# Multicopter Ardea

Multicopters offer rescue workers in disaster scenarios a good opportunity to get a quick overview of dangerous operation areas.

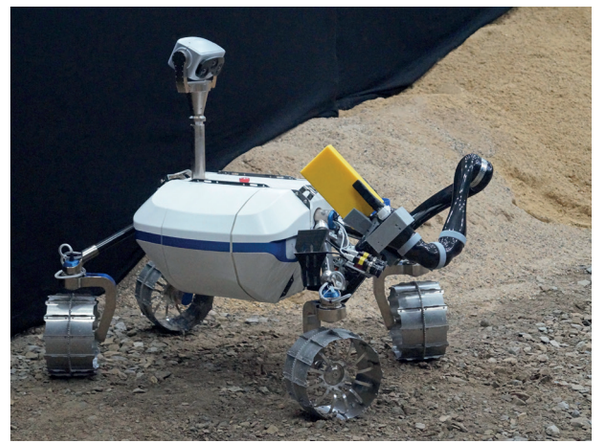
This involves special challenges: flying robots must be stabilised by an onboard computer at any time. The flight systems have to move without collisions in unknown terrain with obstacles, where navigational aids like GPS are often not available. Since there is no guarantee for a stable radio connection to the ground station, it is necessary to have all sensor data for navigation processed directly on board the flight system and to conduct missions completely autonomously.

The severe payload limitation allows the system to carry only limited computational resources. A combination of cameras and inertial sensor technology onboard the flight system offers the opportunity of a robust autonomous navigation for exploring unknown hazardous areas.

# Lightweight Rover Unit (LRU)

The institute's Lightweight Rover Unit (LRU) is the prototype of a semi-autonomous robot for the exploration of the Moon or Mars. It combines a multitude of state-of-the-art technologies that have been developed at the institute, such as drive and steering units, the motors of which have already proven their space-worthiness during the ROKVISS experiment on the ISS over a period of five years.

A stereo camera and the repeatedly awarded Semi-Global Matching stereo technique render the robot capable of perceiving its environment in 3D. Based on its perception, the rover computes maps of the environment and subsequently autonomously approaches predefined targets in unknown and rough terrain. This autonomous navigation is important since signals from Earth take many seconds or even minutes, thus hampering direct remote control. The extension of the LRU with a robotic arm enables manipulation of known and unknown objects.



## LRU: data overview

| | |
|---|---|
| **Size** | - Footprint: 114 x 74 cm<br>- Ground clearance: 23 cm<br>- Camera height: 94 cm |
| **Weight** | Circa 30 kg |
| **Nominal payload** | 5 kg |
| **Powersupply** | Two battery packs with 28.8 V, 5 Ah each |
| **Degrees of freedom** | 4 wheel actuators<br>4 steering actuators<br>2 series elastic body joints |
| **Actuators:**<br>**RoboDrive ILM38x06 BLCD**<br>**Harmonic Drive HFUC11-100** | Nominal output torque: 5 Nm<br>Momentary peak torque: 5 Nm<br>Repeated peak torque: 11 Nm<br>Momentary peak torque: 25 Nm |
| **Speed** | 1.11 m/s, that means 4 km/h |
| **Sensors** | - PanTilt Unit with B/W stereo camera and color camera for scientific usage<br>- Inertial Measurement Unit<br>- In each joint, measurement of current, voltage, temperature, rotational speed, position (incremental)<br>- Steering and bogie have absolute sensors |
| **Operating time** | - 60 minutes with one battery pack<br>- 120 minutes with both battery packs |
| **On-board computer** | - i7 Mini ITX CPU board, Linux RTOS operating system, Links-and-Nodes real-time framework (DLR-RM), ROS non real time parts, EtherCAT Bus System with control frequency 1kHz |

## Multicopter: data overview

| | |
|---|---|
| **Size** | - Footprint: 68 × 68 cm<br>- Height: 30 cm |
| **Take-off weight** | - Without battery: 2.05 kg<br>- With battery: 2.65 kg |
| **Maximum thrust** | 3.6 kg |
| **Flight time** | Circa 10 minutes at 2.65 kg weight |
| **Sensors** | - VRmagic VRmMFC camera base unit and 4 x VRmS-16/C-COB (1280 x 960 px) cameras with wide angle lenses (125° × 80°), total field of view: 180° × 80°<br>- Analog devices ADIS16407 IMU (accelerometer, gyroscope, magnetometer, barometer) |
| **On-board hardware** | - Intel NUC5i7RYH – Intel Core i7-5557U (dual core @ 3.1 GHz) for computer vision, mapping, path planning, high-level tasks<br>- Xilinx Spartan6 FPGA for stereo computation<br>- BeagleBone Black with Linux realtime kernel, running the autopilot at 500 Hz control rate<br>- OpenMesh OM2Pv2 wireless router (2.4 GHz) with OpenWRT Firmware |
| **Navigation** | - FPGA-accelerated Semi-Global Matching (SGM) dense stereo computation Fusion of IMU data and visual odometry for egomotion estimation with time delay compensation (~ 400 ms vision pipeline delay) |

Automatica_LRU Ardea_GB_06/2016

## DLR at a glance

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

DLR has approximately 8000 employees at 16 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

DLR **Deutsches Zentrum für Luft- und Raumfahrt**
German Aerospace Center

**Institute of Robotics and Mechatronics**

**LRU**
Dr. Armin Wedler
Muenchener Strasse 20
82234 Wessling
Germany
Phone: +49 8153 28-1849

**Multicopter**
Teodor Tomic
Muenchener Strasse 20
82234 Wessling
Germany
Phone: +49 8153 28-3820

mobilerobots.DLR.de

mobilerobots.DLR.de

# Lightweight Rover Unit (LRU) and Multicopter Ardea

Mobile exploration

DLR