# The JAviator Project

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Computer Sciences Workshop '06

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# Introduction

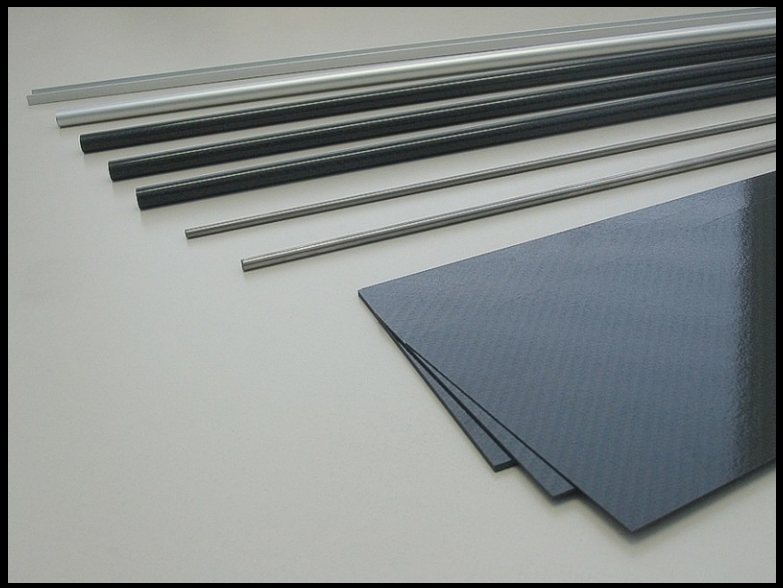
- Collaborative research project of the
  - Computational Systems Group, Department of Computer Sciences, University of Salzburg
  - IBM T. J. Watson Research Center, Hawthorne, New York, USA

- Primary project goals are to
  - develop high-level real-time and concurrent programming abstractions for Java
  - provide an infrastructure that is time-portable
  - verify the system on an unmanned aerial vehicle

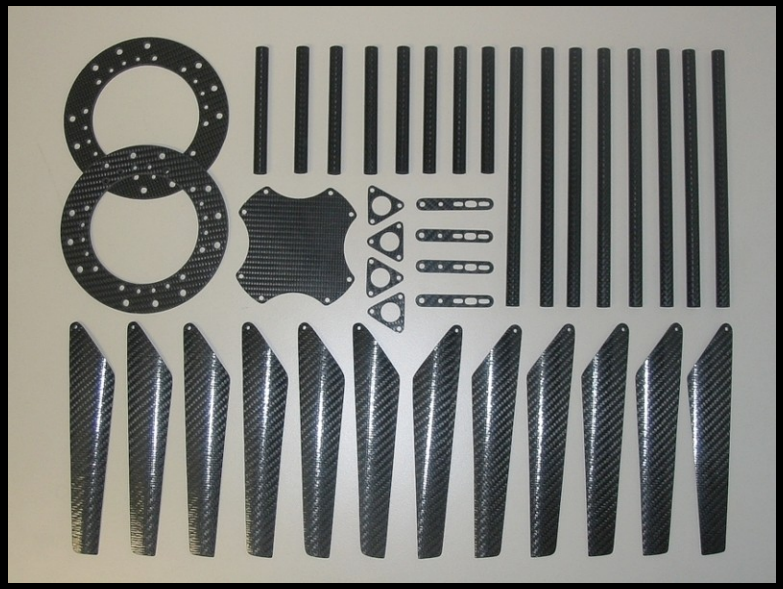
# The JAviator (Java Aviator)

- Self-made 4-rotor model helicopter
  - build of high-quality materials like carbon fiber, aluminium, and titanium
  - equipped with custom-made 3-phase motors
- Technical data:
  - 1100 mm total diameter
  - 1600 g total weight
  - 4000 g maximum thrust
  - 1500 g maximum payload
  - 20 min average flight time

# Basic Components



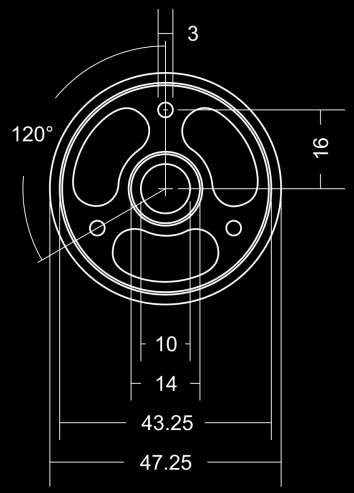
# Machined Components

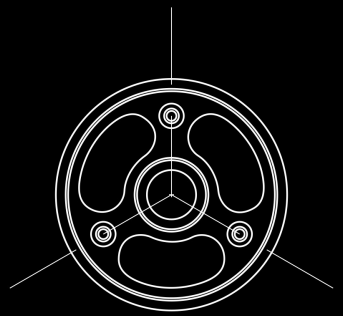


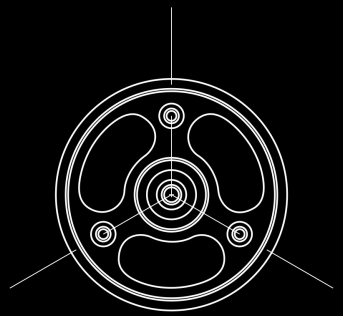
# 3-Phase AC Motors

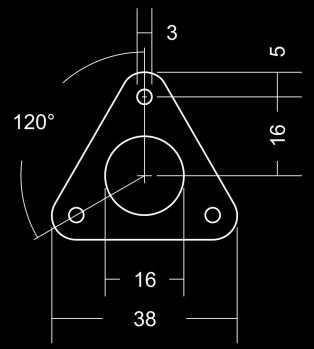
- Technical data:
  - 30 mm diameter
  - 30 mm height
  - 250 W max power (17 A at 15 V DC)

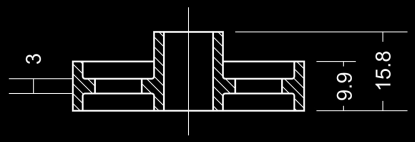

# Rotor Design

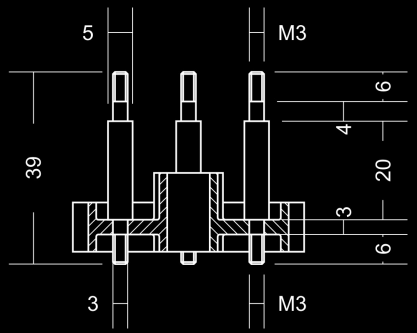


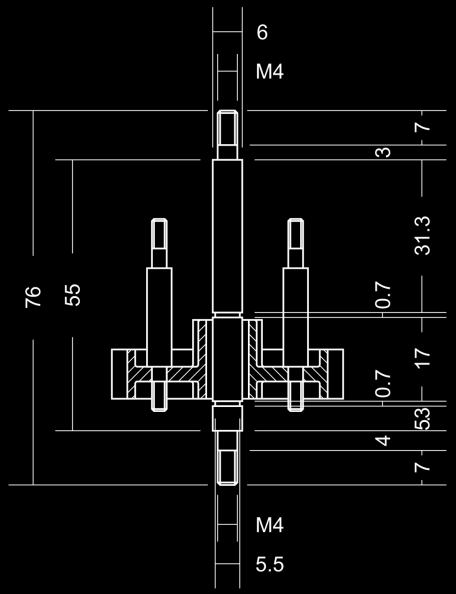







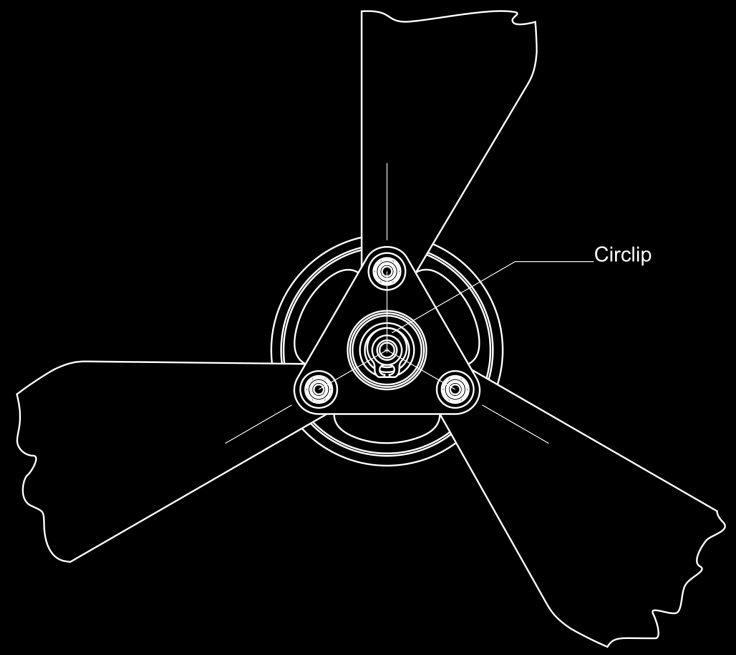



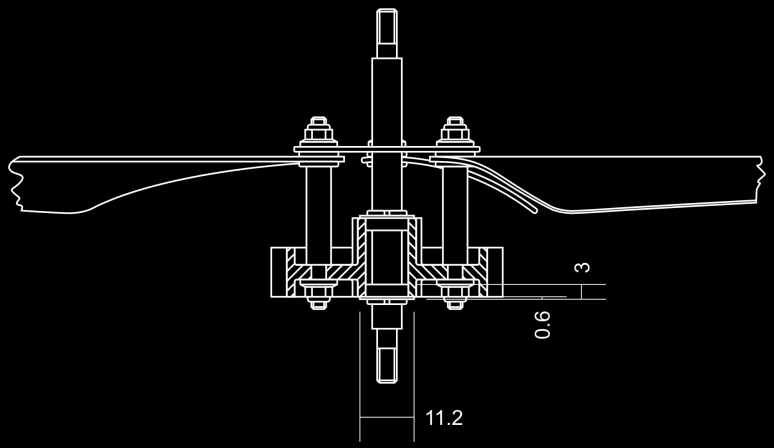



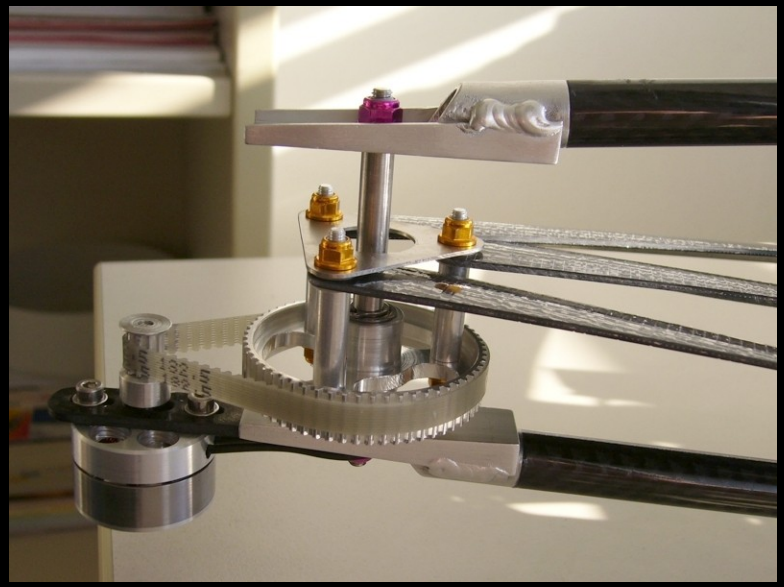




Gear: Aluminium Alloy
Shafts: Aluminium Alloy
Axle: Titanium Alloy
Triangle: Titanium Alloy

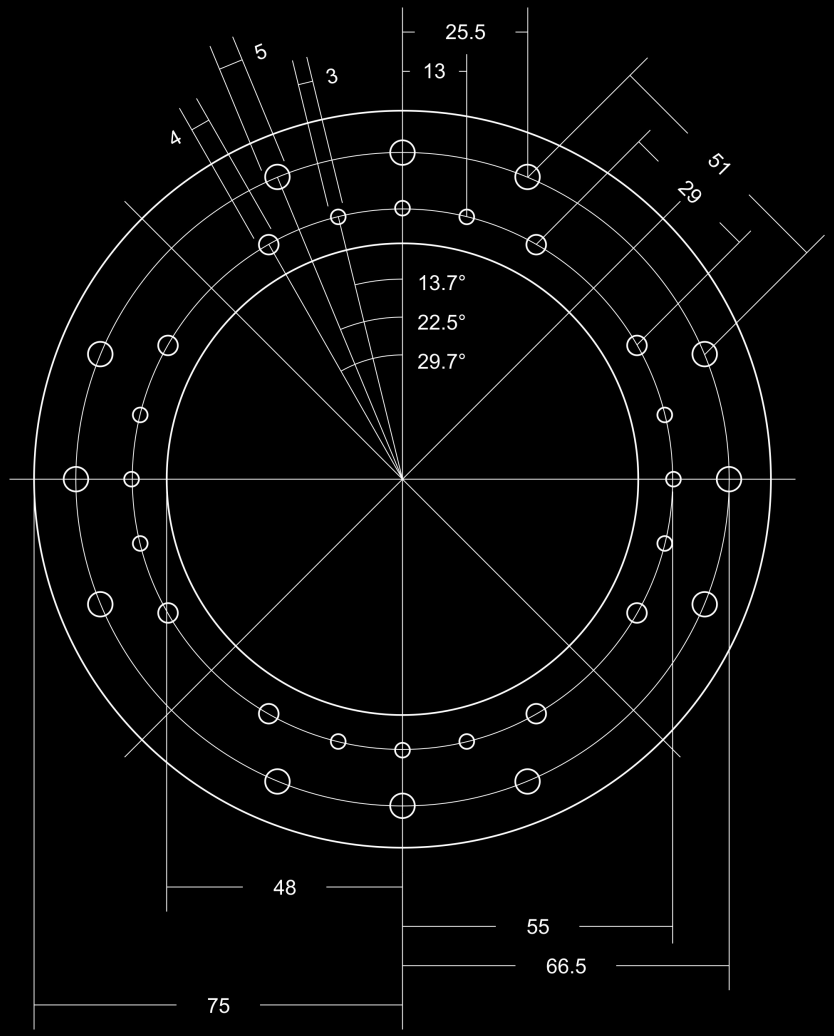
# JAviator Rotor

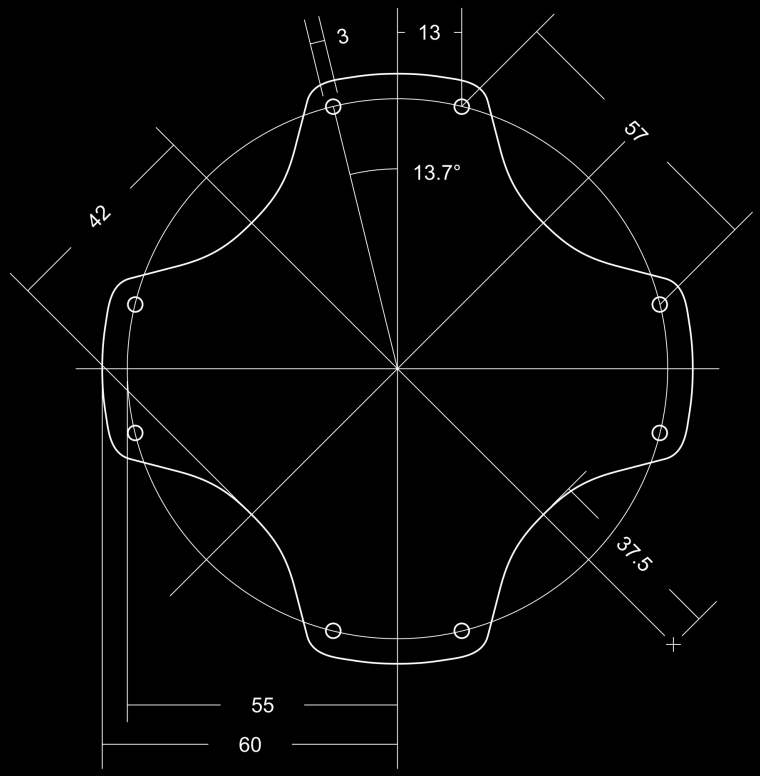


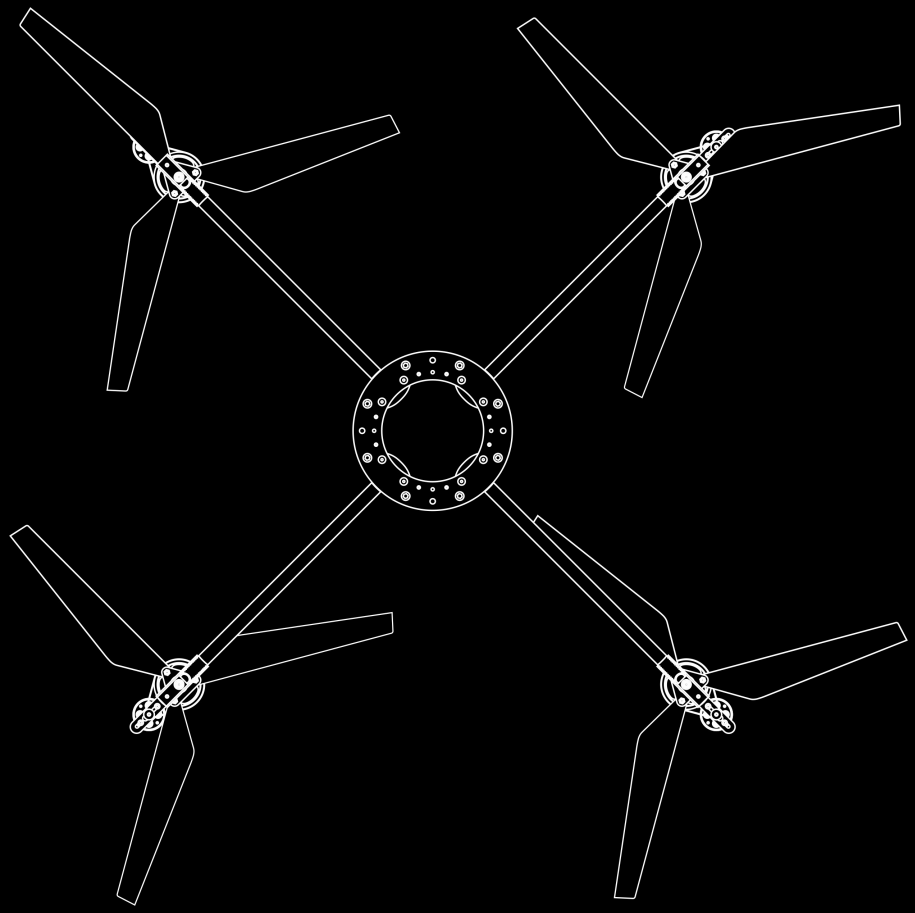



# Fuselage Design

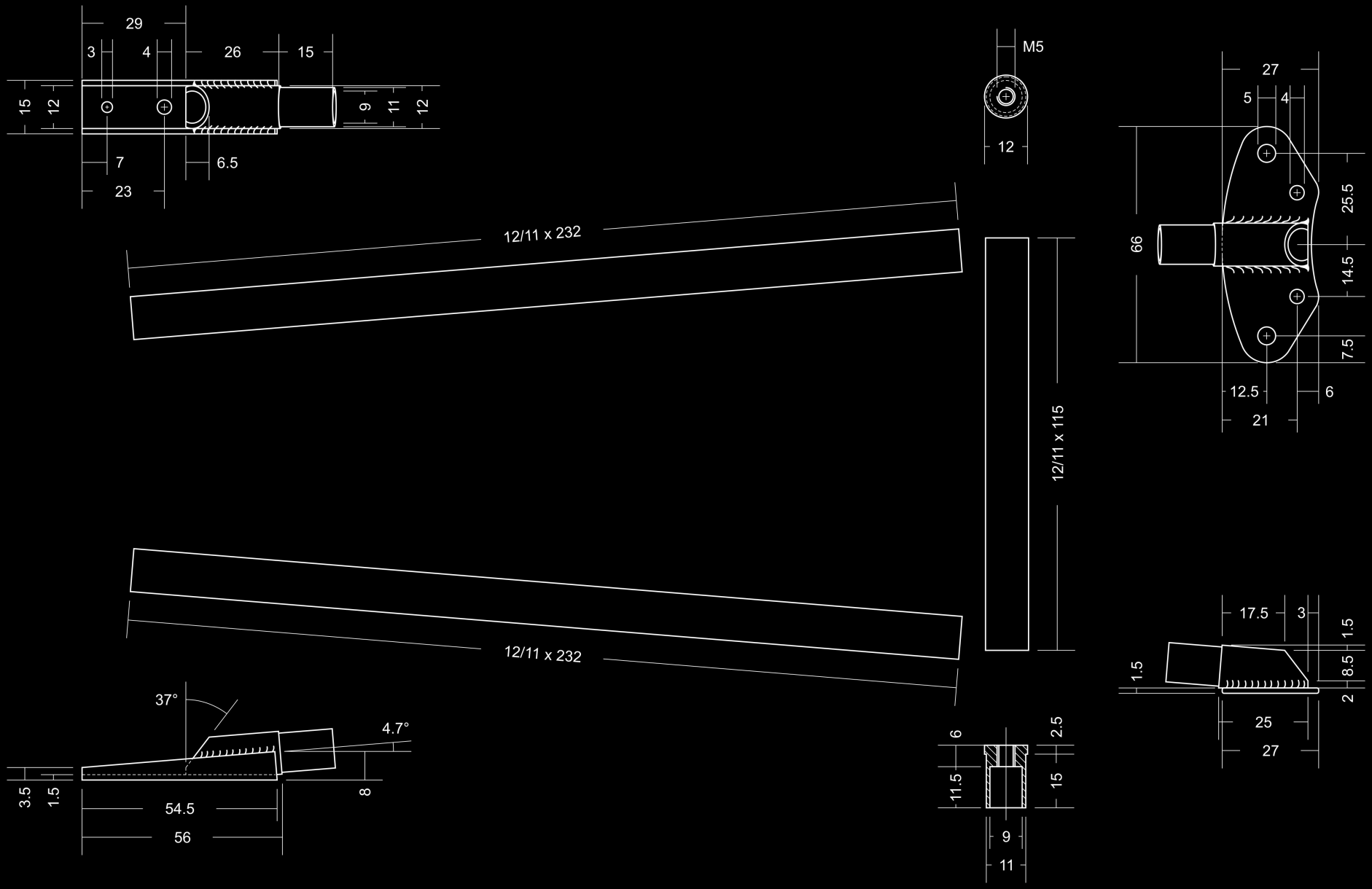


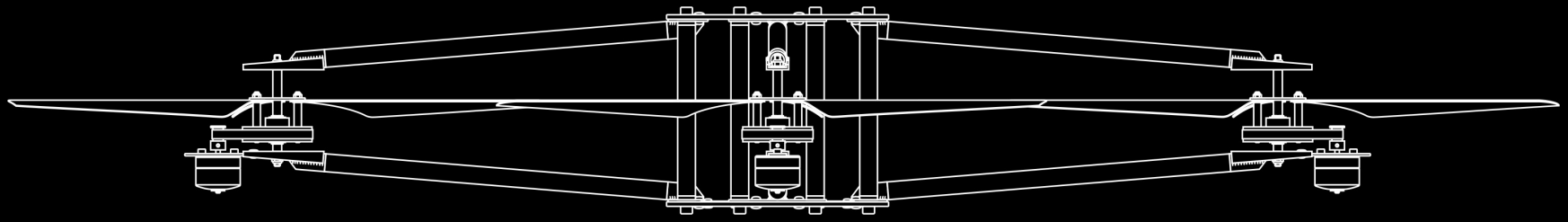
# JAviator Top View



# Stub Frame Design



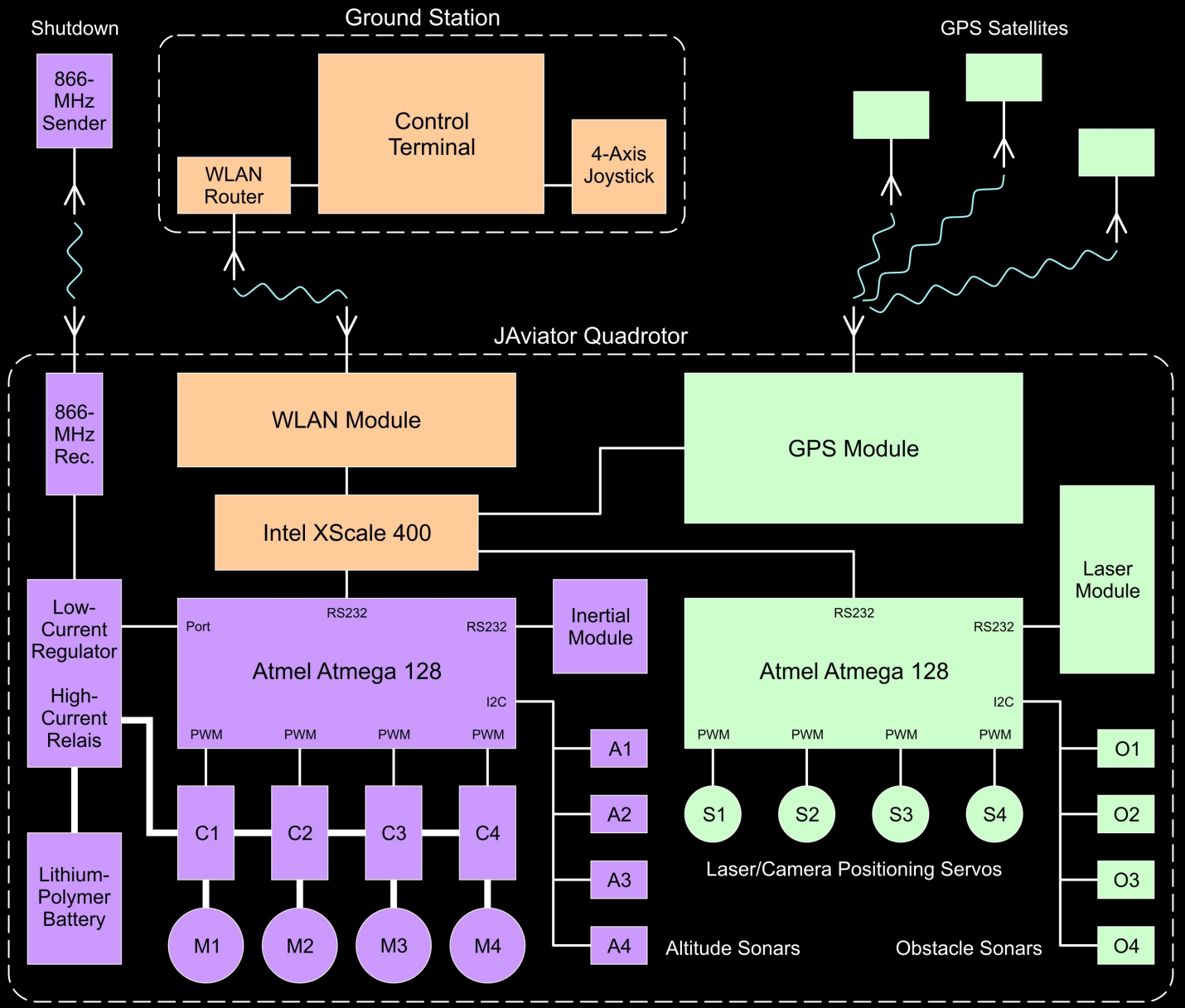
# JAviator Side View



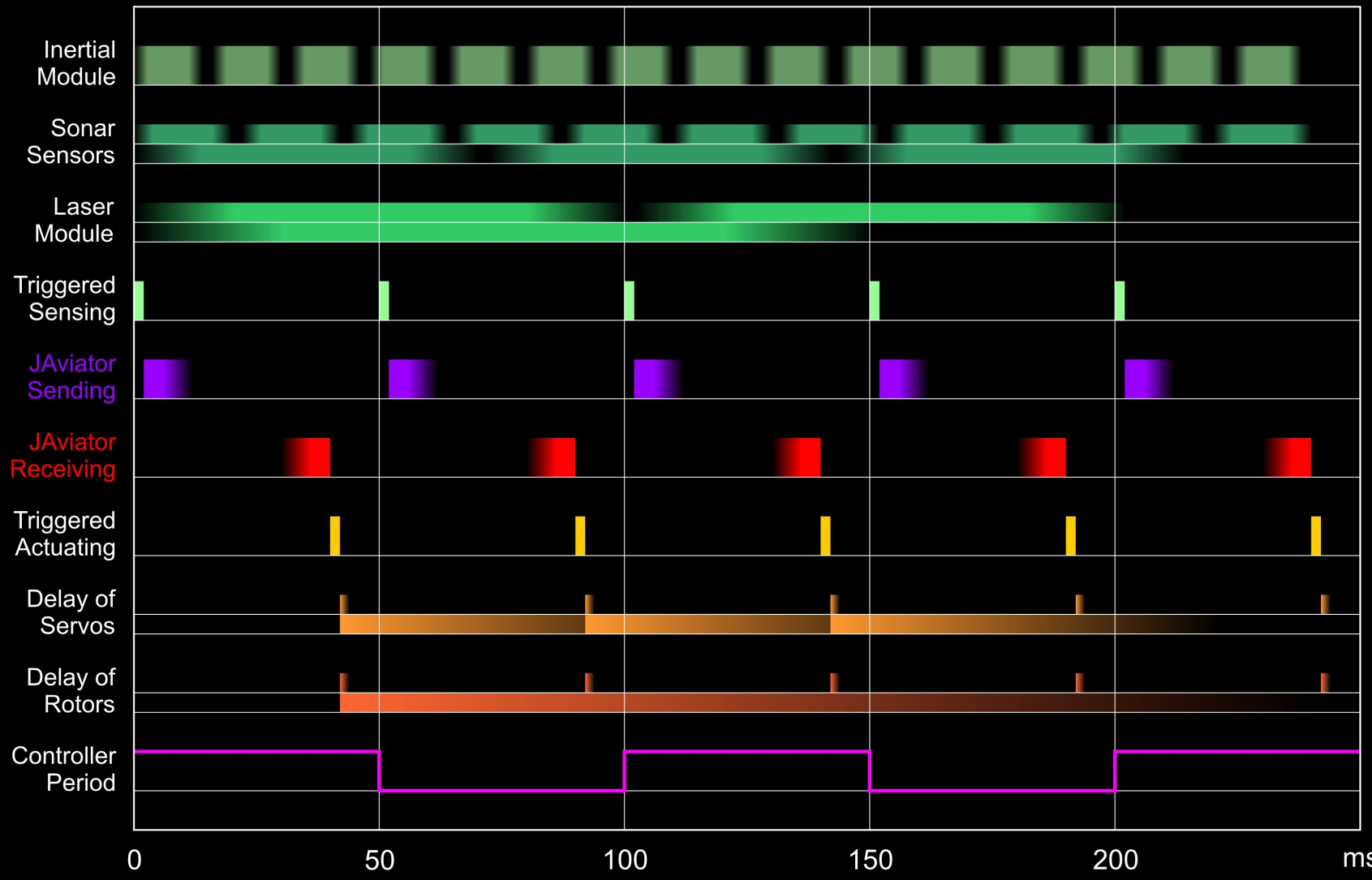
# Control System Design

- Requirements:
  - 4 independent controllers to stabilize roll, pitch, yaw, and altitude
  - Controller period in the range of milliseconds
  - Hard real-time software
  - Reliable remote connection between JAviator and ground station
  - Sufficient computing power for autonomous flight
    - Onboard navigation
    - Trajectory control
    - Obstacle recognition

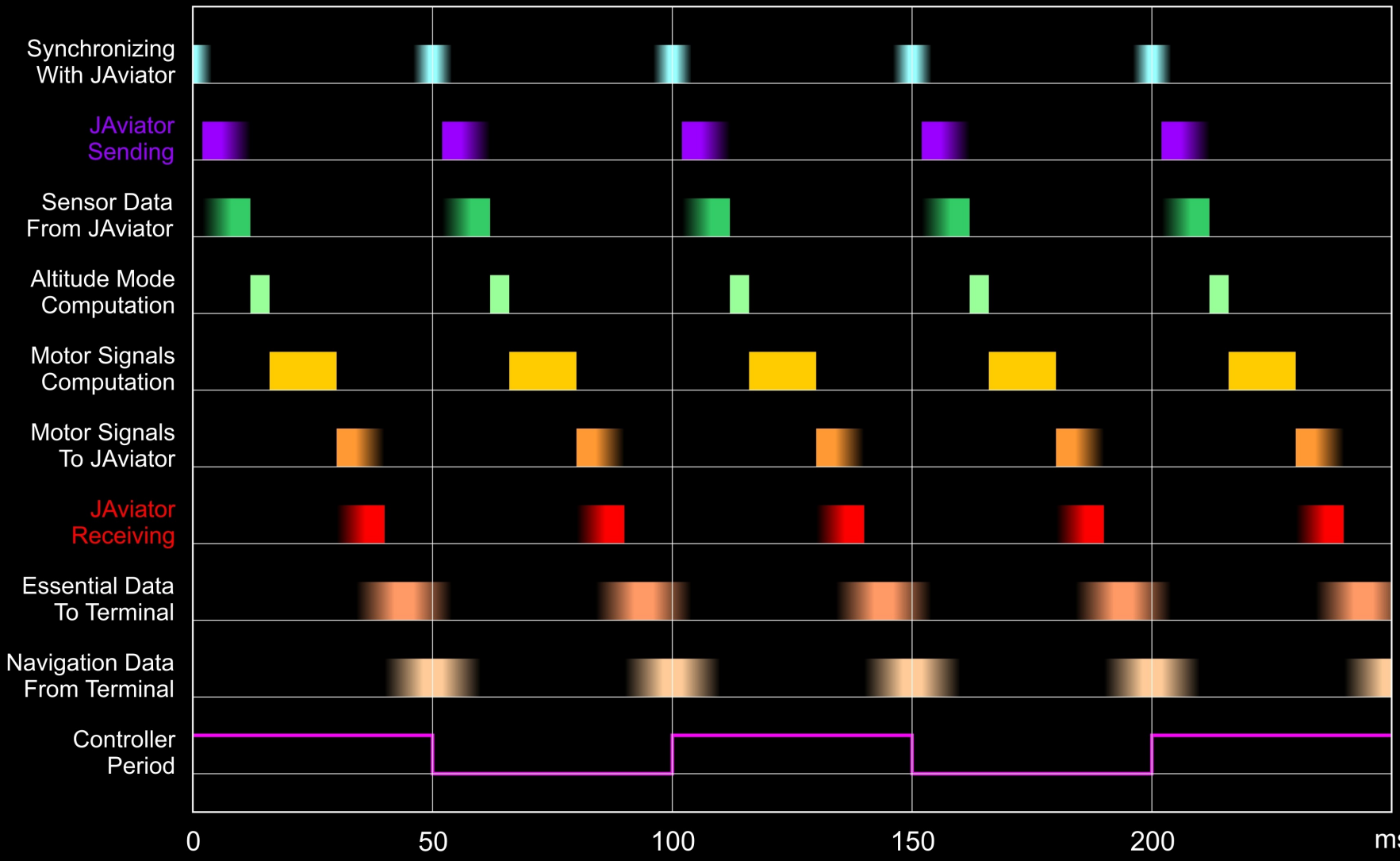
# Embedded System



# Robostix Timing



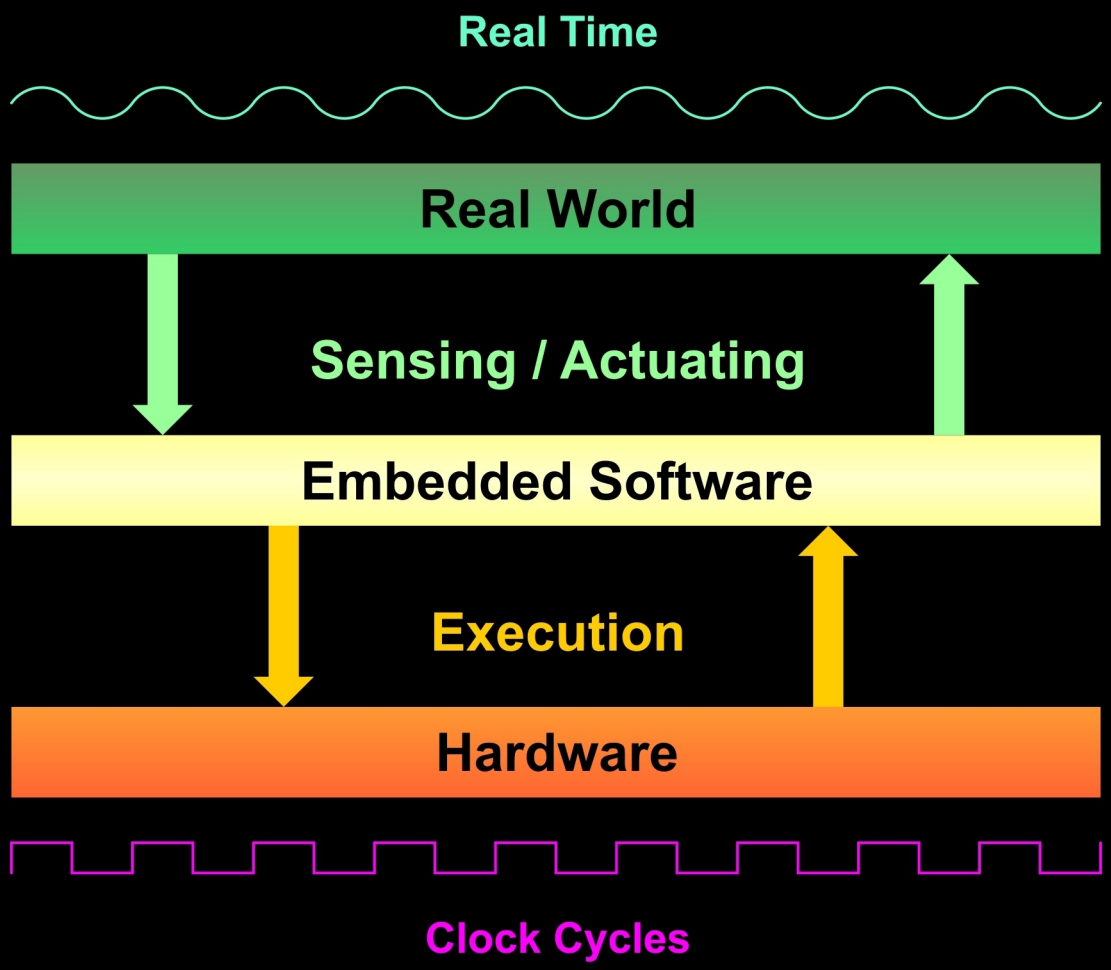
# Gumstix Timing



# Control Software Design

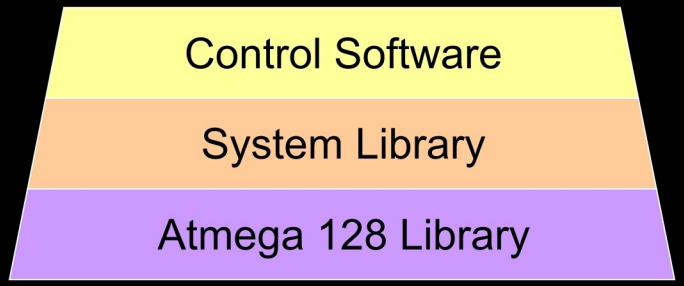
- Atmega-based C software
  - Time-triggered sensing and actuating
  - Fully deterministic controller behavior
- Exotask-based Java software
  - Real-time software infrastructure
  - Each exotask has its own memory space
  - Each exotask has its own garbage collector
  - Exotask system provides time-portability
  - No change of original Java semantics

# Embedded Software

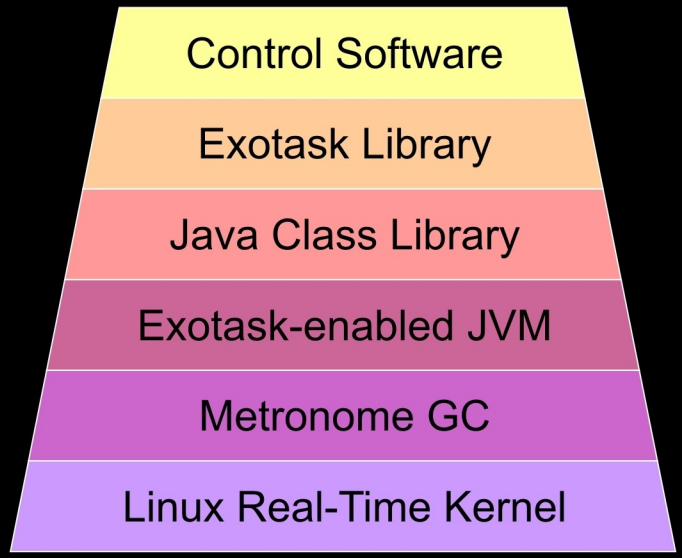


# Software Hierarchy

## Atmel Atmega 128
(Robostix Extension Board)

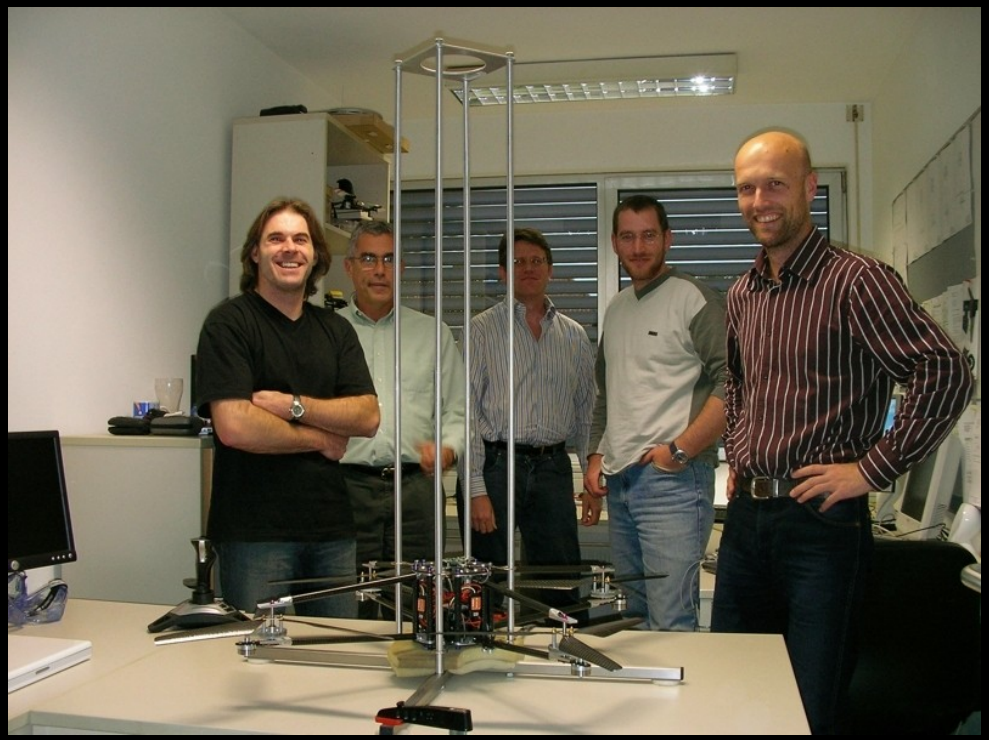


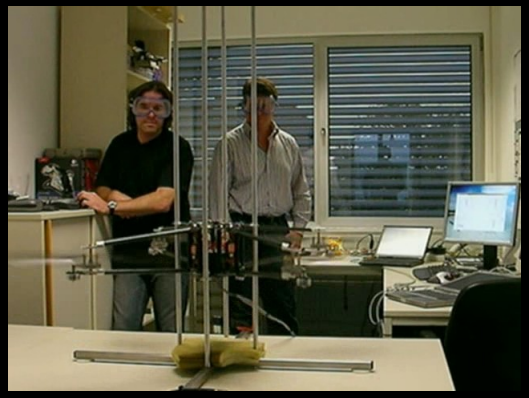

## Intel XScale 400
(Gumstix Connex Board)



# First All-Java Flight

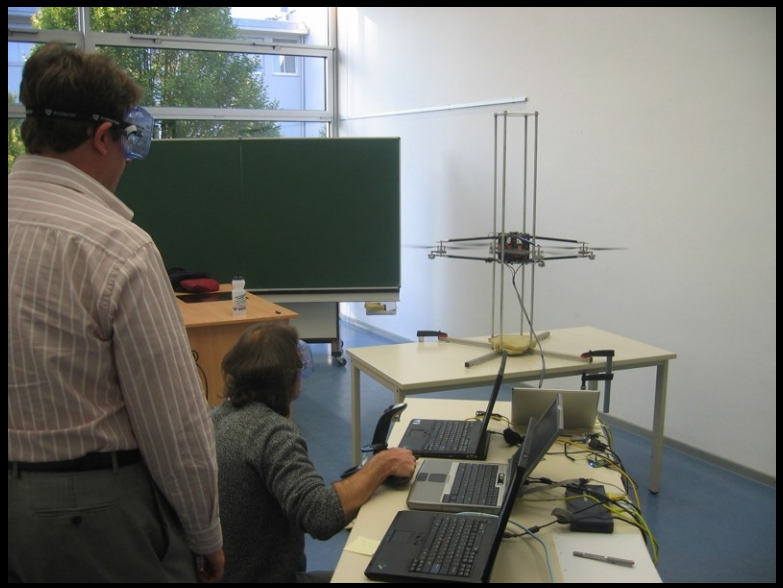
- Oct 4, 2006:
  - Spontaneous software test
  - System fully operational
  - First Java-based flight!





# IBM Demo Session

- Oct 5, 2006:
  - Official demo flights with IBM
  - Real-time tracing of entire system

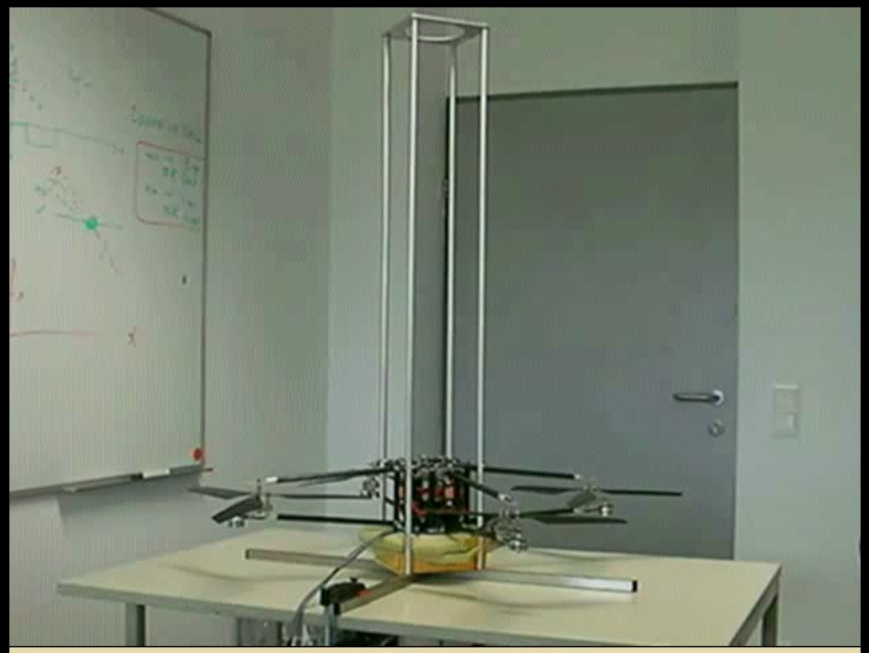


# Work In Progress

- Hardware: JAviator version 2
  - Larger body to carry additional electronics
  - CNC-machined aluminium connectors
  - 3-dimensional laser positioning mechanics

- Software: Trajectory controller
  - Full roll, pitch, yaw, and altitude control
  - Acquisition of GPS and obstacle data
  - Fully autonomous navigation and control

# Thank You!



Oscillating Altitude Control.avi