ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS

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ROBOTS THAT FLY:
COLLEGE TEAMS DEMONSTRATE NEW TECHNOLOGY IN FIRST-OF-ITS-KIND COMPETITION JULY 29

It seems like a simple enough task: move a half-dozen metal discs from one side of a volleyball court to another in three minutes or less.

But for five groups of college students, the assignment will be a real test of their ability to design and construct a new type of flying machine -- autonomous aerial robots able to locate, retrieve and transport the discs without human direction.

"It's very much of a technical challenge," said Rob Michelson, vice-president of the Association of Unmanned Vehicle Systems (AUVS), which is sponsoring the contest to showcase the technology. "Once the vehicle is started, each robot must travel on its own, using its machine vision to perceive the environment. It's going to have to search for a disc, acquire it, then find its way across the barrier to drop it."

Student competitors from one team have modified a small radio-controlled helicopter which was originally designed for use in the movie industry. (Photo by Gary Meek)

Believed to be the first of its kind, the competition will be held July 29 on the campus of the Georgia Institute of Technology in Atlanta. Aerial robots are expected from the California Polytechnic University, University of Dayton, Georgia Institute of Technology, Massachusetts Institute of Technology, and University of Texas.

FOR MORE INFORMATION:

ASSISTANCE/PHOTO: *John Toon/Lea McLees, Research Communications Office, (404) 894-3444; or Charles Harmon/Pam Rountree, GT News Bureau, (404) 894-2452*

WRITER: John Toon

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The team winning this first "Aerial Robotics Competition" will receive a $10,000 prize and an opportunity to attend the AUVS annual symposium in Washington, D.C.

Unmanned aerial vehicles are of interest to the military for battlefield usage to avoid exposing soldiers to hostile fire. Forestry, utility and other companies could also use the machines to replace humans in such tasks as monitoring utility lines and checking forest disease problems.

"Autonomous aerial vehicles offer tremendous commercial and military potential in avoiding risks to human operators, reducing operating costs and cutting the overall investment in vehicle systems," said Michelson, also a senior research engineer with the Georgia Tech Research Institute (GTRI). "They can handle the dull, dirty or dangerous tasks in place of a human."

Improvements in machine vision systems, computing power and software have combined over the past several years to make such unmanned systems feasible. Though the technology is still in experimental stages, Michelson hopes the competition will demonstrate the possibilities offered by unmanned aerial robots.

"A lot of people think that autonomous aerial systems are off in the future," he added. "One of the things this competition will show is that autonomy in aerial vehicles is not that far off."

For the most part, the vehicles were built from existing "off-the-shelf" equipment. The Georgia Tech team, for example, has adapted a small helicopter originally designed for use in the movie industry, adding sensors, computers and other equipment needed to operate independently.

Artificial intelligence systems guiding the vehicles will know the configuration of the volleyball court, approximately where the discs are located, where obstacles are and where the discs must be placed. The vehicles will rely on sophisticated machine vision systems to locate the discs, while robotics technology will be used to pick up each disc. The students will also have to overcome the flight control and stability problems inherent in any flying machine.

Within certain size restrictions, the contestants were free to choose the aerial vehicle they felt could best complete the task. They were also free to equip it as they saw fit, though the small size (a six-foot cube) placed limits on the sensing, guidance and computer equipment that could be carried on-board.

To encourage interaction between universities and industry, the student groups were allowed to obtain assistance and support from companies or government agencies. Michelson hopes these partnerships will lead to further research as the student competitors graduate to become unmanned system designers of the future.

Remotely controlled flying vehicles have existed for years, but most depended on guidance from human operators communicating by radio. Such craft have recently been used by the military to perform dangerous reconnaissance missions during Operation Desert Storm. The Department of Defense (DOD) recently established a Joint Program Office which has received funding from the U.S. Congress to develop more advanced versions of the unmanned aerial vehicles used in the Gulf War.

Thanks to their intelligence, autonomous vehicles could simply be given a mission description, then sent out to plan their own routes and react to conditions -- such as hostile fire -- that they may encounter on the way. Because they would not rely on radio control for guidance, such autonomous vehicles would be more difficult for enemy forces to jam or disable.

Since the technology is experimental, Michelson expects that some of the student-built aerial vehicles may fail. And he doubts that any will be able to retrieve all six discs in the allotted time.

"Whoever progresses the farthest will win," he explained. "Also, a lot depends on how well each team has implemented its design concept. If only one of the five machines is able to complete the task, that will demonstrate the viability of the technology."

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EDITOR'S NOTE: Public information departments from the Georgia Institute of Technology are providing media relations assistance during the event. Please call if you (1) need information on attending the event, (2) would like additional information on the competition, (3) need assistance in arranging telephone interviews with the participants, or (4) would like to obtain photography or broadcast-quality video of the event. Please contact John Toon or Lea McLees in the Research Communications Office (404-894-3444); or Charles Harmon or Pam Rountree in the Georgia Tech News Bureau (404-894-2452).

Official Competition Rules

for the First International Aerial Robotics Competition

GENERAL RULES GOVERNING AIR VEHICLES

1. Vehicles must be unmanned and autonomous. They must compete based on their ability to sense the structured environment of the Competition Arena. They may be intelligent or preprogrammed, but they must *not* be flown by a remote human operator.

2. Computational power need not be carried by the air vehicle. Computers operating from standard commercial power may be set up outside the Competition Arena and uni- or bidirectional data may be transmitted to/from the air vehicle.

3. Data links will be by radio, infrared, acoustic, or other means so long as no tethers are employed. The air vehicles must be free-flying with no entangling encumbrances.

4. Any form of propulsion is acceptable.

5. Air vehicles may be no larger than a six-foot (side dimension) cube.

6. Intention to compete must be received no later than December 31, 1990. A brief concept paper describing the air vehicle must be submitted at that time for safety review by AUVS. AUVS will either confirm that the submitting team is a qualified competitor, or will suggest safety improvements that must be made in order to qualify.
   The competition will be held in Atlanta Georgia on the campus of the Georgia Institute of Technology in July of 1991.

7. Two classes of teams will be considered, student and industrial/student. Student teams may be comprised of undergraduate and/or graduate students. Interdisciplinary teams are encouraged (EE, AE, ME, etc.). "Industrial teams" may be comprised of members of a single company, government agency (or university, in the case of Faculty), or may be teams from various companies, however in each case, the industrial team *must* be associated with a student team. The student members of an industrial team must make significant contributions to the development of their entry. "Students" must be enrolled at least half-time (12 hours or more per quarter/semester) during winter and spring 1991. Only the student component of each team will be eligible for the *cash awards*.

COMPETITION RULES

1. Members from only one team are permitted within the Competition Arena at any given time. A vehicle team will be given 3 minutes to start its vehicle. When the team indicates that its vehicle is ready, the heat will begin upon the signal of the designated judge.

2. All air vehicles must start from the designated starting area. Only two members from the team may be within the boundaries of the Competition Arena at a time. Once the heat has begun, all team members must remain outside the Competition Arena

3. During the competition, after a team is called to start, a maximum set-up time of three minutes will be allowed. Teams will be given at least one minute warning of their heat assignment. Air vehicles which are unable to be readied within the three-minute starting period are placed at the end of the competitor list. Teams unable to compete during their heat are given two more chances to perform. After three attempts, the team is disqualified.

4. Each team must use the same air vehicle in each heat, i.e., all of the same component types (e.g. a six-inch propeller can not be replaced with a 12-inch propeller between heats).

5. Air vehicles must transfer six randomly placed tin disks from the ring to the inner ring on the other side of the three-foot high central barrier. The disks must be transported one at a time. Though randomly placed, the disks will initially be at least three inches from the edge of the outer ring.

6. A given heat will last only three minutes. At the end of three minutes, the score will be based on the number of disks successfully transferred from the outer ring to the inner ring. The competition winner will be determined by 1) the air vehicle having transferring the most disks during its three-minute heat, or 2) in the event that more than one air vehicle is able to transfer all six disks within the allotted three-minute period, the air vehicle having transferred the most disks in the minimum amount of time will be declared the winner of the competition. A tie in both the number of disks and execution time will result in a final fly-off.

7. In the event that no air vehicle is capable of completing the course in a given heat, the one progressing the farthest will be declared the winner.

8. Air vehicles may only land within one of the two rings or within the starting area. The air vehicle must be airborne at all other times. "Airborne" is defined as not intentionally being in contact with the ground for more than one second (as such, pogo sticks and similar momentary ground-contact vehicles are not considered to be *flying air vehicles*).

9. Air vehicles may not latch onto, or use, the central barrier or boundary fencing for locomotion or stability.

10. Disks placed within the inner ring, but which are later knocked out by other disks or the air vehicle itself, still count toward the total. Disks which bounce or roll out of the inner ring during initial placement do not count.

11. Each air vehicle must be equipped with a non-pyrotechnic termination mechanism that will render the vehicle ballistic upon command of the judges.

HOW COMPETITORS WILL BE JUDGED

1. A team of three judges will determine compliance with all rules.

GROUNDS FOR DISQUALIFICATION

1. Team members entering the Competition Arena during a heat will cause their vehicle to be disqualified.

2. Judges will disqualify any vehicle which appears to be a safety hazard.

3. Intentional interference with the competitor's data link will result in disqualification.

4. Damaging the Competition Arena, disks, or navigation aids may result in disqualification.

5. Strategies aimed only at destruction of, or damage to, an opponent vehicle are not in the spirit of the competition and will not be allowed. Any contestant who deliberately causes an opponent's air vehicle to crash will be disqualified.

6. Air vehicles should attempt to remain within the Competition Arena. Air vehicles which somehow circumvent the central boundary by flying around it at an altitude of less than 3 feet will be disqualified. Note: for reasons of safety, the competition arena will be surrounded by a chain link fence approximately in excess of 10 feet in height and lying several feet outside the Competition Arena boundaries. A net will be stretched across the top of the fence to assure that no air vehicle can escape the arena.

AWARDS

1. Cash tuition awards to winning student team members.

2. National recognition for the winning student's university.

3. National recognition through AUVS for the winning industrial/government/faculty organization.

4. Free full page advertisement for the winning company, governmental agency, or university faculty department in *Unmanned Systems* magazine.

5. Special recognition to the winning team at AUVS '91 to be held in Washington D.C., including free attendance to the symposium, an invitation to display the winning air vehicle, and the opportunity to present a paper for inclusion in the conference proceedings detailing winning design and construction strategies.

ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS

FIRST UNMANNED AERIAL ROBOTICS COMPETITION

Georgia Institute of Technology
July 29, 1991

Team Rosters
(*denotes team spokespersons)

THE UNIVERSITY OF DAYTON
DAYTON, OHIO

1. Orville Baker, electronics engineering technician
2. Chuck Cross, senior, mechanical and aerospace engineering
3. Scott Costello, senior, electronics engineering technology
4. Steve Olson, senior, mechanical and aerospace engineering
5. Greg Steinlage, senior, mechanical/aerospace engineering

* 6. Paul Szalek, graduate student, aerospace engineering

Faculty adviser: Dr. Earl Miller, associate professor of mechanical and aerospace engineering

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

1. Brian Clark, graduate student, aerospace engineering
2. Russ Clark, graduate student, computer engineering
3. Chris Coughlin, senior, civil engineering
4. Robbie Cowart, graduate student, aerospace engineering
5. Dan Ganser, graduate student, electrical engineering
6. Mark Gordon, graduate student, aerospace engineering

*7. Stephen Ingalls, graduate student, aerospace engineering

8. Shayne Kondor, graduate student, aerospace engineering
9. Andreas Lipp, graduate student, aerospace engineering
10. Doug MacKenzie, graduate student, computer engineering
11. Victor Nelson, graduate student, electrical engineering
12. Walter Patterson, graduate student, civil engineering
13. David Pauli, senior, electrical engineering
14. Steve Smith, graduate student, electrical engineering
15. Kevin Su, graduate student, electrical engineering
16. Doug Wheelock, graduate student, aerospace engineering

Faculty adviser: Dr. Dan Schrage, professor, aerospace engineering

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

1. Mike Bolotski, graduate student, electrical engineering/computer science
2. David Decaprio, undergraduate, undeclared major
3. Chris Foley, undergraduate, mechanical engineering
4. Marie Lamb, senior staff assistant, Artificial Intelligence Lab
5. Yang Min, recent PhD recipient, aeronautics/astronautics
6. Jon Speigle, recent graduate, aeronautics/astronautics
7. Gerrie Van Zyl, graduate student, mechanical engineering

*8. Paul Viola, graduate student, electrical engineering/computer science

9. Ben Weintraub, undergraduate, aeronautics/astronautics
10. Anne Wright, undergraduate, electrical engineering/computer science
11. Garth Zeglin, recent graduate, electrical engineering/computer science

The MIT team is working with a group at Purdue University led by Shaheen Ahmad, assistant professor of electrical engineering, and including Mohammed Shaikh, graduate student. Also assisting are Erica Atkeson of Yale University, undergraduate, mechanical engineering, and Paul Tradelius, Fort Worth, Texas.

**Faculty adviser:* Dr. Chris Atkeson, associate professor, Department of Brain and Cognitive Science and the Artificial Intelligence Laboratory.

THE UNIVERSITY OF TEXAS
ARLINGTON, TEXAS

1. David Berry, recent graduate, aerospace engineering
2. Mark Chivers, junior, electrical engineering
3. Andrew Cilia, graduate student, electrical engineering
4. Jeff Edwards, recent graduate, aerospace engineering
5. William Page, junior, electrical engineering
6. Rick Roberts, graduate student, electrical engineering
7. John Sirney, senior, electrical engineering

* 8. Jeff Smith, graduate student, computer science/engineering

9. Mike Walti, senior, computer science and engineering
10. Matt Wilson, senior, computer science and engineering

Faculty adviser: Dr. Jack Fitzer, associate chairman, electrical engineering department

CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CALIFORNIA

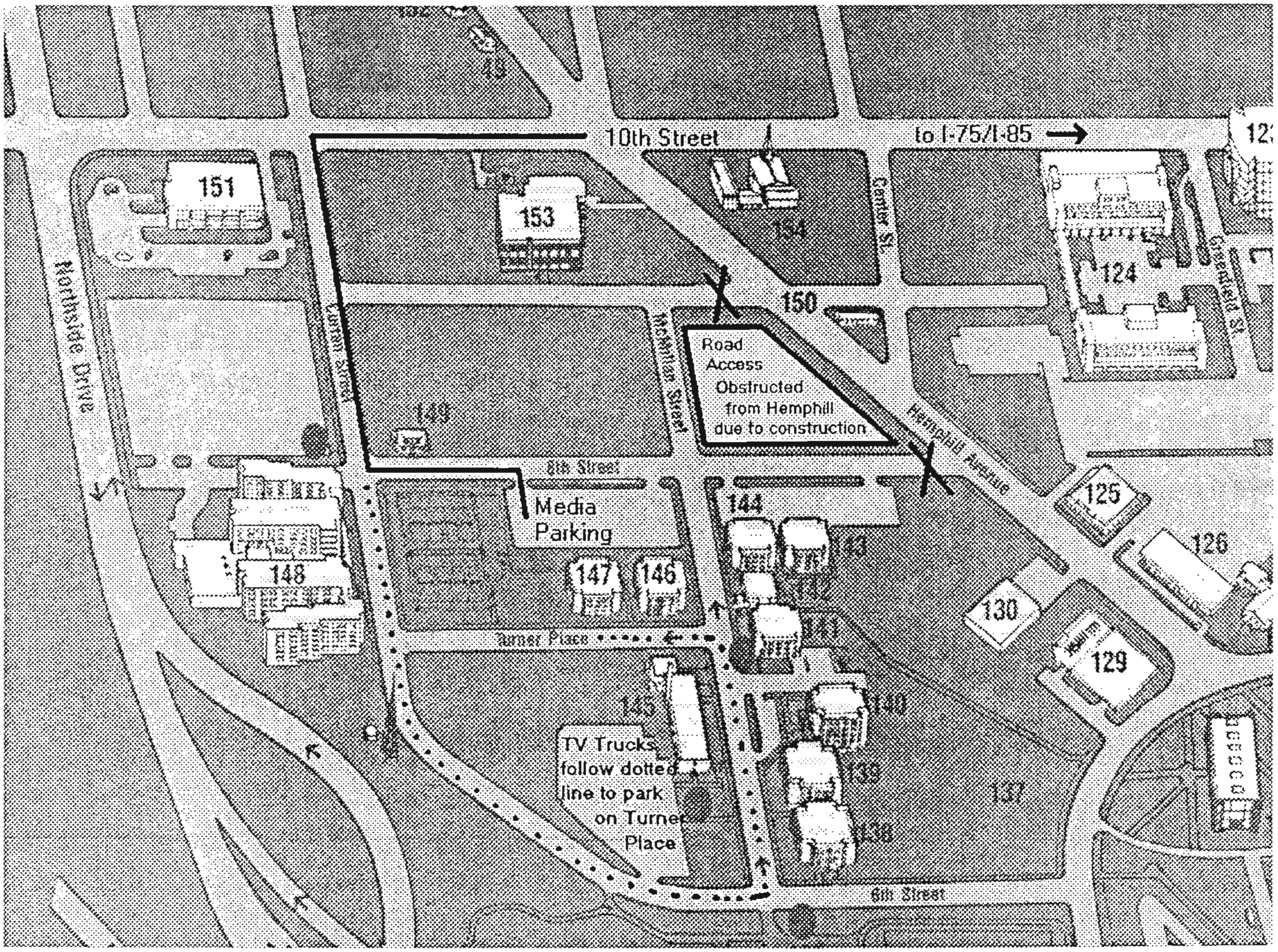
1. Aerobel Banuelos, senior, aeronautical engineering
2. Martin Braun, senior, computer science
3. Harold Brown, senior, computer engineering
4. Rich Howe, senior, electronic engineering
5. Chris McCollam, recent graduate, mechanical and aeronautical engineering
6. Doug Muretic, recent graduate, engineering technology electronics

*7. Dave Pessin, recent graduate, aeronautical engineering

8. Marc Peters, senior, computer engineering
9. Lonny Rollins, sophomore, computer engineering
10. Brian Suffradini, senior, aeronautical engineering

Faculty adviser: Dr. Daniel Biezad, professor, aeronautical engineering

Map to Unmanned Aerial Robotics Competition

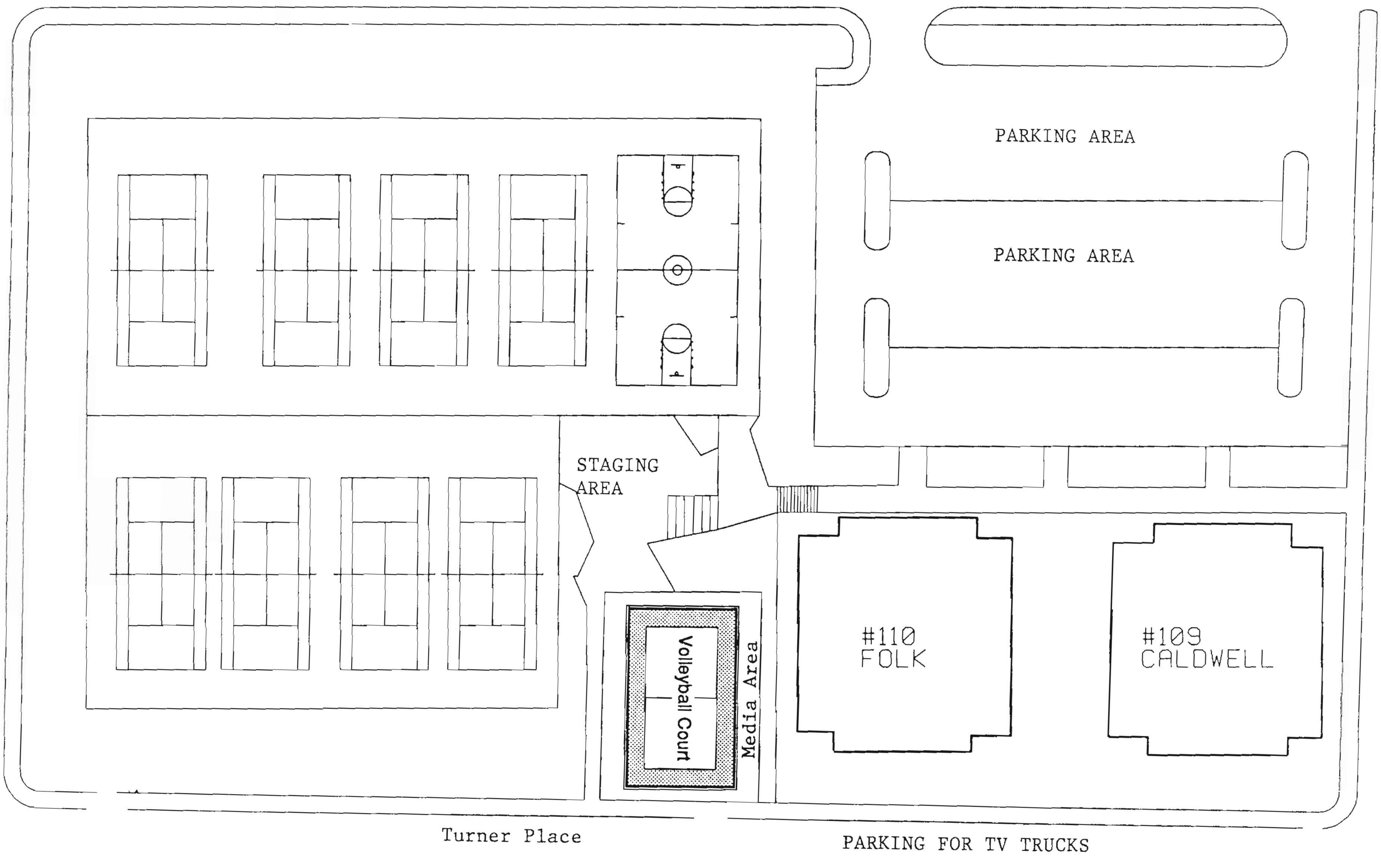


Take I-75/85 to 10th Street, going toward the basketball arena (away from Peachtree St). Take a left on Curran St. and then a left on 8th. The lot is on your right. TV trucks can park directly adjacent to the event - go down Curran to McMillian and take a left, then take another left on Turner.

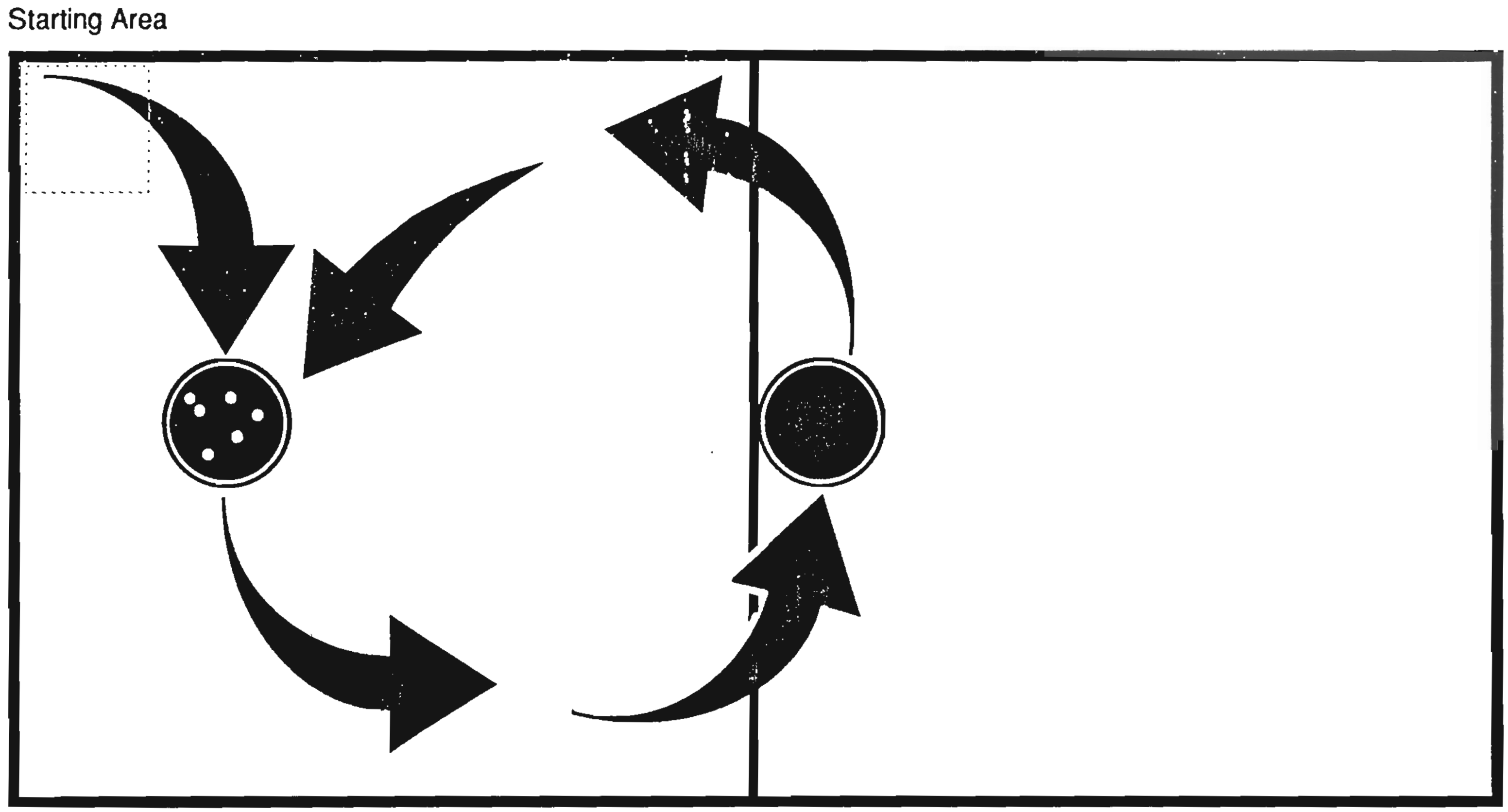
Proposed Competition Arena for the

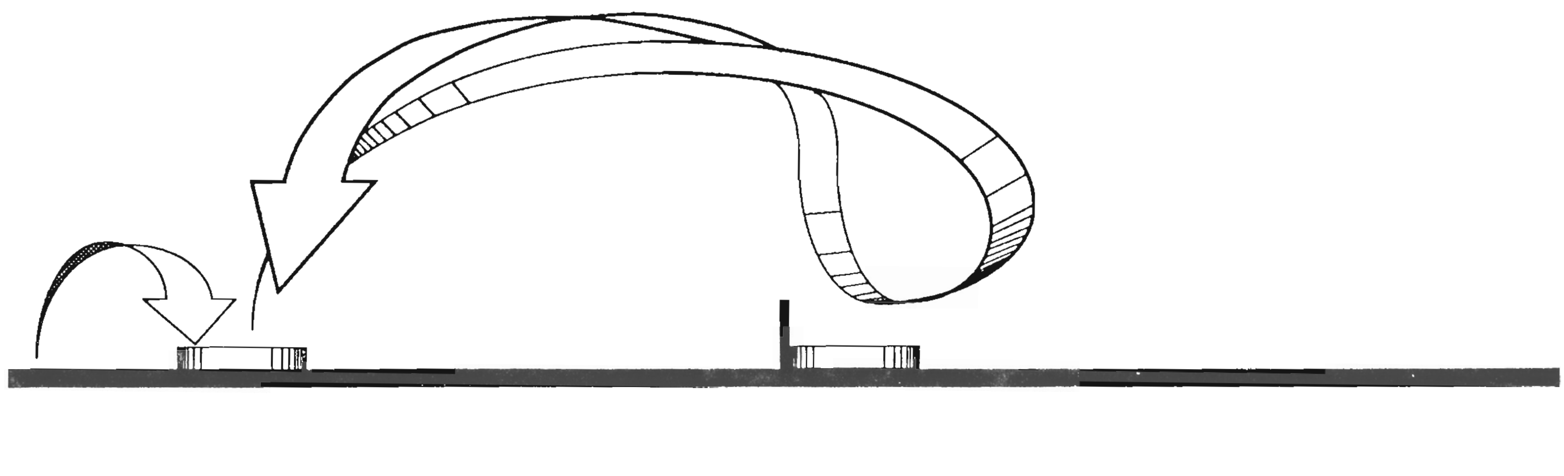
First International Aerial Robotics Competition

Fenced volleyball court adjacent to Folk Dormitory and Turner Place



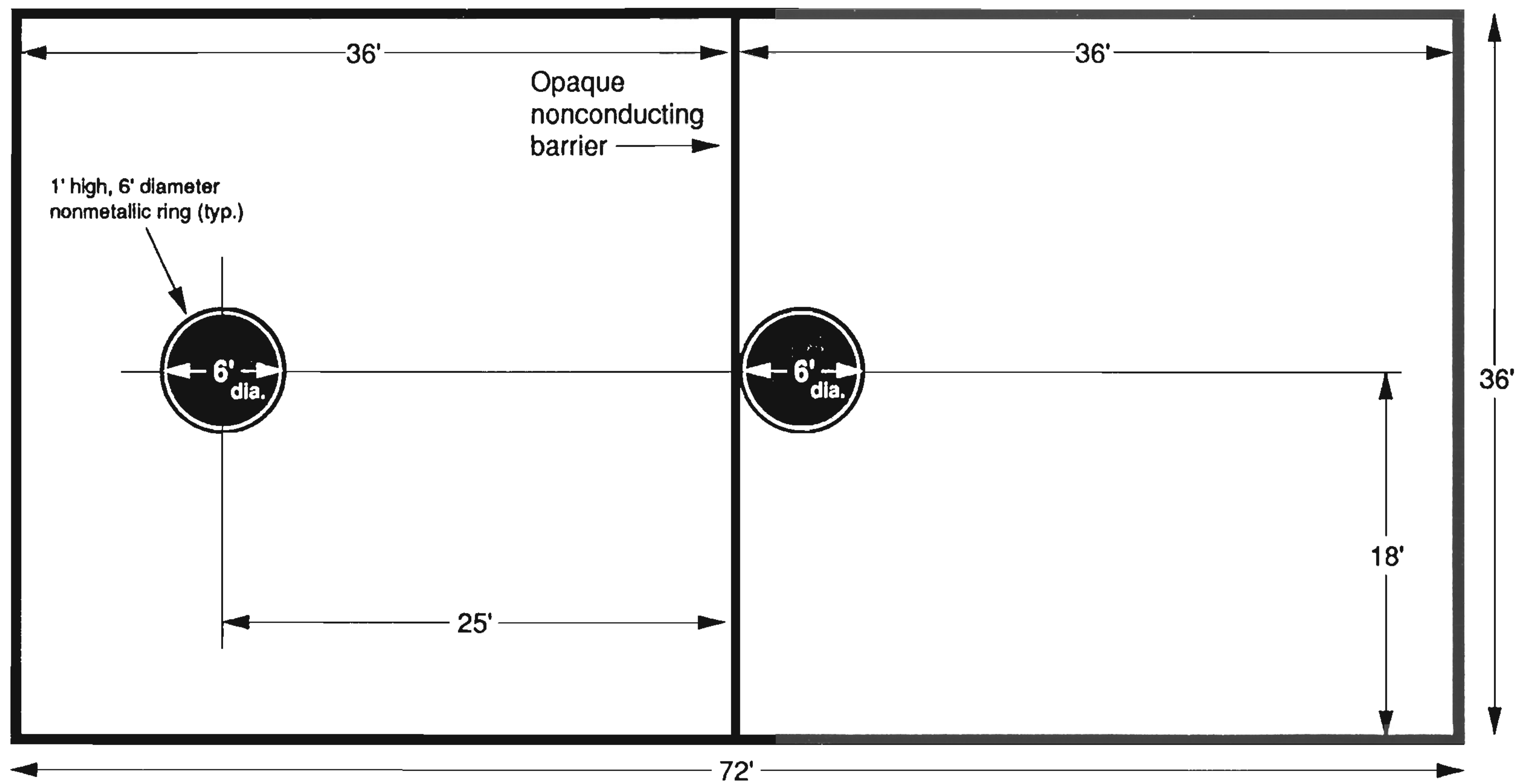
ONE POSSIBLE FLIGHT PATH





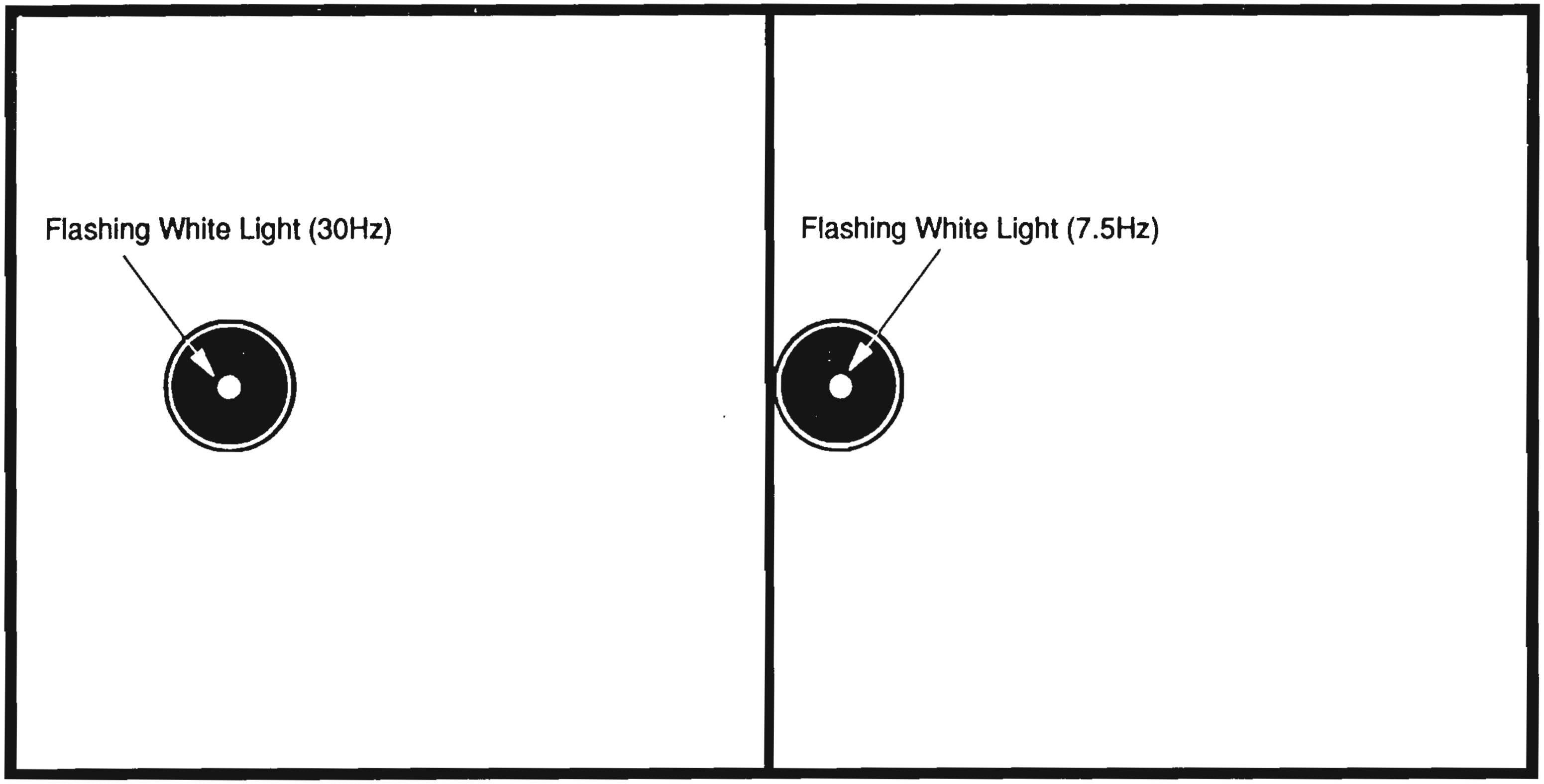
COMPETITION ARENA

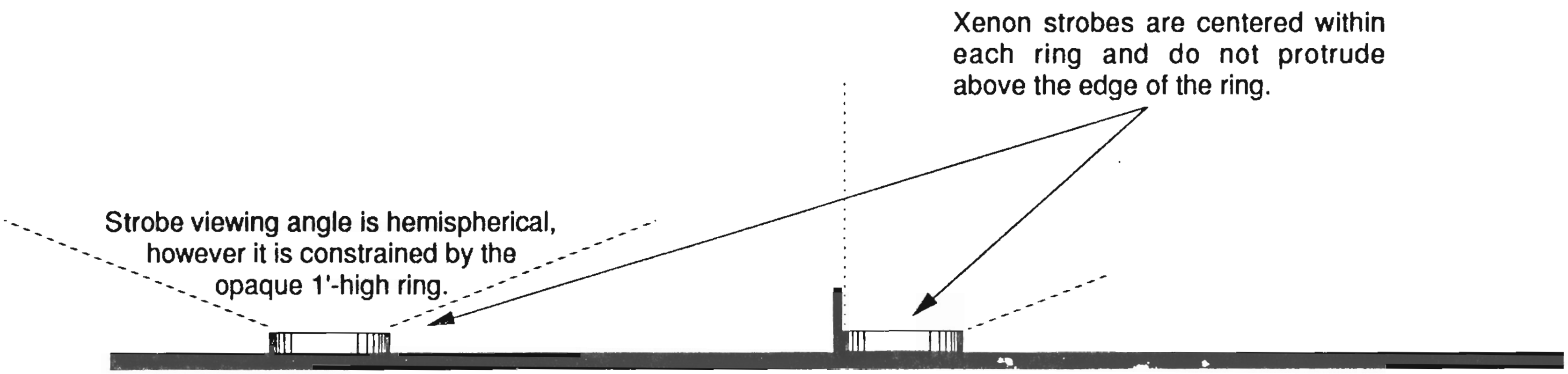
Olympic Tennis Court or Volleyball Court



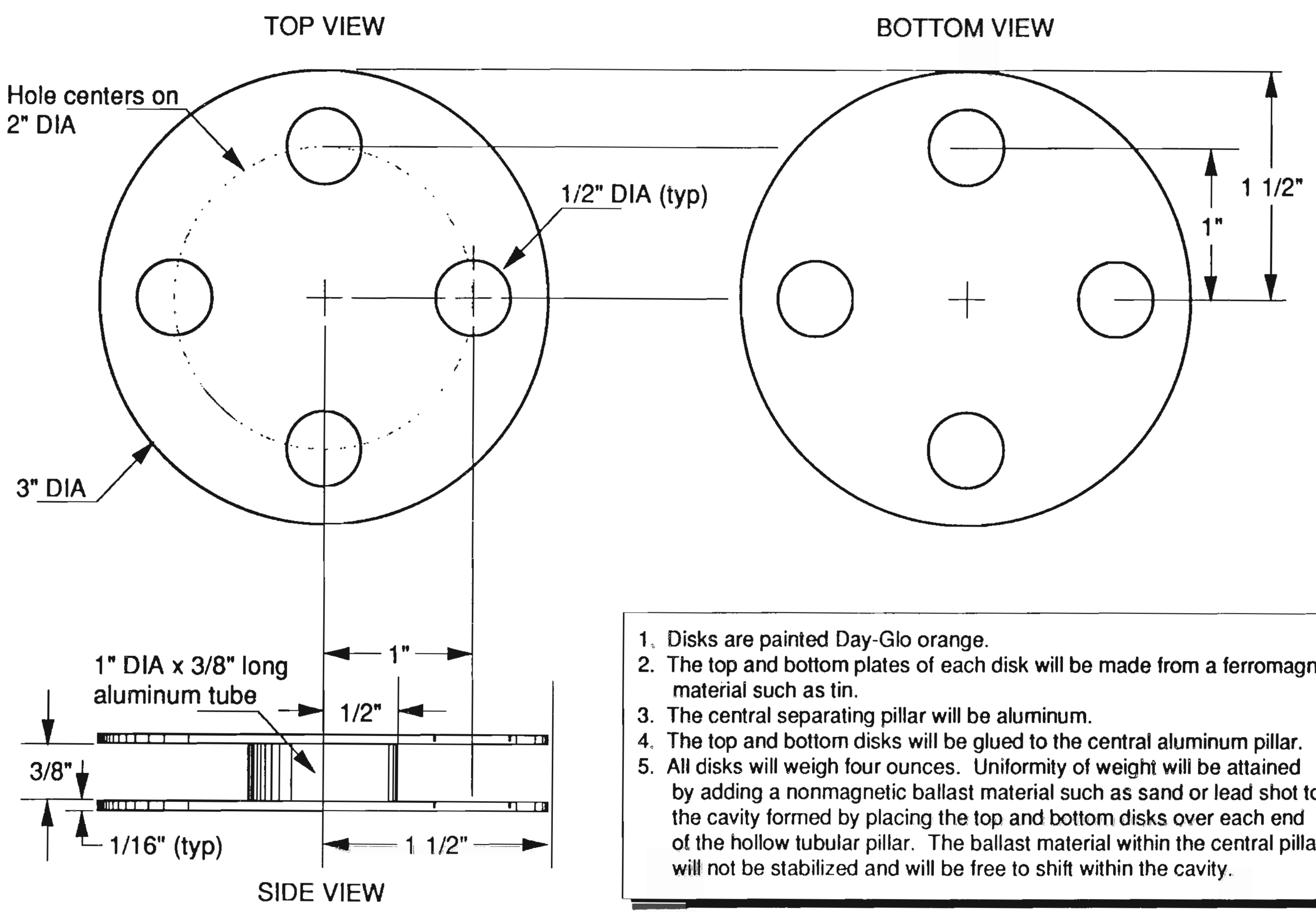
The opaque central barrier is 36' long and 3' high. The thickness of the barrier is less than 1' at all points. The entire arena is surrounded by a chain-link safety fence to a height in excess of 10 feet. The fence is offset several feet to the outside of the 36' x' 72' competition area boundary. The top of the arena is covered with a non-conducting net.

NAVIGATION AID LOCATIONS





DISK GEOMETRY



1. Disks are painted Day-Glo orange.
2. The top and bottom plates of each disk will be made from a ferromagnetic material such as tin.
3. The central separating pillar will be aluminum.
4. The top and bottom disks will be glued to the central aluminum pillar.
5. All disks will weigh four ounces. Uniformity of weight will be attained by adding a nonmagnetic ballast material such as sand or lead shot to the cavity formed by placing the top and bottom disks over each end of the hollow tubular pillar. The ballast material within the central pillar will not be stabilized and will be free to shift within the cavity.