National Technical University of Athens, Greece
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Advanced Surveying Techniques for Measuring the Marathon Course

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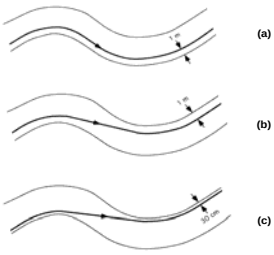
Marathon Course

- Unlike track races that follow a standardised construction, road races vary greatly
- Marathon times are referred to as “world best” times not “world records”
- The IAAF (International Association of Athletics Federation) emphasises the requirement of producing "accurate" courses that are at least the stated distance

Current IAAF Regulations

- IAAF rule 165: “*the course shall be measured along the shortest possible route (SPR) that a competitor could follow within the section of the road*”

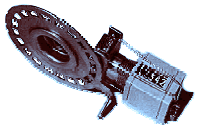


Measurement Procedures

- The “lay-out” procedure uses the SCPF - *short course prevention factor* - equal to 1:1000, which guarantees that the actual length is not less than the advertised course length
- The “validation” process determines and certifies the true length of the course
- The uncertainty to determine the true length should not exceed 0.1% of the distance of the course (IAAF rule 240.3)

Measurement Techniques

- IAAF does not enforce any specific technique- however, the preferred method is the “calibrated bicycle”
- The wheel revolution counter is called the Jones-Oerth (JO) counter (1990)
- The number of revolutions of the bicycle wheel needed to cover the course are compared to the number of revolutions needed to cover a standard calibration course



Steps in Measuring the Course

- A calibration course of 300- 500m is laid out. The measurement may be performed using steel tape, EDM or GPS
- The calibration of the bicycle over the course defines the “working constant” = number of counts/km x 1.001
- The full racecourse is measured following the SPR (tentative start and finish marks)

Steps in Measuring the Course (cont'd)

- A recalibration of the bicycle is performed and a "constant of the day" is calculated
- The measured distance of the race course is calculated using the "constant of the day" (< 0.8% difference)
- When differences between the measured course and desired length exist, additions are added to the course

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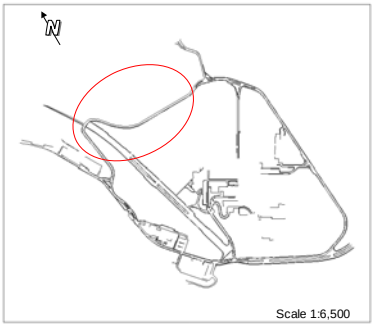
Course Measurement Experiment

- Test site of a typical non-linear course of length ~0.5km
- Course was selected on ring road of the university campus



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Conventional Surveying

- The SPR was laid out using 39 HILTI nails
- The course was measured independently using a 50m steel tape and a Leica TC1800 total station (±2mm ±2ppm)
- Difference of 29mm between the two computations (not significant at 95%)

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Bicycle Method

- A calibration baseline of 300m was measured using GPS receivers and a steel tape
- The cyclist performed two laps of the road course (difference <0.8%)
- Mean of laps differs from distance measured by total station (1.99m) and tape (2.02m)
- The use of SCPF factor of 0.1% was incorporated

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Terrestrial Laser Scanning

- The Riegl LMS-Z360 scanner was used (FOV 90º x 360º)
- 3 scans were taken at angular resolution of 120mdeg (~ 15 million points)
- Retroreflector targets positioned over the HILTI nails

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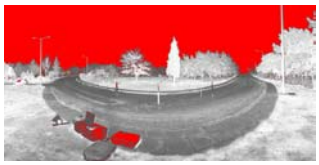
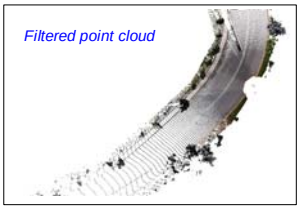
Point Clouds

- Processing of laser scanner data with propriety software
- Decimation of data at 10cm
- Georeferencing of the registered data to the local system (RMS ~ 3-8cm)





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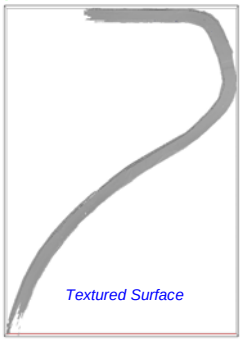
Surface Model



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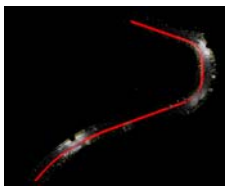
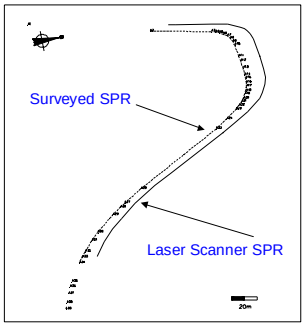
Short Possible Route

- Digitisation of the SPR on the surface model
- Total distance of SPR is measured in 3D (i.e. slope) and not onto the plane





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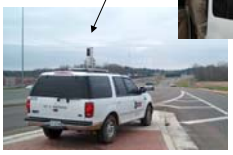
Moving Platform for Rapid Documentation

Imaging Sensor Z210



Mississippi DOT, USA

Automatic extraction of features (eg curbs)

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Summary

- The bicycle method provides a single value of the distance and no permanent record of the traversed path
- Disadvantage of method is lack of repeatability
- GPS attached to a bicycle is not practical because of obstructed line-of-sight
- Standard surveying is extremely cumbersome for non-linear routes

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Summary (cont'd)

- Terrestrial laser scanning provides a permanent 3D record of the road course and easily defined SPR
- Disadvantage of method is the slow set-up of instrument
- Use of mobile survey platform allows for fast data acquisition

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