Goals

Assignment Overview

Tasks

Logistics

ESELU
Term Project Assignment

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182.722 Embedded Systems Engineering LU

November, 2013

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Disclaimer

Beside exercises, this is most novel part of ESELU.
Expect problems. Give feedback. Have fun.

Goals
Assignment Overview
Tasks
Logistics

ESELU Term Project (meta)Goals

- introduction to state-of-the art design tools used in research & industry
- model (real-time) systems to control 'the environment'
- decomposition + platform allocation
- component/system design
  - non-functional properties: fault tolerance, security, safety
  - control theory
  - sensor fusion: confidence weighted averaging, Kalman filtering, ...
  - artificial intelligence: localization, planning, ...
- verification/testing

opportunity to reach these goals by doing something **relevant**

ESELU Term Project Tasks Overview

- target platform introduction
- create a simulation environment
- implement attitude and altitude flight controllers
- self chosen aspect (focus)

Goals
Assignment Overview
Tasks
Logistics

Target Platform: AscTec Pelican

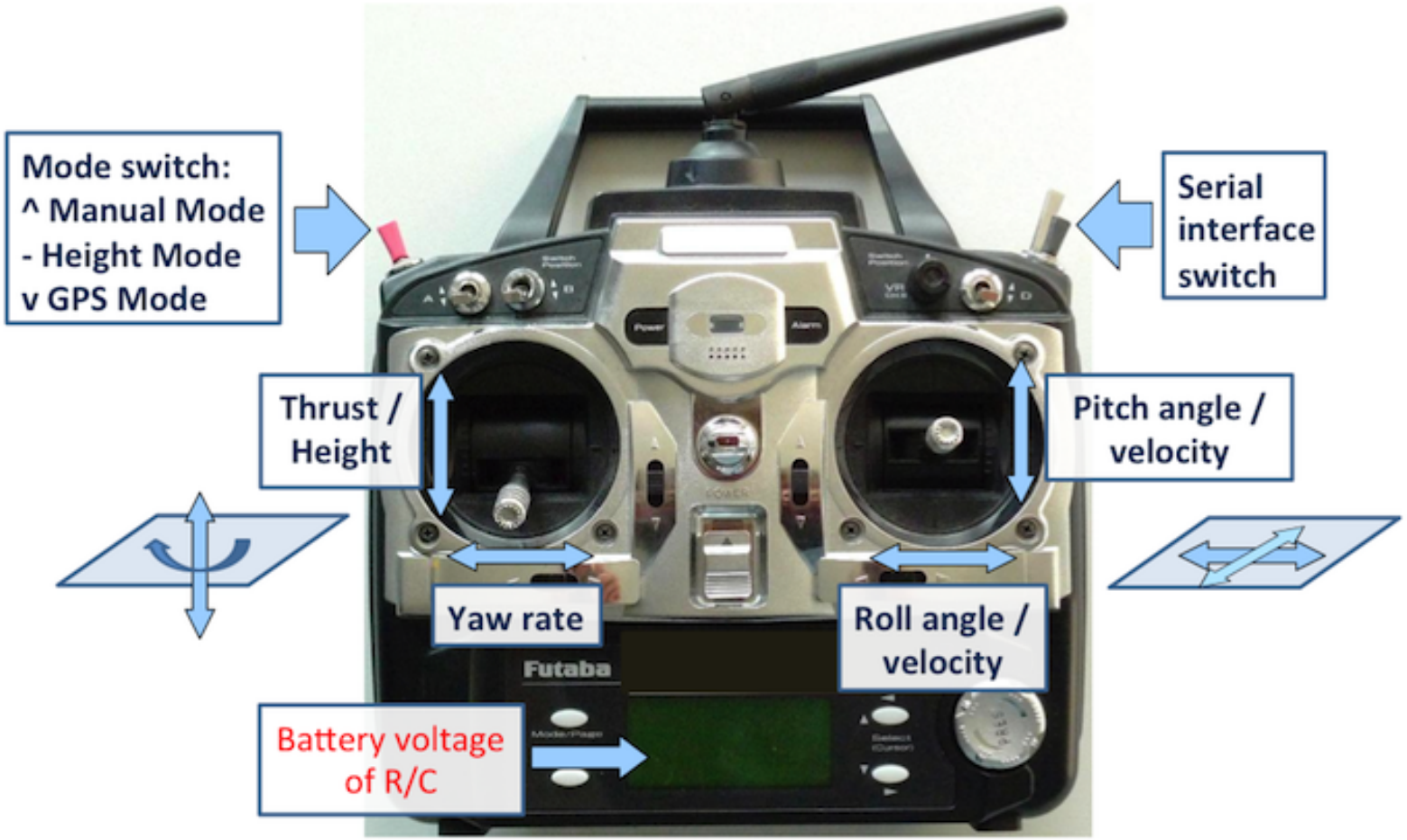
- 'professional' quadrotor/quadcoptor: well tested, extensible research platform
- brushless motor driven, 10" propellors, max. payload 650g

Target Platform: AscTec Pelican, Overview

- product link:
  http://www.asctec.de/uav-applications/research/products/asctec-pelican/
- developer wiki (incl. SDKs, manuals, ...):
  http://wiki.asctec.de/xwiki/bin/view/Main/
- base features:
  - autopilot sensor board (accelerometer, gyroscope, pressure sensor, low-level and high-level control systems)
  - magnetometer
  - GPS receiver
  - Futuba R/C
  - X-bee Pro, Datalink
  - 6100mAh, 11.1V, LiPo battery pack, 450g
- autopilot high-level controller programmable
  - C programs, API and SDK available
  - Simulink models

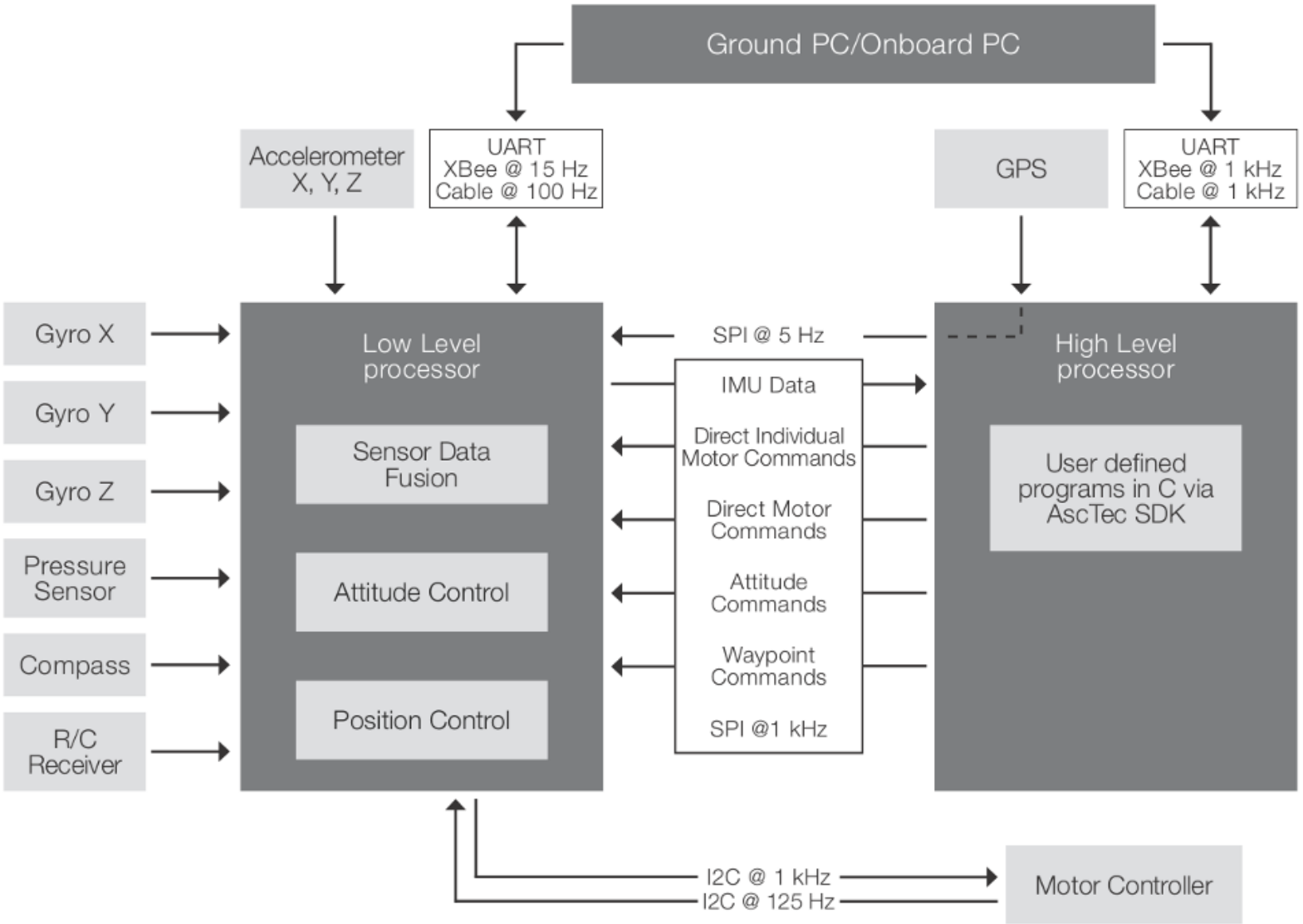
Target Platform, AscTec Pelican, R/C Controls

AscTec: *"It is mandatory to provide a safety pilot during the tests of your control algorithms."*



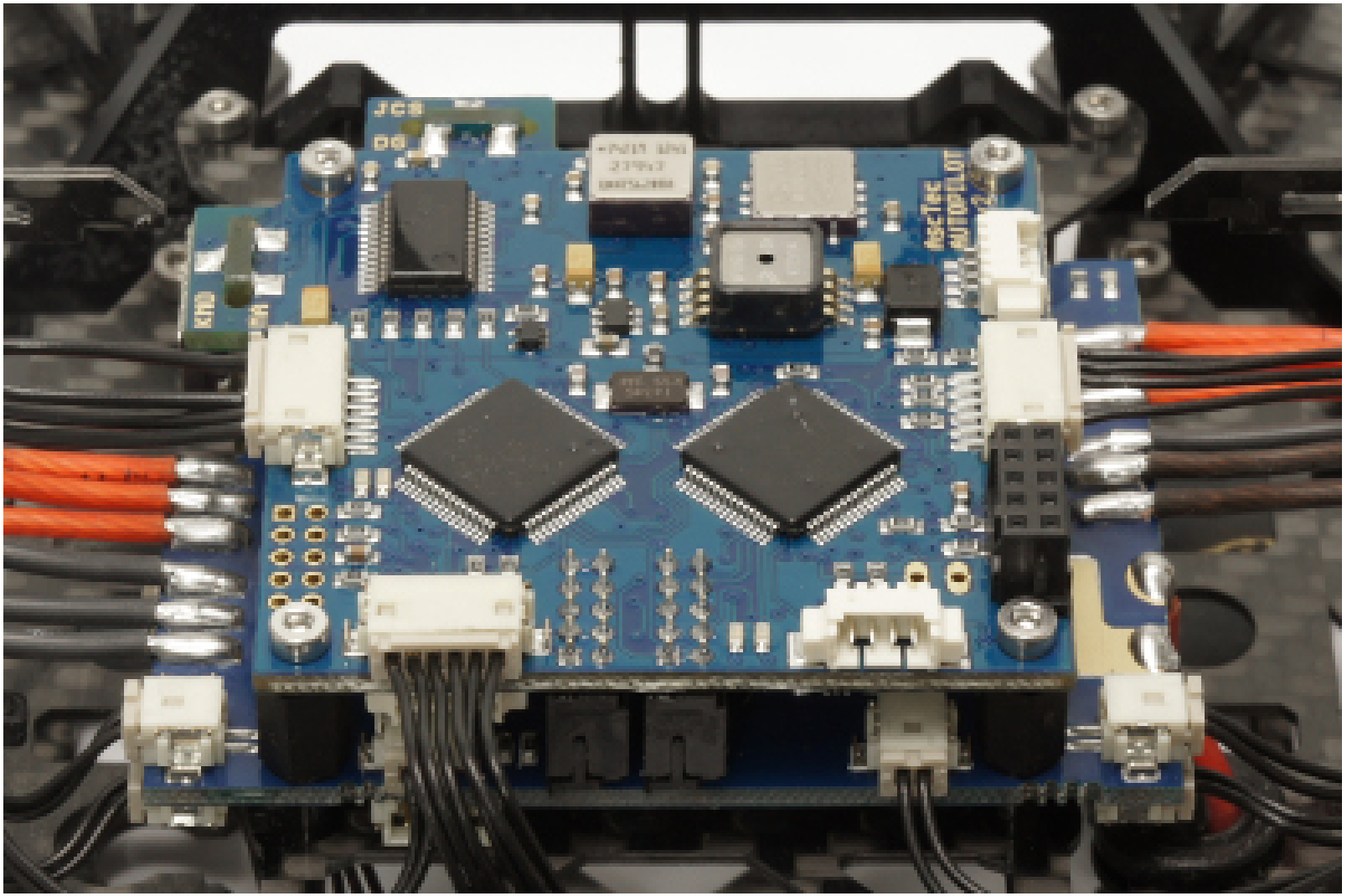
Goals
Assignment Overview
Tasks
Logistics

Target Platform, AscTec Pelican, Autopilot Board



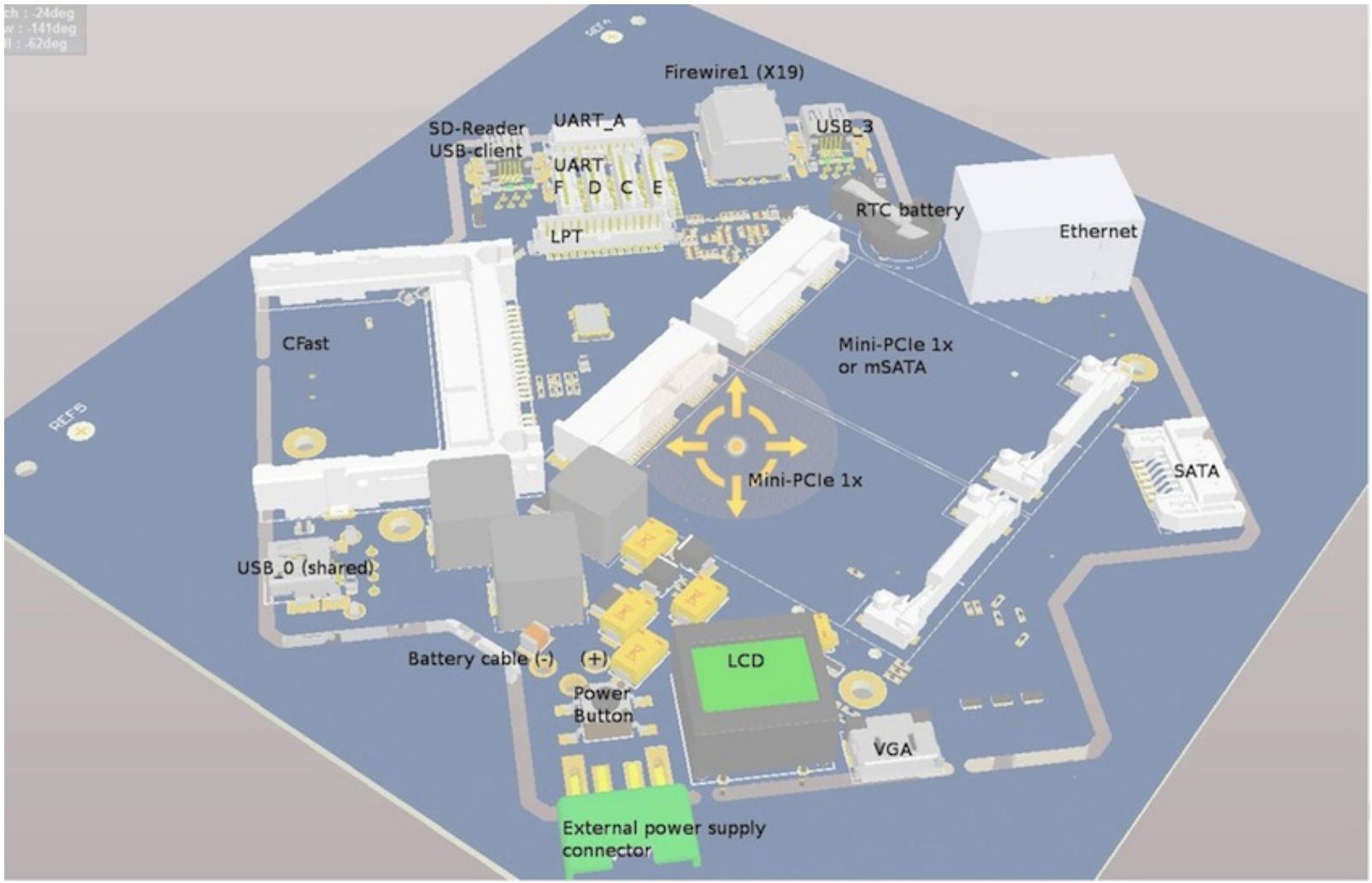
Goals
Assignment Overview
Tasks
Logistics

Target Platform, AscTec Pelican, Autopilot Board



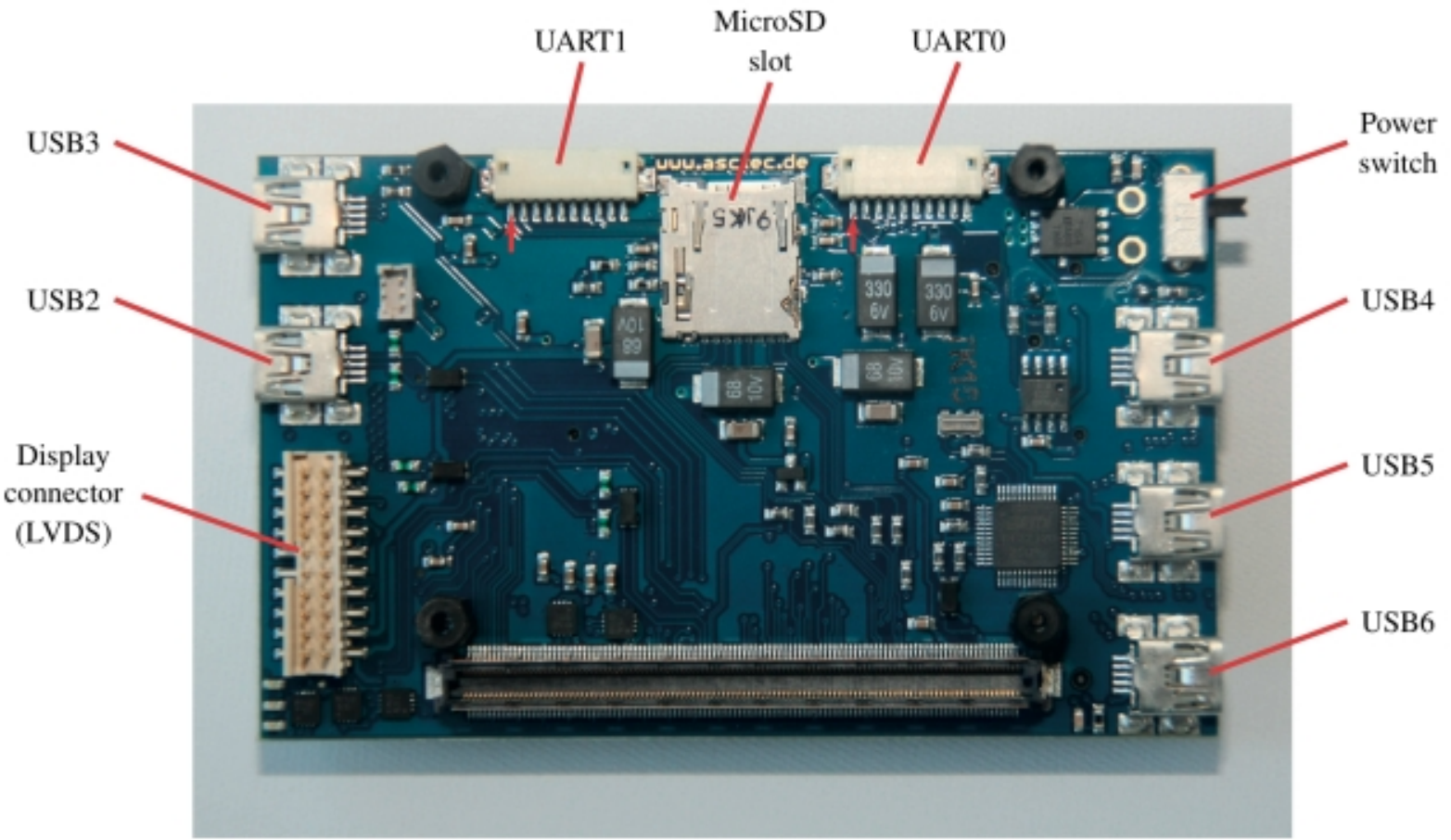
Target Platform, AscTec Pelican, PELICAN 1

- Camera, 1/3" CMOS, 752x480 @ 90 fps, 8-bit MONOCHROME, 50g
- Intel® CoreTM i7-3612QE (4 x 2.1 GHz), Linux system

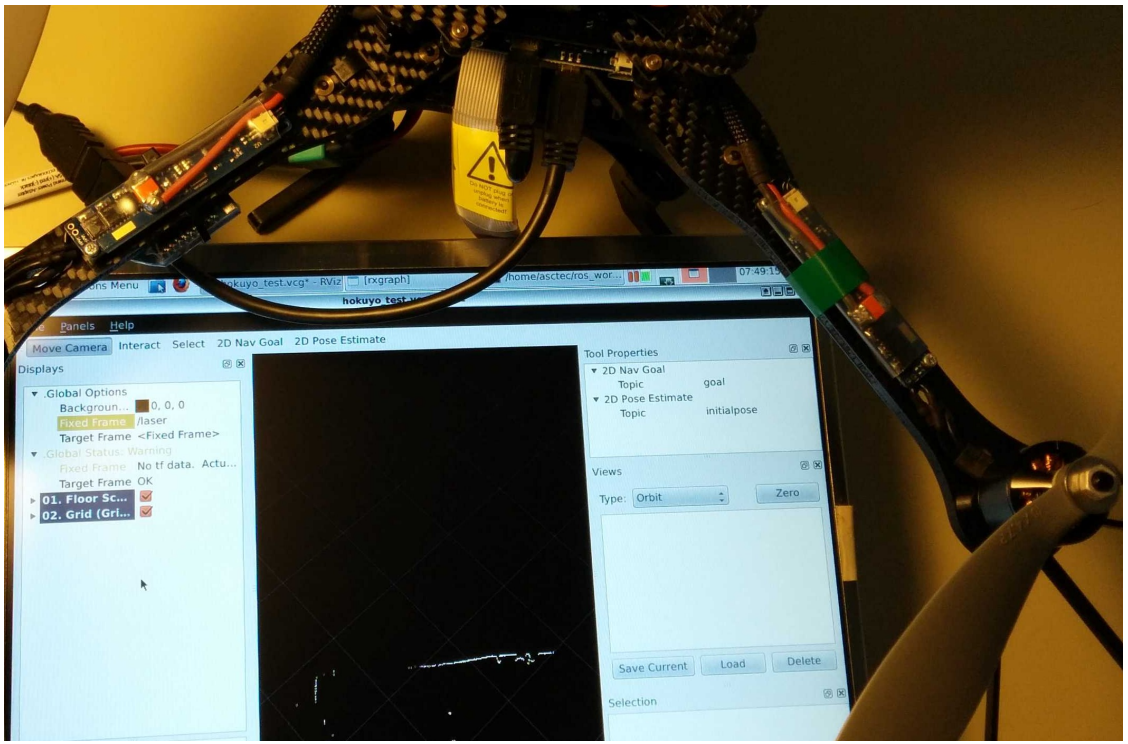


Target Platform, AscTec Pelican, PELICAN 2

- Hokuyo URG 04LX laser range finder, detection range: 0.06 - 4 m, 10 Hz, measuring area: 240°, angular resolution: 0.36°, 190 g
- 1.6 GHz Intel Atom processor board, 1GB DDR2 RAM, Linux system



Target Platform, AscTec Pelican, Application Board



- capable to run Ubuntu Desktop (!) and various (partly Wine-emulated (!!)) GUI tools
- serial interface to Autopilot board: access to all sensors and motor control
- Google ROS nodes preinstalled (`www.ros.org`)
- high-speed interface: wireless LAN access point

Task 1: Simulation Environment

- model or (refactor existing) quadcoptor dynamics in Simulink
  - vast amount of literature + many implementations available
  - choose something 'adequate', i.e., you should be able to comprehend/explain the modeled system dynamics
- model sensors (ranges, error, noise, . . .)
- basic visualization in Simulink
- utility functions to do plots (movement, forces, . . .)
- obtain and process inputs from joystick

Task 2: Attitude and Altitude Flight Controllers

- consider that flight control algorithms need to run on microcontrollers:
  - discrete time
  - fixed-point instead of floating point number format
- choose adequate controllers to keep
  - orientation
  - altitude (assuming we have an altitude sensor)
- partial flight controller: able to 'accurately' hold an altitude
- full flight controller: able to 'accurately' steer drone within simulation environment

Goals

Assignment Overview

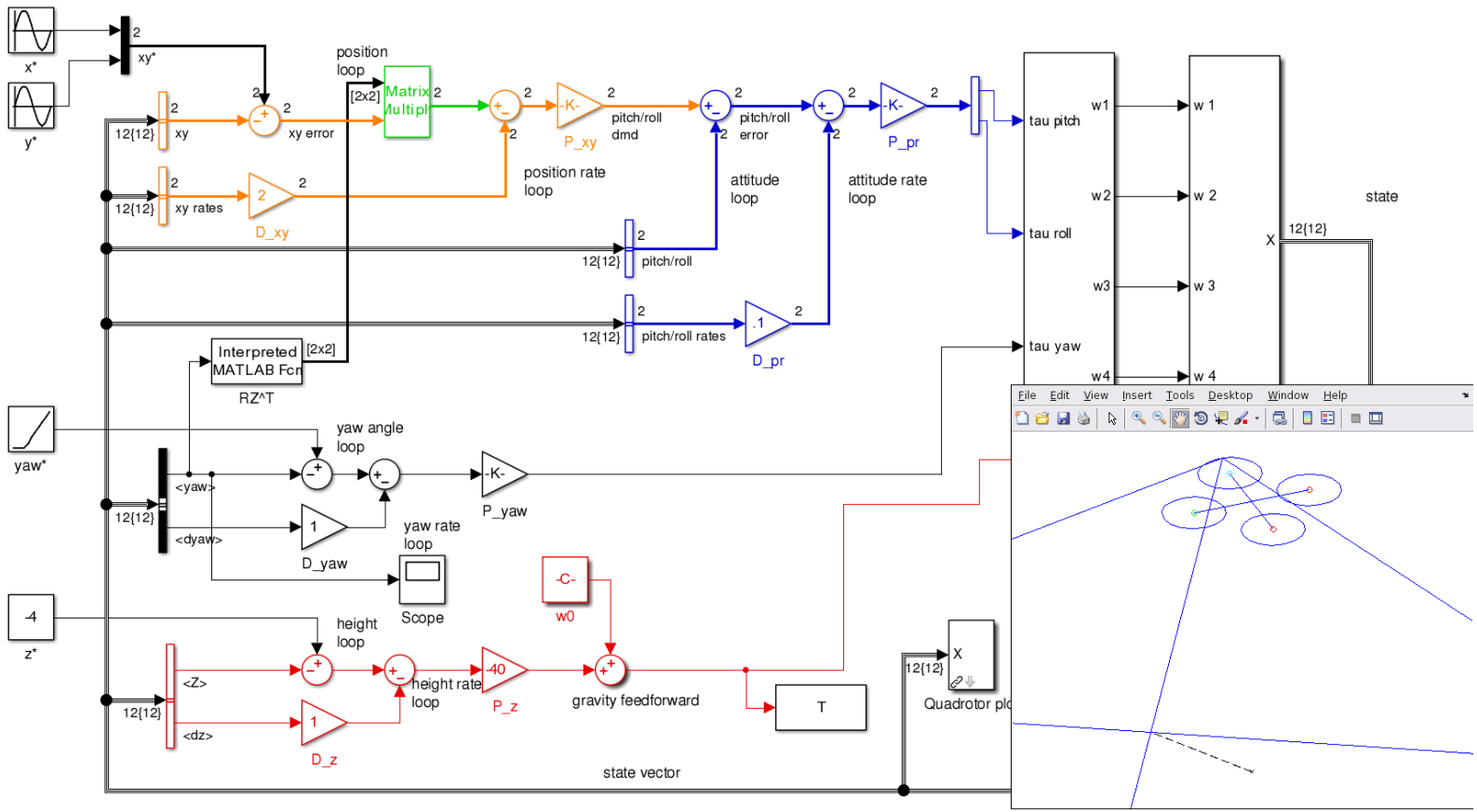
Tasks

Logistics

Exisiting Simulation Frameworks (1)

Robotics Toolbox, Peter Corke,

http://petercorke.com/Robotics_Toolbox.html



Goals

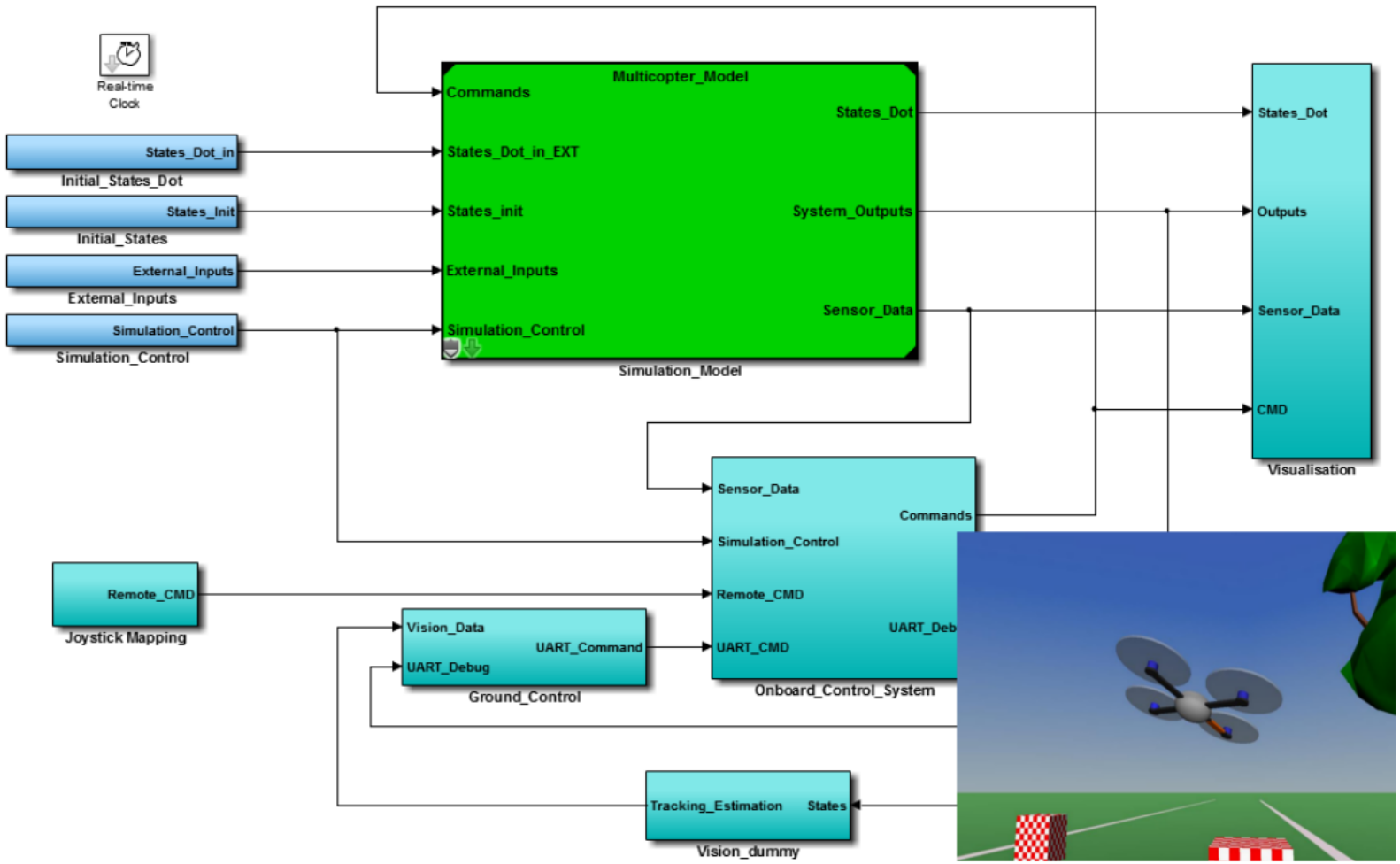
Assignment Overview

Tasks

Logistics

Exisiting Simulation Frameworks (2)

proprietary simulation framework of AscTec drones by Technische Universtät München, Institute of Flight Systems Dynamics, Special thanks to Thomas Raffler



Goals

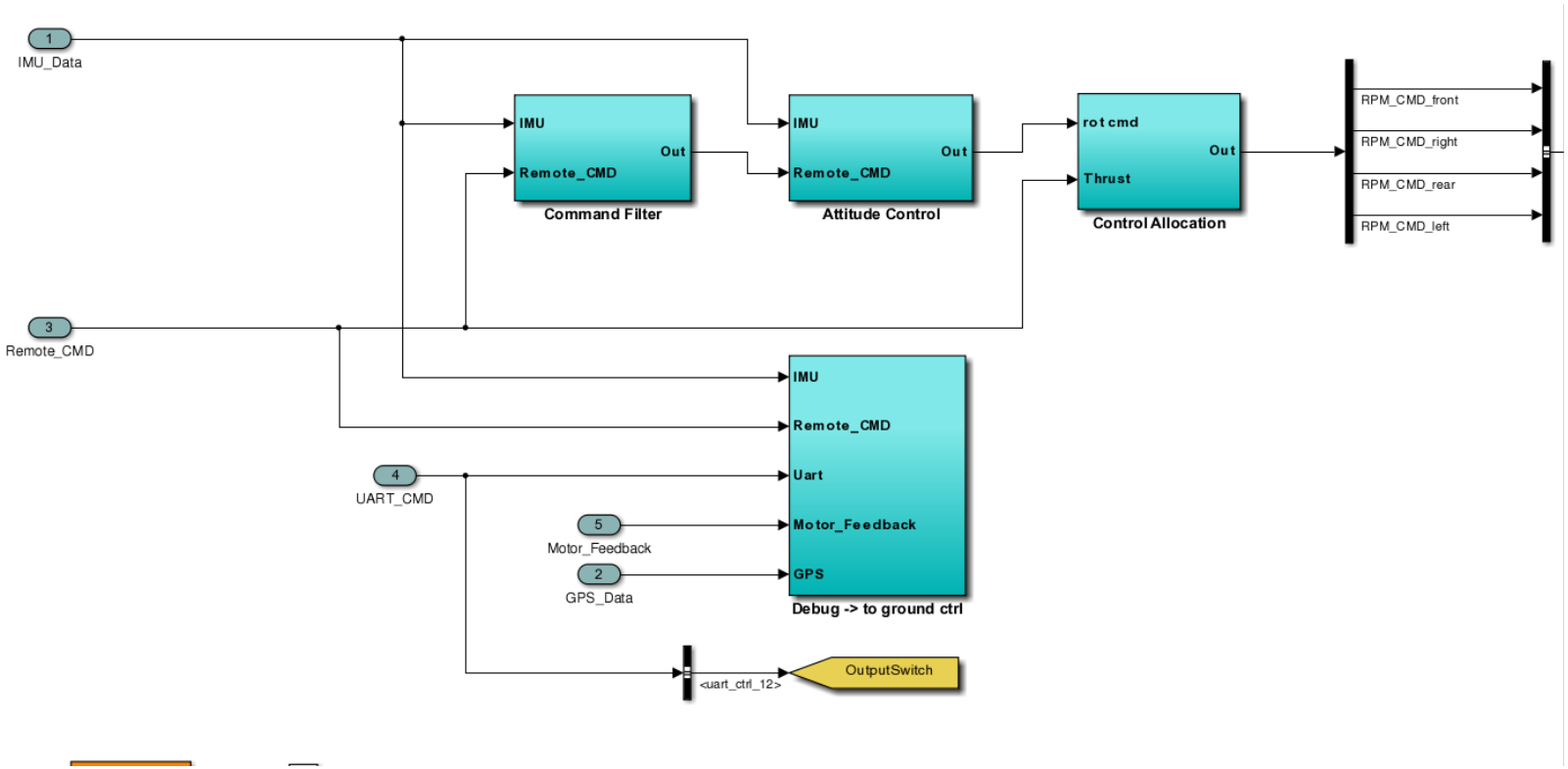
Assignment Overview

Tasks

Logistics

Existing Simulation Frameworks (3)

simple sample flight controller (incl. in AscTec Simulink Toolkit)



Task 3: Self-Chosen Aspect

- should be related to quadrocopter drones and lecture contents
  - no restrictions concerning tools/programming languages: use whatever you want
  - some restrictions concerning additional materials: money & availability
- examples:
  1. document and present the AscTec Pelican drones incl. optional equipment and ROS-based demos
  2. advanced simulation environment (obstacles, weather, flightgear visualization, ...)
  3. laser scanner + localization via particle filter
  4. sensor fusion: camera image + accelerometers + magnetometers + GPS
  5. search & rescue mission planning
  6. design, manufacture and test FPGA-based application PCB
  7. implement certifiable flight controller in Scade
  8. more ideas:
     www.youtube.com/watch?v=w2itwFJCgFQ

Procedure

- use version management (e.g., Github)
- simulation environment and flight controller
  - use (and credit) existing material (papers, quadrocopter Simulink models, . . .)
  - deadline: 24.01.2014 (hard)
- self chosen aspect
  - agree on topic within group
  - write a proposal (max. 1 A4 page) and send by email to: froemel@vmars.tuwien.ac.at
    - define problem statement and solution methods
    - include list of additional tools/materials you need
    - carefully limit the scope (only 25h per person!)
    - deadline: as soon as possible (within 2013)
  - await proposal feedback/acceptance
  - deadline: 24.01.2014 (firm, TI-lab access ends on 30.01.2014)
  - opportunity to carry on:
    `Embedded Systems Engineering Project, 6.0 ECTS`

Expected Results & Grading

- documentation/lab protocol
  - single PDF document, keep it short
  - sections: introduction, concepts and background, <self-chosen aspect>, implementation, conclusion, appendix: spent effort per person/task, references
- delivery talk on 24.01.2014
- optional: present results in front of CE institute audience
  $\Rightarrow$ easy ticket to find master-thesis topic & supervisor
- grading: documentation + delivery talk
  - 25%: simulation environment, partial flight controller
  - 50%: simulation environment, full flight controller
  - 100%: everything from above + self-chosen aspect

Goals

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Tasks

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Sources

All graphics/photos of AscTec drones (c) by AscTec, Germany.