send me $\underline{\text{two}}$ copies? I would like to have an extra copy to give to Oklahoma TAC, who were nice enough to provide me with \$200, or about half the cost of my trip to Los Angeles this past April.

Dear PR.

I'm sorry you found the word "retrodicted" so hilarious. But it was the best I could think of. The word "actual" is certainly misleading. And your suggestion of "derived" doesn't convey as much information. You might be interested to know that I didn't make up the word "retrodicted". I have previously seen it in an article or book on the theory of measurement in quantum mechanics, but I can't cite the reference just now.

Thanks for reminding me about your LIN TVC calculation. I had probably seen it before, but hadn't paid much attention and had forgotten it. In any case, it confirms my statement on page 37 that the difference is negligible for the total course distance, and is most noticeable for the intervals between baselines 3 and 4. In practical terms, the major difference (of just over a meter) was on Admiralty - Mindanao (just before baseline 4), where TVC was used for the official proposed distance, even though LIN TVC was probably more accurate. Of course, the difference between TVC and LIN TVC is much smaller than the effects of including or omitting baselines 2 and 6, as shown by the 3 columns on page 36. I included the step-function graph in the interest of accuracy -- in case anybody tries reproducing our calculations. I also needed to mention linear interpolation because it is used in STVC.

Even though your "Personal Afterward" is back in the report, you may be interested to know that I will leave my "Winston Smithsonian" revised letters in their present form; i.e. I have no intention of putting back my criticism of your Personal Afterward. So there!

Best regards to you both,

Note: Bob letson views as tragic the possibility be rejected by an imperfect that a perfectly accurate nace course could be rejected by an imperfect reascurement. Item and Riegel advocate disqualification only if the remeasurement proves, beyond doubt that the course is too about (ie, that the remeasurement is less than 42195-X on is greater than 42245+X miles to do X remeasurement is less than 42195-X on is greater than 42245+X miles that the region of should of the technique used for remeasurement.

ON "REGIONS OF DOUBT" by Bob Baumel

Bob Letson's statements about "region of doubt" in his discussion of "Validation Remeasurement" do not correspond to the philosophy advocated by certification authorities in this country. Race courses do not have legal rights under the Constitution of the United States. They are not considered innocent until proven guilty (i.e. short). They need not be proven guilty (i.e. short) "beyond reasonable doubt". In fact, the reverse is true; a course is valid only if it can be shown beyond reasonable doubt that it is not short.

According to the U.S. Validation Standard scheduled to take effect on 1 Jan 1985, a course is considered to pass a Validation Test only if the result of a remeasurement (with no consideration of "regions of doubt") shows the course to be at least as long as the nominal length. (Note: U.S. races held in 1984 will be subject to a more lenient (interim) standard which allows a short course tolerance of 0.1%. This is to allow time for older certified courses to be upgraded to the no-short-course-tolerance standard). All courses currently being certified in the United States are intended to meet the 1985 validation standard.

In order to provide a high probability that a course can pass a validation test by the 1985 U.S. standard, the <u>short course prevention factor</u> which is applied to the course must be sufficiently large as to encompass the regions of doubt of both the original measurement and the remeasurement. This is, in fact, the philosophy behind all the probability calculations in my letters (which are reproduced at the end of this section). In all those calculations, I consider probability distributions for both the original measurers and the remeasurers.

In particular, Letson's stated region of doubt of 1/2700 was calculated using the probability methods from my letters, and is thus an estimate of a combined region of doubt for the original measurers and hypothetical remeasurer (assuming the remeasurer to be statistically similar to the original measurers). What it represents is an interval, surrounding the mean value of our measurements, in which the results of future measurements will most likely lie. To be precise, the estimated probability is 98% that any given remeasurement will lie within the interval (and more importantly, the probability is 99% that the remeasurement won't lie below the interval).

There is another philosophical point which is more subtle, but I will attempt an explanation anyway. The quantity of interest in my probability calculations is not the difference between a measurement of a course and the "actual length" of the course, but rather the difference between measurements on two different occasions; i.e. the original measurements (24 April 1983) as compared with a presumed later (validation) remeasurement. Given our measurement results, I can calculate a "region of doubt" in which the results of future measurements will most likely be contained. But it's far more difficult to calculate a "region of doubt" for the actual length of the course. The problem is that it's a very sticky question to define exactly what we mean by the "actual length" of a course!

One possible definition of "actual length" would be the distance along the geometrically shortest possible path, following perfectly straight tangent lines (on stretches between curves), and hugging the inner edges of curves at distances of exactly 30 cm from curbs, or 20 cm from lines or curbless road edges. This geometrical definition works perfectly well in the case of a track, but road courses are more complicated.

The best method anybody has found for measuring road courses is the Calibrated Bicycle Method. Nevertheless, we have no good data on just how close a bicycle measurement can really come to the geometrically idealized shortest possible path. In fact, there is considerable doubt as to whether a real bicycle can be ridden around a street corner with its front wheel as close as 30 cm from the curb (without having its inside pedal strike the curb)!

But whether or not a bicycle can really match the idealized geometrical shortest possible path (including the specified 30 cm and 20 cm distances), it is generally believed that in practice the bicycle method is perfectly capable of satisfying the rule of measuring the shortest possible running path; i.e. if the course is created by competent bicycle measurements, then no runner will actually succeed in running a shorter path than has been traversed by the bicycles. This concept has led some observors (such as Peter Riegel) to suggest an operational definition of "actual length", based on the calibrated bicycle method.

The idea of such an operational definition would be to "define" actual length as (more or less) the shortest distance obtainable by competent calibrated bicycle measurements. This statement is still rather fuzzy, and I have not seen a really precise formulation. In any case, from the viewpoint of such an operational definition, if we can calculate an interval (or "region of doubt") in which future measurements of the course will probably be contained, then this interval can also be regarded as a "region of doubt" for the true length of the course. However, the most likely value of the "true length" would be somewhere at the lower end of the interval, rather than the center of the interval.

The shortest possible path rule makes statistical error analysis more complicated for a race course measurement than for measurements in most other areas of experience. In a "normal" measurement, if it can be assumed that systematic errors have been removed, then the remaining errors are "random" and just as likely positive as negative. But the shortest path rule introduces a funny sort of bias. Departures from the shortest possible path (e.g. by lapses of concentration of a measurer), although "random," are nevertheless one-sided; i.e. any deviations from the shortest path can only increase the measured distance. The resulting bias creates a difficult problem of interpretation.

To return to my original subject, let me reiterate that the probability calculations in my letters are concerned solely with the statistically well-defined problem of predicting the results of <u>future measurements</u> of the course, and make no attempt whatever to estimate <u>differences</u> between our measurements and the "actual length" of the course.

Note: These statements have an interesting implication for Validation Remeasurements. It seems that the majority of measurements of a course probably yield a length greater than the "actual" length. This means that if a remeasurement finds a race course to be short, then the course most likely really is short! However, it is also very likely that a

most likely really is short! However, it is also very likely that a perfectly accurate course (measured electrically & via steel tape) will appear to be short if remeasured by bicycles. Military

Probability of Remeasurers bettering the "best" measurements on n intervals of the course

If an interval is originally measured by 13 measurers, and is then remeasured by a single remeasurer (assumed to be just as skilled as the original measurers), then there is a 1/14 chance of the remeasurer getting a lower (or "better") measurement than the lowest (or "best") of the original measurements. In other words, there's a 1/14 chance of this particular measurer having the best of the grand total of 14 measurements of the interval.

Similarly, if the interval originally measured by 13 measurers is then checked by 10 remeasurers, there's a 10/23 chance of at least one of the 10 remeasurers doing "better" than the best of the original 13 measurers.

More generally, suppose that N intervals are measured by m original measurers and r remeasurers. Then the probability of at least one of the remeasurements bettering the best of the original measurements on precisely n of the N intervals is given by a binomial distribution:

$$P(n) = {N \choose n} \left(\frac{r}{m+r}\right)^n \left(\frac{m}{m+r}\right)^{N-n}$$

This is worked out in the following table for the special cases of N = 13 intervals, m = 13 original measurers, and r = 1 or 10 remeasurers:

	P(n)		P(n)			
n	(1 remeasurer)				(10 remeasurers)	
0	0.381 592				0.000 600 899	
1	0.381 592				0.006 008 99	
2	0.176 119				0.027 733 8	
3	0.049 674 7				0.078 223 5	
4	0.009 552 83				0.150 430	
5	0.001 322 70				0.208 288	
6	0.000 135 661				0.213 628	
7	0.000 010 435 5				0.164 329	
8	0.000 000 602 048				0.094 805 4	
9	0.000 000 025 728	5			0.040 515 1	
10	0.000 000 000 791	647			0.012 466 2	
11	0.000 000 000 016	608	0		0.002 615 29	
12	0.000 000 000 000	212	923		0.000 335 293	
13	0.000 000 000 000	001	259	90	0.000 019 839 8	

Note that even for a single remeasurer, there's a 62% chance of bettering the original measurements on at least one interval. Thus, it's not surprising that when Tom Knight remeasured the course on 5 June 1983, he bettered the best of the original measurements on one interval.

But in order for a remeasurer's <u>overall</u> measurement of the whole course to be lower than the best original measurement from each interval, he would probably need to better the original measurements on roughly <u>half</u> the intervals (or more). From the table, the probability of a single remeasurer bettering the original measurements on 4 or more of the 13 intervals of the course is only 1.1%. The probability of bettering the original measurements on 5 or more intervals is only 0.15%.

In the case of 10 remeasurers, the probability of bettering the original measurements on 5 or more intervals is about 74%. Even for 7 or more intervals, the probability is still about 31.5%. But fortunately, validation remeasurements are not performed by doing 10 remeasurements and then picking the lowest remeasurement of each interval! (Note: No matter what scheme we advocate for choosing an official course length, if a validation measurement were to be performed using precisely the same scheme, then the probability of a short course upon remeasurement would be exactly 50%)!

92 From Peter Riegal:

Dear BB. BL

Here's my personal afterword for the report. The relative respite during the last few weeks has allowed me to come to the realization that I'm relatively indifferent as to what the final distance for the course really turns out to be. No matter what number we pick, of all those we've discussed, the course will be right enough. I don't think a full 0.1 percent is much of a burden, and if it's shaved because we have better numbers than an ordinary measurement would give I don't think the runners will note the difference. Since the exact truth as to course length will be forever a secret, we must go with what we've got, which is pretty good.

The validation measurement I did last weekend got me to thinking, and I'm going to press Ken Young on this - I think it will be a big mistake to close the shortness tolerance to zero, as the shhedule calls for. I think that our ultimate layout and checking method should be:

- 1) Lay out the course 0.1 percent long
- 2) If a record is set, a validation ride must be 0.1 percent short to shoot down the course.

What do you guys think? Our data strongly suggests that such a standard is reasonable. In addition, most measurers will not, in reality, achieve the true extra length that the 0.1 addition implies. And a 0.1 percent difference is needed in a validation to be <u>sure</u> that a course is indeed short. The result will be a standard which is centered on the nominal course length, as long advocated by BL and others.

The measurement process cannot achieve more than an idea of true length unless every course is measured as the Olympic course was. We must live with greater error than we might like, but even if we treated every course like the Olympics there would still be error. The standard method is not too bad, and I think that if we treat measurement as suggested above we will achieve a reasonable measurement and validation system.

As to riding skills, I'm glad that the report will have no such bushwa as a reference to our supposed superiority at this. I think it's true that we all have a higher consciousness as to the importance of riding the SPR, but our abilities to perform remain suspect. Some monomaniacal idiot somewhete, perhaps recruited from a mental institution, might be able to focus totally on riding straight. Maybe he couldn't figure out his data, but it could be a hell of a set of data. Guess we'll never know.

Ken - I hope that you and Jen and NRDC are high and dry. What we're seeing on TV is <u>awful</u>. I suppose that in a week or so you'll be dry again, but right now it looks pretty bad.

I must now do some work. Hang in there.

Best regards.

fite

From Peter Riegal:

November 15, 1983

Dear BL.

Enjoyed our conversations yesterday.

Here are my slightly revised "personal afterword" and my only copy of the latest version of the report. I have tried to catch all the misspellings and grammatical weirdities that I'm capable of. I've also stuck on a bunch of wee notes here and there. Pages with an "x" in the upper corner have a correction somewhere on the page.

I could have tried to spell out all these minor corrections in a letter, but this way is better. Please send back the report when you have finished with it, but there is no hurry.

The more I read it, the better I like it. You have done a masterful job of putting the whole thing together. I don't see how approval can fail to follow.

As I said last night, I have many times gnashed my teeth at the way that you and Baumel would fail to perceive things correctly (i.e. my way), but after all this, if somebody ever comes to me with a measurement problem, and I'm stuck, I can't think of anybody I know who I'd recommend before you guys. You two are Good.

It can be a real drag trying to work with fools, or people who are so stuck in a fixed mindset that they are incapable of compromise. All of us have done some bending, and speaking for myself, the final product is far superior to anything I could have done on my own.

Your own patience and willingness to do things over and over has contributed greatly to the quality of the product. BB's excellent playing of the academic game, in which one devastates one's opponent with wit and courtesy, has given me much amusement as well as made me wiser.

I doubt that anyone will attempt to duplicate, or even check, our computations. Maybe they will, but I think that, in the main, they will be bowled over by the immensity and meticulousness of the report. In short, they will be snowed.

As long as I have BB reading, I'll reiterate the little problem we began exploring last night. I think that cal courses are mainly on a cambered surface. Is there a good way to check the difference between a cal ride on a cambered surface and one on a flat surface? I'm going to experiment some with my pet course and see what I get. I'm not sure what should be done with the information so obtained, but I'm curious.

My mind is beginning to wander. Must be my dotage approaching. Stay loose,

fet

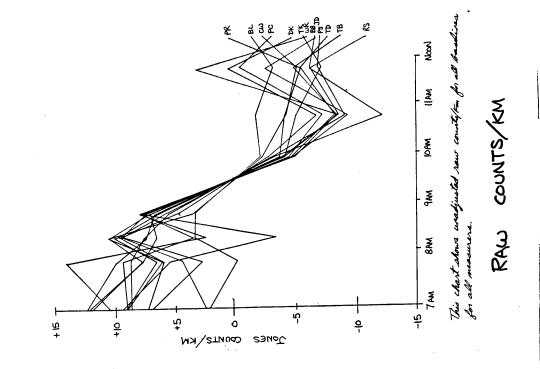
A PERSONAL AFTERWORD

During the course of this work the three of us expended hundreds of man-hours analyzing everything in great detail - certainly more analysis was done than the job really required. After all, it is only a course measurement for a footrace. Still, as we tested our ideas on one another I think we became obsessed with the idea of seeing just how much we could squeeze out of the numbers. I know I did. I had a lot of fun with this analysis.

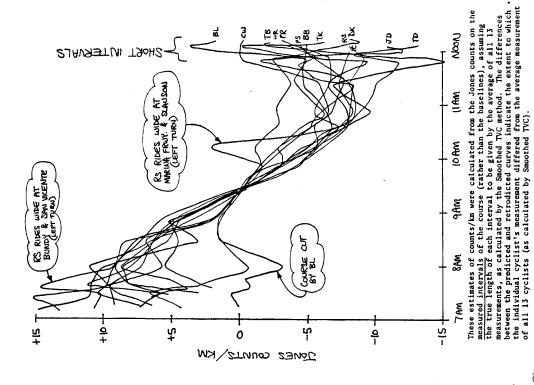
The most valuable thing to come out of the measurement, in my opinion, was the confirmation that our present measurement method is reasonably accurate. The enroute calibration stretches, infrequently used in course measurements, allowed the <u>accuracy</u> of the measurement process to be measured. The thirteen measurers, drawn by the Olympic magnet, provided sufficient numbers so that we could begin to understand the limits of <u>precision</u> as well. The Olympians will have an accurate course. That much is certain. In addition, all runners will benefit from our increased understanding of the measurement process.

On a personal level, the scores of letters and calculations which we exchanged brought us close. I value the friendship and respect which grew with our correspondence. We certainly did not always agree, but now that this work is done, our differences seem unimportant. What remains, for me, is a warm memory of shared work with two truly competent and witty people. The course riding was fun, but these months of analysis forced the three of us to confront what we did not know, as well as to examine what we thought we did know. I think that we have separated fact from fancy.

fite Rige



GOUNTS/KM



3 3 X K 6 8 7

7

SOLID RUBBER WHEEL

COUNTS KM

JONES

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COUNTS

2007

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2

9

COUNTS

RETRODICTED

Each measurer's counts/km, as determined by Smoothed TVC, is shown in the above chart as it varied throughout the morning. These are smoothed lines, determined by the baseline rides, and adjusted for systematic errors. They represent the predicted counts/km for each rider. PREDICTED

COUNTS/KM FOR BICYCLE MEASUREMENTS

Counts/km is not constant. The actual counts per kilometer is sensitive to changes in wind, temperature, incline, riding posture, etc. If graphed, as in the previous illustrations, actual counts/km is certainly erratic.

We never know exactly what the actual counts/km is during a measurement. Instead, the actual counts/km must be estimated by taking samples from accurate baselines before, during, and after measuring. Then we must study this data to estimate the counts/km during the measurement.

The April 24, 1983, measurements had eight samples of counts/km for each measurer. Seven different methods of interpreting these samples were used to predict the actual counts/km for each measurer:

LIN REG Linear Regression method
COS REG Cosine Regression method

RAW TVC TVC method

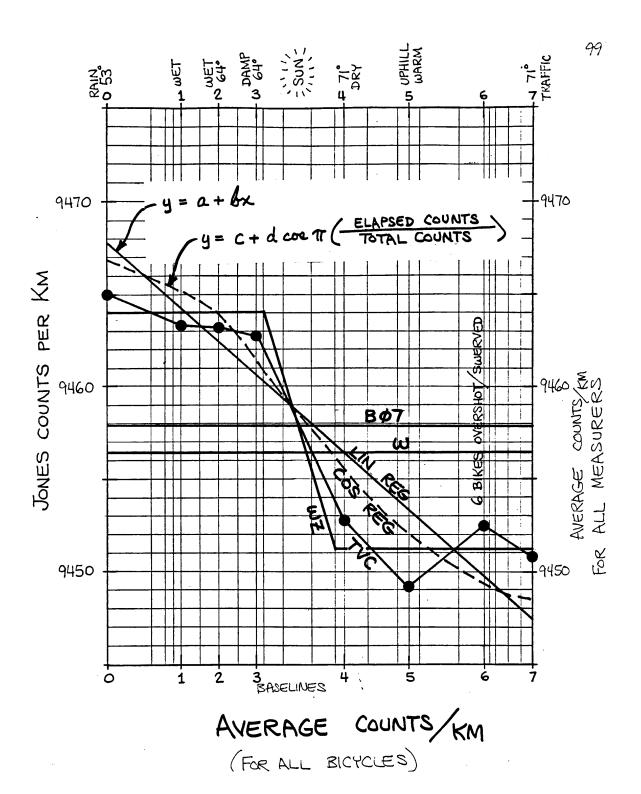
SMOOTHED TVC Smoothed TVC method

W Weighted Baselines method WZ Weighted Zones method

BØ7 Baselines Ø,7 Constant method

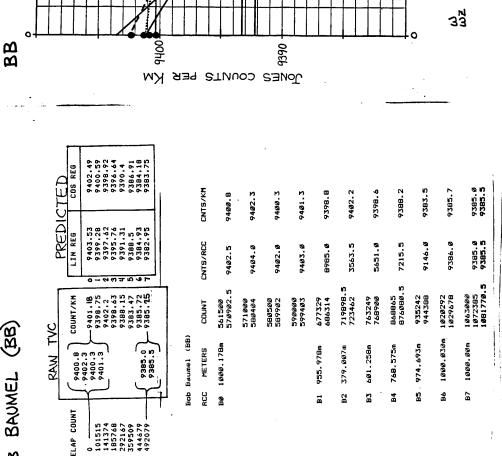
The first six methods are described in the "Standard Method" section of this report. The "BØ7" (baselines Ø and 7 only) is included for academic interest, because this tends to be the usual way that most other certifications are calculated. "BØ7" assumes that counts/km is a constant throughout the entire day, equal to the average of the pre-measurement and post-measurement samples.

The counts/km predicted by each method have been graphed on the following pages for each measurer. Each graph plots counts/km on the y-axis versus distance on the x-axis. The x-axis is divided into lines that represent the midpoints for each interval. Black dots represent actual recorded counts/km. Lines represent predicted counts/km for specific methods. The graph for "Smoothed TVC" shows both the "predicted" and "retrodicted" lines. The "retro" line is merely an estimate assuming that the actual length of each interval is equal to the mean of all measurements.



BOB BAUMEL (BB)

0 101515 141374 185768 292167 359509 444679



9390

DEIGHTED = 9392.19
DEIGHTED ZONES: WET = 9400.30
DRY = 9385.45

9400

1VC

SMOOTHED TVC.

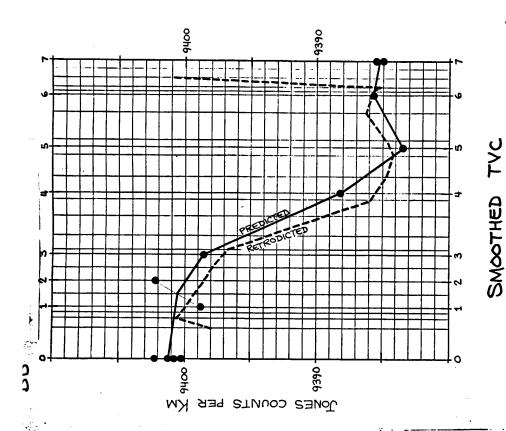
BB

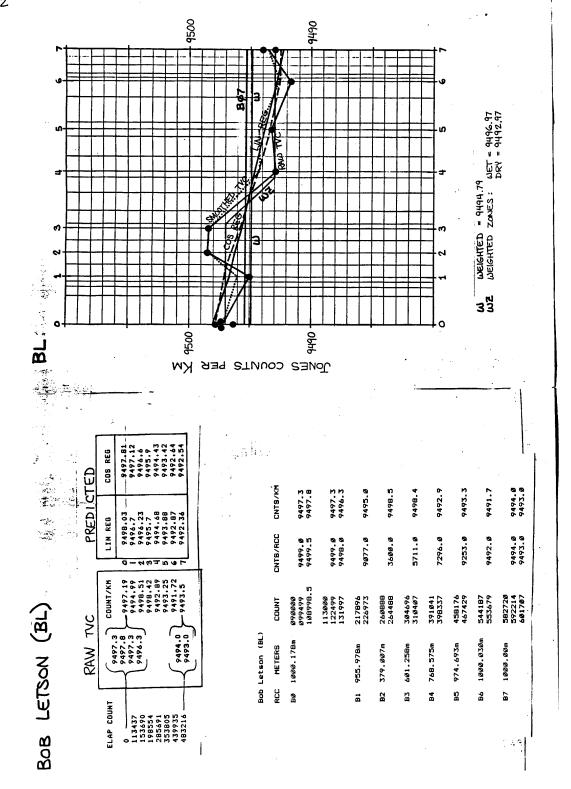
THE SAWTOOTH FROM BASELINE*1 TO BASELINE*2 CAN BE SMOOTHED BY REPLACING IT WITH THEIR MEAN.

THE "ACTUAL" COUNTS/KM IS UNKNOWN FOR EACH MEASUREMENT, BUT CAN BE ESTIMATED BY ASSUMINGS THAT THE ACTUAL LENGTH OF EACH INTERVAL IS THE NEAR FOR ALL 13 MEASUREMENTS. THIS ESTIMATE IS REFERED TO AS "RETRODICTED. THE DIFFERENCE BETWEEN PREDICTED AND RETRODICTED. THE DIFFERENCE THE "SPERAD" AND THE "SPERAD" BETWEEN A SPECIFIC MEASUREMENT AND THE WERRGE MEASUREMENT. A GRAPH SHOWING THIS SPERAD CAN REVEAL ANOMALIES SUCH AS A BAD (INVALID) MEASUREMENT BIS'S GRAPH SHOWS NO SIGNIFICANT ANOMALIES. THE ANOMALIES THE ANOMALIES IN SIGNIFICANT DUE TO THE SMALL LENGTH OF THE INTERVAL (IGB METERS).

COUNTS/KM FOR BB (TVC)

CNTS/KM	9397.99 9400.27 9400.27 9388.23 9387.21 938.63 938.63 938.63 938.63 938.63 938.63 938.63 938.63 938.72	
METERS	2998.94 1293.89 1293.89 955.98 3573.08 3573.08 601.26 101.	
END	WILSHIRE BUNDY CARMLINA GAVONDALE GEORGINA GATA NAVA MINDANAO CULVER HANUM SUBELEY HOBART EBURLONG MENLO UTURN STADIN STADIN STADIN STADIN STADIN STADIN STADIN	





SMOOTHED TVC

BL

8

BL WALKED HIS BICYCLE TD/FROM LANDMARKS
APPROXIMATELY HALF OF THE TIME, AVERAGING
ABOUT 45 FEET OF WALKING FER INTERVAL. STUDIES
SHOW THAT A WALKING CONSTANT IS ABOUT 13S COUNTY/MILE
LESS THAN A RIDING CONSTANT, OR ABOUT 1 COUNT/45.
THIS SYSTEMATIC ERROR CAN BE CORRECTED BY ADDING 1 OUNT/INTERVAL. THE OVERSIZED COUNTY/KM FOR BADELINES 213 REPREDENT UNSTEADY, BICYCLING, AND CAN BE SMOOTHED BY SUBTRACTING 1 COUNT/INTERVAL. ONE SIGNIFICANT ANOMALY EXISTS FOR BL'S MEASUREMANTS, IMMEDAFTELY PRIOR TO BASELINE 2 AT GEORGINA. THIS REPRESENTS AN ULESAL SHORT CUT AT THE LEFT TURN FROM SAN VICENTE ONTO OCEAN BLVD.

CNTS/KM

WILSHIRE BUNDY CARMLINA O-AVONDALE GEORGINA 3- PARK VIADOLCE

O-ALTA

ADMRLTY1
MINDANAO

CULVER
HANYUM SUMRTIME

SUTTIVITE

SUTTIVITE

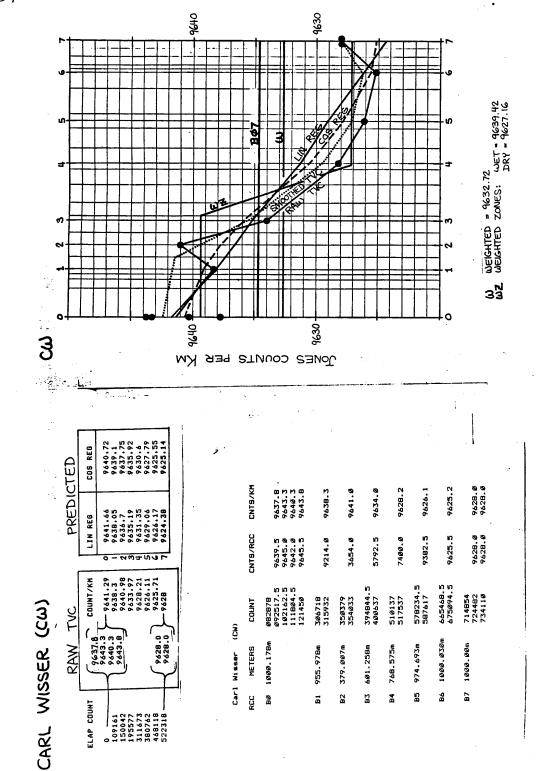
FINANCIA

FINA

RETRODICTED COUNTS/KM FOR BL (TVC) METERS 2998.94

-9490								
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	= .							
	7							
	77							
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WF=1								
	+ *							
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(OE-IO) (INCOMENTAL (NE-IO)	7							
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9490								
JONES COUNTS PER KM								
 								

SMOOTHED



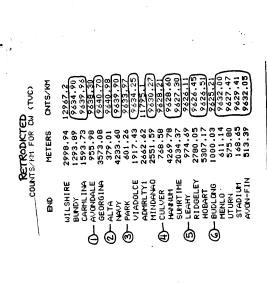
SMOOTHED TVC

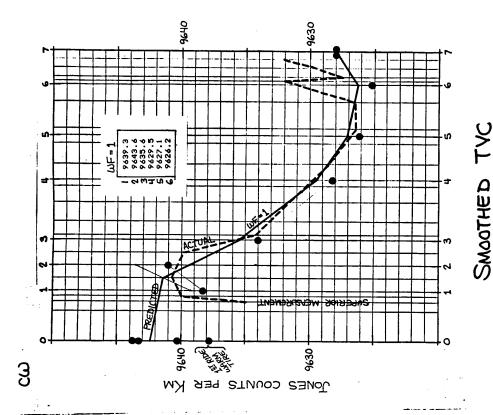
3

THE FIRST RIDE ON BASELINE & IS ABNORMALLY LOW, WHICH REPRESENTS A WARM TIRE NOT COMPLETELY COOLED TO THE ENVIRONMENTAL TEMPERATURE. THIS INITIAL VALUE CAN BE OMITTED AS A SYSTEMATIC ERROR.

CW WALKED SIMILAR TO BL, WHICH CAN BE CORRECTED BY ADDING 1 COUNT/INTERVAL (WALK FACTOR = WF). THE SAWTOOTH FROM BASELINE 1 TO BABELINE 2 CAN BE

SMOOTHED BY REPLACING IT WITH THEIR MEAN.
THE ANOMALY FOR THE FIRST MEASUREMENT (ABNORMALLY LOW "ACTUAL" LINE) MIGHT BE CAUSED BY A SUPERIOR MEASUREMENT.
MOST OTHER MEASURERS STRAKED FROM THE STR. IN ANTICIPATION OF TRAVELLING ACROSS THE STREET, BUT OU WAS FAR BEHIND AND AVOIDED THIS MISTAKE.





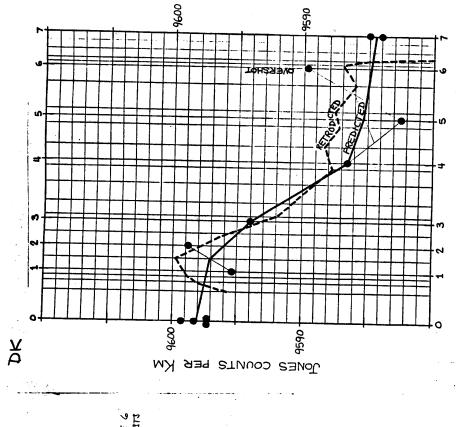
9600 4590 **W** WEIGHTED = 4590.67 UST = 9596.87 **WZ** WEIGHTED ZONES: WET = 9585.52 -0096 9590 ጀ JONES COUNTS PER KM 9598.12 9596.74 9595.51 9593.83 9589.26 9586.73 9584.81 PREDICTED 9584.0 9585.0 9582.5 9589.7 LIN REG 9584.0 9585.0 9340.0 9290.0 CNTS/RCC 5768.5 7368.0 3638.0 9173.0 9601.0 9599.0 9599.0 9600.0 519230.5 COUNT/KM 695170 704510 782038 791628 820400 829984 839569 627358 634726 474968 4786Ø6 RAW TVC 314000 323601 333200 342799 352399 431494 440667 NAVID KATZ (DK) David Katz (DK) 1*000*.030m 1000.00m 974.693m METERS BØ 1000.178m 601.258m B4 768.575m 955.97Bm 379.007m B B3 **B**2 ELAP COUNT 0 102881 143588 188915 297843 366641 453634

SMOOTHED TVC.

岩

THE SAUTOOTH FROM BASELINE 1 TO BASELINE 2 CAN BE SMOOTHED BY REPLACING IT WITH THEIR MEAN.

THE SAUTOOTH FROM BASELINE 5 TO BASELINE 6 CAN BE SMOOTHED BY REPLACING IT WITH THEIR MEAN. HOWEVER, THIS RESULTS IN AN WERSIZED VALUE BECAUSE THE BASELINE 6 WALVE WAS OVERSIZED DUE TO DK BEING ONE OF THE SIX CACLUITS WHO OVERSHOT THE TERMINUS, THIS CAN (ARBITRARILY) BE REDUCED SLIGHTLY BY REUSING BASELINE 5 ASHIN (TO GIVE IT MORE WEIGHT): THE SWOOTHED POINT CAN BE SET TO THE MEAN OF BASELINES HES MEAN OF BASELINES HE



RETRODICTED COUNTS/KM FOR DK (TUC)

WILSHIRE
BUNDY
CARMILINA
CANONALE
BEORGINA
BEORGINA
CANONALE
NAVY
CANONA

SMOOTHED TVC

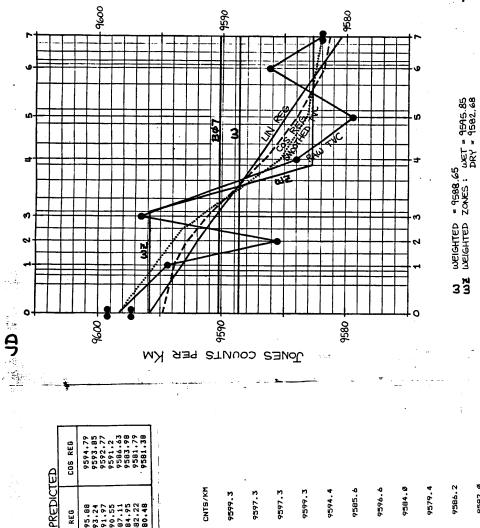
JIM DELANEY (JD)

LIN REG

RAW TVC

ELAP COUNT

0 83875 124556 169881 279536 348301 435251



CNTG/KM		9599.3	9597.3	9597.3	9599.3	9594.4	9585.6	9596.6	9584.0	9579.4	9586.2	9582.0 9582.0
COO. OF IAC	CN13/ACL	9601.0	9299.0	9299.0	9661.0	9172.8	3633.0	5770.0	7366.0	9337.0	9586.5	9582.0 9582.0
	COUNT	062000 071601	071600 081199	Ø812ØØ Ø9Ø799	090800 100401	160489 169661	203939 207572	248196 253966	357053	424832 434169	511657.5 521244	562200 571782 581364
	METERS	1000.178m				955.978m	379.007m	601.258m	768.575m	974.693m	1000.030m	1 <i>000.0</i> 00
:	ROC	99.				18	B 2	83	B4	E C	99	187

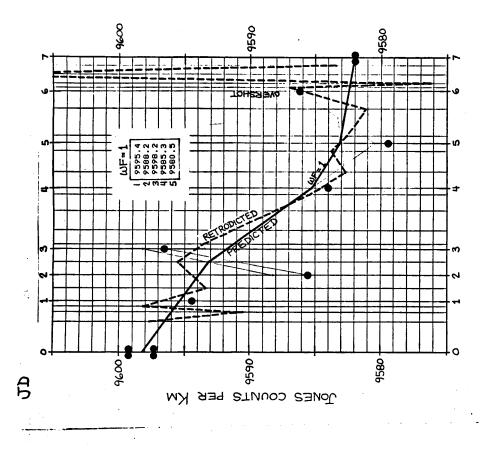
...

SMOOTHED TVC

25

JD WALKED SIMILAR TO BL, AND THIS SYSTEMPTIC ERROR DESERVES TO BE COMPENSATED BY ADDING 1 COUNT/INTERVAL. THE SAWTEETH FOR JD ARE SIMILAR TO THOSE FOR DK, AND CAN BE SMOOTHED IN THE SAME. MANNER.

JD'S MEASUREMENTS FROM WILSHIRE TO BUNDY, AND FROM MENLO TO UTURN, WERE SUPERIOR.



RETRODICTED
COUNTS/KM FOR JD (TVC)
METERS CNTS/M

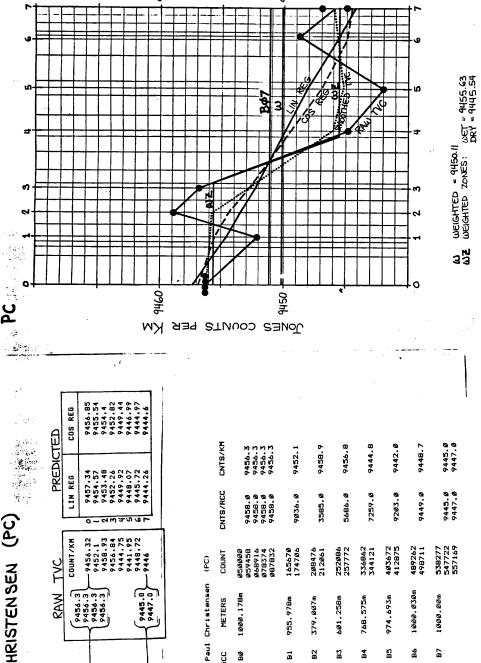
WILSHIRE
WINCY
CARMITINA
CANONDALE
GEORGINA
CANTA
CANT

SMOOTHED TVC

PAUL CHRISTENSEN (PC)

ELAP COUNT

0 101272 141353 186013 271576 339358 425071



955.978m

B

B@

B2 B3 **B4** EG. 98 **B**3

SMOOTHED TVC

ባ

PC WALKED SIMILAR TO BL, WHICH CAN BE CORRECTED BY ADDING 1 COUNT/INTERVAL.

SMOOTHING FOR BASELINES 1,2,3 IS ARTISTIC.

IT IS POSSIBLE, THOUGH UNLIKELY, THAT PC'S ACTUAL

COUNTS/KM MAY BE AS LARGE AS SHOWN FOR BASELINES 213,

WHICH WERE SHORT AND UPON WHICH MANY CYCLISTS WERE

OBSERVED TO BE ARNORMALLY UNSTEADY DUE TO SLOW RIDING SPEED.

SMOOTHING FOR THE SAWTOOTH FROM BAJELING 5 TO BAJELING 6 IS SMILAR TO JD, AND DK.

PC ADMITS HE CUT THE COURSE SIMILAR TO BL AT AN VICENTE AND OCERN BLVD.

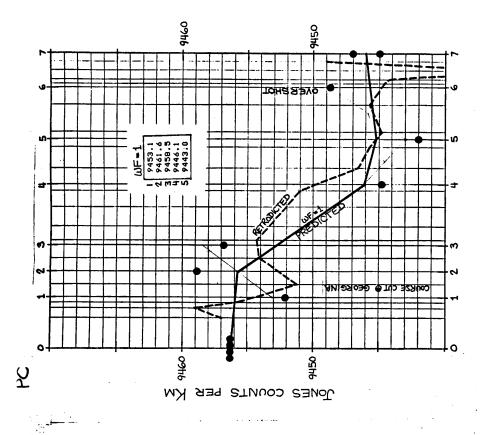
CNTS/KM

WILSHIRE BUNDY

CARPILINA
CARPILINA
CARPILINA
CARPILINA
CALPA
CALPA
CALPA
CALVER
CALVER
FARRITINE
CALVER
RIDGEEY
RIDGEEY
HOBBRT
GERULOR
HOBBRT
OTURN

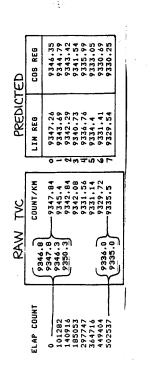
STADIUM AVON-FIN

RCTRODICTED COUNTS/KM FOR PC (TVC) METERS



SMOOTHED TVC

PETER RIEGEL (PR)



- 9350

- 9340

JONES COUNTS PER KM

	CNTS/KM	9346.8 9347.8 9346.3 9350.3	9345.4	9342.8	9342.1	9331.6	9331.1	9329.7	9336.0
	CNTS/RCC	9348.5 9349.5 9348.0 9352.0	8934.0	3541.0	5617.0	7172.0	9095.0	9330.0	9336.0 9335.0
(PR)	COUNT	364500 373848.5 383198 392546 401898	480014 488948	522344 525885	565443 571060	67736Ø 684532	743367 752462	827938 837268	87 6400 885736 895071
Peter Riegel (F	METERS	1 <i>000</i> .178m	955.978m	379.007m	601.258m	7 68. 575m	974.693m	1000.030m	1 <i>000.00</i> m
Peter	RCC	9	B	B2	B3	8	SE SE	98	B7

9330-

330

W WEIGHTED = 9338.71 **WZ** WEIGHTED ZAVES: WET = 9345.89

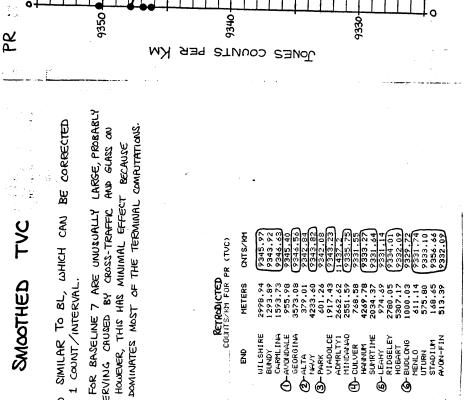
DRY = 9332.75

PR

PR WALKED SIMILAR TO BL, WHICH CAN BE CORRECTED BY ADDING 1 COUNT/INTERVAL.

THE VALUES FOR BASELINE 7 ARE UNUSUALLY LARGE, PROBABLY DUE TO SUERVING CAUSED BY CROSS-TRAFFIC AND GLASS ON THE ROAD. HOWEVER, THIS HAS MINIMAL EFFECT BECAUSE BASELINE 6 DOMINATES MOST OF THE TERMINAL COMPUTATIONS.

9350



-9340

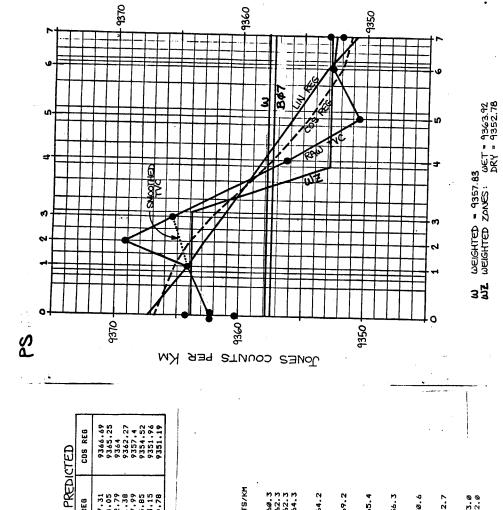
SMOOTHED TVC

PETE SHANDERA (PS)

LIN REG

RAW TVC

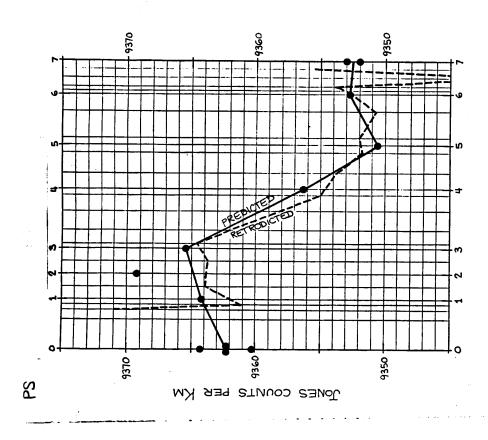
ELAP COUNT



	CNTS/KM	9360.3 9362.3 9362.3 9364.3	9364.2	9369.2	9365.4	9356.3	9350.6	9352.7	9353.0
	CNT8/RCC	9362.0 9364.0 9364.0 9366.0	8952.0	3551.0	5631.0	7191.0	9114.0	9353.0	9353.0
(PS)	COUNT	024366 033728 043092 052456	540802 549754	583212 586763	6264Ø5 632Ø36	732119	798269 8Ø7383	883ØØ8 8923&1	952706 962059 971411
Fete Shandera	METERS	1000.178m	955.978m	379.007m	601.258m	768.575m	974.693m	1000.030m	1 <i>000</i> .00m
Pete	RCC	B.6	1	B 2	13	B4	SE SE	98	187

SMOOTHED TVC

1 CONCERNING WHERE THE TERMINUS WAS
2. OBSERVED MOST OF THE CYCLISTS SWERVE
3. BASELINE 2. IT IS THEREFORE REASON ABLE
5. BASELINE 2. DATA. CAUSE OF SWERVING DUE TO SLOW RIDING, HAS AN ABNORMALLY HIGH VALUE,



CNTS/KM

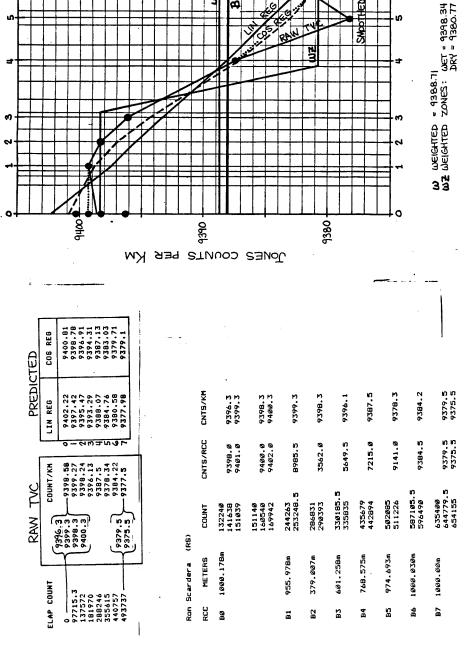
WILSHIRE
BUNDY
CARTILINA
CANONDALE
CALTA
ANONDALE
ANON
CALTA
NAVY

RETRODICTED COUNTS/KM FOR PS (TUC) METERS SMOOTHED TVC

9400

RON SCARDERA (RS)

RS



U)

RS

SMOOTHED TVC BESTER 6

RS

THE SAWTOOTH FROM BASELINE 5 TO BASELINE 6 CAN BE SMOOTHED BY REPLACING IT WITH THEIR MEAN. 0016

9400

WARM TIRE

TWO ANOMALIES ARE VISIBLE IN THE "RETRODICTED".

LINE, AND BOTH OF THEM REPRESENT DEPARTURES FROM
THE S.P.R. WHILE MAKING A LEFT TURN (SWINGING TOO WIDE).

RS HAS SPECIFICALLY CONFIRMED THESE ERRORS. IT IS THEREFORE
REASONABLE TO OMIT THESE TWO MERSUREMENTS FOR RS.

BUNDY-CARMELINA & CULVER-HANNUM ARE INVALID FOR RS.

A THIRD ANOMALY AT THE STADIUM REPRESENTS A SUPERIOR MEASUREMENT.

THE FIRST RIDE ON BASELINE & IS SLIGHTLY LOW, WHICH REPREJENTS A WARM TIRE NOT COMPLETELY ADJUSTED TO GUVIRONIMENTAL TEMPERATURE. THIS FIRST VALUE CAN BE OMITTED.

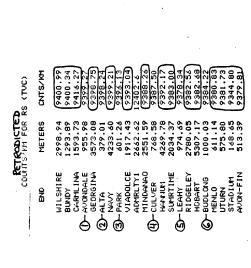
9390

JONES COUNTS PER KM

-9390

9380

9380

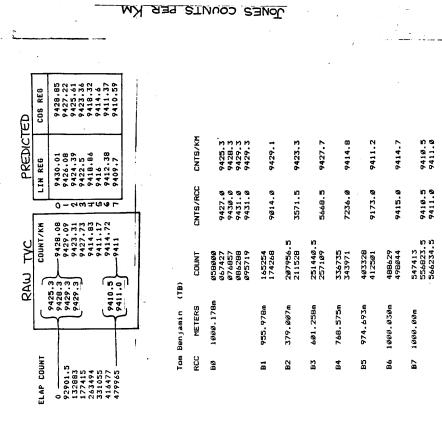


SMOOTHED TVC

* RS WAS THE LEAD BIKE

9430

TOM BENJAMIN (TB)



9420

- 9420

융

용

W WEIGHTED = 9419.41 **WZ** WEIGHTED ZONES: WET = 9427.81

DRY = 9412.44

SMOOTHED TVC

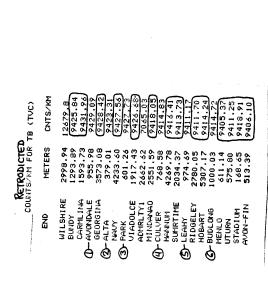
18

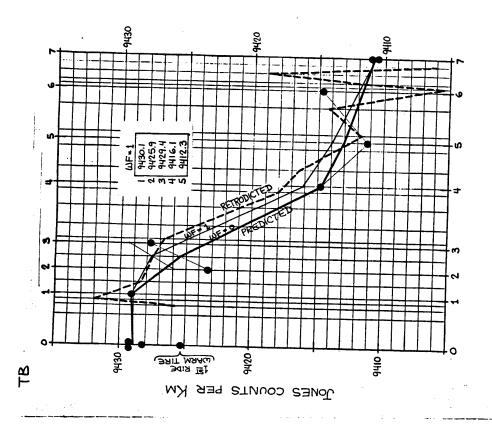
THE SAWTEETH FOR BASELINES 2-3 AND 5-6 CAN BE SMOOTHED BY USING THEIR MEANS.

THE FIRST RIDE FOR BASELINE & IS ABNORMALLY LOW, PROBABLY BECAUSE THE TIRE WAS WARM FROM THE CAR. AND NOT COMPLETELY COLED TO ATMOSPHERIC TEMPERATURE. THIS CAN BE OMITTED.

TE SWERVED WHILE STOPPING AT THE TERMINUY OF BASELINE 6, WHICH CAN BE ACCOMODATED BY A SLIGHT ARTISTIC REDUCTION SIMILAR TO DK.

TB DID NOT WALK, BUT HIS MEASUREMENTS SHOWN BY THE "ACTUAL" LINE SUGGEST AN EFFECT SMILCHR TO WF-1.? TB'S MEASUREMENT OF MENLO-UTURN IS SUPERIOR.

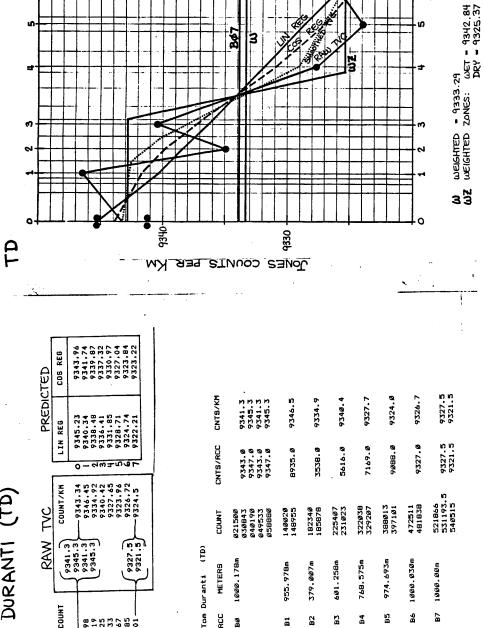




SMOOTHED TVC

TOM DURANTI (TD)

ELAP COUNT



B

E

B2

-9330

93%

SMOOTHED TVC

5

TD WALKED SIMILAR TO BL, WHICH CAN BE CORRECTED BY ADDING 1 COUNT/INTERVAL.

THE SAWTEETH FOR BAJELINES 2=3 AND 5-6 CAN BE SMOOTHED BY USING THEIR MEANS.

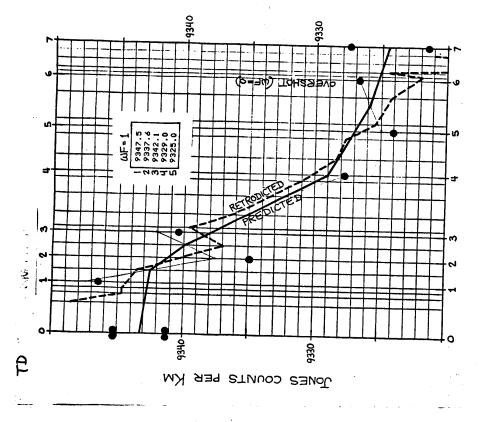
TD OVERSHOT THE TERMINUS OF BASELINE 6, WHICH CAN BE

ADJUSTED BY SUBTRACTING 1 COUNT/BASELINGG.

THE FIRST MEASUREMENT (SMCC-WILSHIRE) IS ABNORMALLY HIGH, AS SEEN BY THE "RETRODICTED" LING.

RETRODICTED COUNTS/FIN FOR TO (TUC)

WILSHIRE
BUNDY
CARMILING
CANDALE
GEORGINA
GPALTA
NAVI
GPARK
ADOLCE
ADMRITTINE
CULVER
HANNUM
STADIUM
HEBART
GPARK
TOGELEY
RIDGELEY



SMOOTHED TVC

ELAP COUNT

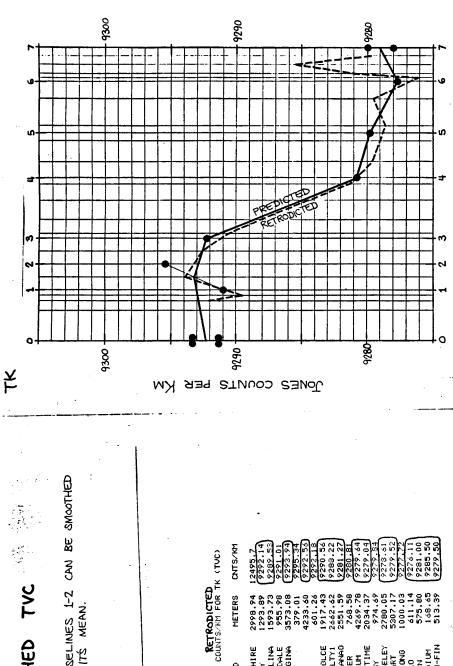
91155 130566 174462 27464 339052 423256

9290 WEIGHTED = 9285.13 WEIGHTED ZONES: WET = 9292.29 DRY = 9279.20 SMOOTHED TVC 33 4280 9290 는 노 JONES COUNTS PER KM 9294.21 9292.81 9291.43 9284.29 9280.95 9277.98 PREDICTED 9280.0 9278.0 9280.0 9278.0 CNTS/RCC 9278.0 7133.0 9045.0 9293.0 9295.0 9293.0 9295.0 8882.0 162392 205256 210843 3Ø2485 3Ø9618 368117 377162 120302 129184 015000 024293 033588 042881 052176 TOM KNIGHT (TK) RAW Tom Knight (TK) METERS 1000.178m 955.978m 1*0*00.00m

B 4 S

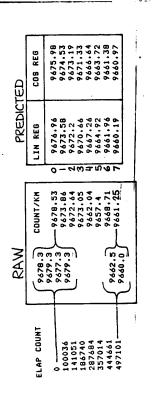
B2

9300 -THE SAWTOOTH FOR BASELINES 1-2 CAN BE SMOOTHED BY REPLACING IT WITH IT'S MEAN. SMOOTHED TVC



WILSHIRE
BLNDY
CARNILINA
CANNOLLE
ACTOR
BANY
BYANY
BYANY
CANNOLLE
ADMINISHUR
HANNIN
BUNRTINE
BURLEHY
RIDGELEY
RIDGELEY
RIDGELEY
RIDGELEY
MERARI
RIDGELEY
MERARI
RIDGELEY
MERARI
RIDGELEY
MERARI
RIDGELEY
MENLO
MINISHUR
STAGILN
STAGILN
STAGILN
STAGILN
STAGILN

WILL RASMUSSEN (WR)



9680

. %270

9670

JONES COUNTS PER

	CNTS/KM	9678.3 9679.3	9677.3 9679.3	9673.9	9672.7	9673.1	9662.0	9657.4	9669.2	9662.5 9660.0
	CNTS/RCC	9680.0 9681.0	9679.0 9681.0	9248.0	3666.0	5816.0	7426.0	9413.0	9669.5	9662.5 9660.0
(WR)	COUNT	#272## #3588# #45541	046600 056279 065960	141972	185778 189444	236208 236208	330531 337957	398868 4Ø8281	486386.5 496056	534000 543662.5 553322.5
Will Rasmussen	METERS	1000.178m		955.978m	379.007m	601.258m	768.575m	974.693m	1000.030m	1 <i>000.00</i> m
Wi 1 1	RCC	g E		181	B2	B3	B	E E	B6	B7

9660

W WEIGHTED - 9668.43

W WEIGHTED ZONES: WET - 9625.16

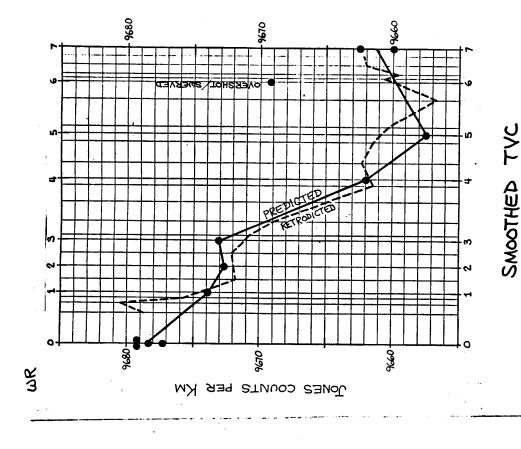
W WEIGHTED ZONES: WET - 9626.16

WZ-6 (9660.41; WITHOUT BASELINE 6)

•

SMOOTHED TVC

WR OVERSHOT THE TERMINUS OF BASELINE & AND SWERVED WHILE STOPPINS ABRUPTLY. THIS POINT CAN THEREFORE BE OMITTED AS INVALID.



CNTS/KM

RETRODICTED COUNTS/NN FOR WR (TUC) METERS WILSHIRE
WINDY
CARPILINA
CAPALINA
CAPALINA
CAPALINA
CAPALINA
CAPARIT
C

MAPS & MEASUREMENTS

MAPS & MEASUREMENTS

The following pages contain maps and data for all of the intervals used during the April 24, 1983, measurements. Additional sketches are provided for measurements made via steel tape or electronic distance meter.

<u>Underlined values</u> represent the lowest value in the set. *Italics* represent the median value. (Parenthetical) values are invalid.

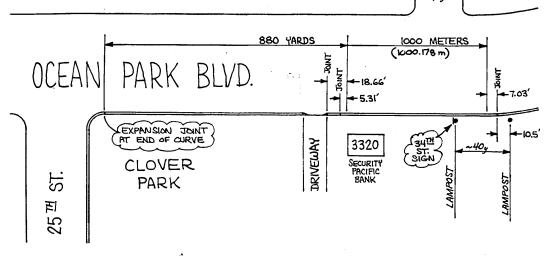
```
Codes:
             LR
                           Linear Regression method
             CR
                           Cosine Regression method
             TVC
                           TVC method
             STVC
                           Smoothed TVC method
             WZ
                           Weighted Zones method
             BB
                           Dr. Bob Baumel
             BL
                           Bob Letson
             CW
                           Carl Wisser
             DK
                           David Katz
             JD
                           Jim Delaney
                          Paul Christensen
             FC
             PR
                           Peter Riegel
             F'S
                           Pete Shandera
             RS
                           Ron Scardera
             TB
                           Tom Benjamin
             TD
                           Tom Duranti
             TK
                           Dr. Tom Knight
                           Dr. Will Rasmussen
             WR
             Md
                           median
             \overline{X}_{n}
                           sample mean for "n" measurements
             Sn
                           sample standard deviation
                                      for "n" measurements
             99% confidence = (\overline{X}_9-3.068_9) for 9 measurements (\overline{X}_{11}-2.888_{11}) for 11 measurements (\overline{X}_{12}-2.838_{12}) for 12 measurements (\overline{X}_{13}-2.788_{13}) for 13 measurements
```

(.999Md) = Standard Method's official length 1/1000 less than the median

SANTA MONICA 088 000) YARDS METERS



S. 344



DATES WHEN COURSE WAS MEASURED: 28 AUG 82 (STEEL TAPE), 22JANB3 (HP3810A) EXACT AVERAGE MEASURED LENGTH OF THE COURSE: 2640.49' (OCO.178 METERS RAN- 6907 CAMROSE DR., LOS ANGELES, CA 90068 (213) 874-6867 Pacific Southwest Association Inc. Track MEASURED BY (name, address, phone): BOB (ETSON, RON SCARDERA DISTANCE BETWEEN THE SHORTEST AND LONGEST MEASUREMENTS: 6 = 1/2 INCH walking wheel
 electronic meter San Diego and Impertal Counties, California, 1135 Garnet St. San Diego, Californio 92109 (714) 275-1292 X calibration STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: 8804 HIGHEST LOWEST: SANTA MONICA 8804, 1000 CERTIFICATION CODE: Certification NUMBER OF MEASUREMENTS OF THE ENTIRE COURSE: LOCATION: CLOVER PARK, SANTA MONICA cross-country hilly Steel tape 7 bicycle FINISH: START: | rolling Athletics Congress 0 (feet above sea level) road race paved MEASURING METHOD: NAME OF COURSE: ^{د ہو} USA TERRAIN:

Association Certifier, Bob Letson 4369 Hamilton St. #4; San Diego, CA 92104

The course described above and defined by the attached map is hereby certified to fulfill national standards for accurate measurement. A copy of this letter and map should accompany race results mailed to the National Running Data Center, PO Box 42888, Tucson, AZ 85733.

February 5, 1983 National Cert, date National Certifier, Ted Corbitt Apt 8H Sect 4; 150 W 225 St; NY, NY 10463

Aloni Steel Ca	9. If a bicycl for each pe	Date:	Date:	COURSE MEASUREMENTS standard distance a	10. Was the me	run by the 11. Were all 1. If not ex	12. If part of	14. If steel to a. How man	b. How was	C. How was	15. If a bicyc	a. Was the both di	b. Was the	16. List the 22 JAN 83. 2.	Palat () = () I ()	# 088 = @	(C) = 10000 MB (A) = HP3810P	E. C.D. C.	WERHGE XH = 1315 XB = 1329	XC= 1466	⊗ -	OCEAN	HP 17. Describe an	33¥. 2∡Ş	O石 18. What is the 19. What is the	RETURN THIS FORM WIT NY, New England DC, III), VA, WV.	011	LA	(oneith art) 17 Lat.
•	3 Name of course: SANTA MONICA 880 YARDS, KM	D Measuring method used: B	Describe the measuring de	EDBE	W Name: Bok LETS		THE COURSE	2 1. Is the course (flat?) rolling? h		عہ = ادب ل	, Y2	יאר בפג	יא כני נעכני יא כ) li Tən	211 1 01 0	TF REW	. (հդ u zA	80 & Describe the known standard distance:	F C Location: BIKE PATH S. of SEA LOCATION: B AND OF SEA LOCATION: BIKE PATH S. of SEA LOCATION:		T Cortified? YES PSA	If the known standard distance is not certified, apply now by answering all appropriate questions on another (FPLICATION OF ACCURACY for the known standard distance.	7. Describe how each measuring device was compared with the known standard distance.	1717-18 17 = 171 18	MERCHENTS = 2874 348		REFLECTOR " 344	Politic 3.38	
	UM	,	۷۵,	-シいみ	66	U ₀	=:	SA2	309	7	-0		133	-0	A١	· •	ک)(ح	٠,	r 3 90	.70	γ ₹	200.	الصد	,,	21HT	: 310	•		

- De or walking wheel was compared, what is the average correction factor? \mathbf{E}
- e was compared, what is the average digits/mile for all of the comparisons rson for each day:

. Certification requires two measurements. If a bicycle is used, the known the race count mark both by Tiden during the same day by the same person it. (comparisons from a previous day are not acceptable). Average digits/mile: Average digits/mile: Name: Name:

assuring route identical to the shortest route that can be permitted to be winner of the race?

- oft/right turns measured to within one yard of the inside edge of all turns?

 - the race course is on dirt or grass, how were these stretches measured?
 - ape was used, answer the following questions:
- ny people were in the survey party? List their specific duties:
- s the tape tension maintained during measuring? s the tape increments count maintained?

 - re the curves measured? le was used, answer the following questions:
- e bicycle ridden over the known standard distance and over the race course uring the same day by the same person for each measuring occasion?
- e known standard distance compared before and after measuring the race course? date, time, and raw data for each measurement of the course:

PM, S9°F, LIGHT RAIN (VIDORS OVER ALL OFTICS)

× 48.28.88 1325 W.F. 8 1315.128 .135 128 .235 251 .251 251 .251 251 .251 148 148 Ş APTERS MARK (WHITE UNE)
A LETTER BLANDEST 29 THE ST. MARK (WHITE LINE) 3281.424 = 1000.178 m 5.134 2640.49

0

3320 measurements) made to create an exact length: S John T **@** 18.66 PARK BLVD.

difference between all of the measurements? $\sigma = 7/6$ (NCH

RETURN THIS FORM WITH ALL QUESTIONS ANSWERED TO THE REGIONAL CERTIFIER IN YOUR AREA:

NY, Wee England, Allan Steinfeld, B E 8014 St. WIN 17 1020

DC, IID, YA, WY CASTO EDIANCY, 1012 HEYMOND ST. THEORY ST. AND 18012

NJ DE, PA, CASTO EDIANCY, 1012 HEYMOND ST. THEORY ST. AND 18012

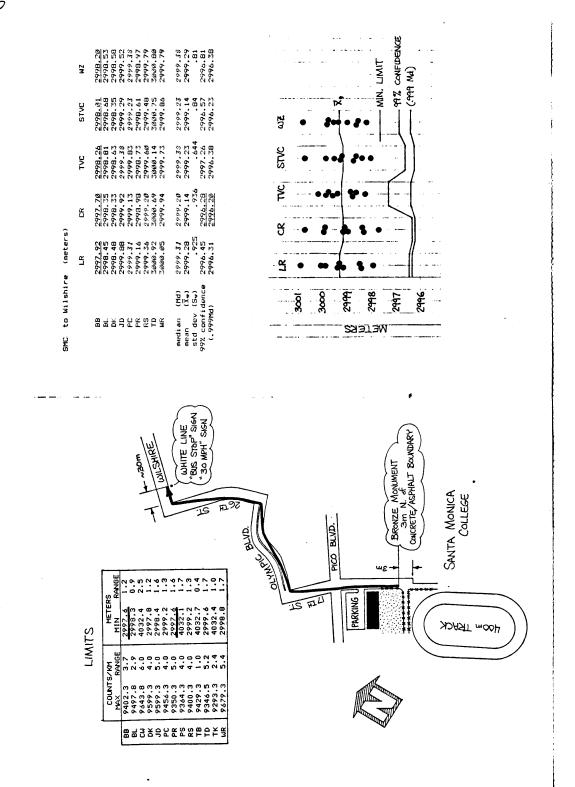
OLI CHARLES ST. AND ST. AND 18012

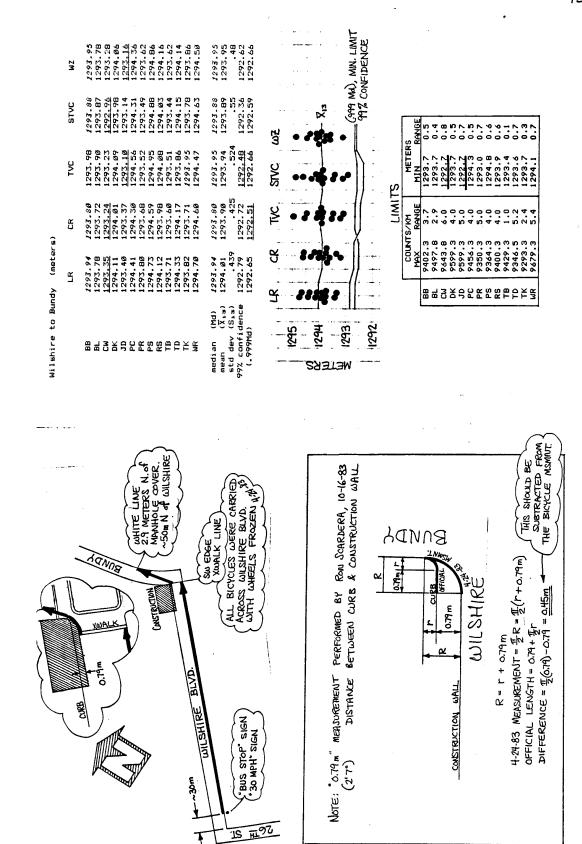
LL CASTO ENGLAND ST. AND 18012

OK CASTO ENGLAND ST. AND 18012

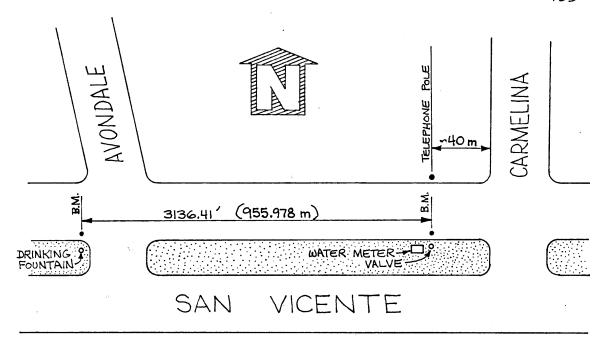
OK

±, 18.





Bundy to Carmelina (meters)	LR CR TVC STVC WZ	1593.81 1593.61 1593.76 1593.66 1593.84 1593.37 1593.38 1593.56 1593.66 1593.64 1593.44 1594.18 1594.02 1594.07 1594.05 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1593.73 1594.07 1593.73 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1594.07 1593.75 1593.75 1593.17 1593.13 1593	* RS's measurement is invalid because he rode wide around the left turn from Bundy to Carmelina. NOTE: Wr remeasured this interval on June 5, 1983, ahead of the Avon Marathon, when Bundy had no parked cars. This remeasurement = 1592.8 meters 1596
		COUNTS.KM HETERS HAX RANGE HIN RANGE BL 9497.8 2.9 1593.4 0.6 CM 9497.8 4.0 1593.1 1.0 DK 9599.3 5.0 1593.6 0.8 PR 9350.3 4.0 1593.6 0.7 PR 9350.3 4.0 1593.2 0.7 PR 9429.3 1.0 1593.2 0.7 TR 9429.3 1.0 1593.2 0.7 TK 9429.3 5.4 1593.1 0.4 UM 9679.3 5.4 1593.1 0.4	RS RODE HERE (INVALID) REPRESENTING (INVALID) REPRESENTED (



BRONZE MONUMENTS (B.M.) MARK EACH END OF THIS BASELINE. THEY ARE EMBEDDED IN ASPHALT 30 INCHES N. OF CURB. MEASURED VIA HP381ØA BY JOHN BRENNAND, MARCH, 1983.

DATA:

PRESSURE - 29.6

DEGREES - 66°

ATMOSPHERIC CORRECTION - 8 PPM

DISTANCE - 3136.41

3136.40

3136.39

"CORRECT FOR ONE HUNDRETH OF A FOOT INCREASE AT OTHER END"

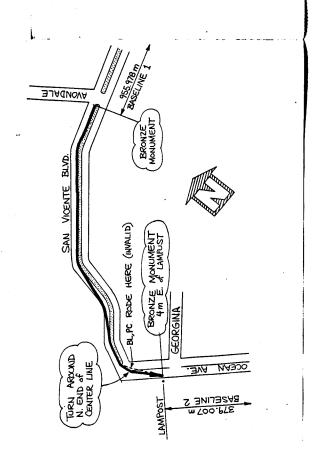
CORRECTED MEASUREMENT = 3136.41 FEET

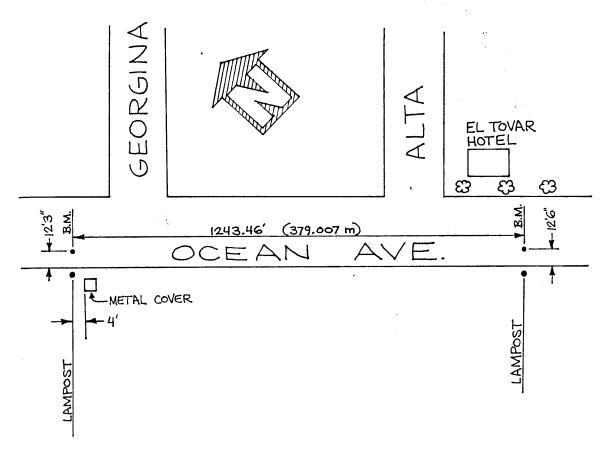
BASELINE 1 184 L.A. OLYMPIC MARATHON, BRENTWOOD

Avondale to Georgina (meters)

묘목으로	0 × 0 0 0 0 0 0	S/KM RANGE 3.7 5.6 5.9 4.8 12.7 7.0	METERS MGE MIN R 3571.9 (3570.6) 3572.0 3573.5 3571.3 (3570.2)	RS RANGE 1.4 2.1 2.2 1.8 1.8 2.6
R S S B C F F B	9346.5 9369.2 9399.3 9429.3 9346.5 9295.4	7.00.0 0.00 7.14.1	3573.1 3571.1 3572.9 3572.7 3571.9 3572.5	4410875

ZM	3572, 71 (3571, 14) (3571, 14) 3574, 19 3574, 19 3573, 33 3573, 33 3573, 33 3573, 32 3573, 32
STVC	3572.63 3572.78 3572.78 2574.18 3571.32 3573.86 3573.86 3573.86 3573.86 3573.45 3573.45 3573.45 3573.45 3573.45 3573.47 3572.51
140	3572.64 3573.47 3573.47 3574.19 3574.86 3574.81 3574.81 3574.91 3574.92 3574.92 3574.15 3573.37 3573.37 3573.47 3573.37 3573.47 3573.47 3573.47
R	3572.93 3573.94 3573.94 3574.48 3574.03 3574.03 3572.82 3573.44 3573.47 3573.47 3573.47 3573.47 3573.47
5	3573.43 3574.34 3574.83 3574.83 3574.46 3572.64 3573.28 3574.31 3574.31 3574.25 3574.66 3574.66 3574.66 3574.66 3574.66
	BB





BRONZE MONUMENTS (B.M.) MARK EACH END OF THIS BASELINE. THEY ARE EMBEDDED IN ASPHALT ABOUT 12 FEET FROM THE CURB. MEASURED VIA HP381ØA BY JOHN BRENNAND, MARCH, 1983. DATA:

PRESSURE = 29.7

DEGREES = 66°

ATMOSPHERIC CORRECTION = 6 PPM

DISTANCE = 1243.46

1243.46

1243.46

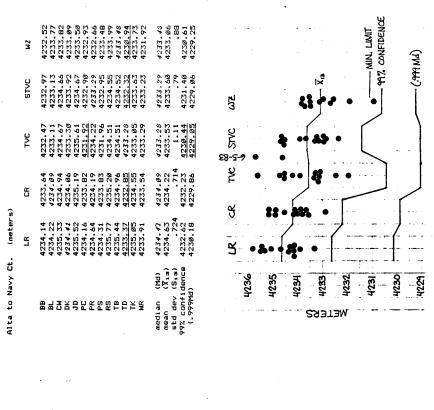
1243.46

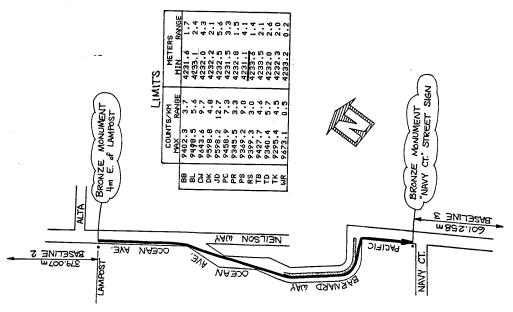
1243.46

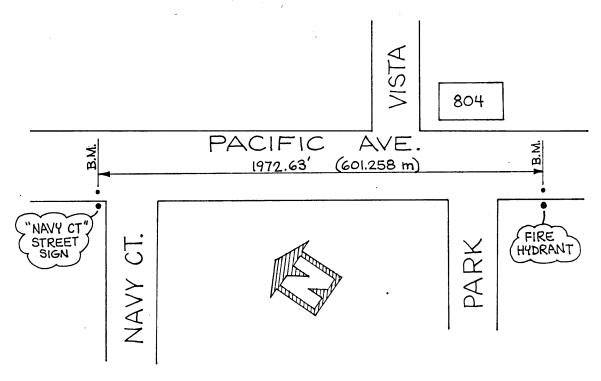
1243.46

1243.46

BASELINE 2
184 L.A. OLYMPIC MARATHON, SANTA MONICA







BRONZE MONUMENTS (B.M.) MARK EACH END OF THIS BASELINE.
THEY ARE EMBEDDED IN ASPHALT ABOUT 30 INCHES FROM
THE CURB. MEASURED VIA HP381ØA BY JOHN BRENNAND
IN MARCH, 1983. DATA:

PRESSURE = 29.6 DEGREES = 70°

ATMOSPHERIC CORRECTION = 8 PPM

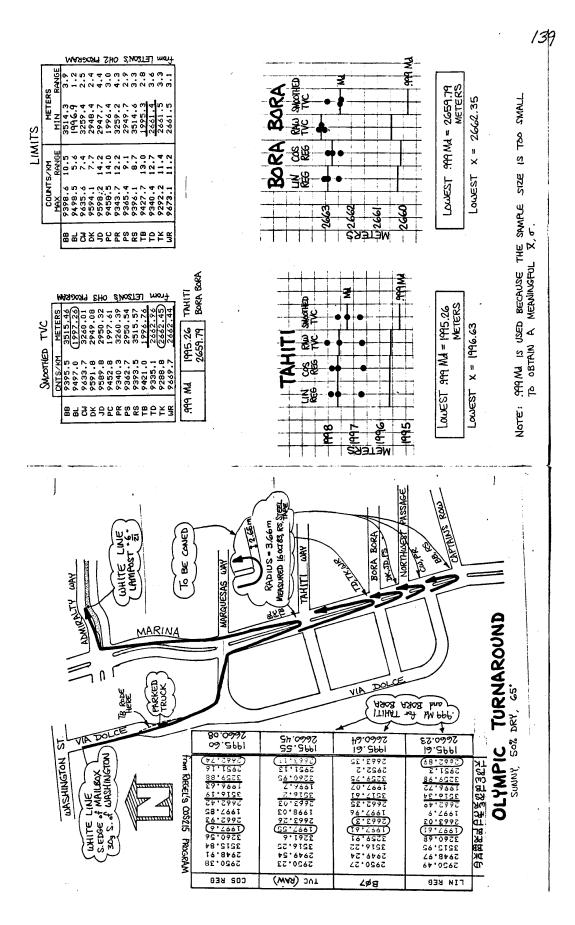
DISTANCE = 1972.60 1972.59 1972.59 1972.57

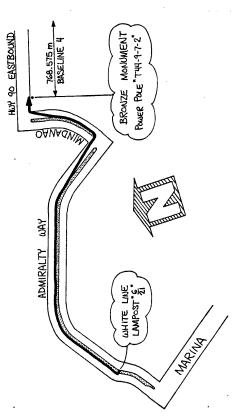
CORRECTION = +.04'
CORRECTED DISTANCE = 1972.63'

BASELINE 3

'84 L.A. OLYMPIC MARATHON, SANTA MONICA

	ZM	1916.69	1917.55	1916.46	1917.16	1916.89	1916.35	1917.20	1916.76	1916.39	1916.89	.42	1914.98	F RIS MIN. LIMIT PRZ CONFIDENCE (999 Md)	
	STVC	1917.20	1917.35	1917.13	1917.31	1917.52	1916.95	1918.18	1917.28	1917.14	18.7191	35	1915.39	법 3464	
-	77	1918.10	1917.82	1917.77	1918.15	1918.75	1917.68	1918.53	1918.27	1918.07	1918.10	315	1916.18	SH -2-5 XI	
	(g 25	1917.58	1917.82	1917.16	1917.83	1917.89	1917.33	1918.24	1917.78	1917.42	1917.82	346	1915.90	\$ 4 64	
	ce (meter LR	1917.72	1917.84	1917.26	1917.92	1918.03	1917.50	1918.38	1917.94	1917.53	1917.92		1916.00	의 생 하	
	rark to Via Doice (meters)	88	ᅜ	ž	1 Z	ar a	. Æ	87 5	2 ¥	EF.	median (Md)	std dev (S ₁₃) 99% confidence	(PW666')	METERS 19 19 19 19 16 15 16 17 18 18 18 19 18 18 18 18 18 18 18 18 18 18 18 18 18	
agency or		****													
						-			٠					WA DOLCE S. ETISCE of MAIL BOX	
· .	-	S	METERS MIN BONGE	1	- -		N 0	1917.3 2.5			1917.3 2.6	Ш		TS NOTONIHSAW	
	<i>y</i>	LIMITS	COUNTS/KM	vo 18				9343.7 12.2			9340.4 12.7	- li		FIC AVE.	
-				1							2 * 9	7		BROAZE MOWUMENT HYDRANT	
												-		SELINE 3 SELINE 3 SELINE 3 FRACE HTM HTM	

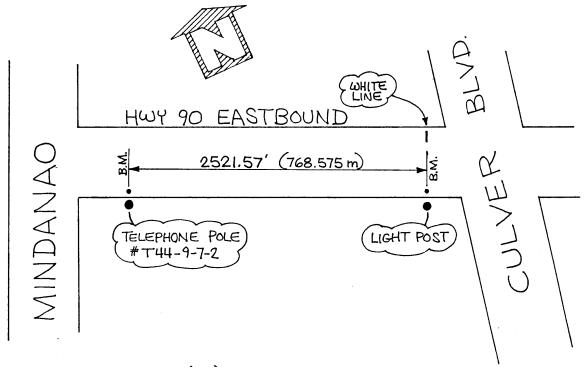




2549

WETERS

MIN. LIMIT



BRONZE MONUMENTS (B.M.) MARK EACH END OF THIS BASELINE.
THEY ARE EMBEDDED IN ASPHALT ABOUT 35 INCHES FROM THE CURB.
MEASURED VIA HP38IØA BY JOHN BRENNAND IN MARCH, 1983:

PRESSURE = 29.5

DEGREES = 66°

ATMOSPHERIC CORRECTION = 6 PPM

DISTANCE = 2521.58

2521.57

2521.57

2521.57

2521.57

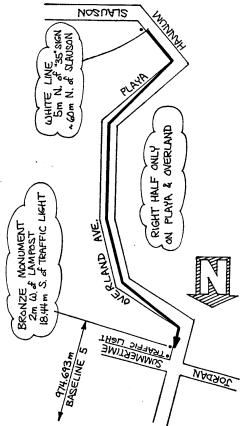
CORRECTED DISTANCE = 2521.57'

BASELINE 4

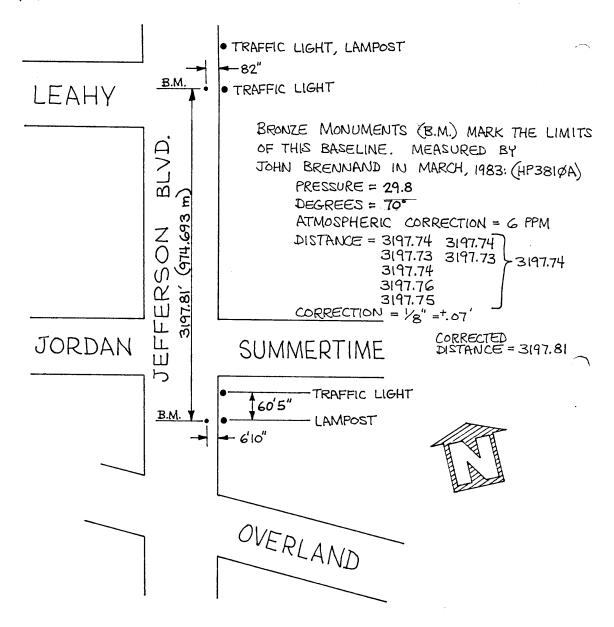
'84 L.A. OLYMPIC MARATHON, MARINA DEL REY

Culver to Hannum (meters)	LR CR TVC STVC WZ	## 4265.21 4267.72 4269.79 4269.75 4269.78 4269.73 426	4266.48 4 4268.81 4278.40 4269.78 6.44 4269.78 4266.60 4266.60 4266.57 4266.57 4266.57 4265.62 4266.57 4266.57 4265.62 4269.08 4265.62 4269.09 4265.62 4269.09 4265.62 4269.09 4265.62 4265.62 4269.09 4265.62	
	OT MILL		SCAW HERSURED SHOULDER L. SHOULDER L. SHOULDER L.	

STVC WZ	2034.33 2034.10	2034.33 2034.40			2034.43 2034.40				•	2034.52 2034.88		2035.06 2034.23	2034.41 2034.34	•	.31			MZ TIB TIB TIB TIB TIB TIB TIB TI
TVC	2034.03				2034.87 2	•	•		•	•	•	2034.74 2	•••	•	D -			₩ ₩ ₹ €-5-83
č	2033,64	2034.15	2034.38	2034.22	2033.99	2033.94	2033.65	2034.19	2034.02	2034.35	2033.81	2033,78	2033.99	2034.00	.246	2033,32	2031.96	유
L,	2033.32	2033.90	2034.14	2034.03	2033.77	2033.66	2033.39	2033.84	2033.75	2034.01	2033.54	2033.54	2033.75	2033.75	. 249	2033.06	2031.72	g •
	83 a	1 3	š	дſ	PC	æ.	e.	RS	18	40	¥	, was	median (Md)		std dev (S13)	99% confidence	(PW666°)	2032 33 44 35 35 35 35 35 35 35 35 35 35 35 35 35
																-		Nozuals



		LIMITS	2	
	COUNTS/KM	S/KM	METERS	RS.
	MAX	RANGE	ZΞ	RANGE
88	388	4.8	2033.5	-
ᆸ	9494.3	1.5	2033.7	6.0
₹	629.	•	033.	•
ž	9286.6	4.0	034.	
9	9585.3	6.0	34.	1.3
5	446.	4.0	2034.3	
8	9332.9	2.1	2034.1	
S	356.	5.7	က	
RS	9387.5	9.5	8	2.0
8	414.		18	
2	9327.7	٠.	0	
¥	280	1.0	8	0.2
3	9662.0	4.6	8	٠.



BASELINE 5

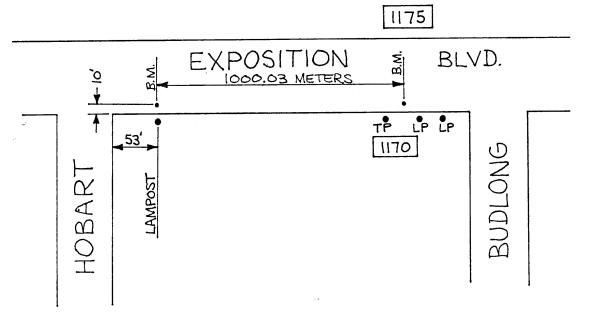
'84 L.A. OLYMPIC MARATHON, CULVER CITY

•	•				145
	ZM	2779, 83 2779, 84 2779, 84 2786, 64 2779, 83 2779, 81 2779, 81 2779, 84 2779, 84 2779, 84 2779, 84	2779.84 2779.96 .48 2778.85 2777.06	X _{ls} PPT CONFIDENCE MIN. LIMIT (999 MJ)	
	STVC	2780.32 2778.91 2779.99 2780.45 2779.99 2780.45 2779.95 2779.67 2779.79 2779.79	2779.92 2786.05 .52 2778.60	602 PP Tes MIN. LIMI (999 Md)	
	740	2780.09 2779.36 2780.20 2780.48 2779.98 2779.98 2780.11 2780.43 2780.06 2780.06	2780.06 2780.05 .483 2778.71	SIN	
(s	S	2779.62 2779.14 2779.14 2779.83 2779.56 2779.56 2779.49 2786.17 2779.44 2779.57	2779.62 2779.74 424 2778.56 2776.84	8	
ey (meters)	LR	2779.15 2779.01 2779.01 2779.52 2779.23 2779.02 2779.06 2779.06 2779.00 2779.14	2779.30 2779.36 .403 2778.24 2776.52	¥ - 8 • 225	
Leahy to Ridgeley		8 4 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	median (Md) mean (X ₁ x) std dev (S ₁ x) 99% confidence (.999Md)	2780 2780 2779 2776 2776 2776	
	COUNTS/KM METERS	6E HIN ESTANCE OF COLORS O	7002:3	BUYD. RICHT HALF ONLY ON JEFFERSON & RODEO SOME CYCLISTS RODE HERE RODE HERE SOME CYCLISTS RODE HERE RODE HERE SOME CYCLISTS RODE HERE The Author Some Cyclists RODE HERE SOME CYCLISTS SOME CYCLISTS SOME CYCLISTS SOME CYCLISTS SOME CYCLISTS SOME CYCLISTS RODE HERE SOME CYCLISTS SOME CYC	9248
			I	Most Jene (Section 1) July (Section 1) J	

Ridgeley to Hobart (meters)

LR CR TVC STVC MZ	BB 5207.17 5207.85 5208.06 5307.83 5307.58 BL 5206.42 5306.42 5306.83 5306.37 5306.55 CW 5306.40 5307.34 5307.50 5307.12 5306.81 DK 5207.01 5307.47 5307.02 5307.02 5307.02 530.31 JD 5507.02 5507.47 5507.00 5307.00 5307.00	5306.71 5307.25 5307.38 5307.23	5306.97 5305.27 5307.54	5307.51 5308.25 5307.90 5308.32 5306.07 5306.83 5306.51 5306.36 5306.77 5307.54 5307.59 5307.75	mn <u>3202.14</u> 3204.15 3205.71 3202.85 5204.14 median (Md) 5306.77 5307.34 5307.38 5307.23 5306.81 mean (X _{1,2}) 5206.46 5307.06 5307.09 5307.17 5306.85 std dev (S _{1,2}) 1.078 1 1078	5303.46 5302.03 5302.07 5301.92 530	5308 5309 W 5305 W 5309	NOTE: THE BEST ESTIMATE FOR WR. IS STVC, WHICH OMITS WR'S ERRONGOUS BASELINE-6 DATA.
	LIMITS	MAX RANGE MIN RANGE	9385.8 2.4 5307.4 9494.3 2.7 5305.8 9427 1 2.0 520.0	9585.0 2.5 9586.2 7.0 9448.7 7.0	2 2.6 5307.1 7 2.3 5306.1 2 6.0 5306.3 8 4.4 5306.9	TK 9280.0 2.3 5306.9 1.3 WR 9662.5 5.1 5304.0 2.8	RODEO RD. WHITE LINE LAMPOST IGM E. of RIDGELEY RODEO RD. EXPOSITION BLVD. IGM E. of RIDGELEY IGM	





BRONZE MONUMENTS (B.M.) MARK EACH END OF THIS BASELINE. MEASURED VIA HP381\$A BY JOHN BRENNAND IN MARCH, 1983.

PRESSURE = 29.4 DEGREES = 69° ATMOSPHERIC CORRECTION = 12 PPM DISTANCE = 1000.014 METERS 1000.015 1000.013 1000.012 +.017 CORRECTION 1000.012 1000.014 1000.030 CORRECTED 110.0001 DISTANCE 1000.012 110.000

BASELINE 6

'84 L.A. OLYMPIC MARATHON, U.S.C. - STADIUM AREA

	Budlang to Menla	o Menla	(meters)	•				
			2	85	TVC	STVC	ZΜ	
	BB		611.213	611.250	611.148	611.15	611.16	
	Я		610.991	611.002	611.002	610.99	610.98	
	30		611.474	611.504	611.415	611.50	611.45	
	ă		611.264	611.285	611.133	611.28	611.23	
	ar P		611.460	611.479	611,325	611.43	611.41	
	5		611.084	611.125	610.964	611.07	611.08	
	æ		611.179	611.217	611.083	611.18	611.08	
	S		611.147	611.218	611.166	611.16	611.15	
	æ		611.180	611.223	611.138	611.23	611.15	
•	EL		610.706	610.762	610.654	610.74	610.69	
	Œ		610.979	611.025	610.898	610.93	610.92	
	¥		610.961	611.028	610.992	611.02	610.94	
	¥.		611.073	611.100	610.857	611.18	611.04	
	median	(PW)	611.147	611.217	611.083	611.16	611.08	
	mean	(X	611.131	611.171	611.66	611.14	611.10	
	std dev		. 207	199	199	20	20	
	99% confidence	dence	610.56	610.62	610.51	610.58	616.54	
	(PM666")	â	610.54	610.61	610.47	610.55	610.47	
-								
					83			
					-9			
			LR	CR TVC		E(n)		
			8	•	ر در			
	S		•	•	LK	•		
		. ;		1		×		
	31	-		8	*	e K		
	L3				•			
	W			•		47	CONFIDENCE	
					\	666/	/999 MJ)	
		-				5	min)	
		9						
		2						

COUNTS, KM METERS

MAX. RANGE

BL 9985.8 0.8 611.1 0.1

BL 9985.0 2.8 611.2 0.1

CM 9285.0 2.8 611.2 0.2

DV 9285.2 7.0 611.2 0.4

PC 9448.7 4.0 610.9 0.3

PS 9353.0 1.0 610.9 0.4

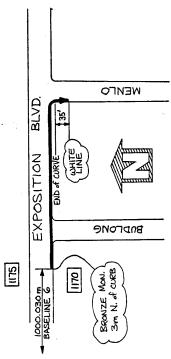
PS 9353.0 1.0 610.9 0.4

PS 9353.0 1.0 610.9 0.4

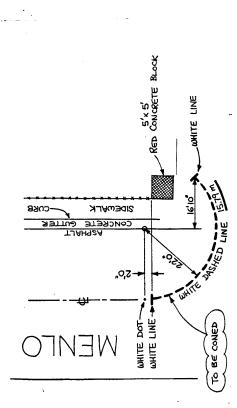
TB 944.8 4.4 610.5 0.3

TD 9227.5 6.0 610.9 0.4

TW 926.0 5.1 611.0 0.3



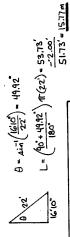
Menla ta U-turn (meters)	LR CR TVC STVC WZ	BB 575.850 575.875 575.78 575.79 575.79 EL 575.80 EL 575.810 575.810 575.810 575.810 575.810 575.810 575.810 575.810 575.810 575.810 575.82 575.810 575.82 575.810 575.82 575.81 575.82 575.82 575.81 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.82 575.92	STS STA CR TVC STVC WZ Xis W STS
	STIMIT	COLNTS/KM METERS BB 9985.8 0.8 575.8 0.0 CM 9628.0 2.8 575.8 0.2 CM 9628.0 2.8 575.8 0.2 CM 9628.0 2.8 575.9 0.2 UD 9686.2 7.0 575.5 0.4 PC 9448.7 4.0 575.5 0.4 PS 933.0 1.0 575.5 0.4 PS 933.0 1.0 575.5 0.4 PS 933.0 1.0 575.6 0.4 PS 933.0 2.3 575.6 0.4 TK 9280.0 2.3 575.6 0.4 TK 9280.0 2.3 575.6 0.4 WR 9262.5 5.1 575.6 0.3	EXPOSITION BLVD. END of CURVE WHITE LINE CONTER of SITE ET N. FACE of SIX5 CONCRETE BLOCK CONCRETE BLOCK



ALL OF THE ABOVE MEASUREMENTS WERE MADE BY BOB LETSON AND TOM KNIGHT, JÜNE 4, 1983, USING STEEL TAPE.

LETSON (4-24-83) 64945> 148 + (UF-2) = 150 = 15.80 m BICYCLE MEASUREMENTS: (MEASURED ON THE DASHED LINE) 61000>147 = 15.86 m KNIGHT (6-4-83)

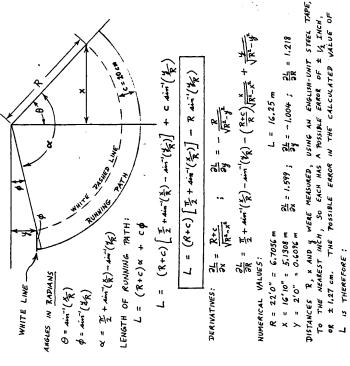
CALCULATION:



AJERAGE STEEL TAPE MEASUREMENT = 15.78 m DASHED LINE X= 15.80 METERS

U-TURN @ STADIŪM

ERROR ANALYSIS FOR STEEL TAPE MEASUREMENT U-TURN (by Bob Baunel) OF STADIUM



WE CONCLUDE THAT

L = 16.25 ± 0.05 meters

= 4.85 cm

AL = 1.599 x 1.27 + 1,004 x 1.27 + 1,218 x 1.27

min ratio

	ZM	168.93	168.49	169.16	169.08	168.90	168.77	168.77	768.69 168.64 .34 167.69	Kis (999 Md) —— MIN. LIMIT
	STVC	168.93	168.69 168.50	169.17	169.08	168.94	168.79	168.78 168.68	168.69 168.65 .33 167.73 168.52	402 413 414 417 417 417 417 417 417 417
	TVC	168.929	168.455	169.134	169.085	168.992	168.759	168.78Ø 168.596	168.695 168.627 .339 167.68 168.53	3 3 3
ĵ,	85	168.959	168.721	169.179	169,124	168.928 168.928	168.792	168.793 168.665	168.721 168.659 .339 167.72 168.55	≥ ***
um (meteri	LR	168.954	168.717	169.177	169.117	168.921	168.780	168.777 168.661	168.717 168.652 .341 167.71 168.55	∀
U-turn to Stadium (meters)		88 48	38	d c	. E.	ກຸກ	e f	3 X X	median (Md) mean (Xis) std dev (Sis) 99% confidence (.999Md)	жете <i>ка</i>
			,a						Zenct Zenct	S. WALL S. WALL OF S. WALL C. of STORM DRAIN
		,								m'sg)
	RS	0.00		0.1	0.0	0.0			TADIUN	SE PRIORY
175	METERS	168.7	168.5	169.1	169.0	167.9	168.7	168.7	MULGATE STADLUM	ASURED HURY FROM DRAINS KS. RED BLOCK SW CARNER OF RED CL. STORM DRAINS
LIMIT	/KM RANGE	8.00	5.0	0.4	6.9	8.7	4 4 4 c	2.3	মতি	MEASURED 12" AWAY FRO STEEL STORM A S'XS' RED E of SW CARRED
	COUNTS/KM	9385.8	9585.0	9586.2	9336.0	9384.2	9414.8	9280.0	ŀ	(13. S. 9. S.
		88 8	₹ă	S 5	Z 2	8 3	2 5	; ; ; ; ;		30=
										WENTO WENTO

AVE

8.27

OLYMPIC COLESEUM 1000 METERS

DRIVE

EXPOSITION BLVD

VERMONT MENLO

Pacific Southwest Association Inc.	
Athletics Congress San Diego and Imperial Countles, California, 1135 Garnet St. San Diego, California 92109 (714) 275-1292	
E ertification	
NAME OF COURSE: OLYMPIC COLESEUM 1000 METERS	
TYPE: I road race Cross-country Scalibration Track LOCATION: OLYMPIC COLESEUM Los ANGELES, CA	<u>ب</u> ا
TERRAIN: paved CO % dirt % grass %	
X flat rolling hilly	
STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: 8804, 1000 m	
ALTITUDE: START: ~ 250 HIGHEST:	
(feet above sea level) FINISH: LOWEST:	
MEASURED BY (name, address, phone): BOB LETSON, RON SCARDERA	
RON - 6907 CAMROSE DR., LOS ANGELES, CA 90068 (213) 874-6867	1867
MEASURING METHOD: Dicycle The walking wheel	
steel tape	:
NUMBER OF MEASUREMENTS OF THE ENTIRE COURSE: 7	
DATES WHEN COURSE WAS MEASURED: 22 JANUARY 1983	
EXACT AVERAGE MEASURED LENGTH OF THE COURSE: 880 4 1000,000 METERS	TERS
DISTANCE BETWEEN THE SHORTEST AND LONGEST MEASUREMENTS: G = 1/4 INCH	_
CERTIFICATION CODE: PSA- 83011	

1413

, 12,

HALLDALE

NORMANDIE

The course described above and defined by the attached map is hereby certified to fulfill national standards for accurate measurement. A copy of this letter and map should accompany race results malled to the National Running Data Center, PO Box 42888, Tucson, AZ 85733.

January 30 1983 Assoc. Cett. date	Tebuary 5 1983
Association Certifier, Bob Letson 4369 Hamilton St. #4; San Diego, CA 92104	National Certifier, Ted Corbitt Apt 8H Sect 4: 150 W 225 St; NY, NY 10463

ITION FOR CERTIFICATION OF A
APPLICATION
Ĕ

m		l			,
OLYMPIC CALESEUM 1000 METERS DATE: 30 JAN'83					
305	Ą	ter?)	١		
Spate	LES.	nic me			,
FER	Location (place, city, state): OLYMPIC COLESEUM, LOS ANGELES, CA	Measuring method used: Bicycle? Walking wheel? Steel tape? (Electronic meter?)			
₩ O	SOI) jed	, ::	S.	
8	NO.	eel ta	i, etc.	ECT	
MO	98 <i>3</i> 0	17 S1	ension	HP3810A ONE PRISM REFLECTOR	
LESE	3	g whee	1, dim	WS!	TSe?
ප	YMPI	Walkin	e, mode	2	the co.
APIC	Ö	cle?	e (nak	S. O.	uring
25	state	Bicy	devic	, Y	r meas
	, city,	1 used:	ssuring	3810	ible fo
ourse:	(place	metho	the me	노	espons
Name of course:	ation	ısuring	Describe the measuring device (make, model, dimensions, etc.):		Who was responsible for measuring the course?
Nan	ž	ž	ä		ĕ

Name: BOB LETZON DIEGO, CA 92104
No. vill be responsible for locating the start/finish points, marking the course, measuring future changes and reporting them to the National Standards Comittee:

Name: Ron SCARDERA Address: GOT CAMROSE DR, Los RNGELES, CA

CAIS) B14-6867 1. Is the course (Latz) rolling? hilly? mountainous? uphill? downhill? Elevation (feet above sea level): START 250 Highest Lowest FINISH
URSE (lat?) rolling? hilly? mountainous? et above sea level): START 250 Highest
URSE (flat?) rolling? hilly? et above sea level): START
URSE (flat?) rolling? et above sea level):
URSE flat?
SCRIPTION OF THE COURSE 1. Is the course(flat Elevation (feet ab

- FINISH Lowest dirt? 2. How much of the course is paved? 1007 grass?
 - 3. Straight-line distance between the START and FINISH: 1000 m. 8804

4. Bescribe exactly where the START, FINISH, TURNAROUND, and MILE/GN points are located with reference to unique persanent landaeris (e.g., 1) vds w of 534 beach St. mailbox):

E.END — 1'AIM. Beach St. mailbox):

8809 — 4.77 FEET 60. of 1'AIM. (SOVER of R.D) 0'11+50' (1413 3770 DRIVE IOCOM— 8.27 FEET E0. of CONCRETE STRIP OF E0. 10' (1413 3770 DRIVE IOCOM— 131 Jain/Finish Stripe Conspicte, detailed amy of the course with mass of all varies/strails showing road was measured, and how all interest were tarner. Use additional sketches or writeups to clearly communicate the running/measured route.

COMPAISONS THIS KNOWN STANDARD DISTANCE. Certification requires two comparisons of each measuring device with measurement and distance. If series impositions used, this standard distandand there is series to standard must be standard must be series of the surroy instruments. If a wheel its used, any standard must have been created via series.

6. Describe the known standard distance:

Name: MISSION EAY MILE, REFERENCE POINTS "B" PAD"C" (NAUS)
Location: Like PATH S. of SEA WORLD DRIVE
Longth: 2874.216 ± .026 FEET
How measured: 21 MERSURENGINS: 1773, H73800A + 3 DWG. "CBUTHPE'S
Certified: VES FSA-7301 If the known standard distance is not certified, apply now by answering all appropriate questions on another APPLCATION. Poy CERTIFICATION OF ACCEMENT for the known standard distance.

BOB LETSON, HP3810A @ POINT "B" -. 113 PT 7. Describe how each messuring device was compared with the known standard distance.
List the date, time, and raw date for each Comparison:
23 JPAN BS3 BAM HASSIGN ROBE (ESCAN) HISSIGN @ POINT 'B'-, II3 FF 30.0' Hg Goff PPM=-1 CARL BRANDT, REFLECTOR @ PANT'C. CARL BRANDT, REFLECTOR @ PAINT "C" MEASUREMENTS = 2874,348

8. If steel tape or walking wheel was compared, what is the average correction factor? NONE If a bicycle was compared, what is the average digits/mile for all of the comparisons for each person for each day;

	e:	AND MEASUREMENTS. Certification requires two measurements. If a hickely is used the Landon
Average digits/mile:	digits/mile:	nts. If a bi
Average	Name: Average digits/mile:	two measureme
re:		on requires
te: Name:	Name:	Certification
Date:	Date:	MEASUREMENTS.
		RSE

COUNSE HEASUREMENTS. Certification requires two measurements. If a birvcle is used, the known standard distance and the race courses must both be ridden during the same day by the same person for each measurement (comparisons from a previous day are not acceptable).

10. Mas the measuring route identical to the shortest route that can be permitted to be trun by the winner of the race?

Were all left/right turns measured to within one yard of the inside edge of all turns?
 If not, explain,

12. If part of the race course is on dirt or grass, how were these stretches measured?

14. If steel tape was used, answer the following questions:

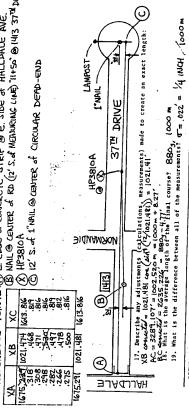
a. How many people were in the survey party? List their specific duties:

b. How was the tape tension maintained during measuring?
c. How was the tape increments count maintained?
d. How were the curves measured?
15. If a bicycle was used, answer the following questions:

a. Was the bicycle ridden over the known standard distance and over the race course both during the same day by the same person for each messuring occasion; Was the from standard distance compared before and after messuring the race course? If not, explain.

16. List the date, time, and raw data for each measurement of the course:

REFERENCE POINTS: (A) E. EDGE of CONCRETE STRIP (B) E. SIDE of HALLDALE AVE. 22 JAN 83, 3 PM, 60°F, 300° Hg, PPM=-1



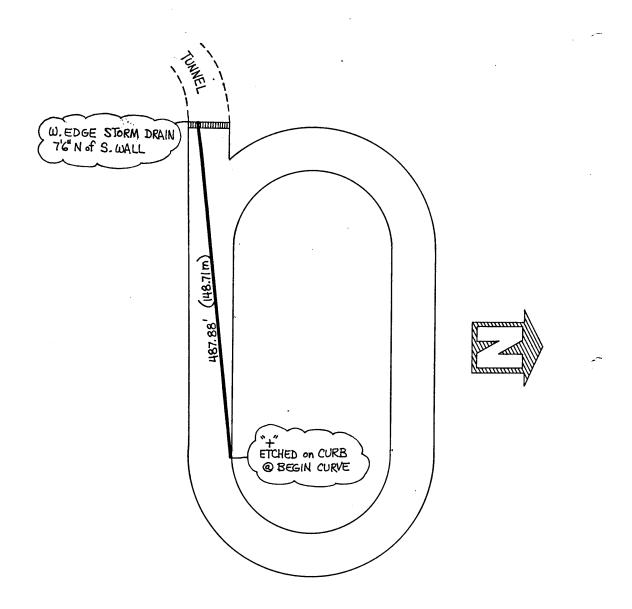
RETURN THIS FORM WITH ALL QUESTIONS ANSWERED TO THE RECIONAL CERTIFIER IN YOUR AREA:

NI New England Sconfedd 9 E 89th St, NY NY 10022

OCHO, YA. NY NY 10022

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NJ, DE, PA	II		OK	an Francisco) Carl Wisser, 2608 Ninth St, Berkeley CA 94710		The Contract the Off Cane of the Contract of t
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NOTE: ADDITIONAL MEASUREMENTS
ARE NEEDED TO DETERMINE
THE LENGTH OF THE RUNNING
ROUTE from THE TONNEL TO
THE FINISH LINE.

OLYMPIC STADIUM

MEASURED VIA 300' STEEL TAPE ON 4-24-83 (ONCE) BY JOHN BRENNAND, DAVID KATZ, BOB LETSON

SUMMARY OF MEASUREMENTS FER RIDER

Each bicyclist's measurements are summarized in the following tables, for intervals with more than $1\emptyset$ measurements. (meters)

⊯⊯ (Bob Baumel)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.94	1293.8Ø	1293.98	1293.88	1293.95
Carmelina	1593.81	1593.61	1593.76	1593.66	1593.73
Georgina	3573.43	3572.93	3572.64	3572.63	3572.71
Navy Ct.	4234.14	4233.64	4232.47	4232.97	4232.52
Via Dolce	1917.72	1917.58	1918.10	1917.20	1916.69
Mindanao	2549.95	255Ø.12	2549.56	2550.64	2551.71
Hannum	4267.21	4267.76	4269.26	4268.95	4269.42
Summertime	2033.32	2033.64	2034.03	2034.33	2034.10
Ridgeley	2779.15	2779.62	2780.09	278Ø.32	2779.83
Hobart	5307.17	5307.85	5308.06	5307.83	5307.58
Menlo	611.213	611.25	611.148	611.15	611.16
U-turn	575.85	575.875	575.775	575.78	575.79
Stadium	168.954	168.959	168.929	168.93	168.93

TOTAL 30905.9 30906.6 30907.8 30908.3 30908.1

EL (Bob Letson)

Courses (4679.54)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.78	1293.72	1293.90	1293.87	1293.78
Carmelina	1593.37	1593.3Ø	1593.50	1593.5Ø	1593.35
Georgina	3571.34	3571.19	3571.22	3571.Ø9	3571.14
Navy Ct.	4234.22	4234.09	4233.11	4233.13	4233.77
Via Dolce	1917.84	1917.82	1917.82	1917.35	1917.56
Mindanao	2551.38	2551.43	2551.17	2551.45	2551.89
Hannum	4268.83	4268.99	4269.43	4268.88	4269.48
Summertime	2033.80	2033.89	2034.01	2033.75	2034.03
Ridgeley	2779.Ø1	2779.14	2779.36	2778.91	2779.21
Hobart	5306.42	5306.62	5306.83	5306.37	5306.55
Menlo	610.991	611.002	611.002	610.99	61Ø.98
U-turn	575.81	575.818	575.816	575.8Ø	575.8Ø
Stadium	168.762	168.763	168.763	168.75	168.75
TOTAL	30905.5	30905.8	30905.9	30903.8	30906.3

□W (Carl Wisser)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.35	1293.24	1293.23	1292.96	1293.28
Carmelina	1594.61	1593.82	1593.76	1593.44	1593.82
Georgina	3574.33	3573.94	3573.47	3572.78	3573.55
Navy Ct.	4235.33	4234.93	4234.67	4234.66	4233.82
Via Dolce	1917.32	1917.20	1918.06	1917.28	1916.40
Mindanao	2551.11	2551.26	2551.32	2551.64	2552.42
Hannum	4268.92	4269.35	427Ø.42	4269.78	4270.42
Summertime	2033.90	2034.15	2034.40	2034.33	2034.40
Ridgeley	2779.47	2779.83	278Ø.2Ø	2779.89	2779.84
Hobart	5306.80	5307.34	53Ø7.5Ø	5307.12	5306.81
Menlo	611.474	611.504	611.415	611.50	611.45
U-turn	575.904	575.926	575.837	575.85	575.82
Stadium	168.717	168.721	168.695	148.49	168.69
TOTAL	30910.6	30911.2	30913.0	30909.9	30910.7

D⊫< (David Katz)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.11	1294.Ø1	1294.09	1293.98	1294.06
Carmelina	1594.18	1594.03	1594.Ø9	1593.97	1594.06
Georgina	3574.83	3574.48	3574.10	3574.1Ø	3574.19
Navy Ct.	4234.41	4234.Ø6	4233.3Ø	4233.92	4233.09
Via Dolce	1917.26	1917.16	1917.77	1917.13	1916.46
Mindanao	2550.88	2551.Ø1	255Ø.91	2551.68	2552.18
Hannum	4269.37	4269.78	4271.46	4270.72	4271.02
Summertime	2034.14	2034.38	2Ø3 4. 94	2034.72	2034.74
Ridgeley	278Ø.12	2780.45	2780.48	2780.72	2780.66
Hobart	5307.01	5307.47	5307.05	5307.67	5307.38
Menlo	611.264	611.285	611.133	611.28	611.23
U-turn	575.8Ø2	575.815	575.669	575.81	575.77
Stadium	168.496	168.498	168.455	168.50	168.49
TOTAL	30911.9	30912.4	30913.5	30914.2	30913.3

JD (Jim Delaney)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.40	1293.37	1293.10	1293.14	1293.16
Carmelina	1594.5Ø	1594.42	1594.Ø5	1594.15	1594.17
Georgina	3573.39	3573.12	3574.36	3572.60	3572.17
Navy Ct.	4235.52	4235.19	4235.61	4234.67	4233.54
Via Dolce	1918.11	1918.ØØ	1918.09	1917.88	1916.97
Mindanao	2551.00	2551.Ø8	2550.30	2551.43	2552.33
Hannum	4268.15	4268.46	427Ø.22	4268.98	4269.77
Summertime	2034.03	2034.22	2034.82	2034.41	2034.66
Ridgeley	2779.52	2779.80	2779.98	2779.92	2780.02
Hobart	5306.02	5306.43	5306.22	5306.28	5306.25
Menlo	611.46	611.479	611.325	611.43	611.42
U-turn	575.466	575.477	575.328	575.43	575.41
Stadium	169.177	169.179	169.134	169.17	169.16
TOTAL	30909.8	30910.2	30912.5	30909.5	30909.0

FC (Paul Christensen)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.41	1294.30	1294.56	1294.31	1294.36
Carmelina	1593.88	1593.73	1594.00	1593.70	1593.76
Georgina	3572.Ø4	3571.68	3571.46	3571.32	3571.42
Navy Ct.	4234.16	4233.82	4231.92	4232.90	4232.93
Via Dolce	1917.92	1917.83	1918.15	1917.31	1917.16
Mindanao	2551.76	2551.84	2551.64	2552.64	2553.06
Hannum	4268.58	4268.91	4271.26	427Ø.15	427Ø.27
Summertime	2033.77	2033.99	2034.87	2034.43	2034.40
Ridgeley	2779.23	2779.56	2779.89	2779.90	2779.83
Hobart	5306.71	5307.25	53Ø7.38	5307.23	5307.26
Menlo	611.084	611.125	610.964	611.07	611.08
U-turn	575.732	575.766	575.611	575.71	575.73
Stadium	168.444	168.453	168.407	168.43	168.43
TOTAL	30907.7	30908.2	30910.1	30909.1	30909.7

戸序 (Peter Riegel)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.80	1293.68	1293.52	1293.49	1293.62
Carmelina	1594.16	1593.99	1593.73	1593.72	1593.86
Georgina	3574.46	3574.03	3574.Ø1	3573.29	3573.33
Navy Ct.	4234.64	4234.19	4234.22	4233.29	4232.66
Via Dolce	1918.03	1917.89	1918.75	1917.52	1916.89
Mindanao	2551.16	2551.32	2551.3Ø	2552.Ø7	2552.41
Hannum ,	4248.54	4269.03	4270.66	427Ø.Ø9	4270.02
Summertime	2033.66	2033.94	2034.43	2034.20	2034.12
Ridgeley	2780.12	2780.52	2781.11	2780.65	2780.43
Hobart	5306.97	5307.58	53Ø8.11	5307.68	5306.80
Menlo	611.179	611.217	611.083	611.18	611.Ø8
U-turn	575.933	575.961	575.83	575.88	575.82
Stadium	169.117	169.124	169.085	169.08	169.Ø8
TOTAL	30911.8	30912.5	30915.8	30912.14	30910.1

FS (Pete Shandera)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.73	1294.59	1294.95	1294.88	1294.86
Carmelina	1593.16	1592.96	1593.35	1593.23	1593.24
Georgina	3573.28	3572.82	3572.Ø1	3572.86	3573.Ø8
Navy Ct.	4234.31	4233.83	4231.96	4232.95	4233.48
Via Dolce	1918.17	1918.02	1918.21	1917.41	1917.57
Mindanao	255Ø.63	255Ø.73	2549.99	2551.00	2552.18
Hannum	4267.71	4268.12	4269.44	4269.10	4269.75
Summertime	2033.39	2033.65	2034.01	2034.41	2034.15
Ridgeley	2779.Ø7	2779.49	278Ø.14	2780.40	2779.81
Hobart	5305.27	5306.04	5306.64	5306.46	5306.02
Menlo	611.147	611.218	611.166	611.16	611.15
U-turn	575.875	575.937	575.882	575.88	575.88
Stadium	168.402	168.419	168.402	168.40	168.40
TOTAL	30905.1	30905.8	30906.1	30908.14	30909.4

RS (Ron Scardera)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.12	1293.98	1294.08	1294.03	1294.16
Carmelina	1596.83	1596.62	1596.67	1596.61	1596.77
Georgina	3573.98	3573.44	3573.Ø8	3573.06	3573.23
Navy Ct.	4235.77	4235.20	4234.51	4234.55	4233.99
Via Dolce	1917.50	1917.33	1917.68	1916.95	1916.35
Mindanao	2551.44	2551.61	255Ø.62	2551.55	2553.63
Hannum	4272.17	4272.76	4273.99	4272.59	4274.97
Summertime	2033.84	2034.19	2034.39	2034.11	2034.85
Ridgeley	2779.66	278Ø.17	278Ø.43	2779.95	2780.58
Hobart	53Ø7.54	5308.30	5307.97	5308.29	5308.25
Menlo	611.18	611.223	611.138	611.23	611.15
U-turn	575.91	575.94	575.853	575.96	575.86
Stadium	168.021	168.028	168.002	168.04	168.00
TOTAL	30917.9	30918.8	30918.4	30916.92	30921.8

T 🖭 (Tom Benjamin)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.71	1293.60	1293.51	1293.44	1293.62
Carmelina	1594.64	1594.47	1594.30	1594.21	1594.43
Georgina	3574.31	3573.85	3573.92	3573.28	3573.31
Navy Ct.	4235.44	4234.96	4234.51	4234.52	4233.48
Via Dolce	1918.38	1918.24	1918.53	1918.18	1917.20
Mindanao	2551.19	2551.26	2550,72	2552.20	2553,11
Hannum	4269.12	4269.53	4271.33	4270.78	4271.58
Summertime	2033.75	2034.02	2034.53	2034.42	2034.65
Ridgeley	2779.00	2779.44	2779.68	2779.67	2779.84
Hobart	5307.51	5308.25	5307.90	5308.32	5308.18
Menlo	610.706	610.762	610.654	610.74	610.69
U-turn	575.765	575.81	575.702	575.78	575.72
Stadium	168.78	168.792	168.759	168.79	168.77
TOTAL	30912.3	3Ø913.Ø	30914.1	30914.33	30914.6

TD (Tom Duranti)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.33	1294.17	1293.86	1294.15	1294.14
Carmelina	1594.39	1594.17	1593.7Ø	1594.Ø8	1594.06
Georgina	3574.66	3574.12	3574.15	3573.45	3573.32
Navy Ct.	4233.37	4232.85	4233.28	4232.32	4230.94
Via Dolce	1918.19	1918.Ø5	1918.57	1917.74	1916.76
Mindanao	2551.17	2551.33	255ø.77	2551.88	2553.15
Hannum	4268.68	4269.24	4270.94	4269.89	4271.14
Summertime	2034.01	2034.35	2034.78	2034.52	2034.88
Ridgeley	2779.3Ø	2779.80	2780.06	2779.77	2780.05
Hobart	5306.07	5306.83	5306.51	5306.36	5306.49
Menlo	610.979	611.025	610.898	610.93	610.92
U-turn	575.818	575.852	575.726	575.76	575.74
Stadium	168.169	168.177	168.139	148.15	168.14
TOTAL	30909.1	30910.0	30911.4	30909.2	30909.7

T⊨ (Tom Knight)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1293.82	1293.7Ø	1293.95	1293.78	1293.86
Carmelina	1593.28	1593.11	1593.36	1593.13	1593.25
Georgina	3574.25	3573.79	3573.37	3573.37	3573.72
Navy Ct.	4235.04	4234.55	4233.05	4233.63	4233.73
Via Dolce	1917.94	1917.78	1918.27	1917.28	1917.Ø8
Mindanao	2550.45	255Ø.53	255Ø.15	2551.39	2552.16
Hannum	4267.80	4268.19	4269.46	4269.38	4269.98
Summertime	2033.54	2033.81	2034.09	2034.16	2034.34
Ridgeley	2779.14	2779.57	278Ø.ØØ	2779.78	2779.87
Hobart	5306.77	5307.54	5307.59	5307.75	5307.35
Menlo	610.961	611.Ø28	610.992	611.02	610.94
U-turn	575.948	576.005	575.964	575.99	575.92
Stadium	168.777	1 68. 793	168.78	168.78	168.77
TOTAL	3Ø9Ø7.7	30908.4	30909.0	30909.4	30911.0

Will Rasmussen)

TERMINUS	LR	CR	TVC	STVC	WZ
Bundy	1294.70	1294.60	1294.47	1294.63	1294.50
Carmelina	1594.01	1593.88	1593.65	1593.95	1593.69
Georgina	3572.68	3572.32	3572.53	3572.51	3571.52
Navy Ct.	4233.91	4233.54	4233.29	4233.23	4231.92
Via Dolce	1917.53	1917.42	1918.07	1917.1 <i>4</i>	1916.39
Mindanao	2549.91	2550.02	2549.98	2551.15	2551.40
Hannum	4267.96	4268.35	4270.93	427Ø.67	4269.85
Summertime	2033.54	2033.78	2034.74	2035.06	2034.23
Ridgeley	2778.89	2779.23	2779.25	278Ø.79	2779.51
Hobart	5303.74	5304.25	5303.71	5305.88	5304.14
Menlo	611.073	611.10	610.857	611.18	611.04
U-turn	575.687	575.705	575.472	575.78	575.65
Stadium	148.461	168.665	148.594	168.68	148.45
TOTAL	30902.3	30902.8	30905.5	30910.65	30902.5

COMPUTER PROGRAMS

name	language	author	subject
Cos1	BASIC	RIEGEL	PREDICTABILITY STUDY
COS 211	BASIC	RIEGEL	MEASUREMENTS/RIDER
COS 215	BASIC	RIEGEL	MEASUREMENTS/INTERVAL
001,0H1	PASCAL	LETSON	BASELINE ANALYSIS
002,042	PASCAL	LETSON	"LIMITS"
OH3A,B	PASCAL	LETSON	"TVC" MEASUREMENTS
0H3 ₂	PASCAL	LETSON	"ACTUAL" COUNTS/KM (RETRODICTED)

02-Sep-83	BASI	C PROGRAMS	Þч	PETER	RIEGEL	_:	
CAL1 .BAS	9			CAL3	.BAS	9	
CAL2 .BAS	9	25-May-83		OLY1	.BAS	8	25-May-83
CAL6 .BAS	11	25-May-83		CAL8	.BAS	11	
CAL12 .BAS	12	27-May-83		CAL10	.BAS	13	31-May-83
CAL13 .BAS	13	31-May-83		OLY3	.BAS	13	31-May-83
OLY2 .BAS	15	02-Jun-83		OLY4	.BAS	15	03-Jun-83
OLY5 .BAS	11			OLYMP2	. BAS	15	13-Jun-83
OLYMP4.BAS	16			OLYMP5	.BAS	16	22-Jun-83
OLYMP6.BAS	17	23-Jun-83		OLYMP7	.BAS	18	23-Jun-83
OLYMP8.BAS	18	23-Jun-83		<u>COS1</u>	.BAS	17	30-Jun-83
COS2 .BAS	18	30-Jun-83		0083	.BAS	16	28-Jul-83
COMP1 .BAS	2	28-Jul-83		COMP2	.BAS	2	28-Jul-83
COS22 .BAS	18			005212	.BAS	17	
COS211.BAS	17			C0S21	.BAS	18	
COS213.BAS	17			COS214	BAS	17	
ORIGD .BAS	10	01-Sep-83		COS215		18	02-Sep-83

32 Files, 436 Blocks 1526 Free blocks

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BASIC PROGRAM LORITTEN BY PETER RIEGEL
                                                                                                                                         - for PREDICTABILITY STUDY -
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        140 NEXT I
150 FOR 1=1 TD 13
150 FOR 1=1 TD 13
150 FOR 1=1 TD 13
150 FEAD C(II.J)
170 NEXT J
170 NE
"COS 1"
```

```
495 REH 700-770 CALCULATE DEVIATIONS FROM REGRESSION
700 FGR Hai TO 8
710 DUN; CK(N)-X7,2
720 E(N)+CK(N)-X7,2
730 FUN; CK(N)-X7,2
730 FUN; CK(N)-X7,2
730 FEFF(N)
770 MEX N
770
```

```
1230 0BSUB 4000
1238 REM 1814
1236 REM 1814
1230 REM 1814
1240 REM 1814
1250 REM 1815
```

```
PRINT #1, SEG ENDING., "LIN REG., "STANDARD", "TUC", "COS REG"
Print #1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                868 A.(J)=F/D

870 & A.(J)=F/D

870 & A.(J)=F/D

880 & GO TD 11933

995 PRINT #1.6#(J)

999 PRINT #1.

999 PRINT #1.

1000 FINT #1.

1000 FINT #1.

1000 FINT #1.

1110 PRINT #1.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  REM SUB 4000 CALCULATES THE DISTANCE BETWEEN REH TWO POINTS
0-3 \ N = 4 \ 0.1=1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       REW 1200-1210 TELL THE COMPUTER WHAT PEOPLE
REM AND PLACES ARE TO BE CALCULATED
FOR J=1 TO 9
                                                                                                                                                                                                                                      L(N)=COS((((X(N)-X(1)))/(X(B)-X(1)))#3.14159)
NEXT N
                                                                                                                               STATEMENT OF THE CONTROL OF CORRELATION

REH R IS THE COEFFICIENT OF CORRELATION
                                                                                             REH G(J)ISTHESLOPEOFTHECALIBRATIONCURVE
G(J)=F/D
                                                                                                                                                                                   R=F/((D#E)~5)
REM S IS THE STD DEVIATION OF THE X'S
                                                                                                                                                                                                                                                                                       X=0 \ Y=0 \ D=0 \ E=0 \ F=0 \ L=0 FOR N=1 TO 8
                                                                                                                                                                                                                                                                                                                                                                                                                                                 F(N)=(L(N)-X)*(Y(N)-Y)

D=D+D(N) \setminus E=E+E(N) \setminus F=F+F(N)

NEXT N
           F(H) = (X(N)-X) # (Y(N)-Y) 
D=D+D(N)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   . u1=1
5 GUSUB 4015
7 R=8 \ 01=2
605UB 401=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            0=4 \ P=5 \ 01=1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              \ 0.1=1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PRINT #1,44(J)
                                                                                                                                                                                                                                                                                                                                                                                                                                  E(N)=(X(N)-X)-
                                                                                                                                                                                                                                                                                                                                                                             X=X/8 \ Y=Y/8
FOR N=1 TO 8
                                                                                                                                                                                                                          S=(E/7)^.5
FOR N=1 TO 8
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             G0SUB 4015
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              GOSUB 4015
                                              E=E+E(N)
F=F+F(N)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   (
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                                                                                                                                                                                                                                                                                               (
                             "COS 211"
BASIC PROGRAM
WRITTEN BY PETER RIEGEL
                                                                                                         - MEASUREMENTS -
                                                                                                                                      for each RIDER
                                                                                                                                                                                                                                                                                                                                                                                                                                                                             MEXI J

MEXI J

REM COUNT OVER THE CAL STRETCH, Y IS THE MEAN

REM COUNT OVER THE CAL STRETCH, Y

REM COUNT OVER THE SAME CAL STRETCH,

REM COUNT OVER THE SAME CAL STRETCH,

REM J=1 T 3

LET X(1)=(C(2,J)+C(1,J))/2

LET X(1)=(C(2,J)+C(1,J))/4,00071

LET X(2)=(C(2,J)+C(1,J))/2,955978

LET X(2)=(C(2,J)+C(1,J))/2
SG GFEN 'LF:' FOR GUTFUT AS FILE #11 'COS 21|
60 DIN 6(14) \ DIN H(14)
70 DIN 6(14) \ DIN H(14)
70 DIN 1030-15)
80 DIN 1030-15
81 DIN F(15)
82 DIN F(15)
83 DIN F(15)
84 DIN H(14)
85 DIN H(14)
87 DIN H(14)
88 DIN H(14)
89 DIN H(14)
80 DIN H(14)
81 DIN BK(10)
82 DIN H(14)
83 DIN E(200-14)
84 DIN H(200-15)
85 REN 100 TO 190 ESTABLISHES DATA IN MATRIX FORM
110 FGR 18 1 TO 27
110 READ BK(17)
110 FGR 18 1 TO 27
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              REH 700-770 CALCULATE DEVIATIONS FROM REGRESSION FOR N=1 TO 8 DENN=(X/N)-X)-Z DENN=(X/N)-X)-Z E(N)=(Y(N)-Y)-Z
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      600-650 CALCULATE THE AVERAGE X AND Y N=1 TO 8
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Y(3) = (C(9,1)-C(8,1)),379007
X(4) = (C(11,1)+C(10,1))/2
Y(4) = (C(11,1)-C(10,1)),601258
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                X(5)=(C(16,J)+C(15,J))/2
Y(5)=(C(16,J)-C(15,J))/,768575
X(6)=(C(19,J)+C(18,J))/2
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Y(6)=(C(19+1)-C(18+1))/,974693
X(7)=(C(22+1)+C(21+1))/2
Y(7)=(C(22+1)-C(21+1))/1.00003
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         X=0 \ Y=0 \ D=0 \ E=0 \ F=0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    Z(N,J)=(Y(N+1)+Y(N))/2
REM Z(N,J)ISTHETUCCONSTANT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   X(8)=(C(27,J)+C(26,J))/2
Y(8)=(C(27,J)-C(26,J))/2
FOR N=1 TO 7
                                                                                                                                                                                                                                                                                                                                        FOR I=1 TO 13
READ A$(I)
                                                                                                                                                                                                                                                                                                                                                                                               FOR J=1 TO 13
FOR I=1 TO 27
                                                                                                                                                                                                                                                                                                                                                                                                                                  READ C(I,J)
                                                                                                                                                                                                                                                              Ċ
                                                                                                                                                        (
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2000 DATA 804621,820400.839567

8000 DATA 81200.7990 IS NATZO 11001841162347.5:177329:16334.219698.5

8000 DATA 81202.21215 120200.29061

8000 DATA 81202.21215 120200.29061

8000 DATA 81202.21215 120200.29071

8000 DATA 81202.2015 120200.190477.20264121766.22673.26088

9000 DATA 81202.2015 120200.190477.20264121766.22673.26088

9000 DATA 81202.2015 120200.190477.20264121766.22673.26088

9000 DATA 81202.2015 120200.110477.20264121766.22673.20088

9000 DATA 81202.200.40189 120200.110477.20264121766.22673.20088

9000 DATA 81202.200.40189 120200.110477.20264121766.22673.20088

9000 DATA 81202.200.40189 120200.110477.20264127766.22673.20088

9000 DATA 812000.802720.15016.401707

9000 DATA 812000.802720.001707

9000 DATA 812000.802720.802773000117020.120206.120200.120270

9000 DATA 812000.8027200.120200.12020.12020.120270.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.120200.1
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        .(
1250 U-7 V F-10 \ 0.1=3
1280 Gu-10 \ V F-10 \ 0.1=3
1280 Gu-10 \ V F-10 \ 0.1=3
1280 Gu-10 \ V F-10 \ 0.1=4
1380 Gu-10 \
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```
K3=(((C(2,J)-C(1,J))/4.00071)+((C(27,J)-C(26,J))/2))/2
REH K3 IS STANDARD CONSTANT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  PRINT #1, FRINT #1, "NAME", "LIN REG", "STANDAKD", "TUC", "COS REG"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  1160 1=F

1170 C=C(1.1)-C(0.J) \ REM C IS THE INTERVAL COUNT

1180 K1=H(J)+G(J)*C(0.J)

1190 K2=H(J)+G(J)*C(0.J)

1200 KC(H)+H(Z)-Z

1210 K= (C(Z,J)+C(J,J))/2

1220 K= (C(Z,J)+C(J,J))/2

1230 K2=(C(Z,J)+C(J,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(Z,J)+C(
1080 REM SUB 1150 CALCULATES THE DISTANCE BETWEEN 1090 REM TWO POINTS BY FOUR METHODS 11100 PRINT #1.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            1010 IF G=99 THEN 2490
1020 PSH 1
1030 PSH 41,84(Q); TO ';84(P)
1040 PRINT 41, NAME', 'LIN REG', 'STH
1050 PRINT 41, NAME', 'LIN REG', 'STH
1060 PRINT 41
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              1140 GO TO 970
1150 FOR J=P1 TO P2 STEP P3
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (
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                                                      "COS 215"
BASIC PROSRAM
WRITTEN BY PETER RIEGEL
                                                                                                                                                                                                                                               for each INTERVAL
                                                                                                                                                                                                             - MEASUREMENTS
             10 DFEM 'LF!: FOR DUTPUT AS FILE #1

20 DIN K(14)

30 DIN K(14)

40 DIN K(14)

40 DIN K(15)

50 DIN K(15)

50 DIN K(15)

50 DIN F(15)

80 DIN H(13)

10 DIN A(14)

10 DIN A(14)

110 DIN A(14)

110 DIN A(14)

120 DIN A(14)

130 DIN L(13)

130 DIN L(13)

140 DIN A(14)

150 DIN H(13)

150 DIN H
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1910 DATA 223422-2623249-268900-286917-5-319947-344916-358865-374080-5
1920 DATA 444181-47232-4441818-2722424-47188-520292-529678-533414-540818
1930 DATA 444181-4723-64443-520-44418-520292-529678-533414-540818
1930 DATA 444181-47435-64443-640-68077-1
1900 DATA 52496-1960 TS RANKEL
1900 DATA 52496-1960 TS RANKEL
1900 DATA 62498-1960 TS RANKEL
1900 DATA 6249-1960 TS RANKEL
1900 DATA 62498-1960 TS RANKE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (
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                                                                                                                                                                                                                                (
                                                                                                                                                                                                                                                                                     (
                                                                ť
                                                                                                                                                   (
                                    KS=Z(G1,J) \ REM KS IS THE TUC CONSTANT
WI=B(J)+A(J)*COS(K8*3,14159)
W2=B(J)+A(J)*COS(K9*3,14159)
```

```
*
                                                                                                                                                                                                                                             *
                                                                                                                                                                                                                        (* FOR PRE & POST R.C.C.*)
                                                                                                                                                      C* CORRECTIONS FOR WALKING
                                                                                                                                                                         FOR MAY1=BB TO WR DO
BEGIN
IF ((1=0) OR (1=7))
THEN RCCII.REMANI.WALK:=0.0
ELSE BEGIN
IF ((MAN=BB) OR
(MAN=PS) OR
                                                     FOR 1:=0 TO 7 DO BEGIN FOR WANT=BB TO WR DO BEGIN FOR SHELL FO S DO BEGIN FEBITO S DO BEGIN
                                        PROCEDURE NAMEDATA,
BEGIN
NAMEC BBJ
NAMEC BLJ
NAMEC BLJ
NAMEC PCJ
NAMEC PCJ
NAMEC PCSJ
NAMEC PCSJ
NAMEC PCSJ
NAMEC PCSJ
NAMEC PCSJ
NAMEC PCSJ
NAMEC TRJ
                                                                                                                                                              FOR 1:=0 TO 7 DO
BEGIN
                   PROCEDURE PRESET1
                                                                                                                                         PROCEDURE RCCDATA;
                                                                                                                                                                                                                                                                                                                   PROCEDURE CALIBOA;
                                                                                                                                                     PROCEDURE WALKF;
                               IMPLEMENTATION
        *
                                                                                                                                                                                                                                        RIDER = RECORD

RIDE : FACKED ARRAYII..5,S..F1 OF REAL; (* JONES COUNTS *)

CPM, (* JONES COUNTS PER METER *)

WALK : REAL; (* WALK FACTOR *)

END;
                                                                                                                                                                                                                                                                                                                                                      (* CALIBRATIONS
    PROGRAM #1 (PART-1)
                                                                                                                                                                                                                                                                       BASELINE ANALYSIS-
WRITTEN BY BOR LETSON
                                                                                                                                                (* MEASURING POINTS *)
"Čout"
                                                                                                                                                                                                                                                                                                                                              J. INTEGER,
RCC :PACKED ARRAYIO..71 OF RC;
NAME:PACKED ARRAYIBB..WR1 OF STRING[21]
                                                                                                                                                                                                                                                                                                                              (* WALK FACTOR
(* RIDER ID#
                                        (* METERS/F00T (* START *)
(* FIN *)
             PASCAL
                                                                (* RIDERS *)
                                                                                                                                             SMCC = 14;
CARRELINA = 15;
AVONDALE = 16;
GERGINA = 17;
ALTA = 18;
NAV = 19;
NAV = 20;
MINDANA = 21;
CULVER = 22;
LEAHY = 24;
HOBART = 25;
SUMERINE = 25;
                                       CONST MPF = 0.3048;
S = 1;
F = 2;
                                                                                                                                                                                                                                                                                                                              WALKK :REAL;
MAN,
                                                               RC = -
              (*$S+*)
UNIT OUI;
                             INTERFACE
                                                                                                                                                                                                                                   TYPE
                                                                                                                                                                                                                                                                                                                        SAR
S
```

169

	81 RCCC01.RFP91.RIDEL1,F1 = 33728.01 82 RCCC01.RFP91.RBDE[2,F1] = 439728.01 83 RCCC01.RFP91.RBDFF9.F1 := 5.0454.01	RCC(01.R(PS).RIDE(4,F) :=	RCC[0].R[TK].RIDE[1,S] ;= RCC[0].R[TK].RIDE[1,F] ;=	188 RCC(0).RTK1.RIDE(2,F] := 33588.0; 89 RCC(0).RTK1.RIDE(3,F] := 42861.0; 90 RCC(0).RTK1.RIDE(4,F] := 52176.0;	191 192 RCC[0].RLJDJ.RIDE[1,S] i= 62000.0; 193 RCC[0].RLJDJ.RIDE[1,F] i= 71601.0; 194 RCC[0].RLJDJ.RIDE[2,S] i= 71600.0;	RCC[0].R[JD].RIDE[2,F] := RCC[0].R[JD].RIDE[3,S] :=		200 END; 201 PROCEDIRE CALIROD;	•	RCC(0).R(PC).RIDE(1,F) := RCC(0).R(PC).RIDE(2,F) :=	RCC(0).R(PC).RIDE(3,F) := RCC(0).R(PC).RIDE(4,F) :=	RCCIOJ.RIRSJ.RIDEII, SJ := 1	RCC(0).R(RS).RIDE(2),F) := 1	13	PCC(0) P(DK) PIDE(1 S) :=	RCCC01.RCDK1.RIDEC1,F1 := RCCC01.RCDK1.RIDEC1,F1 :=	RCC[0].R[DK].RIDE[3,F] := RCC[0].R[DK].RIDE[3,F] :=	RCC(01,R(TD),RIDE(1,S) :=	224 RCC[0], R[TD], RIDE[1,F] := 30843.0; 225 RCC[0], R[TD], RIDE[2,F] := 40190.0;	RCC[0].R[TD].RIDE[3,F] :=	END;	227 PROCEDURE CALIB7A; 231 PEGIN:	RCC[7].R[RS].RIDE[1,S]	! !!	RCC[7].R[PC].RIDE[1,S] :=		240 RCC(7).R[WR].R[DE[1,S] := 34000.0;
100								N (N (10101	44	0.01	4 (4 (4 (4 (4	1016	1010			124 (4		1010	:			4 (4 (
-	·,																							٠.			
	•				-												-										
	DATA	1 i									•																
	CLEAR RIDE DATA														,												
							·							· Fr													
	* 1.01 1.01																										
•	11		1500.0;	570902.5; 571000.0; 580404.0;	580500.0; 589902.0; 590000.0; 599403.0;	364500.0;	373848.51 383198.01 392546.01	401878.09		090000.01	113000.01	122499.0; 131997.0;	21500.04	40190.0; 40190.0; 49533.0;	58880.0;	27200.01	46561.0;	56279.0;	58000.01	67427.0;	86288.0;			082878.0;	102162.5;	111804.5; 121450.0;	24366.0;
	SELJ,S SELJ,F		16	1 9 1	H H B H	11		ii 94		H H	H 11	<u> </u>	II.	1 A R	. !!	E 11	11.19	0.0		1 67				<u> </u>	1 11	H H	1= 24
	M. I.R.		11,83	(1,F) (2,S) (2,F)	13,93 14,93 14,93	11,83	1,5	. [4, F]		111,SJ	12,F)	13,FJ	181	(2,F)	[4,F]	(8,113	(2) (4)	E. 4.	[1.8]	E 61	E 6			13,133	(2,F)	13,FJ	(1,5)
	RCC[1].RIMAN].RIDE[J,S] RCC[1].RIMAN].RIDE[J,F] END:		J.RIDE	RIDE	. RIDE	J.RIDE	RCCIOI.RIPRI.RIDEII,FI RCCIOI.RIPRI.RIDEIZ,FI RCCIOI.RIPRI.RIDEI3,FI	RCCIUJ.RIPRJ.RIDEL4,FJ END;	180B;	1.RIDE	1.RIDE	1.RIDE	J.RIDE	RIDE	J.RIDE	J.RIDE	RIDE	RIDE	J.RIDE	RCC(0).R(TB).RIDE(1,F)	RCC(0).RITBJ.RIDE(3,F)		1B0C;	J.RIDE	RIDE	J.RIDE	RCC[0].R[PS].RIDE[1,S]
	RCCT I	END;	1.RCBB		. REBB 1. REBB 1. REBB	I.REPR	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	¥.	#5 EPF	i.Ribl.	I.RIBL	I.REBL	1.RCTD		I.RCTD	I. REWR	REER	REWR	I.RCTB	RETB	RITB		E CAL	. R. C.	. R. C.		J.RIPS
		END;	RCC [0]	RCCT 0	RCC(0).R(BB).RIDE(3,S) : RCC(0).R(BB).RIDE(3,F) : RCC(0).R(BB).RIDE(4,S) : RCC(0).R(BB).RIDE(4,F) :	RCCI 0	RCC10	END;	PROCEDURE CALIBOB BEGIN:	RCC[0].R[BL].RIDE[1,S]	RCCI 0	RCC10.	RCC 10	RCC(0).RIDJ.RICE(1,F) RCC(0).RIDJ.RIDE(2,F) RCC(0).RITDJ.RIDE(3,F)	RCCI 0.	RCC103	RCCTO	RCC(0).R[WR].RIDE(3,F)	RCCLO	RCCTO	RCCTO	E Co	PROCEDURE CALIBOC;	RCC101	RCCTO	RCCIOI.RICWI.RIDEI3,FI	RCC10
	121	124			132 133 134		138	141		145	147	150	125	55.5	156	20	91	162	164	166	891	22		24.	176	178	180

```
*
                                                                                                                                                                                                                                                                                                                               WALKING CORRECTIONS
CALIBRATION DATA
                                                                                                                                                      LENGTH (METERS)
                                                                                                                                                                                                                                                                                                                                                                                                                                                             ≆ ≆
  RCC[1].LOC1:=CARMELINA;
RCC[3].LOC1:=MANV!
RCC[3].LOC1:=MANV!
RCC[4].LOC1:=MINOANAO;
RCC[5].LOC1:=MINOANAO;
RCC[5].LOC1:=SUMFERTINE;
RCC[7].LOC1:=SUMFERTINE;
RCC[7].LOC1:=STADIUM;
RCC[7].LOC1:=STADIUM;
RCC[7].LENGTH=(2136.41)*MPF;
RCC[3].LENGTH=(2136.41)*MPF;
RCC[3].LENGTH=(2136.41)*MPF;
RCC[3].LENGTH=(3136.41)*MPF;
RCC[4].LENGTH=(3136.41)*MPF;
RCC[5].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[6].LENGTH=(3136.41)*MPF;
RCC[7].LENGTH=(3136.41)*MPF;
RCC[7].LENGTH=(31
                                                                                                                                                                                                                                                                                                                                                                                                                  PROCEDURE PRESET1;
BEGIN
REGIN
NAMEDATA; (* P
RCCATA; (* P
RCCATA; (* P
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            START LOCATION
RCC[7], R[WR], RIDE[1,F] | = 43642.5|

RCC[7], R[WR], RIDE[2,F] | = 53322.5|

RCC[7], R[TD], RIDE[1,S] | = 21846.0|

RCC[7], R[TD], RIDE[1,F] | = 31193.5|

RCC[7], R[TD], RIDE[2,F] | = 40515.0|

RCC[7], R[CM], RIDE[1,F] | = 714834.0|
                                                                                                                                            RCC[7].R[CM].RIDE[1,5] = 714854.0]
RCC[7].R[CM].RIDE[1,5] = 724482.0]
RCC[7].R[CM].RIDE[1,5] = 734110.0]
RCC[7].R[PR].RIDE[1,5] = 875400.0]
RCC[7].R[PR].RIDE[1,5] = 885736.0]
RCC[7].R[PR].RIDE[1,5] = 885736.0]
RCC[7].R[PR].RIDE[1,5] = 895071.0]
RCC[7].R[JD].RIDE[1,5] = 71782.0]
RCC[7].R[JD].RIDE[1,5] = 71782.0]
RCC[7].R[JD].RIDE[1,5] = 81364.0]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            RCC[7].RIDKJ.RIDE[1,S] := 820400.0;
RCC[7].RIDKJ.RIDE[1,F] := 829984.0;
RCC[7].RIDKJ.RIDE[2,F] := 839569.0;
RCC[7].RIBBJ.RIDE[1,S] := 63000.0;
RCC[7].RIBBJ.RIDE[1,F] := 72385.0;
RCC[7].RIBBJ.RIDE[1,F] := 72385.0;
RCC[7].RIBBJ.RIDE[1,F] := 81770.5;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   318541.01
327841.01
337119.01
547413.01
556823.51
566234.51
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       952706.0;
962059.0;
971411.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                  BEGIN; RCBL].RIDE[1,S] := 182720.0]
RCC(7].RCBL].RIDE[1,S] := 192214.0]
RCC(7].RCBL].RIDE[1,F] := 201707.0]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          CALIB. DATA *)
BEFORE *)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        RCC[7],RITK],RIDE[1,5] := :
RCC[7],RITK],RIDE[1,F] := :
RCC[7],RITK],RIDE[2,F] := :
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          RCC(7).R(TB).RIDE(1,S) := RCC(7).R(TB).RIDE(1,F) := RCC(7).R(TB).RIDE(2,F) := R
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   RCC(7).R[PS].RIDE[1,S] :=
RCC(7).R[PS].RIDE[1,F] :=
RCC(7).R[PS].RIDE[2,F] :=
END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 (* RCCDATA *)
BEGIN
RCCI01.L0C1:=SMCC;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       * *
                                                                                                                                                                                                                                                                                                                                                                                                                                               PROCEDURE CALIB7B;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            PROCEDURE CALIB;
BEGIN
CALIBOB;
```

17/

```
207956.5;
108476.0;
10878.0;
10393.0;
474968.0;
18578.0;
18578.0;
522344.0;
719888.5;
350379.0;
                                                                                                                                                                                                                         PROCEDURE M2;

BEGIN

MIALTA, RS. 1.C:= 290393.0;

MIALTA, PS. 1.C:= 586763.0;

MIALTA, PS. 1.C:= 586783.0;

MIALTA, PS. 1.C:= 51528.0;

MIALTA, PS. 1.C:= 11206.1.0;

MIALTA, DS. 1.C:= 11206.1.0;

MIALTA, DS. 1.C:= 11206.1.0;

MIALTA, DS. 1.C:= 189844.0;

MIALTA, MS. 1.C:= 52888.0;

MIALTA, MS. 1.C:= 52888.0;

MIALTA, BS. 1.C:= 52482.0;

MIANAY, PS. 1.C:= 354033.0;

MINAYY, PS. 1.C:= 354033.0;

MINAYY, PS. 1.C:= 25444.0;

MINAYY, MS. 1.C:= 25444.0;

MINAYY, WS. 1.C:= 25444.0;

MS. 2.C:= 25444.0;

                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    MIPARK, RSJ. C:= 335835.0;
MIPARK, PSJ. C:= 632036.0;
MIPARK, TSJ. C:= 227109.0;
MIPARK, PSJ. C:= 1107872.0;
MIPARK, PSJ. C:= 231023.0;
MIPARK, MSJ. C:= 231023.0;
MIPARK, MSJ. C:= 234999.0;
MIPARK, MSJ. C:= 234999.0;
MIPARK, RSJ. C:= 234900.0;
MIPARK, RSJ. C:= 2710407.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                PROCEDURE 1
BEGIN
       TYPE CNT = RECORD

(* JONES COUNT *)

DC, (* JONES COUNTS FOR LAST SEGHENT

CPH, (* JONES COUNTS FER METER

HETERSIREAL;(* METERS FOR LAST SEGMENT

END;

END;
                                                                                                                                                                                                                                                                                                                                                                                                      *
"OHI"
                                                                                                                                                                                                                                                                                                                                                                                                      R
                                                                                                                                                                                                                                                                                              LOC, (* LOCATION # *)
LASTLOC INTEGER! (* LAST LOC *)
LP ITEXT; (* PRINTER FILE *)
C ICHAR;
M!PACKED ARRAY(SHCC..STADIUM,BB..WR] OF
                                                                                                                                                                                                                                   (* COUNTS/METER *
(* LAST CPM *
(* AVERAGE CPM *
(* LOCATION * *
(* LAST LOC *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        PROCEDURE M1;
BEGIN
HICARMELINA, RS1.CI= 244263.01
HICARMELINA, FS1.CI= 365294.01
HICARMELINA, FS1.CI= 365294.01
HICARMELINA, FS1.CI= 360802.01
HICARMELINA, FS1.CI= 920302.01
HICARMELINA, FS1.CI= 920302.01
HICARMELINA, MS1.CI= 414972.01
HICARMELINA, MS1.CI= 414972.01
HICARMELINA, MS1.CI= 414972.01
HICARMELINA, DD1.CI= 606499.01
HICARMELINA, DD1.CI= 606499.01
HICARMELINA, DD1.CI= 114020.01
HICARMELINA, DD1.CI= 606499.01
HICARMONALE, RS1.CI= 360114.01
HICARMONALE, RS1.CI= 364754.01
HICARMONALE, FS1.CI= 584754.01
HICARMONALE, PS1.CI= 649756.01
HICARMONALE, DD1.CI= 074706.01
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     MI GEORGINA, RSJ. C. = 284831.01
MI GEORGINA, PSJ. C. = 583212.01
MI GEORGINA, TKJ. C. = 942392.01
                                   PROGRAM OH1;
(*$U APPLE1:001.CODE*)
USES 0U1;
                                                                                                                                                                                                                     SUM,
CPM,
LASTCPM,
ACPM :REAL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                     PRESET2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                     PROCEDURE
                                                                                                                                                                                                                       ₹
```

```
AVERAGE COUNTS/METER FOR RCCO, RCC7
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            RCCO, RCC7
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            COUNTS/METER
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          ₹
                                                                                                                                                                                                MEBUDLONG, TK1, C:r= 261483.0;
MEBUDLONG, BB1, C:r= 1022678.0;
MEBUDLONG, PS1, C:r= 897268.0;
MEBUDLONG, PS1, C:r= 897268.0;
MEBUDLONG, PS1, C:r= 877268.0;
MEBUDLONG, MS1, C:r= 475094.0;
MEBUDLONG, BL1, C:r= 253679.0;
MEBUDLONG, BL1, C:r= 253679.0;
MEBUDLONG, BL2, C:r= 751628.0;
MEBUDLONG, DN1, C:r= 751628.0;
MEBUDLONG, PC1, C:r= 751628.0;
MEBUDLONG, RC1, C:r= 751628.0;
MEBUDLONG, RC1, C:r= 751624.0;
MEBUDLONG, RC2, C:r= 751644.0;
MEBUDLONG, RC3, C:r= 5526490.0;
                      BEGIN
MI HOBART, RB. C.F. 587105.51
MI HOBART, PCD. C.F. 189262.01
MI HOBART, PRD. C.F. 166386.01
MI HOBART, JDD. C.F. 472511.01
MI HOBART, JDD. C.F. 211677.51
MI HOBART, PBD. C.F. 211677.51
MI HOBART, PBD. C.F. 883008.01
MI HOBART, PRD. C.F. 887008.01
MI HOBART, PRD. C.F. 625468.01
MI HOBART, CAD. C.F. 645468.51
MI HOBART, CAD. C.F. 645468.51
MI HOBART, CAD. C.F. 625468.51
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  8
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  3
                                                                                                                                                                                                                                                                                                                                                                                               BEGIN
Mij M2j M3j M4j M5;
ENDj
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             PROCEDURE ACPMO7;
BEGIN
FOR I:=0 TO 7 DO
BEGIN
FOR MAN:=BB TO WR
BEGIN
SUM:=0; J:=0;
REPEAT
                                                                                                                                                                                                                                                                                                                                                                                                                                                                   VAR TOTAL, PART: REAL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      FUNCTION CPM07:REAL;
BEGIN
                                                                                                                                                                                                                                                                                                                                                                                                                                            PROCEDURE COMPUTE;
            E as
                                                                                                                                                                                                                                                                                                                                                                             MISUWHERTIME, RSJ. CI= 502085.01
MISUWHERTIME, PCJ. CI= 103472.01
MISUWHERTIME, DKJ. CI= 695170.01
MISUWHERTIME, URJ. CI= 124832.01
MISUWHERTIME, UDJ. CI= 124832.01
MISUWHERTIME, TDJ. CI= 124832.01
MISUWHERTIME, PDJ. CI= 798249.01
MISUWHERTIME, PSJ. CI= 798249.01
MISUWHERTIME, PSJ. CI= 79328.01
MISUWHERTIME, PSJ. CI= 783176.01
MISUWHERTIME, PRJ. CI= 158176.01
MISUWHERTIME, PRJ. CI= 783176.01
MISUWHERTIME, PRJ. CI= 783176.01
  MICHINDAMO, ND. (c. = 057053.0)
MICHINDAMO, DD. (c. = 057053.0)
MICHINDAMO, EL. (c. = 057053.0)
MICHINDAMO, PCI. (c. = 057050.0)
MICHINDAMO, PCI. (c. = 07736.0)
MICHINDAMO, PRI. (c. = 07736.0)
MICHINDAMO, MRI. (c. = 130531.0)
MICHINDAMO, MRI. (c. = 130531.0)
MICHINDAMO, MRI. (c. = 102485.0)
MICHINDAMO, DRI. (c. = 0102485.0)
MICHINDAMO, DRI. (c. = 010370.0)
MICHINDAMO, DRI. (c. = 010370.0)
MICHINDAMO, PRI. (c. = 068865.0)
                                                                                                                                                                        MICULVER, RS]. C:= 442894.0;
MICULVER, DD]. C:= 064419.0;
MICULVER, PD]. C:= 064319.0;
MICULVER, PD]. C:= 044121.0;
MICULVER, PR]. C:= 349871.0;
MICULVER, MR]. C:= 349871.0;
MICULVER, MR]. C:= 137957.0;
MICULVER, MR]. C:= 137957.0;
MICULVER, RV]. C:= 109618.0;
MICULVER, CM]. C:= 517537.0;
MICULVER, CM]. C:= 517537.0;
MICULVER, PS]. C:= 517537.0;
MICULVER, PS]. C:= 517537.0;
MICULVER, PS]. C:= 68608.5;
END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             MILEAHY, RSJ.C:= 511226.0;
MILEAHY, PCJ.C:= 112875.0;
MILEAHY, DNI.C:= 704510.0;
MILEAHY, NDI.C:= 139168.0;
MILEAHY, TDJ.C:= 397101.0;
MILEAHY, TDJ.C:= 177122.0;
MILEAHY, FBJ.C:= 412501.0;
MILEAHY, FBJ.C:= 97388.0;
MILEAHY, RBJ.C:= 94428.0;
MILEAHY, RBJ.C:= 94428.0;
MILEAHY, RBJ.C:= 587462.0;
MILEAHY, RBJ.C:= 587462.0;
MILEAHY, CWJ.C:= 587617.0;
                                                                                                                                                                                                                                                                                                                                                                   PROCEDURE M4;
```

PROCEDURE MS

```
WEITELN(LP);
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
PCPMY(B, BL);
PCPMY(B
                                                                                                                                                                                                                                                                                                                      (* COMPUTE *)
(* COUNTS/METER FOR RCCO, RCC7
(* COUNTS/RCC
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   PROCEDURE SOLOFEED; (* PREVENT DOUBLE PRINTER FEEDS *)
TYPE PA=PACKED ARRAY10..13 OF 0..253
TYPE FAECORD CASE BOOLEAN OF TRUE:(INTINTEGER);
FALSE:(PTR:^PA);
                                                                                                                                                                                                     MRITECY OLYMPIC CALIBRATION COMPUTATION');
WRITECY WALK FACTOR = ');
REDCICKLALKK; JWRITELN;
PRESET;
PRESET;
PRESET;
COMPUTE;
UNITIC CONTINUE? Y)ES N)O ');
READLN(C)
UNITIC (C(')'');
CLOSE(LP);
ENO.
IF (((1=0) OR (1=7)) AND
(ROC(11:R(2):R(2):R(2):R))=0))
THEN I |= 1 (* MORE ON RCCO OR RCC7 *)
ELSE Ji=0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            Fi

VAR FLIP:FLOP;

BEGIN

FLIP.INT:=-16625; (* BFOF HEX *)

FLIP.PTR^(0):=255 (* SET FLAG *)

END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               BEGIN
SOLOFEED;
REWRITE(LP,'PRINTER;');
REPEAT
                                                                                                                                                           END;
WRITELN(LP);
END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                   FOR 1:=1 TO 6 DO
BEGIN
LOG:=RCCII).LOCI+1;
MLOC,MANJ.C-MCLOC-1,MANJ.C+RCCIIJ.RIMANJ.WALK;
END;
              IF (RCCII).RIMAN).RIDELJ,SJ(0)
THEN SUM:=RCCIIJ.RIMANJ.RIDELJ,FJ-RCCIIJ.RIMANJ.RIDELJ-1,FJ
ELSE SUM:=RCCIIJ.RIMANJ.RIDELJ,FJ-RCCIIJ.RIMANJ.RIDELJ-1,FJ
CPMO7:=SUM/RCCIIJ.LENGTH; (* COUNTS/METER *)
ENDJ
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        LOC:=RCC[1].LOC!;
ACPH:=MLLOC,MAN1.CPH;
ATTECLP, ' (ACPPH)
PART:=ACPH-HICARPHELINA,MAN1.CPH;
WRITECLP, ' (PART*1000.0):6:1;' ');
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | F (RCCII).RIMANJ.WALK ( -0.5) |
| THEN WRITE(LP, *) |
| ELSE WRITE(LP, *) |
| IF ((1=0) OR (1=7) |
| THEN CPM:=CPMO7 |
| WRITE(LP, CPMP4100.0) 661) |
| F (RCCII).RIMANJ.CPM |
| F (RCCIII).RIMANJ.CPM |
| F (RCCIIII).RIMANJ.CPM |
| F (RCCIIII).RIMANJ.CPM |
| F (RCCIIII.RIMANJ.CPM |
| F (RCCIIII.R
                                                                                                                                                                                                                                                                                                                                                  (* COUNTS/SEGMENT *)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            BEGIN
MRITECLP, 'X)
FOR MANI=T TO 2 DO
URITECLP, 'NAMETMANI,' '128)
MRITELN(LP);
FOR PANIET CONTROL CO
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           PROCEDURE PHEAD(X,Y,Z:INTEGER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ELSE WRITE(LP, ' 117);
END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             PROCEDURE PCPKMKY, Z: INTEGER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          BEGIN

IF ((1=0) OR (1=7))

THEN J1=J+1

ELSE J1=0;

WRITECLP, 11:3; ');

FOR MAN:= Y TO Z DO

BEGIN
                                                                                                                                                                                                                                                                                                                                         PROCEDURE CPSEG;
                                                                                                                                                                                                                                                                                                                                                                                                                FOR MAN = BB TO WR DO
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              J:=0;
FOR I:=0 TO 7 DO
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             PHEAD(6,Y,2);
```

COURT COUNTY CANDERS CATANOW CATANOM CATANOW CATANOM CATANOM	to the control of the	MI SMCC, PCJ i= 010000.01 MI SMCC, RDJ i= 055000.01 MI SMCC, RBJ i= 622000.01 MI SMCC, WBJ i= 322000.01 MI SMCC, WBJ i= 325000.01 MI SMCC, WBJ i= 055000.01 MI SMCC, WBJ i= 045000.01 MI SMCC, PRJ i= 425000.01 MI SMCC, RBJ i= 100000.01 MI MI CANURS, FBJ i= 1242000.01 MI MIL SMIRE CWJ i= 276000.01 MIWIL SMIRE CWJ i= 276000.01 MIWIL SMIRE CWJ i= 276000.01 MIWIL SMIRE FSJ i= 313789.01 MIWIL SMIRE FSJ i= 317093.01 MIWIL SMIRE FSJ i= 317093.01 MIWIL SMIRE FSJ i= 317093.01	MULISHIRE, DV1 = 139345.01 MULISHIRE, DV1 = 403777.01 MULISHIRE, BB1 = 450184.01 MULISHIRE, BB1 = 450184.01 MULISHIRE, BB1 = 650184.01 MULISHIRE, LV1 = 114026.01 MULISHIRE, DV1 = 032783.01 MURINOY, RS1 = 229256.01 MURINOY, RS1 = 229256.01 MURINOY, RS1 = 125222.01 MURINOY, PS1 = 1552883.01 MURINOY, PS1 = 125122.01 MURINOY, PS1 = 125127.01	MIGNOV, FK 1 = 405118.0; MIGNATU, FK 1 = 405118.0; MICARMELINA, RB 1 = 244263.0; MICARMELINA, RB 1 = 542534.0; MICARMELINA, RB 1 = 542534.0; MICARMELINA, RD 1 = 145254.0; MICARMELINA, RD 1 = 145254.0; MICARMELINA, RD 1 = 141972.0; MICARMELINA, RD 1 = 141972.0; MICARMELINA, RD 1 = 141972.0; MICARMELINA, RD 1 = 14002.0; MICARMELINA, RD 1 = 144268.0; MICARMELINA, RD 1 = 144268.0;
		(**S**) UNIT 0U2; UNIT 0U2; UNTERFACE (LETON), UCID PAICAL) CONST BB = 1; CM = 3; CM = 4; DN = 4; DN = 4; DN = 5; PR = 7; PR = 7; PR = 7; PR = 8; PR = 10; PR = 10	WR = 13; SMCC = 14 (* MEASURING POINTS *) AVOID SET = 15; WILSHIRE = 15; WILSHIRE = 15; WAUNDALE = 18; GENGINA = 17; AVOINDALE = 18; AND CET = 21; AND CET = 21; AND CET = 22; AND CET = 23; AND CET = 24; AND CE	REGENT 11 11 11 11 11 11 11

241 MIADMRLTY2, PC11= 012747.0; 242 MIADMRLTY2, PR11= 635559.0; 243 MIADMRLTY2, WR11= 105597.0; 244 MIADMRLTY2, WR11= 105697.0; 245 MIADMRLTY2, WR11= 105697.0; 246 MIADMRLTY2, D11= 282622.0; 247 MIADMRLTY2, DX11= 602697.0; 248 MIADMRLTY2, TX11= 076803.0; 250 MIADMRLTY2, TX11= 076803.0; 250 MIADMRLTY2, MIADMRLTY2, S811= 848916.0;	MCMULVER, PSI := MCMULVER, PSI := MCMINDANAO, DO := MCMINDANAO, PSI := MCCULVER, MCSI := MCMINDANAO, MCCOULVER, MCSI := MCCOULVER, MCCOULVER, MCSI := MCCOULVER, MCSI := MCCOULVER, MCSI := MCCOULVE	ഗവഴ
181 MFPARK,PC]:= 157772.0; 182 MFPARK,JD]:= 231023.0; 183 MFPARK,JD]:= 15366.0; 184 MFPARK,MR]:= 524999.0; 185 MFPARK,MR]:= 236208.0; 186 MFPARK,BB]:= 768900.0; 187 MFPARK,BB]:= 768900.0; 189 MFPARK,RJ]:= 210407.0; 190 END;	192 PROCEDURE H4; 193 BEGIN 194 HUVDOLCEI PS1; = 353845.5; 195 HUVDOLCEI PS1; = 449922.0; 196 HUVDOLCEI, PS1; = 248931.0; 197 HUVDOLCEI, PS1; = 248931.0; 198 HUVDOLCEI, DS1; = 248931.0; 199 HUVDOLCEI, DS1; = 248931.0; 201 HUVDOLCEI, DR1; = 543391.0; 202 HUVDOLCEI, DR1; = 543391.0; 203 HUVDOLCEI, DR1; = 543391.0; 204 HUVDOLCEI, DR1; = 249395.0; 205 HUVDOLCEI, DR1; = 24753.0; 206 HUVDOLCEI, RR1; = 289875.0; 207 HUVDOLCEI, RR1; = 289875.0; 208 HIADMRLTYI, RS1; = 24753.0; 210 HIADMRLTYI, RS1; = 24753.0; 211 MIADMRLTYI, PS1; = 24753.0; 212 HIADMRLTYI, PS1; = 24753.0; 213 HIADMRLTYI, PS1; = 26054.0; 214 HIADMRLTYI, PS1; = 26054.0; 215 HIADMRLTYI, PS1; = 26054.0; 216 HIADMRLTYI, RR1; = 1053388.0; 217 HIADMRLTYI, RR1; = 1053388.0; 218 HIADMRLTYI, RR1; = 459516.0; 220 HIADMRLTYI, RR1; = 649428.0; 221 HIADMRLTYI, RR1; = 649428.0; 222 HIVDOLCEZ, RR1; = 645615.0; 223 HIVDOLCEZ, RR1; = 645615.0; 224 HIVDOLCEZ, RR1; = 645615.0; 225 HIVDOLCEZ, RR1; = 645615.0; 226 HIVDOLCEZ, RR1; = 639000.0; 227 HIVDOLCEZ, RR1; = 639000.0; 228 HIVDOLCEZ, RR1; = 639000.0; 239 HIVDOLCEZ, RR1; = 639000.0; 230 HIVDOLCEZ, RR1; = 639000.0; 231 HIVDOLCEZ, RR1; = 639000.0; 232 HIVDOLCEZ, RR1; = 639000.0; 233 HIVDOLCEZ, RR1; = 649000.0; 234 HIVDOLCEZ, RR1; = 649000.0; 235 HIVDOLCEZ, RR1; = 639000.0; 236 HIVDOLCEZ, RR1; = 639000.0; 237 HIVDOLCEZ, RR1; = 639000.0; 238 HIVDOLCEZ, RR1; = 639000.0; 239 HIVDOLCEZ, RR1; = 639000.0; 230 HIVDOLCEZ, RR1; = 639000.0; 231 HIVDOLCEZ, RR1; = 639000.0; 232 HIVDOLCEZ, RR1; = 639000.0; 233 HIVDOLCEZ, RR1; = 639000.0; 234 HIVDOLCEZ, RR1; = 630000.0; 235 HIPDOLCEZ, RR1; = 630000.0; 236 HIPDOLCEZ, RR1; = 630000.0; 237 HIPDOLCEZ, RR1; = 630000.0; 238 HIPDOLCEZ, RR1; = 630000.0; 238 HIPDOLCEZ, RR1; = 630000.0; 239 HIPDOLCEZ, RR1; = 630000.0; 230 HIPDOLCEZ, RR1; = 630000.0; 230 HIPDOLCEZ, RR1; = 630000.0; 231 HIPDOLCEZ, RR1; = 630000.0; 232 HIPDOLCEZ, RR1; = 630000.0; 234 HIPDOLCEZ, RR1; = 630000.0; 235 HIPDOLCEZ, RR1; = 630000.0	237 FUCEDORE P3; 238 BEGIN 239 MIADMRLTY2,JD3;= 032595.0; 240 MIADMRLTY2,BL3;= 066816.0;
121 MIAVONDALE,TK11= 929184.01 122 MIAVONDALE,PC11= 074706.01 123 MIAVONDALE,DK11= 148955.01 124 MIAVONDALE,DK11= 4406.67.01 125 MIAVONDALE,BR11= 151220.01 127 MIAVONDALE,WR11= 151220.01 128 MIAVONDALE,PR11= 488948.01 129 MIAVONDALE,PR11= 126973.01 130 MIAVONDALE,BL11= 126973.01	132 MIGEORGINA, RS11= 286831.0; 33 MIGEORGINA, TK11= 962391.2; 34 MIGEORGINA, TK11= 962391.2; 35 MIGEORGINA, TK11= 201476.0; 36 MIGEORGINA, D11= 103789.0; 37 MIGEORGINA, D11= 103789.0; 38 MIGEORGINA, DK11= 103789.0; 40 MIGEORGINA, BR11= 119578.0; 41 MIGEORGINA, BR11= 119578.0; 42 MIGEORGINA, BR11= 13088.0; 43 MIGEORGINA, BR11= 13088.0; 44 MIGEORGINA, BR11= 130879.0; 45 MIGHTA, RS11= 280379.0; 46 MIGHTA, RS11= 280379.0; 47 MIGHTA, MR11= 189444.0; 48 MIGHTA, D11= 112064.0; 49 MIGHTA, D11= 189444.0; 40 MIGHTA, D11= 112064.0; 41 MIGHTA, D11= 112064.0; 42 MIGHTA, D11= 112064.0; 43 MIGHTA, D11= 112064.0; 44 MIGHTA, D11= 112064.0; 45 MIGHTA, D11= 112064.0; 46 MIGHTA, D11= 112064.0; 47 MIGHTA, D11= 112064.0; 48 MIGHTA, D11= 112064.0; 49 MIGHTA, D11= 112064.0; 40 MIGHTA, D11= 112064.0; 41 MIGHTA, D11= 11206.0; 42 MIGHTA, D11= 11206.0; 43 MIGHTA, D11= 11206.0; 44 MIGHTA, D11= 11206.0; 45 MIGHTA, D11= 120656.0; 46 MIGHTA, D11= 120656.0; 47 MIGHAY, PS11= 251440.5; 48 MIGHAY, PR11= 251440.5; 49 MIGHAY, MR11= 25140.5; 41 MIGHAY, MR11= 26643.0; 41 MIGHAY, MR11= 26643.0; 41 MIGHAY, MR11= 26640.0; 41 MIGHAY, MR11= 26660.0; 41 MIGHAY, MR11= 26660.0; 41 MIGHAY, MR11= 26660.0; 41 MIGHAY, MR11= 26660.0; 41 MIGHAY, MR11=	MIPARK, TEJ:= 532936. MIPARK, TKJ:= 1010843 MIPARK, TEJ:= 257109.

```
(* PRESET * M7; M8; M9;
                                                         003000.01
282000.01
597000.01
620592.01
017000.01
0.01
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Ψ
9
                                                                                                                                                                                                                                                                                            918803.
622755.
007785.
286764.
049120.
5249120.
701945.
025443.
863728.
021960.
001;
                                                         MI AUGNE, PS 3 := 6
MI AUGNE, RS 3 := 6
MI AUGNE, TX 13 := 5
MI AUGNE, TS 13 := 5
MI AUGNE, TS 13 := 5
MI AUGNE, PS 13 := 5
MI AUGNE, PS 13 := 6
                                                   MIMENLOZ,TD);
MIMENLOZ,TR);
MIMENLOZ,TB];
MIMENLOZ,PC];
MIMENLOZ,PC];
MIMENLOZ,WD);
MIMENLOZ,WD);
MIMENLOZ,WD);
MIMENLOZ,WD);
MIMENLOZ,WD);
MIMENLOZ,WD);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  BEGIN
M1; M2; N
END;
                                                     498044.0;
475094.0;
253479.0;
294056.0;
481838.0;
791628.0;
198711.0;
221244.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 617940.
914000.
    MEBUDLONG, TB)::: 4
MEBUDLONG, DAJ::: 4
MEBUDLONG, BEJ::: 2
MEBUDLONG, TD)::: 4
MEBUDLONG, TD)::: 4
MEBUDLONG, DD)::: 2
MEBUDLONG, DD)::: 2
MEBUDLONG, SS)::: 5
MEBUDLONG, SS)::: 5
MEBUDLONG, SS)::: 5
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              BEGIN
MIMENLO2,RS11= 6
MIMENLO2,PS11= 9
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             PROCEDURE
      \begin{array}{c} \mathbf{7} \\ \mathbf{
  000000000
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             537310.0)
731642.0)
731642.0)
235137.0)
235137.0)
160809.0)
202957.0)
2778411.0)
87386.0)
83382.0)
843866.0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         261483.0;
1029678.0;
892361.0;
837268.0;
198868.0
124832.0
388013.0
168117.0
798269.0
403262.0
158176.0
743367.0
578234.3
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          587105.5;
189262.0;
782038.0;
286386.5;
472511.0;
211657.5;
883008.0;
882798.0;
665468.5;
252205.0;
244187.0;
                                                                                                                                                                                                             511226.0;
704510.0;
704510.0;
208281.0;
37101.0;
37101.0;
177162.0;
807383.0;
412501.0;
167429.0;
752462.0;
    ..........
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       REGEDURE M7;
BEGIN
MIRIDGELEY, RS] 1= 55
MIRIDGELEY, DK) 1= 15
MIRIDGELEY, DK) 1= 75
MIRIDGELEY, DK) 1= 27
MIRIDGELEY, TAD 1= 47
MIRIDGELEY, TK) 1= 27
MIRIDGELEY, TK) 1= 27
MIRIDGELEY, RS] 1= 87
MIRIDGELEY, RS] 1= 87
MIRIDGELEY, SS] 1= 87
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                HOBART, RS11= 56
HOBART, PC11= 18
HOBART, ANS11= 27
HOBART, ANS11= 27
HOBART, ANS11= 24
HOBART, SESSES
HOBART, SESSES
HOBART, PS11= 24
HOBART, PS11= 24
HOBART, RS11= 24
HOBART,
  MISUPPRETIME, UR
MISUPPRETIME, JD
MISUPPRETIME, TE
MISUPPRETIME, PS
MISUPPRETIME, BB
MISUPPRETIME, BB
MISUPPRETIME, BB
MISUPPRETIME, BB
MISUPPRETIME, CA
MILEAHY, DD] = 1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         PROCEDURE
```

	121 S(4).R(CW),D := 2.0; 122 S(7).R(CW).FPK:= 0430.0;	123 S[7].R[CW].D := 2.8;	St 11. Rt DK1. CP	S[2].R[DK].CPK;	S[2].R[DK].D :=		St41.RIDK1.CPK:= 955		S(51.R(DK).D :=	St 61.Rt DKJ.CPK;= St 61.Rt DKJ.D.	137 S[7].R[DK].CPK1= 9585.01	END:		141 PROCEDURE SDATA3; 142 BEGIN				147 S[3].R[JD].CPK1= 9598.2;		150 S[41.R[JD],D := 14.2;	152 S[5].R[JD].CPK:= 9585.3;	St 41.Rt JD1.CPK:= 9584	S[6].R[JD],D :=	156 S[7].R[.ID] D 7.2		PK:= 94€		St21.RtPc1.D :=	162 S[3].R[PC].CPK:= 9458.9;		165 S(41.R[PC].D := 14.0;	S[5] P(PC] CPK;= 94,		S[6].R[PC].D ;=	171 S[7], R[PC], CPK; = 9448.7,	END;	173 174 PROCEDURE SPATA4.		176 Still-REPRICPK:= 9350.3;			
														•				٠	٠		2	٠.		ر بر اي ا			<u> </u>		5 70	5 C	न्त्रः ्र	•										
					p.	1	-	6	س سة	ء م	ندم هيلا	ינו שפי	٦, دو	ינישוני משוני	10) 12	•														T. Gar	4.											
]:= 'STADIUM']:= 'AVON-FIN'		-	CARMELINA	DRG1NA;	V. I	SUMMERTIME	SART;	<u></u>	= 9402.3;	= 9402.3; 7	3.71	3.71	= 9398.6;	9388.21	1 0305 0.	2.41	938	 	4	2.9;	10.8407	ñ	5.63	5.61	*	1.51		9494	2.3			9643.81	6.01	9643.61	4	9.71	7635.61	·6	3.41	••••
10 HOW 1	NAME LUTURN	NAME I AUGNE	END ;	PROCEDURE SDATA11	S[1].LOCF:= CA	S(2) LOCF = GEORGINA;	St 41.LOCF:= NA	S(5).LOCF:= SUP	101.LUCF;= HUE		S[1].R[BB].CPK:= S[1].R[BB].D :=	123.REB3.CPK	(21.K[BB].D	(3).R(BB).D	S[4].R[BB].CPK;= 9398.6; S[4].R[BB].D := 10 E.	(51.R(BB).CPK;	S[5].R[BB].D := S[6].R[BB].CPK:=	[6].R[BB].D	S(7).R(BB).CPK1= S(7).R(BB) D	0.000	S[1].R[BL].CPK1= 9	[1].K[BL].D	(2).R(BL).D	[3].RIBLJ.CPK;	(3).R(BL).D	41.R(BL).D	(5) .R(BL) .CPK1:	S(6).R(BL).D r=	61.R(BL).D	S[7].R[BL].CPK1=	END;	. ;	PROCEDURE SDATA21 BEGIN	S[1].R[CW].CPK1= 9643.B	S(11.R(CW),D :=	2].R[CW].CPK:= 2].R[CW].D	S(3).R(CW).CPK:= 9	3].R[CW].D ;=	4).R[CW].D ;=	51.R[CW].CPK;=	61.R[CM].CPK:=	
•												so (n o										8	ន	3 2	8	ភ ភ	សីត	S	ទ	i 🖫	į	28	S	35	ខ្លួ	S	5 0	Š	S	Š	•
7	629	0 .0 i	6 9	68	69	2 2	22	23	2.5	76	2 %	8 6	8 8	85	8 4 8	82	8 8	88	8 8	2	26,	2 4	9	8 5	8	6	2 5	102	103	104	105	107	200	110	=:	113	4 1	2 -	7	e e	8	
	_																																	-				_	_		-	
S OLY TROCKEN	Compaces limits (MHX/MIN, KANUSE)	for each interval		(* COUNTS/KM FOR THIS SEGMENT *)				11 OF CNT; (* DATA FOR EACH RIDER *)			(* LOCATION *)	אזיי		A DIFFERENCE BETWEEN MAXIMUM AND MINIMUM METERS/SEGMENT, FOR FACE DIAGO	COMPUTED FROM THE MAXIMUM AND MINIMUM	COUNTY MY DETERMINED BY ANALYSIS OF BASELINE DATA.	**	(* TRINIER FILE *)		SIRING[8];												RE',				CE' 1	72,1	AO' 1	- L	EY' J	-	
PROGRAM OHZ;	3 (**U APPLE1:0U2.CODE*)	s uses ouz;	7 TYPE CNT=RECORD	8 CPK,	END;	- B	13 COCF : INTEGER!			CAR.	19 MAN INTEGER,		2 RANGE DEAL		* w	100	8 LP ;TEXT;		30 S :ARRAY[17] OF SEB;	!	3 PROCEDURE NAMES;		NAME (BL) :=	NAME CW1:=	DAME[DK]:= 'DK'; NAME[JD]:= 'ID';	NAME (PC) :=	NAME[PR];=	NAME (RS): IN ARX.	NAME (TB) :=	NAME(TD):=		NAME [WILSHIRE];=	NAME BUNDY 1: * SBUNDY .	NAME GEORGINA 1:=	NAME [NACY]:=	NAME[ADMRLTY: 1:= 'ADMDLTY: 1:= 'ADMDLTY:	NAME CADMIRLTY2]:=	NAME LANGUAGO 1:=	_	NAME RIDGELEY 1:=	THOBART 1:= 'HOBART	
																	,		(-)		.,, (- (1)	eg :	., 0	, (f)	4	4.4	4	4 1	4 4	47	4 6	2 6	ŭ	22	3 10	ù òì	o in	9	9 9	í	

```
METERS:=((MILOC,MAN)-MILOC-1,MAN))*((1000.0)/SI]).RIMAN].CPK));
RANGE==(SI],RIMAN).D*HETERS/SI]],RIMAN].CPK;
WRITELN(LP,MTERSHID:),SI]],RIMAN].CPK;9:1,SI]).RIMAN].D*EID);
END;
END;
CLOSE(LP);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        METERS ');
MIN RANGE');
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            SEGMENT ENDING AT ', NAMETLOCI);
COUNTS/KM METERS ')
                                                                                                                                                             | F ((LOC~VDOLCE2) OR
| (LOC~SII).LOCF+1)
| THEN LOCI=LOC+1;
| WHILE (LOC > SII).LOCF) DO
| 1=1+1;
| F ((J\lo) AND (\J MOD 3)=0)) THEN
| BEGIN | T 0 & DO
| CAN | CAN | T 0 & DO
| CAN | C
                                                                                                                                                                                                                                                                                                                                                                                                                                          WATTELN(LP);

END;

J=J+1;

FOR Ki=1

WRITELN(LP);

BEGIN
                                                                                                                         8
                          REWRITECLP, 'PRINTER;');
WRITELN(LP);
1:=1; Ji=0;
FOR LOG:=WILSHIRE TO AVONF D
BEGIN
                          PROCEDURE SDATA7;
BEGIN
SI13.RUMR3.CPK:= 9679.3;
SI23.RUMR3.CPK:= 9673.4;
SI23.RUMR3.CPK:= 9673.1;
SI33.RUMR3.CPK:= 9673.1;
SI33.RUMR3.CPK:= 9673.1;
SI43.RUMR3.CPK:= 9673.1;
SI43.RUMR3.CPK:= 9662.5;
SI53.RUMR3.CPK:= 9662.5;
SI53.RUMR3.D := 5.1;
SI53.RUMR3.D := 5.1;
SI53.RUMR3.D := 5.1;
             BEGIN

$(1).RTTD1,CPK:= 9346.5;
$(1).RTTD1,D := 5.2;
$(2).RTTD1,CPK:= 9346.5;
$(2).RTTD1,CPK:= 9340.4;
$(3).RTTD1,CPK:= 9340.4;
$(3).RTTD1,CPK:= 9340.4;
$(3).RTTD1,CPK:= 9340.4;
$(3).RTTD1,CPK:= 9340.4;
$(3).RTTD1,CPK:= 9327.7;
$(3).RTTD1,CPK:= 9327.7;
$(3).RTTD1,CPK:= 9327.5;
$(4).RTTD1,CPK:= 9
                                                                                                                                                                                                                                                                                                                                                                                                                                                    5(1), RTK1, CPK; = 9293.3; 5(1), RTK1, D ; = 2.4; 5(2), RTK1, D ; = 4.5; 4; 5(3), RTK1, D ; = 4.5; 4; 5(3), RTK1, D ; = 9295.4; 5(3), RTK1, D ; = 9292.2; 5(4), RTK1, D ; = 11.4; 5(5), RTK1, D ; = 11.4; 5(5), RTK1, D ; = 11.4; 5(5), RTK1, D ; = 2.3; 5(7), RTK1, RTK1, D ; = 2.3; 5(7), RTK1, RTK1
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       PRESET;
NAMES;
SDATA1;
SDATA2;
SDATA3;
SDATA4;
SDATA4;
SDATA6;
SDATA6;
                   S(3).RIPR].D := 3.3]
S(4).RIPR].CPK:= 9343.7]
S(5).RIPR].CPK:= 9322.9]
S(5).RIPR].CPK:= 9322.9]
S(4).RIPR].CPK:= 9322.9]
S(4).RIPR].CPK:= 9322.9]
S(5).RIPR].CPK:= 9322.9]
S(7).RIPR].CPK:= 9322.9]
                                                                                                                                                                                                                                                                            S(1), R(PS), CPK;= 9364.3|
S(2), R(PS), D; = 4.0|
S(2), R(PS), D; = 9.0|
S(3), R(PS), D; = 9.0|
S(3), R(PS), D; = 9.0|
S(4), R(PS), CPK;= 9365.4|
S(5), R(PS), CPK;= 936.3|
S(5), R(PS), CPK;= 936.3|
S(5), R(PS), D; = 9.1|
S(5), R(PS), D; = 9.1|
S(5), R(PS), D; = 9.5|
S(6), R(PS), D; = 9.5|
S(7), R(PS), D; = 9.3|
S(7), R(PS), D; = 9.3|
S(7), R(PS), D; = 1.0|
END
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    BEGIN

SII]. RRS3, CPK:= 9400.3

SII]. RRS3, CPK:= 9399.3

SIZ]. RRS3, CPK:= 9399.3

SIZ]. RRS3, CPK:= 9399.3

SIZ]. RRS3, CPK:= 9396.1

SIZ]. RRS3, CPK:= 936.1

SIZ]. RRS3, CPK:= 936.1

SIZ]. RRS3, CPK:= 9384.2

SIZ]. RRS3, CPK:= 9384.2
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               S(1).RITB).CPK:= 9429.3;
S(2).RITB).D := 10.0;
S(2).RITB).D := 6.0;
S(3).RITB).D := 6.0;
S(3).RITB).D := 9422.7;
S(4).RITB).CPK:= 9422.7;
S(4).RITB).CPK:= 9427.7;
S(5).RITB).D := 13.0;
S(5).RITB).D := 13.0;
S(5).RITB).D := 41.4;
S(5).RITB).D := 41.4;
S(5).RITB).D := 41.4;
S(6).RITB).D := 41.4;
S(7).RITB).D := 41.4;
S(7).RITB).D := 41.4;
S(7).RITB).D := 41.4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          PROCEDURE SDATAS;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   PROCEDURE SDATA6
```

Then walves are altered	before each execution		
SEGIN SEB1.CPK:= 9400.91 SEB1.CPK:= 9400.91 SECHEN SECHE	SIGERGINA).RIBBJ.CPK:= 7400.51 SINAVY INR BBJ.CPK:= 9289.33 SIVODCEI IR (BBJ.CPK:= 9289.34 SIADMRTYIJI REBJ.CPK:= 9282.51 SIADMRTYIJ REBJ.CPK:= 9282.51 SIADMRLYZJ.RIBBJ.CPK:= 9389.51	SIGNICSHIREJ.RFRIJ.CPKi= 9496.5; SIGNICSHIREJ.CPKi= 9496.3; SICARMELLIJ.RFRI= 9495.1; SIGNICSHAJ.REBLJ.CPKi= 9497.1; SINAVY SIVDICELIJ.RRBLJ.CPKi= 9498.4; SIVDICELIJ.RRBLJ.CPKi= 9498.0; SIGNICELIJ.CPKi= 9498.0; SIGNINDAMADI.RIBLJ.CPKi= 9497.0; SIGNINDAMADI.RIBLJ.CPKi= 9497.0; SIGNINDAMADI.RIBLJ.CPKi= 9497.0; SIGNINDAMADI.RIBLJ.CPKi= 9497.0; SIGNINDAMADI.RIBLJ.CPKi= 9497.0;	PROCEDURE SDATA2; SELEIN SEL
2 0 0 0 0 0 1 0 0 0 4 10	68 88 88 72 72 73	73 77 77 78 78 80 81	
SON'S OHSA PAIGH PROGERM Computes Length (enters) of each interval from DMC & MINDANAPO	(* COUNTS/KM FOR THIS SEGMENT *) R) OF CMT; (* DATA FOR EACH RIDER *)	(* LOCATION *) (* RIDER *) (* RIDER *) (* PRINTER FILE *)	IRE; INA; INA; INA; INA; INA; INA; INA; INA
PROGRAM OH3; (**U APPLE1:0U2.CODE*) USES OU2;	CNT=RECORD CPK :REAL; END; SEG=RECORD FN :ARRAY[BBWR]	INTEGER; REAL; TEXT;	1

```
FOR MANI=BB TO WR DO
BEGIN
BEGIN
BEGIN
BEGIN
METERS=<(MCLOC,MANJ-MCLOC-1,MANJ)*<((1000.0)/SCLOC).RCMANJ.CPK)),
WRITE(LP, ' ',NAMELMANJ.SCLOC).RCMANJ.CPK;9:1);
WRITE(LP, METERS:10:12);
END;
END;
END;
END;
END;
END;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            ENDING AT ',NAMETLOC),' (WF = 1.0)');
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      PROBABLE');
CNTS/KM METERS');
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   PROCEDURE SDATA7;

BEGIN
SUMLSHIRE1, RUMR1, CPK;= 9675.8;
SIEUNOY 1., RUMR1, CPK;= 9674.4;
SIEGRAPHELIN1, RUMR1, CPK;= 9674.4;
SIEGRONA1, RUMR1, CPK;= 9673.0;
SIVDOLCE1 1, RUMR1, CPK;= 9673.0;
SIVDOLCE1 1, RUMR1, CPK;= 9672.2;
SIADMRLTY11, RUMR1, CPK;= 9669.7;
SIADMRLTY21, RUMR1, CPK;= 9669.7;
SIADMRLTY21, RUMR1, CPK;= 9669.7;
SIADMRLTY21, RUMR1, CPK;= 9666.1;
SIMINDANAO1, RUMR1, CPK;= 9666.1;
          9342.51
9337.11
9337.11
9335.11
9335.01
9292.71
9292.71
9293.01
9293.01
9291.31
9281.31
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         BEGIN
PRESET;
NAMES;
SDATA;
SDATA;
SDATA;
SDATA;
SDATA;
SDATAS;
SDATAS
                                                                                                                                                                                                                      SEMUNO' I, RTKI, CPK:= 92
SEMUNO' I, RTKI, CPK:= 92
SEGRELINI, RTKI, CPK:= 92
SEGRENALINI, RTKI, CPK:= 92
SENAVY I, RTKI, CPK:= 92
SENAVY I, RTKI, CPK:= 92
SEADMRLTYII, RTKI, CPK:= 92
SEADMRLTYII, RTKI, CPK:= 92
SEMINDANAOI, RTKI, CPK:= 92
      SIGEORGINA).RITD].CPK:= 93.SINAVY 1.RITD].CPK:= 93.SINAMITY11.RITD].CPK:= 93.SIADMRLTY11.RITD].CPK:= 93.SIADMRLTY21.RITD].CPK:= 93.SIANNDANAO1.RITD].CPK:= 93.SIMNDANAO1.RITD].CPK:= 93.SIMDANAO1.RITD].CPK:= 93.SIMDANAO1.RITD]
          SIWILSHIRE].RITB].CPK:= 9429.D;
SIBUNDY J.RITB].CPK:= 9429.1;
SICARMELINJ.RITB].CPK:= 9429.1;
SIGEORGINA].RITB].CPK:= 9427.9;
SINAVY J.RITB].CPK:= 9427.5;
SIVODLCE! J.RITB].CPK:= 9423.D;
SICADMRLTY].RITB].CPK:= 9421.0;
SICADMRLTY2].RITB].CPK:= 9421.0;
SICADMRLTY2].RITB].CPK:= 9418.1;
SIMINDANAOJ.RITB].CPK:= 9418.1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            BEGIN
SIGNLES IN STRESS CPK := 9399.35
SIGNLES IN STRESS CPK := 9399.31
SIGNBY
SIGNBY
SIGNBY
SIGNES CPK := 9398.85
SIGNBY SIGNES CPK := 9399.31
SIGNBY SIGNES CPK := 9399.31
SIGNBY SIGNES CPK := 9395.41
SIGNBY SIGNES CPK := 9395.41
SIGNBY SIGNBY SIGNES CPK := 9395.41
SIGNBY SIGNBY SIGNES CPK := 9395.71
SIGNBY 
SICARMELINI, RIPCI, CPK:= 9456.01, SIGEORGINAI, RIPCI, CPK:= 9455.91, SINAVY
SINAVY
SICHOLCEI I, RIPCI, CPK:= 9455.71, SICHOLCEI I, RIPCI, CPK:= 9452.81, SICHOMRITYII, RIPCI, CPK:= 9452.81, SICHINDANAOI, RIPCI, CPK:= 9449.71, ENDI
                                                                                                                                                                                                                                                                                                                    BEGIN

SEULISHIEE, RFRN, CPK:= 9347.01

SEUNDY STRPN, CPK:= 9346.81

SI CARNELINI, RFRN, CPK:= 9346.71

SI GEORGINA, RFRN, CPK:= 9346.01

SI GEORGINA, RFRN, CPK:= 9344.01

SI GEORGINA, RFRN, CPK:= 9342.81

SI ADMRLTY1, RFRN, CPK:= 9340.31

SI ADMRLTY2, RFRN, CPK:= 9340.31

SI ADMRLTY2, RFRN, CPK:= 9337.01
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               9363.41
9364.01
9364.01
9364.71
9362.71
9352.71
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            BEGIN
SIMICHIREJ.RITDJ.CPK:= 9343.0)
SIBNDY J.RITDJ.CPK:= 9342.8J
SICARMELINJ.RITDJ.CPK:= 9342.7j
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      SIGNLSHIRE), RIPS], CPK:= 93
SIGNAY J. RIPS], CPK:= 93
SIGNALNI, RIPS], CPK:= 93
SIGNAY J. RIPS], CPK:= 93
SINAVY J. RIPS], CPK:= 93
SIADMRITY1
                                                                                                                                                                                                                                                                                            SDATA4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    PROCEDURE SDATAS;
                                                                                                                                                                                                                                                                                        PROCEDURE
```

les of meter	tual	į	alter
USES OUZ;	STABICIN 54	SIMPANUM 1.R[BB].CPK:= 9384.5; SISUMMERTI1.R[BB].CPK:= 9384.4; SIRIDGELEY1.R[BB].CPK:= 9383.8;	They walnus year
TYPE CNT=RECORD CPK :REAL; (* COUNTS/KM FOR THIS SEGMENT END;	.	SCHOBART 1.RCB31.CPK:= 9385.0; SCHBALO1 1.RCB31.CPK:= 9385.6; SCUTURN 1.RCB31.CPK:= 9385.6; SCSTADIUM 1.RCB31.CPK:= 9385.5;	byon to
SEG=RECORD R :ARRAY[88WR] OF CMT; (* DATA FOR EACH RIDER END;	*	1.RfBB1.CPK;= 1.RfBL1.CPK;= 1.RfBL1.CPK;=	
UAR 1,J,K, LOC, (* LOCATION *) MAN :INTEGER; (* RIDER *)	2	1.R(BL).CPK:= 1.R(BL).CPK:= 1.R(BL).CPK:= 1.R(BL).CPK:=	
METERS ; REAL;	82 .	ADIUM J.RIBLJ.CPK;=	
LP :TEXT; (* PRINTER FILE *)		END;	
S IARRAY[SMCCAVONF] OF SEG; (* COLNTS/KM DATA FOR EACH RIDER NAME :ARRAY[BBAVONF] OF STRING[8];	*) 83 84 84	PROCEDURE SDATA2; BEGIN STHANNIM 1 RICH1 FDV:- 6436 4.	
	910	FI].R(CW),CPK;= EY).R(CW),CPK;=	
NAME(B):= 'BB'; NAME(E):= 'BB';	28	SI HOBART 1.RICW1.CPK;= 9626.6; SIMENLO! 1.RICW1.CPK;= 9626.4;	
1 11 1	68	Ξ	
	91		
NAME[PC];= 'PC'; NAME[PR];= 'PR';	93	SIMMERII ROKI CPK:= 9586.2;	
NAME(PS);= 'PS'; NAME(RS);= 'RS';	26		
	26	J.RIDKI.CPK:=	
	866	J.RIDKJ.CPK;= UM J.RIDKJ.CPK;=	
	101	StavonF 1.RtDK1.CPK:= 9584.6; END;	
Z S		PROCEDURE SDATA3;	
	401 1001	BEGIN SIHANNIM 1.R[.ID].CPK:= 9584 5.	
NAME(UDOLCE) 1:= 'UIADOLCE'; NAME(ADMRITY: 1:= 'ONMRITY';	901	S(SUMMERTI].R(JD].CPK:= 9583.6;	
		SIKIDGELEY1.R[JD].CPK:= 9583.0; S[HOBART].R[JD].CPK:= 9582.7;	
		SIMENLO1 1.RIJD1.CPK:= 9582.4;	
ME]:=		SICIORN 1.KIJD1.CPK:= 9582.4; SISTADIUM 1.RIJD1.CPK:= 9582.2;	
NAME[RIDGELEY];= 'RIDGELEY'; NAME[HOBART];= 'HOBART ';		SIAUGNF 1.RIJD1.CPK:= 9582.1;	
# !	4-11	SI HANNUM 1.RIPC1.CPK:= 9445.8;	
		SISUMMERTII.RIPCI.CPK;= 9445.4; SIRIDGELFYI.RIPCI.CPK;= 9445.9;	
	117	SI HOBART 1.RIPC1.CPK:= 9445.6; SIMENLO1 1.RIPC1.CPK:= 9445.7;	
		STITTION 1 DEDCT COV 0445 0.	

```
121 SIGNOR INTPOLICPKIE 9445.91
122 BND;
123 PROCEDURE SDATA4;
124 SIGNUTERTINERS. CPKIE 9332.4;
125 SIGNUTERTINERS. CPKIE 933.2, 1
126 SIGNUTERTINERS. CPKIE 933.2, 1
127 SIGNUTERTINERS. CPKIE 933.2, 1
138 SIGNORELEYI.REPS. CPKIE 933.8;
139 SIGNORELEYI.REPS. CPKIE 933.8;
130 SIGNUTERTINERS. CPKIE 933.8;
131 SIGNUTERTINERS. CPKIE 933.8;
132 SIGNUTERTINERS. CPKIE 933.8;
133 SIGNUTERTINERS. CPKIE 935.2, 1
134 SIGNUTERTINERS. CPKIE 935.2, 1
140 SIGNUTERTINERS. CPKIE 935.2, 1
141 SIGNUTERTINERS. CPKIE 935.2, 1
142 SIGNUTERTINERS. CPKIE 935.2, 1
143 SIGNUTERTINERS. CPKIE 935.2, 1
144 SIGNUTERTINERS. CPKIE 935.2, 1
145 SIGNUTERTINERS. CPKIE 935.2, 1
146 SIGNUTERTINERS. CPKIE 935.2, 1
147 SIGNUTERTINERS. CPKIE 935.2, 1
148 SIGNUTERTINERS. CPKIE 935.2, 1
149 SIGNUTERTINERS. CPKIE 935.2, 1
140 SIGNUTERTINERS. CPKIE 935.2, 1
151 SIGNUTERTINERS. CPKIE 935.2, 1
152 SIGNUTERTINERS. CPKIE 937.9, 1
153 SIGNUTERTINERS. CPKIE 937.9, 1
154 SIGNUTERTINERS. CPKIE 937.9, 1
155 SIGNUTERTINERS. CPKIE 937.9, 1
156 SIGNUTERTINERS. CPKIE 937.9, 1
157 SIGNUTERTINERS. CPKIE 937.9, 1
158 SIGNUTERTINERS. CPKIE 937.9, 1
159 SIGNUTERTINERS. CPKIE 937.9, 1
150 SIGNUTERTINERS. CPKIE 937.9, 1
150 SIGNUTERTINERS. CPKIE 937.9, 1
151 SIGNUTERTINERS. CPKIE 937.9, 1
152 SIGNUTERTINERS. CPKIE 937.9, 1
153 SIGNUTERTINERS. CPKIE 937.9, 1
154 SIGNUTERTINERS. CPKIE 937.9, 1
155 SIGNUTERTINERS. CPKIE 937.9, 1
156 SIGNUTERTINERS. CPKIE 937.9, 1
157 SIGNUTERTINERS. CPKIE 937.9, 1
158 SIGNUTERTINERS. CPKIE 937.9, 1
159 SIGNUTERTINERS. CPKIE 937.9, 1
150 SIGNUTERTINERS. CPKIE 937.9, 1
151 SIGNUTERY. RITED. CPKIE 937.9, 1
152 SIGNUTERY. RITED. CPKIE 937.9, 1
153 SIGNUTERY. RITED. CPKIE 937.9, 1
154 SIGNUTERY. RITED. CPKIE 937.9, 1
155 SIGNUTERY. RITED. CPKIE 937.9, 1
157 SIGNUTERY. RITED. CPKIE 937.9, 1
158 SIGNUTERY. RITED. CPKIE 937.9, 1
159 SIGNUTERY. RITED. CPKIE 937.9, 1
150 SIGNUTERY. RITED. CPKIE 937.9, 1
151 SIGNUTERY. RITED. CPKIE 937.9, 1
152 SIGNUTERY. RITED. CPKIE 937.9, 1
153 SIGNUTERY. RITED. CPKIE 937.9, 1
154 SIGNUTERY. RITED. CPKIE 937.9, 1
155
```

```
| 18 | SITEMANO | J.RTTM1.CPK!= 9278.0; |
| 18 | SIGNANO | J.RTM1.CPK!= 9278.7; |
| 18 | SIGNANO | J.RTM1.CPK!= 9280.2; |
| 19 | SIGNANO | J.RTM1.CPK!= 9280.2; |
| 19 | SIGNANO | J.RTM1.CPK!= 9280.2; |
| 19 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 10 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 11 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 12 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 13 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 14 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 15 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 16 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 17 | SIGNANO | J.RTM1.CPK!= 9280.0; |
| 18 | SIGNANO | J.RTM1.CPK!= 9280.0;
```

```
THESE VALUES ARE ALTERED
PRIOR TO RUNNINIS THE PROSEAM.
                                                                                                                                                EACH METHOD (TVC, L.R., COL.R.)
HAS ITS OWN UNIQUE VALUES.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                FOR K:= 1 TO 4 DO
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
WRITELN(LP);
FOR LOC := WILSHIRE TO AVUNF DO
BEGIN
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | F (LOC=VDOLCE2) THEN LOC:=LOC+2;
| F (LOC=MENLO2) THEN LOC:=LOC+1;
| F (LOC=MENLO2) THEN LOC:=1; MENJ) **(1000.0) //SILOC);
| WRITELN(LP, ', NWAMELLOC); SILOC);110:11, CPK:10:1);
                                                                                                                                                                                                                                                                                                                                                                                                           BEGIN
PRESET;
NAMES;
SORTA;
SORTA;
REWRITE(LP,'PRINTER;');
WRITELN(LP);
FOR MAN;=BB TO WR DO
BEGIN
                      SIWILSHIRE]:= 2998.94;
SIGRAMELIN:= 1893.89;
SIGNONDALE]:= 955.973;
SIGNONDALE]:= 955.973;
SIGNONDALE]:= 955.978;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 375.003;
SIGNONDALE]:= 2007.17;
SIGNONDALE]:= 5007.17;
SIGNONDALE]:= 5007.17;
SIGNONDALE]:= 5007.17;
SIGNONDALE]:= 5100.03;
SIGNONDALE]:= 5100.03;
SIGNONDALE]:= 5100.03;
SIGNONDALE]:= 5100.03;
SIGNONDALE]:= 5100.03;
                          PASCAL PROGRAM

WRITTEN BY BOB LETSON

COMPUTES "ACTUAL" COUNTS/KM (RETRODICTED)

for BIKE-MEASURED INTERVALS
                                                                                                                                                                                                                                                   S :ARRAY[SMCC..AVONF] OF REAL; (* PROBABLE LENGTH OF EACH SEGHENT * NAME :ARRAY[BB..AVONF] OF STRING[8];
                                                                                                                                                  * *
                                                                                                                                                                                                                         (* PRINTER FILE *)
                                                                                                                                                (* LOCATION
(* RIDER
                                                                                                                                                                                                                                                                                                            NAME(EBS):= 88 |
NAME(EBS):= 88 |
NAME(EBS):= 86 |
NAME(EBS):= 70 |
NAME(EDS):= 70 |
NAME(ALT):= 70 |
NAME(ALT):= 70 |
NAME(ALT):= 70 |
NAME(ANDALE):= 70 |
NAME(ADS):= 70 |
NAME(ADNELTY):= 70 |
NAME(ADNEL
                                                                                                                                                             INTEGER
                                                                                                                                                                                           REAL !
                                                                                                                                                                                                                         TEXT
                                                      (**U APPLE1:0U2.CODE*)
                                                                                                                                                                                                                                                                                                 PROCEDURE NAMES;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 PROCEDURE SDATA1;
BEGIN
                                                                                                                             VAR I,J,K,
LOC,
MAN
                          PROGRAM OH3;
                                                                                  uses ouz;
                                                                                                                                                                                     CPX
                                                                                                                                                                                                                   4
```

CONCLUSIONS

The conclusions of this report are summarized below:

SHORT COURSE PREVENTION FACTORS

The following short course prevention factors, provide more than 99% confidence that an accurate remeasurement will result in a combined length larger than 42195 meters:

- For each interval measured via HP3810A, an adequate short course prevention factor is (0.01m + 1/100,000).
- For each interval with less than 10 bicycle measurements, the official length should be 1/1000 below the lowest median.
- 3. For each interval with more than 10 bicycle measurements, the "best" (lowest) measurement for all methods provides about 99.8% confidence that the combined length of all such intervals will not be found short upon an equally accurate remeasurement.
- Each steel tape measurement performed for the U-turn at the coliseum is accurate to about 1/2 inch.

PROPOSED LENGTHS

The table on the following page lists the proposed lengths for the intervals measured on April 24, 1983, using the above short course prevention factors.

VALIDATION REMEASUREMENT

- Remeasurement is the criterion for judging whether a certified course should be rejected.
- A validation remeasurement should use the most accurate methods available, including EDM measurements for all enroute baselines, and bicycle measurements that utilize all enroute baselines to determine counts/km.
- The course should be rejected if remeasurement proves that the length of the course is not between 42195 and 42245 meters.

PROPOSED LENGTHS

	TERMINUS	MEAS	UREME	NTS	LEI	NGTH (me	eters)
		steel	EDM	bike	Ма	SCPF	Proposed
	Wilshire			9	2999.3ø	3.1Ø	2996.20
	Bundy			13	1293.45	Ø.94	1292.51
	Carmelina			14	1593.84	1.04	1592.8Ø
B1	Avondale		3		955.978	.020	955.96
	Georgina			13	3573.38	1.86	3571.52
B2	Alta		5		379.007	.Ø14	378.99
	Navy Ct.			13	4233.71	2.77	423Ø.94
B3	Park		4		6Ø1.258	.016	601.24
	Via Dolce			13	1917.61	1.26	1916.35
	(Tahiti)			3	1997.51	2.25	1995.26
	(Bora Bora)			3	2662.8Ø	3.Ø1	2659.79
	Mindanao			13	2551.39	1.83	2549.56
B4	Culver		6		768.575	.Ø18	768.56
	Hannum			13	4269.63	2.42	4267.21
	Summertime			13	2034.18	. 86	2033.32
B5	Leahy		5		974.693	.020	974.67
	Ridgeley			13	2779.75	.86	2778.89
	Hobart			13	5307.11	3.40	5303.71
B6	Budlong		8		1000.030	.022	1000.01
	Menlo			13	611.14	. 49	610.65
	U-turn			13	575.81	. 48	575.33
	U-turn arc	3		2	16.25	.05	16.20
	Stadium			13	168.7Ø	. 7Ø	168.00
	TOTAL: Tah	iti			40602.30	24.42	40577.88
	Bor	a Bora			41267.59	25.18	41242.41

If the above proposed lengths are used to establish the overall length of the 1984 Olympic Marathon, this will result in an average median length of about 42195+25 meters, which is exactly in the middle of the $5\emptyset$ meters tolerance range specified by IAAF Rule 145.5. In other words, the proposed lengths will have as much risk of being proven oversized as undersized.

If the remeasurement is as accurate as the April 24 measurement, the risk of it being less than 42195 meters is about 1/500, and the risk of it being more than 42245 meters is about 1/500.

FUTURE MEASUREMENTS

After the lengths of the 23 intervals from SMCC to the Coliseum have been certified, the following decisions must be made to completely define the Olympic Marathon course:

- One of the Marina intervals (Tahiti or Bora Bora) must be selected for the final course. Bora Bora utilizes slightly less than one lap at the SMCC track, with a start on the north curve. Tahiti utilizes about 2.5 laps at SMC, with a start at the south corner of the track, in front of the west bleachers.
- The exact shortest possible running route in the Coliseum must be determined. If all lanes are open, then the measuring route will be 30 centimeters from the curb. If one or more lanes are blocked, preventing their use, then the measuring route will be 20 centimeters from the left-hand line of the open lane closest to the curb.

After the above decisions are made, the following measurements will be required:

- Steel tape measurements will be required in the Coliseum to determine the length from the last bicycle reference point at the Coliseum tunnel (west edge of storm drain, 7'6" north of the south wall) to the finish line. The steel tape measurement taken on April 24, 1983, provides a good estimate, but is incomplete.
- After the above measurement is achieved, the exact length required at SMC can be computed. This length should be measured via steel tape twice, and marked.
- After the above measurements and marks are made, the kilometer points can be measured, marked, and recorded.

A report of the above measurements should then be submitted to the National TAC LDR Standards Committee for certification of the complete 1984 Olympic Marathon course.

Bob Letson hereby volunteers to perform the above measurements and reports, with an open invitation for assistance to all of the April 24 measurers, to be accomplished at our own expense.

After the complete 1984 Olympic Marathon course is certified, copies of the final certification documents may be distributed to all interested parties.



Pacific Southwest Association Inc.

P8.

San Diego and Imperial Counties, California, 1135 Gurnet St. San Diego, California 92109 (714) 275-1292

Certification

NAME OF COURSE: 1984 OLYMPIC MARATHON REFERENCE POINTS	TERRAIN: paved (OO % dirt % grass %	A flat Nolling hilly	STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: (7 KM	ALTITUDE: START: 45 m HIGHEST: (O7 m	(reet above sea level) FINISH: 50m LOWEST: 5 m	MEASURED BY (name, address, phone): John Brennand Allan Grewier And	13 BICYCLE MEASURERS (ANNIETS) SERVE LANGISTELL MEASURERS (ANNIETS)	MEASURING METHOD: Nicycle walking wheel	Steel tape A electronic meter	NUMBER OF MEASUREMENTS OF THE ENTIRE COURSE: (3(4-24-83) 3(2-5-8-2)	DATES WHEN COURSE WAS MEASURED: 24 APRIL 1983 5 JUNE 1983	EXACT AVERAGE MEASURED LENGTH OF THE COURSE: 46602.3 m /41267.6 m *	DISTANCE BETWEEN THE SHORTEST AND LONGEST MEASUREMENTS: 16 METERS	CERTIFICATION CODE: PSA- 83068	*OFFICIAL LENGTH = 40577.9 (TAHIT), 41242.4 in (BORA BORA)	The course described above and defined by the attached map is hereby	certified to fulfill national standards for accurate measurement. A copy of this letter and map should accompany race results mailed	to the National Running Data Center, PO Box 42888, Tucson, AZ 85733.
]	* grass	1 1	1 1	LINE DISTANCE BETWEEN START: 45 MIGHEST: (C	LOCATION: Los Angeles CA TERRAIN: paved Oo	LOCATION: Los Angeles CA TERRAIN: paved loo 4 dirt 4 grass 4 X flat X rolling hilly STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: 17 KM ALTITUDE: START: 45 m HIGHEST: 107 m (feet above sea level) FINISH: 50 m LOWEST: 5 m MEASURED BY (name, address, phone): John Refamman Allahah Carameters and	TERRAIN: paved loo 1 dirt 1 grass 1 TERRAIN: paved loo 1 dirt 1 grass 1 Stat	ANGELES CA	TERRAIN: paved loo \$ dirt \$ grass \$ \$ TERRAIN: paved loo \$ dirt \$ grass \$ \$ X flat X rolling hilly STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: 7 KM ALTITUDE: START: 45 m HIGHEST: 107 m MEASURED BY (name, address, phone): JOHN BREWNAND ALAN STEINFELD AND 3 BICYCLE MEASURERS (ANN STEINFELD AND NEASURING METHOD:	TERRAIN: paved loo \$ dirt \$ grass \$ \$ TERRAIN: paved loo \$ dirt \$ dirt \$ grass \$ \$ \$ TERRAIN: paved loo \$ dirt \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	TERRAIN: paved loo \$ dirt \$ grass \$ \$ TERRAIN: paved loo \$ dirt \$ dirt \$ grass \$ \$ \$ TERRAIN: paved loo \$ dirt \$ dirt \$ grass \$ \$ \$ \$ TERRAIN: paved loo \$ dirt \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	TERRAIN: paved 100 \$ dirt \$ grass \$ \$ TERRAIN: paved 100 \$ dirt \$ grass \$ \$ \$ TERRAIN: paved 100 \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	TERRAIN: paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the partial \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ grass \$ for the paved 100 \$ dirt \$ for \$ for the paved 100 \$ dirt \$ for the pav	TERRAIN: paved 100 \$ dirt \$ grass \$ \$ TERRAIN: paved 100 \$ dirt \$ grass \$ \$ \$ TERRAIN: paved 100 \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	TERRAIN: paved 100 \$ dirt \$ grass \$ f	TERRIN: paved 100 \$ dirt \$ grass \$ \$ TERRIN: paved 100 \$ dirt \$ dirt \$ grass \$ \$ \$ TERRIN: paved 100 \$ dirt \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	TERRIN: paved 100 \$ dirt \$ grass \$ \$ TERRIN: paved 100 \$ dirt \$ grass \$ \$ \$ TERRIN: paved 100 \$ dirt \$ grass \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
TYPE: X road race Cross-country Calibration Track		paved OO % dirt % grass	11	1 1	TERRAIN: paved $ \infty $ dirt $ $ grass $ $ $ $ state	TERRAIN: paved $ \bigcirc \bigcirc$ dirt $\$$ grass $\$$ STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: $ 7 \bigcirc$ KM ALTITUDE: START: $ 4 \bigcirc$ M (feet above sea level) FINISH: $ 5 \bigcirc$ M LOWEST: $ 5 \bigcirc$ M	TERRAIN: paved $ \bigcirc \bigcirc$ dirt $\$$ grass $\$$ the state of th	TERRAIN: paved Oc	TERRAIN: paved Oc	TERRAIN: paved Oc	TERRAIN: paved Oc	TERRAIN: paved Oc	TERRAIN: paved OO \$ dirt \$ grass \$ \$ tests STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: T KM ALTITUDE: Cfeet above sea level FINISH: SCM LOWEST: CT MEASURED BY (name, address, phone): SCH STRAIGHT-LINE CT CM LOWEST: SCH CM CM CM CM CM CM CM	TERRAIN: paved Oc	TERRAIN: paved OO \$ dirt \$ grass \$ \$ tender STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: T KM ALTITUDE: Cfeet above sea level FINISH: SCM HIGHEST: CT m Cfeet above sea level FINISH: SCM HIGHEST: CT m Cfeet above sea level FINISH: SCM HIGHEST: CT m Cfeet above sea level FINISH: SCM HIGHEST: CT m Cfeet above sea level FINISH: SCM Cfeet above sea level Cfeet above sea level FINISH: SCM Cfeet above sea level Cfeet abov	TERRAIN: paved OO \$ dirt \$ grass \$ \$ from STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: T KM ALTITUDE: T KM HIGHEST: OT m HIGHEST:	TERRAIN: paved OO \$ dirt \$ grass \$ from STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: T KM HIGHEST: OT m HIGH	TERRAIN: paved OO \$ dirt \$ grass \$ from STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH: T KM HIGHEST: OT m UWEST: S m

BORA BORA

BASELINE*1

9 AVONDALE

1984 OLYMPIC MARATHON REFERENCE POINTS MEASURED APRIL 24, 1983

> 24 December 83 National Cert. date

> > National Certifier, Ted Corbitt Apt 8H Sect 4; 150 W 225 St; NY, NY 10463

Association Certifier, Bob Letson 4369 Hamilton St. #4; San Diego, CA 92104

CONCLUSIONS

The conclusions of this report are summarized below:

SHORT COURSE PREVENTION FACTORS

The following short course prevention factors, provide more than 99% confidence that an accurate remeasurement will result in a combined length larger than 42195 meters:

- For each interval measured via HP3810A, an adequate short course prevention factor is (0.01m + 1/100,000).
 - course prevention factor is (0.01m + 1/100,000).
 For each interval with less than 10 bicycle measurements,
 the official length should be 1/1000 below the lowest

median.

6

- 3. For each interval with more than 10 bicycle measurements, the "best" (lowest) measurement for all methods provides about 99.8% confidence that the combined length of all such intervals will not be found short upon an equally accurate remeasurement.
- 4. Each steel tape measurement performed for the U-turn at the coliseum is accurate to about 1/2 inch.

PROPOSED LENGTHS

The table on the following page lists the proposed lengths for the intervals measured on April 24, 1983, using the above short course prevention factors.

VALIDATION REMEASUREMENT

- Remeasurement is the criterion for judging whether certified course should be rejected.
- A validation remeasurement should use the most accurate methods available, including EDM measurements for all enroute baselines, and bicycle measurements that utilize all enroute baselines to determine counts/km.
- The course should be rejected if remeasurement proves that the length of the course is not between 42195 and 42245 meters.

PROPOSED LENGTHS

Hd 2999.30 1293.45 1293.45 1293.45 1293.38 3573.38 3573.38 379.007 4233.71 1997.51 2662.80 2262.80 2262.80 2263.18 274.65 2779.75 2779.75 168.70 40662.30 24267.59 24269.53		TERMINUS	MEASUREMENTS	4ENTS		LENGTH (meters)	ters)
Wilshire 9 2999.30 3 Bundy 13 1293.45 6 Carmelina 3 1293.45 8 Avondale 3 13 3573.38 1 Georgina 13 3573.38 1 Navy 4 4 601.258 Vaniti 3 1975.51 1 Bora Bora 3 1977.51 1 Bora Bora 3 2662.80 3 Mindanao 13 2662.80 3 Culver 5 768.575 9 Hannum 13 2662.80 3 Summertime 13 2662.80 3 Lashy 6 768.575 9 Hobart 13 2662.80 3 Ridgeley 13 2662.80 3 Ridgeley 13 2779.75 9 Hobart 5 13 2779.75 Bura Bora 13 611.14 10 U-turn 3 16.25 8 10-turn 13 660.25 26 10-turn 13 168.70 16.70 10-turn 13 16.26.75 29				1 bike	P	SCPF	Proposed
Bundy 13 1293,45 0 Avondale 3 14 1593,84 1 1 1593,84 1 1 1 1593,84 1		Wilshire		0	2999.30	3.10	2996.20
Carmelina 14 1593,84 1 Avondale 3 955,786 Georgina 13 955,786 Alta Alta Sarx, 12 373,38 1 Ana Dolce 13 1917,41 1 Wis Dolce 13 197,51 2 Windanao 13 2662,80 3 Mindanao 13 2651,39 1 Culver 6 768,575 Hannum Sudmartime 13 2634,18 Ridgley 13 2777,75 Hobart 13 2777,75 Hobart 13 2777,75 Hobart 13 2777,75 Hotorn 13 2777,75 Hotorn 13 2777,75 Hotorn 2 13 576,81 U-turn arc 3 16,25 Stadium 13 168,70 TOTAL: Tahiti 406,02,59 24 Bora Bora Bora Alz67,59 28		Bundy		13	1293,45	6.94	1292.51
Avondale 3 555.978 Aboundale 5 13 5575.38 Abordale 5 1575.38 Abordale 6 15 575.38 Abordale 6 15 575.38 Abordale 6 15 601.258 Abordale 6 15 197.51 Abordale 7 13 2657.5 Abordale 7 13 26757.5 Abordale 7 13 2779.75 Abordale 7 14.25 Abordale 7 14.25 Abordale 7 14.25 Abordale 7 15 16.25 Abordale 8 Abordale 7 15 16.25 Abordale 8 Abordale 7 15 16.25 Abordale 8 Abordale 7 15 15.59 22 Abordale 8 Abordale 7 15 15.59 25 25 25 25 25 25 25 25 25 25 25 25 25		Carmelina		14	1593.84	1.04	1592.80
Georgina 13 3573.38 1 Alta Navy Ct. 13 4233.71 2 Park (Yab Dolce 13 1917.61 1 (Tahiti) 3 2662.80 3 Mindanao 13 2662.80 3 Mindanao 13 2662.80 3 Mindanao 13 2662.80 3 Mindanao 13 2662.80 3 Kidgeley 13 2779.75 Hobart 13 2779.75 Hobart 13 2779.75 Hobart 13 2779.75 Holon 13 2779.75 Holon 13 5387.11 3 Menlo 0 -turn arc 3 12 16.25 Stadium arc 3 16.25 Bora Bora Bora A1267.59 28	B	Avondale	m		955.978	.016	955.96
Alta Park Park Via Dolce V		Georgina		13	3573.38	1.86	3571.52
Navy Ct. 13 4233,71 2 Via bolce 15 1917.458 Via bolce 15 1977.51 2 (Bora Bora) 3 2662.80 3 Culver 6 7682.875 1 Hannum 13 4269.63 2 Summertine 13 4269.63 2 Ridgeley 13 2779.75 Hobart 13 5307.11 3 Henlo 1 13 6411.44 U-turn arc 3 2 16.25 Stadium 15 1066.20 24 Bora Bora Bora 15 126.25	B 2	Alta	it)		379.007	.013	378.99
Park (Tain in a police) (Tain in a police) (Tain in a police) (Bora Bora) (Culver 6 768.256.39 (Total in a police) (Bora Bora 13 266.280 (Total in a police) (Bora Bora 14 269.43 (Bora Bora 15 2779.75 (Bora Bora Bora 16 26.11.14 (Bora Bora Bora 16 26.29 (Total in a police) (Tota		Navy Ct.		13	4233.71	2.77	4230.94
Via Dolce 13 1917.61 1 (Bora Bora) 3 1997.51 1 (Bora Bora) 3 2662.80 3 2662.80 1 Mindanao 13 2651.39 1 2651.39 1 Mindanao 6 768.575 1 269.53 1 Summertime 13 2694.18 2694.18 2694.18 1 Ridgeley 13 2779.75 1 3 2779.75 Hobart 13 2779.75 1 3 2779.75 Menlo 13 5060.11 3 611.14 1 1 U-turn 3 575.81 1 16.25 5 2 Stadium 13 168.70 24 1 <td< td=""><td>B3</td><td>Park</td><td>4</td><td></td><td>601.258</td><td>.019</td><td>601.24</td></td<>	B3	Park	4		601.258	.019	601.24
(Tahiti) 3 1997,51 2 (Bora Bora) 3 266.289 3 (Bora Bora) 3 266.289 3 Culver Hannum 13 4269,63 2 Summertime 13 2834.18 Leahy 5 13 2834.18 Ridgeley 13 2834.18 Hobart 13 5387.11 3 Budlong 8 1668.30 Menlo 13 55.81 U-turn arc 3 2 16.25 Stadium arc 3 16.25 Stadium arc 3 2 16.25 Stadium arc 3 12.15.59 Stadium arc 3 12.15.59 Stadium arc 3 12.26.79 Stadium arc 3 12.26.79 Stadium arc 3 12.25 Stadium arc 3 12.26.59 Stadium arc 3 12.26.79 Stadium arc 3 12.26.79 Stadium arc 3 12.26.79 Stadium arc 3 12.26.75		Via Dolce		13	1917.61	1.26	1916.35
Bora Bora 3 2662.80 3 3 200.20 3 3 3 3 3 3 3 3 3		(Tahiti)		n	1997.51	2.25	1995.26
Hindanao 13 2551.39 1 Outuver 6 768.535 Hannumertime 13 2654.18 Summertime 13 2654.18 Lealy 13 2774.75 Hobart 13 2777.75 Hobart 13 2777.75 Hobart 13 2777.75 Hotorn 13 2777.11 3 Hellong 8 1606.636 Hellong 13 611.14 U-turn arc 3 2 16.25 Stadium 13 168.76 TOTAL: Taniti 40662.36 24 Bora Bora Bora 125.57 25		(Bora Bora)		m	2662.80	3.01	2659.79
Culver 6 768.575 Hannum 13 4269.43 2 Leahy 13 2034.18 Leahy 5 13 2779.75 Ridgeley 13 2779.75 Hobart 13 5307.11 3 Menlo 13 611.14 U-turn arc 3 611.14 U-turn arc 3 16.25 Stadium arc 3 16.25 Stadium Bora Bora 41267.59 28		Mindanao		13	2551.39	1.83	2549.56
Hannum 13 4269,63 2 Summertime 13 2634,18 Leahy 5 13 2779,75 Ridgeley 13 2779,75 Hobart 13 2779,75 Hobart 13 2779,75 Hohlong 8 1006,030 Henlo 13 575,81 U-turn 13 575,81 U-turn 2 2 16,25 Stadium 168,70 TOTAL: Tahiti 406,02,30 24 Bora Bora Bora 125,575,57	84	Culver	9		768.575	.013	768.56
Summertime 13 2034.18 Ridgeley 5 794.693 Ridgeley 13 2779.75 Hobart 13 5307.11 3 Budlong 8 10000.030 Menlo 13 575.81 U-turn arc 3 2 16.25 Stadium 13 168.70 TOTAL: Tahiti 406.02.30 24 Bora Bora Bora 13 2037.57 57		Hannum		13	4269.63	2.42	4267.21
Leahy Kidgeley Kidgel		Summertime		13	2034.18	98.	2033, 32
Ridgeley 13 2779,75 Hobart 13 5207.11 3 Budlong 8 1000.030 Menlo 13 575.81 U-turn arc 3 2 16.25 Stadium 168.70 TOTAL: Tahiti 406.02.30 24 Bora Bora Bora	B	Leahy	SO.		974.693	.019	974.67
Hobart 13 5307.11 3 Budlong 8 1606.036 Menlo 13 575.81 U-turn arc 3 2 16.25 Stadium 13 168.70 TOTAL: Tahiti 406.02.30 24 Bora Bora Bora Bora 13 1267.57 57		Ridgeley		13	2779.75	. 86	2778.89
Budlong B 1606.030 Menlo 13 51.14 Menlo 13 575.81 U-turn arc 3 2 16.25 Stadium 13 168.76 TOTAL: Tahiti 40602.30 24 Bora Bora 41267.59 25		Hobart		13	5307.11	3.40	5303.71
13 611.14 arc 3 2 16.25 13 168.70 Tahiti 40602.30 24 Bora Bora 809	B 6	Bud1 ong	œ		1000.030	. 022	1000.01
arc 3 2 16.25 16.25 13 168.70 Tahiti 40602.30 24 Bora Bora 41267.59 25		Menlo		13	611.14	. 49	610.65
arc 3 2 16.25 13 168.70 Tahiti 40602.30 24 Bora Bora 41267.59 25		U-turn		13	575.81	. 48	575.33
13 168.70 . Tahiti 40602.30 24. Bora Bora 41267.59 25.			n	7	16.25	.03	16.20
Tahiti 40602.30 Bora Bora 41267.59		Stadium		13	168.70	.70	168.00
Bora Bora 41267.59			iti		40602.30	24.42	40577.88
֡֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜			a Bora		41267.59	25.18	41242.41

If the above proposed lengths are used to establish the overall length of the 1984 Olympic Marathon, this will result in an average median length of about 42195±75 meters, which is exactly in the middle of the 50 meters tolerance range specified by IAAF Rule 145.5. In other words, the proposed lengths will have as much risk of being proven oversized as undersized.

If the remeasurement is as accurate as the April 24 measurement, the risk of it being less than 42195 meters is about 1/500, and the risk of it being more than 42245 meters is about 1/500.

APPENDIX A

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DECEMBER 20, 1983

On December 20, 1983, John Brennand and Bob Letson performed several steel tape measurements at the Coliseum using a Lufkin surveyor's steel tape which had been certified via multiple comparisons with NBS baselines ("11.0" lbs tension at 70° F provides 100.000 feet). These measurements are documented on the following page.

Previous Measurement

The distance from R29 (the last reference point used for the Olympic marathon bicycle measurements on April 24, 1983) to the finish point (outside face of the concrete curb adjacent to the "+" etched on top of the curb at the southeast corner of the track) was measured once on April 24, 1983, by John Brennand, David Katz, and Bob Letson: 487.88 feet (148.71 meters). This measurement was precarious because the ground was litered with debris, and the intermediate chaining point at 300 feet was marked by an unstable wooden plank. Another measurement was needed to confirm the accuracy of the April 24 measurement.

Curb

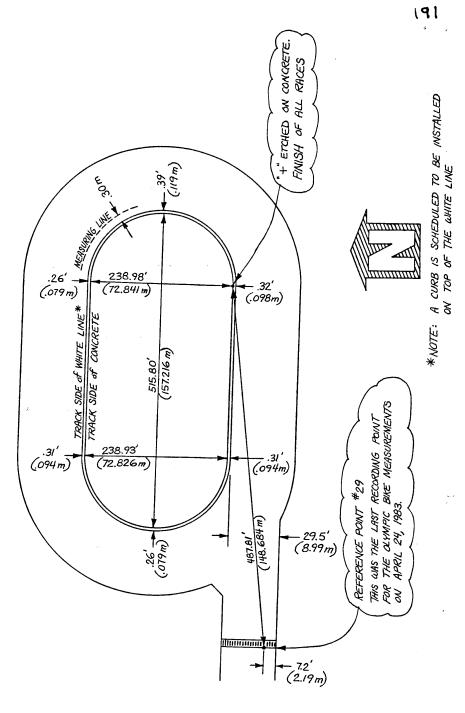
The concrete "curb" described for the April 24 measurement was no longer a curb on December 20. The track surface was installed in May, 1983. The top of the track surface is even with the top of the concrete "curb" that had existed on April 24. The curb that will be used for the 1984 Olympics is scheduled to be installed in the spring of 1984. The official curb will be placed on top of a white line that was measured on December 20.

Distance from R29 to the FINISH

The December $2\emptyset$ measurements indicate a lap length of $4\emptyset\emptyset.\emptyset4$ meters $3\emptyset$ centimeters from the white line upon which the official curb is scheduled to be installed in the Coliseum. The December $2\emptyset$ measurement from R29 to the finish line ("+" on top of the concrete) is 487.81 feet (148.684 meters), which is in close agreement with the April 24 measurement. When this figure is adjusted for temperature ($-.\emptyset1\emptyset$ m) and short course prevention ($-.\emptyset25$ m), and the extra finish lap is added, the result is the official distance from R29 to the finish line: 548.63 meters.

OLYMPIC COLISEUM

~ 58°F DECEMBER 20,1984, ~5 PM, SURVEYOR'S TAPE, "LUFKIN" JOHN BRENNAND & BOB LETSON, (100.000' @ 70°F @ 11 LBS) STEEL Βζ MEASUREMENTS



TEMPERATURE CORRECTION

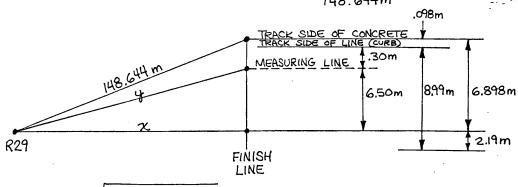
(.00000645)(58°F-68°F) = .0000645

LAP LENGTH

W. CURB DIAMETER =
$$(72.826 + .094 + .094) = 73.014 \text{ m}$$
 73.016 m
E. CURB DIAMETER = $(72.841 + .079 + .098) = 73.018 \text{ m}$ AVERAGE
RUNNING DIAMETER = $(73.016 + .300 + .300) = 73.616 \text{ m}$
STRAIGHTAWAY = $(157.216 + .079 + .119 - 73.016) = 84.398 \text{ m}$

DISTANCE FROM R29 TO FINISH

RAW MEASUREMENT = 148.684mTEMP, COR. = (148.684m)(.0000645) = -.010 mSHORT COURSE PREVENTION: $\pm 5^{\circ}F$ = -.005m $\pm .005m/(00')$ = -.025m148.644m



$$\chi = \sqrt{(48.644)^2 - (6.898)^2} = 148.484m$$

$$y = \sqrt{(48.484)^2 + (6.50)} = 148.626m + 400m$$

$$= 548.63 m$$

Reference Points for 20 December 1983

The distances between reference points, using the proposed lengths documented in the initial certification report ("1984 Olympic Marathon Reference Points", 24 November 1983), plus the Coliseum measurements on 20 December 1983, are as follows:

	REFE	RENCE POINT	LENGTH	(meters)		
			interval	sum		
		Start	Ø.ØØ	0.00		
	R3	SMCC	1068.49	1068.49		
	R4	Wilshire	2996.20			
	R7	Bundy	1292.51	4064.69	5	k m
	R8	Carmelina		5357.20		
			1592.8Ø	695Ø.ØØ		
	<u>F:7</u>	Avondale	955.96	7905.96	1 (2)	le m
	R1Ø	Georgina	3571.52	11477.48		
	R11	Alta	378.99	11856.47	1 25	le m
	R12	Navy Ct.	4230.94	16087.41		
	R13	Park	601.24	16688.65		
	R14	Via Dolce	1916.35	18605.00	201	кm
	R15	Admiralty (Tahiti)	1995.26	20600.26		
	R16	Mindanao	2549.56	23149.82		
	R17	Culver	768.56	23918.38	25	km
	R19	Hannum	4267.21	28185.59	30	km
_	R2Ø	Summertime	2033.32	30218.91	.310	PC 111
	R21	Leahy	974.67	31193.58		
	R23	Ridgelev	2778.89	33972.47	35 85	•
	R24	Hobart	5303.71	39276.18	40	k m
	R25	Budlong	1000.01	40276.19	410	кm
	R26	Menlo	610.65	40886.84		
	R27	U-turn,	575.33	41462.17		
	R28	U-turn ₂	16.20	41478.37		
	R29	Stadium				
	N#7		168.00	41646.37		
		Finish	548.63	42195.00		

The five kilometer points are at the following locations:

5	km	R4	+	935.31m	(R7		357.20m)
1Ø	km	R9	+	2094.04m	(R1Ø		1477.48m)
15	km	R11	+	3143.53m	(R12		1Ø87.41m)
2Ø	km	R14	+	1395.ØØm	(R15		600.26m)
25	km	R17	+	1081.62m	(R19		3185.59m)
3Ø	km	R19	+	1814.41m	(R2Ø	_	218.91m)
35		R23	+	1027.53m	(R24		4276.18m)
4Ø	km	R24	+	723.82m	(R25		276.19m)

APPENDIX B

APRIL 15, 1984

Aldo Scandurra recommended several design changes to the Olympic Marathon course to eliminate sharp turns and reduce the opportunity for short-cuts. The LAOOC responded by authorizing four adjustments to the 24 April 1983 version of the course. These adjustments were measured on 15 April 1984 by the following people:

LAPD: Rich Molony

Mitch Robbins

Recorders: John Brennand

Ole Oleson Ron Scardera

Measurers: Tom Knight (TK)

Bob Letson (BL)

Noel Montrucchio (NM)

April 15, 1984, was spent as follows:

7:30 am Calibrate bicycles on the Santa Monica 1000.178m

9:00 am Measure new/old routes for Via Marina

9:30 am Measure new/old routes for Mindanao

10:00 am Calibrate bicycles on the Mindanao 768.575m

10:30 am Measure new/old routes for Slauson

11:30 am Measure new/old routes for Bundy & San Vicente

12:30 am Calibrate bicycles on the Santa Monica 1000.178m

1:00 pm Steel tape the Santa Monica College 400m track

Clain Jones assemblies were used on all bicycles. The steel tape used on 15 April 1984 is a professional surveyor's Lufkin 100.000' steel tape, graduated in 1/100' increments, owned by Cathy Hargus, wife of the late Bill Hargus, Licensed Surveyor and former member of the AAU National Standards Committee. Multiple comparisons of this tape with two NBS 100.0000' baselines in San Diego indicate that it is accurate at 70°F and "11.0" lbs.

The weather on 15 April 1984 was designed by the Chamber of Commerce: sunny, clear, dry, $80^{\rm op}$ F (air), almost no wind. This tended to bring out the best in people, especially near the beach. Los Angeles is truely a beautiful city on a clear day.

Bicycle Calibration Data

Bob Letson (BL)

7:3Øam	Raw Counts /1000.178m /1000.000m	9507 9507
10:00am	Raw Counts /768.575m /1000.000m	73ø3
1:ØØpm	Raw Counts /1000.178m /1000.000m	

Noel Montrucchio (NM)

7:30am	Raw Counts	19000283	47376	96472	149563	
	/1000.178m	9347	9349	9353	9349	
	/1000.000m	9345.3	9347.3	9351.3	9347.3	
10:00am	/768.575m	20000271 7181 9343.3	81			
1:00pm	/1000.178m	55000643 9341 9339.3	9343		000823 9342 93 40. 3	

Tom Knight (TK)

7:30am	Raw Counts	99@@@84	ØØ178	Ø1272	Ø2366Ø1
	/1000.178m	9400	94Ø1	94Ø1	9399
	/1000.000m	9398.3	9399.3	9399.3	9397.3
10:00am	/768.575m		20	÷ *	
	/1000.000m	9394			
1:00pm	Raw Counts	67000763	96857	94951	88Ø4584
	/1000.178m	9396	9398	9394	9396
	/1000.000m	9394.3	9396.3	9392.3	9394.3

	BL	NM	TK
Maximum	9505.3	9351.3	9399.3
Average	9503.5	9344.Ø	9396.2
Minimum	9502.0	9339.3	9392.3

Bundy & San Vicente Measurement

1.01

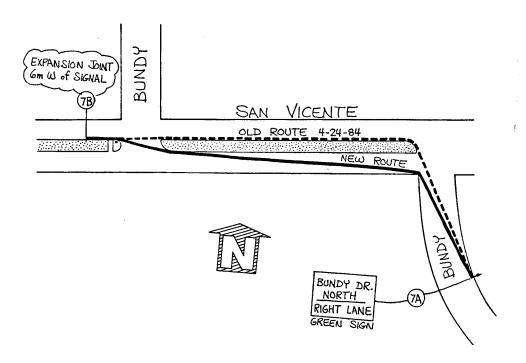
Bundy & San Vicente was measured between reference points 7A and 7B along the shortest possible route within $3\emptyset \text{cm}$ of curbs at turns:

NEW	ROUT			LENGTH (meters)				
	BL NM TK	7A 7B 6Ø76Ø61927 = 53ØØØ54149 = 6ØØØØ61153 =	1149	<u>minimum</u> 122.77m 122.87m 122.67m	average 122.80m 122.97m 122.71m	<u>maximum</u>		
OLD	ROUT			LEN	GTH (mete	rs)		
	BL NM TK	7A 7B 5790059204 = 5000051284 = 5700058288 =	1284	<u>minimum</u> 137.19m 137.31m 137.03m	average 137.21m	<u>maximum</u> 137.23m		

The differences between the new and old route measurements are:

	NE	EW-OLD		NEW	OL.D	NEW-OLD		
BL	-137	(-14.41m)	maximum	123.Ø3m	137.48m	-14.81m		
NM	-135	(-14.45m)	average	122.83m	137.23m			
ΤK	-135	(-14.37m)	minimum	122.67m	137.23m	-14.40m		

The maximum absolute value for NEW-OLD (-14.81m) provides a short course prevention factor of $\emptyset.41$ meters.



<u>Via Marina Measurements</u>

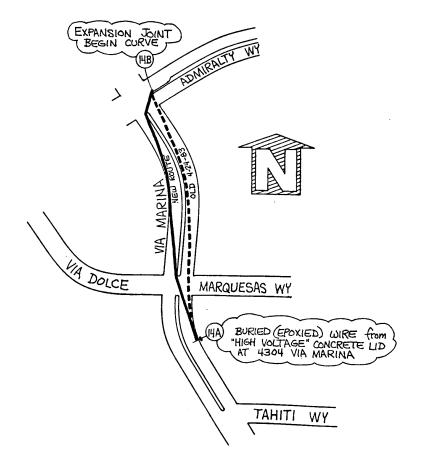
Via Marina was measured between reference points 14A and 14B along the shortest possible route within $30\,\mathrm{cm}$ of curbs at turns:

NEW ROU	TE:		LEN	GTH (mete	r5)
	14B 14A		minimum	average	maximum
BL	7320979325	= 6116	643.43m	643.55m	643.65m
ММ	7540081415.5	= 6Ø15.5	643.28m	643.78m	644.11m
TK	78ØØØ84Ø44	= 6044	643.Ø3m	643.24m	643.51m
our moun					
OLD ROU			LENG	TH (meter	5)
	14A 14B		<u>minimum</u>	average	<u>maximum</u>
BL	7932585448	= 6123	644.17m	644.29m	644.39m
NM	81415.587435	= 6019.5	643.71m	644.21m	644.53m
TK	8404490093	= 6049	643.56m	643.77m	644.Ø4m

The differences between the new and old route measurements are:

	NEW-OLD		NEW	OLD	NEW-OLD
BL	-7 (-Ø.74m)	maximum	644.11m	644.53m	-1.5Øm
NM	-4 (-Ø.43m)	average	643.52m	644.Ø9m	$-\emptyset.57m$
TK	−5 (−∅.53m)	minimum	643.Ø3m	643.56m	+Ø.55m

The maximum absolute value for NEW-OLD (-1.50) provides a short course prevention factor of 0.93 meters.



<u>Mindanao Measurements</u>

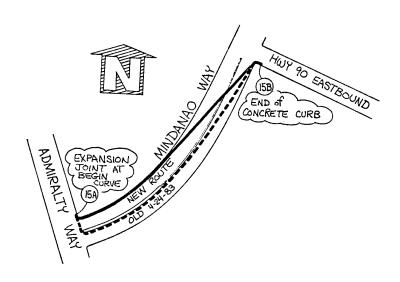
Mindanao was measured between reference points 15A and 15B along the shortest possible route within $3\emptyset \text{cm}$ of curbs at turns:

NEW ROL	JTE:		LENGTH (meters)				
BL	15A 15B Ø66ØØ1Ø464	= 3864	<u>minimum</u> 406.51m	<u>average</u> 406.59m	maximum		
NM	Ø811Ø11911	= 3801	406.47m	406.79m	406.65m 406.99m		
TK	1100014819	= 3819	406.31m	406.44m	406.61m		
OLD ROL	JTE:		LEN	NGTH (mete	ers)		
	15A 15B		minimum	average	maximum		
BL	1400018071	= 4Ø71	428.29m	428.37m	428.44m		
MM	1576019762	= 4002	427.96m	428.3Øm	428.51m		
TK	1900023022.	5 = 4022.5	427.96m	428.10m	428.28m		

The differences between the new and old route measurements are:

	NEW-	-OLD	NEW	OL.D	NEW-OLD	
BL	-2Ø7	(-21.78m)	maximum	406.99m	428.51m	-22.20m
MM	-201	(-21.51m)	average	406.61m	428.26m	-21.65m
TK	-203.5	(-21.66m)	minimum	406.31m	427.96m	-20.97m

The maximum absolute value for NEW-OLD (-22.20m) provides a short course prevention factor of $\emptyset.55$ meters.



Slauson Measurements

Some detective work was required to locate the old route which was almost completely obliterated by road improvements. Fortunately, remnants of the old double-yellow line on Hwy 90 were visible, and the location of the old traffic island at the middle of Slauson could be located due to the difference between the ages of asphalt. These control points were painted white to insure visibility during the measurement of the old route.

The new route was designed to provide a fast left turn onto Slauson by painting an arc of radius 29.9 feet, measured via steel tape, from the existing double-yellow line to 12 inches past the corner of the existing triangular traffic island. Cones/barriers will be placed directly on the painted arc to define the left-hand limit of this left turn.

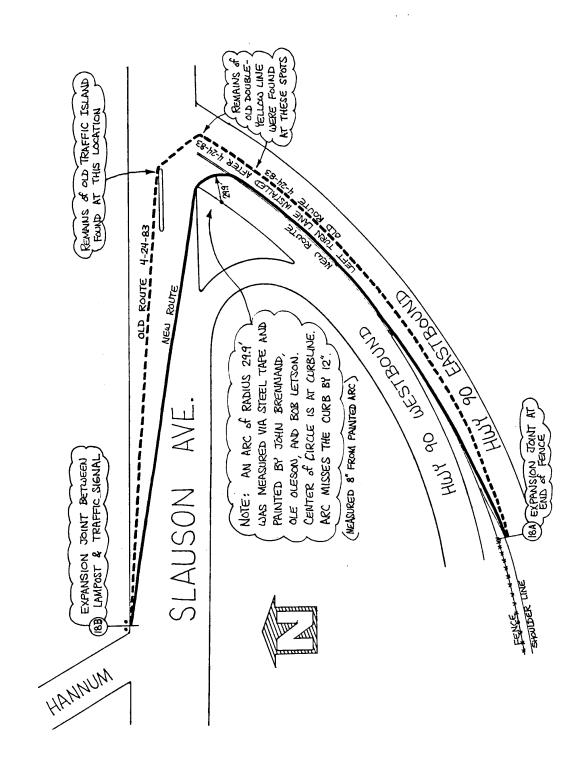
Slauson was then measured between reference points 18A and 18B along the shortest possible route within $2\emptyset \text{cm}$ of lines at turns:

NEW ROL	ITE:		LEN	IGTH (mete	GTH (meters)		
	18A 18B		<u>minimum</u>	average	maximum		
BL	3726040923	= 3663	385.36m	385.44m	385.50m		
NM	3700040602	= 3602	385.19m	385.49m	385.68m		
TK	4200045622	= 3622	385.35m	385.47m	385.64m		
OLD ROU	ITE:		LEN	rs)			
	18A 18B		<u>minimum</u>	average	<u>maximum</u>		
BL	4460048477	= 3877	407.88m	4Ø7.95m	408.02m		
NM	4400047813	= 3813	407.75m	408.07m	408.27m		
TK	4900052828	= 3828	407.26m	407.40m	407.57m		

The differences between the new and old route measurements are:

	NEW-OLD		NEW	OLD	NEW-OLD
BL	-214 (-22.52m)	maximum	385.68m	4Ø8.27m	-23.Ø8m
NM	-211 (-22.58m)	average	385.47m	407.81m	-22.34m
ΤK	-206 (-21.92m)	minimum	385.19m	407.26m	-21.58m

The maximum absolute value for NEW-OLD (-23.08m) provides a short course prevention factor of 0.74 meters.



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Santa Monica 400m Track Measurements

The Santa Monica track was measured exclusively with a 100° Lufkin steel surveyor's tape graduated in 1/100 foot increments. This tape had been verified via multiple comparisons with two NBS 100.0000° baselines in San Diego. The end of each 100.000° length was marked with a pen on masking tape. The 400m oval lap length was measured twice, clockwise and counterclockwise, along the vertical face of curb next to lane one, assuming a tape temperature of 90° F, using a separate set of 100° marks for each measurement. These two measurements differed by 0.03 foot (approximately one centimeter). The origin of both lap measurements (3A) and two of the clockwise 100° marks were used as reference points:

3A = South edge of the "3000-5000" start line at the curb

3B = 300.00° clockwise from 3A along the curb

3C = 900.00° clockwise from 3A along the curb

Ole Oleson used his son's metal detector to relocate and dig up R3, the bronze monument used for the 4-24-83 measurement, which had been covered with new pavement. The location of R3 was measured with respect to the brick wall to the east (17.45°) and concrete slab to the south (9.75°) .

R3-3B was then steel taped in both directions using a separate set of 100° marks (452.20° , 452.18°), assuming a tape temperature of 110° F. R3-3B has a turning point in it in order to avoid a drainage dip near the 3000-5000 start line. The point at which the tape was bent for the R3-3B measurement is on the white line between lanes 7 and 8 adjacent to the "3000-5000" numerals by lane 8. Barriers will be placed at this point on race day to keep runners away from the drainage dip by denying access to lane eight at the 3000-5000 start line.

A tentative start point (S) was marked on the curb $25.\emptyset8^\circ$ clockwise from (north of) 3C. Then the distance from this mark to the following nearby reference points was steel taped:

"S" = tentative start, 25.08' north of 3C

3D = begin curve (painted), NW corner of oval 4.84' north of "S", 29.92' north of 3C

3E = nail next to curb, by yellow hurdle marks 13.27' north of "S", 38.35' north of 3C

Temperature corrections for 15 April 1984 were based on experience with the same tape and identical weather experienced on 22 August 1982 during the steel taping of the Santa Monica 1000.178m, which was intended to be exactly 1000.000m. This 0.178m error was caused by direct sunlight heating the tape to approximately 113.59F, 27.59F hotter than the estimated 869F used for the 8-22-83 measurement. The 909F lap measurement on 15 April 1984 was therefore corrected mathematically to 113.59F.

Congress		
	of the USA	

Pacific Southwest Association Inc.

BRONZE MONOWENT

USED ON 4-24-84

[THS]

ASPHALT PAVEMENT

San Diego and Imperial Counties, California, 1135 Garnet St. San Diego, California 92109 (714) 275-1292

Certification

NAME OF COURSE: SANTA MONICA COLLEGE 400 TRACK	TYPE: I road race	LOCATION: SANTA MONICA, LOS ANGELES, CA	TERRAIN: paved OO % dirt % grass %	X flat rolling hilly	STRAIGHT-LINE DISTANCE BETWEEN START AND FINISH:	ALTITUDE: START: (50 HIGHEST:	(feet above sea level) FINISH: LONEST:	MEASURED BY (name, address, phone): BOB LETSON OLE OLSON,	MOEL MONTRUCCHIO, JOHN BRENNAND, TOM KNIGHT	MEASURING METHOD: Dicycle alking wheel	Steel tape ☐ electronic meter	NUMBER OF MEASUREMENTS OF THE ENTIRE COURSE: 2	DATES WHEN COURSE WAS MEASURED: 15 APRIL 1984	EXACT AVERAGE MEASURED LENGTH OF THE COURSE: 400.010 METERS/LAP	DISTANCE BETWEEN THE SHORTEST AND LONGEST MEASUREMENTS: .OO9 m	CERTIFICATION CODE: PSA- 84028	
--	-------------------	---	------------------------------------	----------------------	--	-------------------------------	--	---	---	--	-------------------------------	--	---	---	--	--------------------------------	--

The course described above and defined by the attached map is hereby certified to fulfill national standards for accurate measurement. A copy of this letter and map should accompany race results mailed to the National Running Data Center, PO Box 42888, Tucson, AZ 85733.

19 april 1984	ユギ ハアスルー 台中
Assod. Cert. date	National Cert. date
Konert C. Letton Association Certifier, Bob Letson 4369 Hamilton St. #4; San Diego, CA 92104	National Certifier, Ted Corbitt Apt 811 Sect 4; 150 W 225 St; NY, NY 10463

**	**										
	=			 							
TIGNING PRINT 18 18 (HT 3500-5000 SIGN (LN.8)	BEGIN CURVE	3000	A-900'		Steel Steel	SANTA	COLLEGE	`	(A-300)	STATE A	\
NAIL @ YELLOW HURDLE MK.	,	E.8E									
NAIL											

APPLICATION FOR CERTIFICATION OF ACCURACY

HARE OF COURTS SANTA MONJICA COLLEGE 400m TRACK Date of Suprication 15 APR 84	Ing wheel? (Steel tage?) Electronic Distance Reter (EDH)?	Resuring or arking the course:	MMY DR., SAN DIEGO, CA 92110
ocation four. City state SANTA MonICA COLL	leasuring metrod used: Bicycle: Walking wheel easuring instrueent (make, model, dimensions) ()F	Hates and addresses of people responsible for assuring or arking the course;	NOEL MONTRUCCHIO, 7806, TOMMY 1

JOHN BREMAND, BOX GEIG, SNITA BARBARA, CA TBIII TOM FUICHT, 724 ARASTRADERO KD #107, FALO ALTO, CA 94306

- DESCRIPTION OF THE COURSE

 1. Is the course assetly (III) railing? hilly uphill? downlill?
 2. Althous electrodret above sea levell. SIRM 150 Higher towers
 3. How wind to the course is passed. 1902.
 4. It this is a track, describe the curb: Height, 5,cm, Width 5,cm, Gapposition R.UEBSER.

 1. Universely 1. Univ
- Straight-line distance between SIARI and FINISH.
 Dear a detailed map of the eact measured route, with masses of all streets, showing all dirtigrass stretches, including a north arrow. Indicate which sidehalf-offerion of the street was measured.
 Give there any contests turns in..., turns where the inside boundar/limit is not defined by permanent curbs or obstrictes?
 Describe/sizett the eract measured/running for each curbless turn. (NOTE. All curbless turns west be used by permanent curbs or obstrictes).
 - 6. If this is a baseline or road race course, describe/stetch the SIARIFHUISH/UBNAROUND locations to the nexest exertived (road course), or nearest centiaeter/inch (baseline). (e.g., '28e 1224) W of mailton 9445 Bay Ct. i'ar a road course) (e.g., '341cm (B'4) S of expansion joint at hydrant 45m S of Bay Ct. for a baseline.)

VERIFICATION OF INSTRUMENT ACCURACY. Bicycles and valking wheels must be calibrated by solicity of experience and valking wheels must be calibrated or easier is steen tape or Ed. Steel tape and ED should be verified by a professional surveyor.

5. Steel Like Like to verified the steel tape or ED. S. C. SON.

6. We as at verified "CAMERED to IT A NESS TO COOK TABLES OF THE WAR WAS TO F TO COOK TABLES OF THE WAS TABLES OF THE WAS

7. WHEELS. BICKLES: Baseline location and length.

Is this baseline Inc Certified? (If not, apply now by filling out another APPLICATION FOR CERTIFICATION List the date, time, temperature, and raw data for each calibration occasion:

wag~ RUBBER ~ LA PE

Nave digits/mile Nave digits/mile Average digits per mile/km for each day for each operator; Date

~5cm

digits/te____ digits/ke

HEASUREMENTS. Baselines aust be seasured tence via EDN or steel tape. Iracts aust have their lap length Load seasured tence via stell tops along the vertical face of curb next to lane! (This iap length along the curb aust be leavested than 180.115 of or a 4040 oash, or longer than 1812. Feel or a 449 oash. Rad rice courses must be researed before the face of the face of the same of the s

505

- WEATHER/TEMPERATURE ON 4/5/84 WAS DENTICAL TO 8/22/82 WHEN THE SAME THE CANS USED WITH II.O'LES TENSION TO GREATE THE SAMITA MONICA. TOOCH METERS' REACHING WHICH LAS REPIETAS WHE DAY ON 1/22/83 = 1000.178 m (101): It he diet, they, and that he cash resourced if the baselian/tack/rae course.
 - FACE OF CURB BY LANE 1. MEASUREMENTS INCLUDE 90'F TEMPERATURE LAP LENGTH WAS MEASURED TWICE ON 15 APRIL 84 ALONG THE VERTICAL COMPENSATION.

DETITIER/SOUN/TEMPERRITURE CHR SAME ON 4-15-84 AS B-22-82 WHEN
THE SAME THE CREATED A" (COC. OCC) METERS BATELINE CHRICH CAR'S FOUND TO BE 17.8 ON OVERSIZED BY EDM METEROREMENT ON 1-23-82.
THE 8-22-82 METADOREMENT ASSUMED A THYE TEMPERATURE OF 86°F.

(86"-90") COORECTION (1306") = . 034") . 198' NET CORRECTION TOTAL TEMPERATURE CORRECTION FOR 4-15-84:

CORRECTED LAP CURB LENGTH = (305,985'+,198' = 1306,183'= 398,125 m 400.010 m HOTAL POTAL 30cm FROM CURB = (30 m)21T = 1.885m (3048m/L)

LAP LENGTH 30cm RRM Coputations/aessureaents) to set the course to the desired length:

MAIL THIS FORM WITH \$5 FEE TO THE REGIDUAL CERTIFIER 1% YOUR AREA;

Pa-166 (Central, Acritem Californas): Carl Wasser, 2388 Kinth St; Berkeley, CA 94318
SPA-766 (Los Angeles area): Ean Scardera, A997 Carcoss Ori Los Anseles, CA 99688
- PSA-786 (San Disgo & loperal Counties, Californas): Bob Letson, 435 Maniton St. Mt, San Disgo, CA 92184
Al-16C (Southern Arizona): Dale & Jahon Hatty, 11331 Sunsaith Or., Tucson, A2 85715

SUMMARY

Location of the START

The new route is shorter than the old route for each of the four course adjustments. The largest computable difference between the new and old routes for each adjustment, and the associated short course prevention factor (SCPF), are as follows for each adjustment:

	LENGTH	SCPF
Bundy	-14.81m	Ø.41m
Via Marina	-1.5∅m	Ø.93m
Mindanao	-22.2Øm	0.55m
Slauson	<u>-23.Ø8m</u>	0.74m
	-61.59m (202.07°)	2.63m (8.63°)

The Santa Monica 400m track is of legal size; therefore, two laps of this oval are assumed to be 800m meters.

The length from R3 to the tentative start (TS), adjusted for 30cm from curb, using the smallest-valued measurement, is: (452.18' + (700-300)' + 25.08' + 3.09') = 1080.35' (329.291m) With two laps, R3-TS = 1129.29 meters.

The length required for R3-START, prior to the four course adjustments, is 1068.49 meters. With the four adjustments, the required length for R3-START = (1068.49 m + 61.59 m) = 1130.08 meters.

The correct location for the START should therefore be north of TS by (1130.08m - 1129.29m) = 0.79m (2.59):

```
START = 0.79m (2.59') north of TS
= 0.69m (2.25') south of 3D
= 3.26m (10.68') south of 3E
```

<u>Length of New Intervals</u>

The lengths of the four intervals that encompass the adjustments to the course are:

		OLD	ADJUSTI	MENT NEW
Bundy	R7-R8	15 92. 8Øm	-14.81m	1577.99m
Via Marina	R14-R15	1995.26m	-1.5∅m	1993.76m
Mindanao	R15-R16	2549.56m	-22.2Øm	2527.36m
Slauson	R17-R19	4267.21m	-23.Ø8m	4244.13m

Reference Points for 15 April 1984

The distances between reference points, using the proposed lengths documented in the initial certification report ("1984 Olympic Marathon Reference Foints", 24 November 1983), the Coliseum measurements on $2\emptyset$ December 1983, and four course adjustments measured on 15 April 1984, are as follows:

REF	ERENCE POINT	LENGTH	(meters)		
		interval	sum		
	Start	Ø.ØØ	Ø.ØØ		
R3	SMCC	113Ø.Ø8	1130.08		
R4	Wilshire	2996.2Ø	4126.28	5 1	k: m
R7	Bundy	1292.51	5418.79		
R8	Carmelina	1577.99	6996.78		
R9	Avondale	955.96	7952.74	10	km
R1Ø	Georgina	3571.52	11524.26		
R11	Alta	378 . 99	11903.25	1.55	km
R12	Navy Ct.	4230.94	16134.19		
R13	Park	601.24	16735.43		
<u>R14</u>	Via Dolce	1916.35	18451.78	20	k m
R15	Admiralty (Tahiti)	1993.76	20645.54		
R16	Mindanao	2527.36	23172.90		
R17	Culver	768.56	23941.46	25	l-cm
F(19	Hannum	4244.13	28185,59	30	km
R2Ø	Summertime	2033.32	30218.91		
R21	Leahy	974.67	31193.58		
R23	Ridgeley	2778.89	33972.47	35 25	te m
R24	Hobart	5303.71	39276.18	40	km
R25	Bud1 ong	1000.01	40276.19		P 111
R26	Menlo	61Ø.65	4Ø886.84		
R27	U-turn ₁	575.33	41462.17		
R28	U-turn₂	16.20	41478.37		
R29	Stadium	168.00	41646.37		
	Finish	548.63	42195.00		

The five-kilometer points are at the following locations:

5	km	R4	+	873.72m	(R7	 418.79m)
$1 \varnothing$	km	R9	+	2Ø47.26m	(R1Ø	 1524.26m)
15	km	R11	+	3096.75m	(R12	 1134.19m)
$2\emptyset$	km	R14	+	1348.22m	(R15	 645.54m)
25	km	R17	+	1058.54m	(R19	 3185.59m)
JØ	km	R19	+	1814.41m	(R2Ø	 218.91m)
35	km	R23	+	1027.53m	(R24	 4276.18m)
4Ø	km	R24	+	723.82m	(R25	 276.19m)