In addition to the ground robots, there are four obstacle robots. The obstacle robots are Roombas as well, but have a 1-2 meter high pole on top. They are programmed to drive around in a circle, and are there to create havoc. If the drone touches the obstacle robots more than two times, the run will be terminated.

Our drone‘s mission is to «herd» or guide these ground robots over the green edge, and to keep them from running over any of the other edges, as shown in figure 2. It has to do this autonomously; we are not allowed to control its movement in any way. To interact with the ground robots we have two possibilities:

- Tapping a tactile button on the top of the ground robots, turning them 45 degrees, clockwise. Seen in figure
- Bumping into the groud robots from the front, turning them 180 degrees. Seen in figure

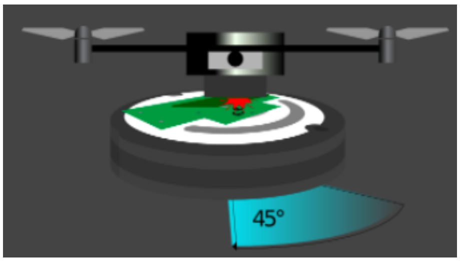

Figure 4: Drone landing on the tactile switch

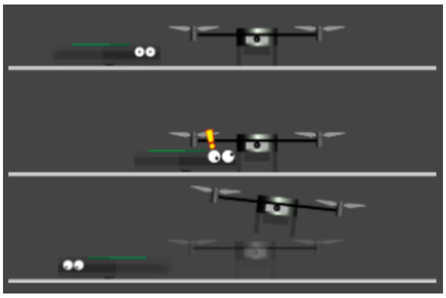

Figure 5: Drone landing in front of a ground robot

All sensors we use, have to be onboard the drone. We are allowed to have an external machine for number crunching, but other than that the drone act alone. Each run is 10 min long, and each team has three rounds each to try to complete the mission.

To complete part a of mission 7 we have to herd at least four ground robots to over the green line during one of our runs. Teams who complete part a will move over to part b. Part b is a competition between two teams, where each team have their own «goal side» and try to herd as many ground robots over their own side as possible.

2.2 Why is this a challenge?

The goal of IARC is to push the limits of autonomous flying vehicles, so what limits are they trying to push with mission 7? The organizers have set up three aspects which the participants will have to master to complete this challenge. Printed as is from the rules we have:

1. Interaction between aerial robots and moving objects (specifically, autonomous ground robots)
2. Navigation in a sterile environment with no external navigation aids such as GPS or large stationary points of reference such as walls
3. Interaction between competing autonomous air vehicles.

2.2.1 Navigation

Let‘s start with the second aspect: «navigation in a sterile environment with no external navigation aids such as GPS or large stationary points of reference such as walls». Navigation has always been a part of the IARC missions, and have been the main challenge in many of them. In mission 7 they have purposely made many of the existing navigational tools illegal or useless. As the competition is indoors we cannot use GPS, as GPS is highly unreliable indoors, and because it would break the rule of not using external navigation aids. A common technique for flying indoor which does not break this rule is SLAM. SLAM or Simultaneous Localisation And Mapping is a method using lidar or cameras where the drone continuously creates a map of its environment. SLAM works wonderfully when flying in corridors or smaller rooms, as it typically uses walls, columns and other stationary objects to localise itself. Mission 5 and 6 relied heavily on SLAM usage. Mission 7 on the other hand, is designed to render SLAM useless. As the arena is completely flat except the robots, and the robots continuously move in semi random motions, SLAM has no stationary objects navigate by. All in all, to navigate the arena new innovative tools needs to be developed.

Every square of the grid making up the arena, looks equivalent; the only unique, and stationary features in the whole mission are the corners. As two sides are white, one is blue and another is red (see figure), every corner is unique, and if the drones position relative to the corners are known, the drone knows where it is. To fly safely, all the obstacle robots needs to be avoided. The obstacle robots are programmed to drive in a 5m radius circle in the middle of the arena, but from experience, they will stray from the circle every run. On top of everything else, there is a hidden challenge in all of this. As all the sensors are onboard the drone, what we can observe varies with the position and orientation of the drone. If the drone is a couple of meters up in the air, it can observe most of the arena, however we can not be a couple of meters in the air at all times. Whenever we need to interact with the ground robots the drone has to land, and what we can observe from the cameras is highly reduced.

2.2.2 Interaction

Moving on to the first aspect: "interaction between aerial robots and moving objects". The tactile switches on the ground robots are 10cm X 10cm, the ground robots move at a speed of 0.33m/s, and their movement is only deterministic upto 5 seconds at the time. Landing on these robots and pressing the tactile switch is a challenge in its own right, but there are several other challenges to overcome before we can think about landing on the robots. First, the drone must be able to detect and track the ground robots. Then, as there is only 10 minutes to complete the mission, there is not enough time to guide the ground robots over the green line one by one. Therefore the drone needs to be able to plan the best course of action live in a highly dynamic environment. The problem can be modelled as a less known generalisation of the travelling salesman problem called Time-dependent Orienteering Problem with Time Windows (TDOPTW).

Another way of characterising the complexity of the task and environment for the classification system introduced in Russell and Norvig (2009). In the table below we can see the different aspects used to classify the different environments. The left column represents less complexity and the right column represents a higher degree of complexity. As one can see from the checkmarks, IARC mission 7 scores high on complexity on all fronts. If the system is known or unknown at the moment is arguable, but come part b and the challenge is firmly in the right column.

Fully Observable	Partially Observable ✓
Single agent	Multiagent ✓
Deterministic	Stochastic ✓
Episodic	Sequential ✓
Static	Dynamic ✓
Discrete	Continuous ✓
✓ Known	Unknown ✓

Figure 6: AI-environment classification table

These challenges encompasses all of Ascend's technical groups.

2.2.3 Impact and scalability

Solving the challenges above would help break new ground in robotics within many fields that could create useful technology for the society. The competition is closely monitored by stakeholders of any kind looking to find the next big thing within robotics. Specifically, the tasks revolve around solutions for herding autonomous units with flying autonomous units but looking at the bigger picture the technologies developed could be used in any kind of industry.

3 Mist 2018

The drone for the IARC competition 2018 is illustrated in a rendered picture in figure 7. The completed drone is planned to be finished with testing and ready for competition by the 15. of March. Between the 15. of March and the competition in July the drone will only be updated with optimization solutions, but no major changes will be applied to the drone. The color of the drone has not been decided yet so the figures colors vary between black and red. Figure 8 shows the drone in a real life photo. In this paper, mainly