



Draft RoboCup Nanogram Rules

2009

Version 1.0

October 31, 2008

1. THE EVENTS

Events Overview

The 2009 RoboCup Nanogram competition will consist of two **qualifier events** and one **competition event**:

1. The Two Millimeter Dash [first qualifier event]
2. The Slalom Drill [second qualifier event]
3. The Shootout [competition event]

Each team will have 30 minutes to perform three trials of each event. If a team has not completed three trials in 30 minutes, the remaining trials will be scored as fouls.

The Two Millimeter Dash

The field of play will be unobstructed between the two goal lines. The team will place a microrobot behind one goal line. The entire body of the microrobot must be behind the goal line before the trial begins. Upon the signal of the referee, the microrobot will sprint to the opposite goal. The trial is complete when the microrobot control system has electronically signaled completion as described in "Event Timing," below. If the microrobot control system does not signal completion within two minutes, the referee will award a foul. Before signaling completion, the entire body of the microrobot must pass the line of the opposite goal. The microrobot must then remain in the goal for at least 5 seconds after signaling completion. Failing to do so will result in a foul.

The microrobot's **finish time** for a trial of the two millimeter dash is measured from the start signal of the referee to the completion signal of the microrobot. The maximum finish time is two minutes.

The microrobot's **score** for the event will be the quadratic mean of its finish times on each of the three trials. Lower scores beat higher scores. A teleoperation penalty will be assessed to teams whose robots are controlled by operators; see section 3 for a description of this penalty.

The Slalom Drill

The field of play will be obstructed between the two goal lines by one or more obstacles. Prior to beginning the trial, the team must choose the number of obstacles on the field. The team must choose no more than six obstacles, and no fewer than one. The team will place a microrobot behind one goal line, and the event proceeds as in the Two Millimeter Dash.

The microrobot's **finish time** for a trial of the slalom drill is measured from the start signal of the referee to the completion signal of the microrobot. The maximum finish time is two minutes.

The microrobot's **modified finish time** for a trial of the slalom drill is its finish time divided by the number of obstacles on the field. If the trial was disqualified, the modified finish time is two minutes.

The microrobot's **score** for the event will be the quadratic mean of its modified finish times on each of the three trials. Lower scores beat higher scores. A teleoperation penalty will be assessed to teams whose robots are controlled by operators; see section 3 for a description of this penalty.

The Shootout

The microrobot begins behind the goal line as in the previous two events. The field is obstructed by one or more obstacles, and there are one or more balls placed on the field. Upon the signal of the referee, the microrobot retrieves the balls and dribbles them into the opposite goal. The trial ends after two minutes, or when the microrobot control system signals completion.

Prior to beginning the trial, the team must choose the number of balls available on the field. The number of obstacles on the field will equal the number of balls.

The microrobot's **trial score** is the number of balls that are entirely within the opposing goal at the end of the trial.

The microrobot's **score** for the event will be the quadratic mean of its trial scores. Higher scores beat lower scores. If the team has accepted a teleoperation penalty, this score will be decreased (see section 3).

The Order of Competition

The events will be held in the following order:

1. The Two Millimeter Dash
2. The Slalom Drill
3. The Shootout

All teams will perform all three trials of an earlier event before any team begins any subsequent event. An earlier team will perform all three trials of an event before a subsequent team begins any trial of that event.

For the Two Millimeter Dash, the order of teams will be determined by lot.

For the Slalom Drill, teams will choose where they will fall in the order of teams. Teams with superior Two Millimeter Dash scores will choose before teams with inferior scores. Tie scores will be broken by lot.

For the Shootout, teams will choose where they fall in the order of teams. Teams with superior Slalom Drill scores will choose before teams with inferior scores. Tie scores will be broken by lot.

Qualification

All teams automatically qualify for the Two Millimeter Dash. A team must qualify for the Slalom Drill and the Shootout by demonstrating good performance in the earlier events. A team will automatically qualify for the slalom drill upon completion of at least two out of three trials of the two millimeter dash in two minutes or less. To automatically qualify for the shootout, a team must complete at least two out of three trials of the slalom drill in two minutes or less. Otherwise qualification will be based on relative time: no fewer than five teams will qualify for the slalom drill; no fewer than three teams will qualify for the ball handling drill.

Fouls

In the event that a foul occurs during a trial, that trial will be awarded a pessimal value. For the qualifier events, this means a value of two minutes. For the Shootout, this means a value of zero goals. A trial in which a foul occurs cannot count towards qualification.

Ties

Ties in the final shootout will be broken by sudden death. The order of teams in sudden death will be determined by lot. Each team will perform one additional trial. The team with the highest score in that trial wins. Teams tied in sudden death will proceed to an additional trial. Up to three sudden death trials will be permitted to break ties.

Event Timing

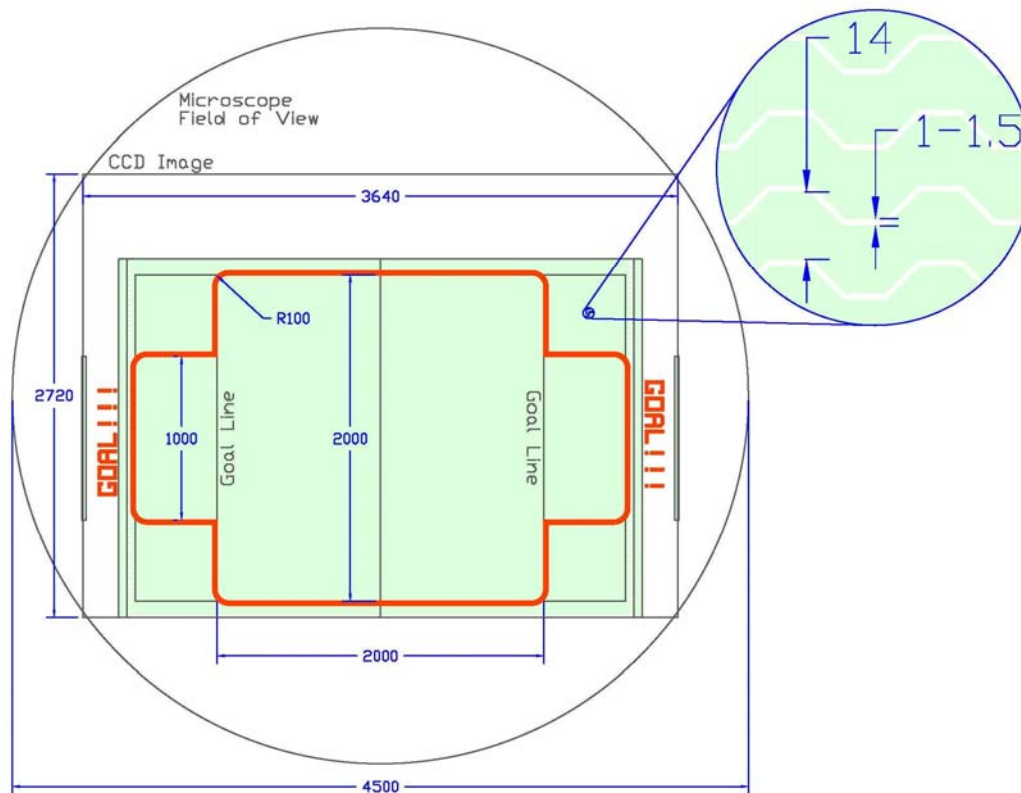
Each trial will be electronically timed. The trial will begin when a rising-edge 5 V TTL signal is sent from the competition timer to the microrobot control system. The microrobot must remain behind the starting goal line until after this signal is sent. Crossing the starting goal line prior to when the start signal is sent will result in disqualification of the trial. When the microrobot has completed the trial, it must send a rising-edge 5 V TTL signal back to the competition timer, completing the trial. Any actions performed after the finish signal has been received will not be considered in determining the microrobot's score for the trial. In some cases, this can result in a foul.

2. THE FIELD OF PLAY

Dimensions

The field of play will be provided by the contest organizers. The field of play is rectangular. Its dimensions do not include boundary lines.

- Length Between Goal Lines: 2000 μm
- Width of Field: 2000 μm
- Width of Goal: 1000 μm
- Depth of Goal: 500 μm
- Width of Boundary Lines: 25 μm
- Boundary Fillet: 100 μm



Field Surface

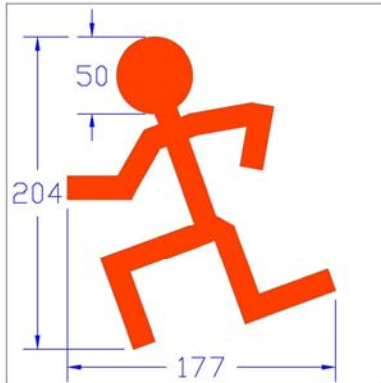
The field of play will be covered with conductive interdigitated electrodes that have a half-pitch of 15-15.5 micrometers, as illustrated. Interelectrode spacings will be 1-1.5 micrometers wide. The electrodes will be coated with a dielectric layer sufficient to withstand at least 250 volts applied between adjacent electrodes.

Field Boundaries

The boundaries of the field of play will be formed from a polymer film at least 10 micrometers thick, and will be 25 micrometers wide. The boundaries will be defined immediately outside the field of play.

Obstacles

Obstacles on the field of play will be formed from a polymer film at least 10 micrometers thick, having the following shape:



Dimensions all in micrometers

THE BALL

The balls will be provided by the contest organizers. Each ball will be a disc of single-crystal silicon, having a diameter of 100 micrometers and a thickness of 10 micrometers. It will have a dimpled underside so that no more than 1% of its area will contact any flat surface on which it rests.

Ball Diameter: 100 μm

Ball Height: 6-12 μm

Dimple Diameter: 2 μm

Dimple Height: 1 μm

THE OPTICS

The Microscope

The microscope will be provided by the contest organizers. It will have a 4.5 mm field of view, with a depth of field of at least 200 μm , and a working distance of at least 70 mm. The optics will be arranged to accept a 1/2-inch CCD camera with a standard C-mount. It will have coaxial illumination which will be adjustable by each individual team. Limits of adjustment will be set by the contest organizers to ensure adequate visibility by spectators.

The microscope will be equipped with a manual XY motion stage with an area measuring 200 mm x 200 mm, and having a free travel range of at least 25 mm in each direction.

The surface of the stage will be equipped with standard M6 optical breadboard with 25 mm spacing. The focal plane of the microscope will be adjustable from 0 mm above the surface of the stage to 150 mm above the surface.

The Camera

Each team will provide its own camera system as needed for machine vision capability. The camera must be adaptable to the 1/2-inch CCD C-mount available on the microscope. The camera must weigh no more than 1 kg.

3. THE MICROROBOTS

Safety

Microrobots are to be provided by the competing teams. Microrobots and any associated equipment must not pose a danger to contest participants or spectators. Any participating team whose equipment is deemed to be unsafe will be disqualified from the contest until such time as it can demonstrate to the contest organizers that the safety hazard has been eliminated.

Shape

A robot must at all time fit inside a 300 μm diameter cylinder, and must be no more than 300 μm high at its tallest point.

Control Systems

A robot may include a machine vision system to be mounted on the microscope. Power and instructions may be provided to the robot through the electrodes imbedded in the field of play, or through other means that do not make direct physical contact with the microrobot or field of play. Off-board computers may be used to process data generated by these systems, and to generate signals to the microrobots.

Auxiliary Equipment

The microrobotic system may include auxiliary equipment to control the ambient environment of the microrobot, to perform off-board computation, to generate electromagnetic signals, or for other necessary functions. This equipment must fit either on the stage of the competition microscope, or to the side of the microscope. Equipment placed on the microscope stage must fit in a box 25 cm long by 25 cm wide by 15 cm high. Equipment placed to the side of the microscope must fit in a box 80 cm long by 80 cm wide by 50 cm high. The nearest edge of the available area to the side of the microscope will be no more than 150 cm away from the microscope stage. Connections between these two areas may be made with tubes and wires whose combined cross section does not exceed 16 cm^2 .

Autonomy

The robotic equipment, to include any control systems, machine vision systems, and other auxiliary equipment as described above, should be fully autonomous for the duration of each event. To receive a full score, human operators are not permitted to enter any information into the equipment from the time its first trial playing field is received to the time its last trial ends.

A team may choose to accept a **teleoperation penalty** in exchange for the ability to interact with the equipment during the event. The teleoperation penalty will detract from the team's score by a significant amount to be specified at a later date.

THE REFEREE

The Authority of the Referee

Each trial will be controlled by a referee who has full authority to enforce these rules and award scores to competitors.

Powers and Duties

The referee:

- Enforces these rules.
- Controls each trial in cooperation with any assistants.
- Starts each trial as described in these rules.
- Stops a trial if a situation is deemed to be unsafe to participants.
- Stops a trial if a situation is deemed to be unsafe to spectators.
- Stops a trial if a situation presents a hazard to competition equipment.
- Stops a trial if competition equipment is not operating correctly.
- Assigns scores for each trial, and for each event.
- Provides a report of each trial to the Technical Committee, to include field selection, trial times, scores, and any disqualifications.

All decisions of the referee are final.