Magnetic Coils for Attitude Control

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COMPASS-1 Satellite

- **Gain ‘hands-on’ experience in satellite engineering**
- **Build a complete satellite**

CubeSat Project

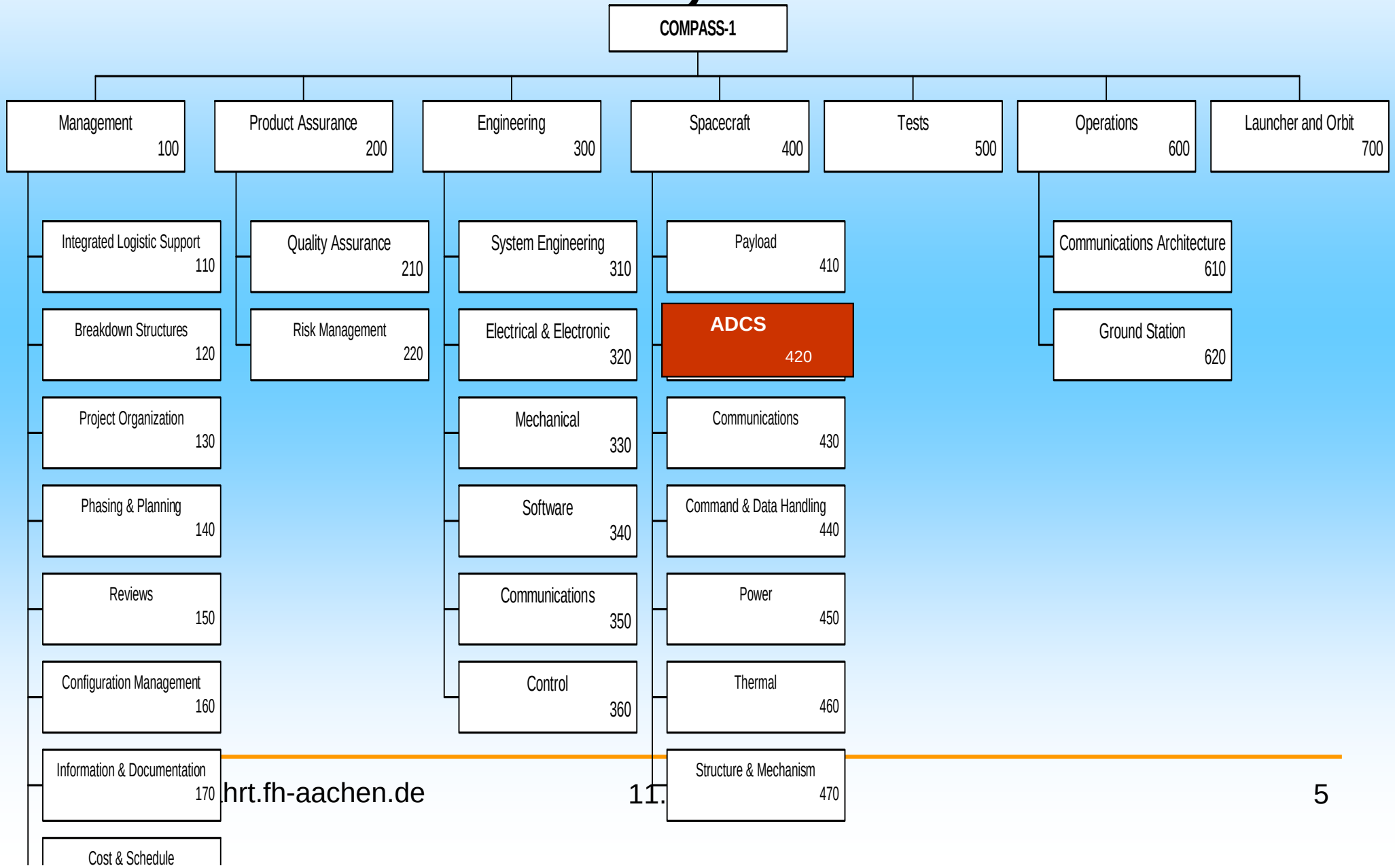
- **Why CubeSat Missions ?**

  - **Relative short development time**

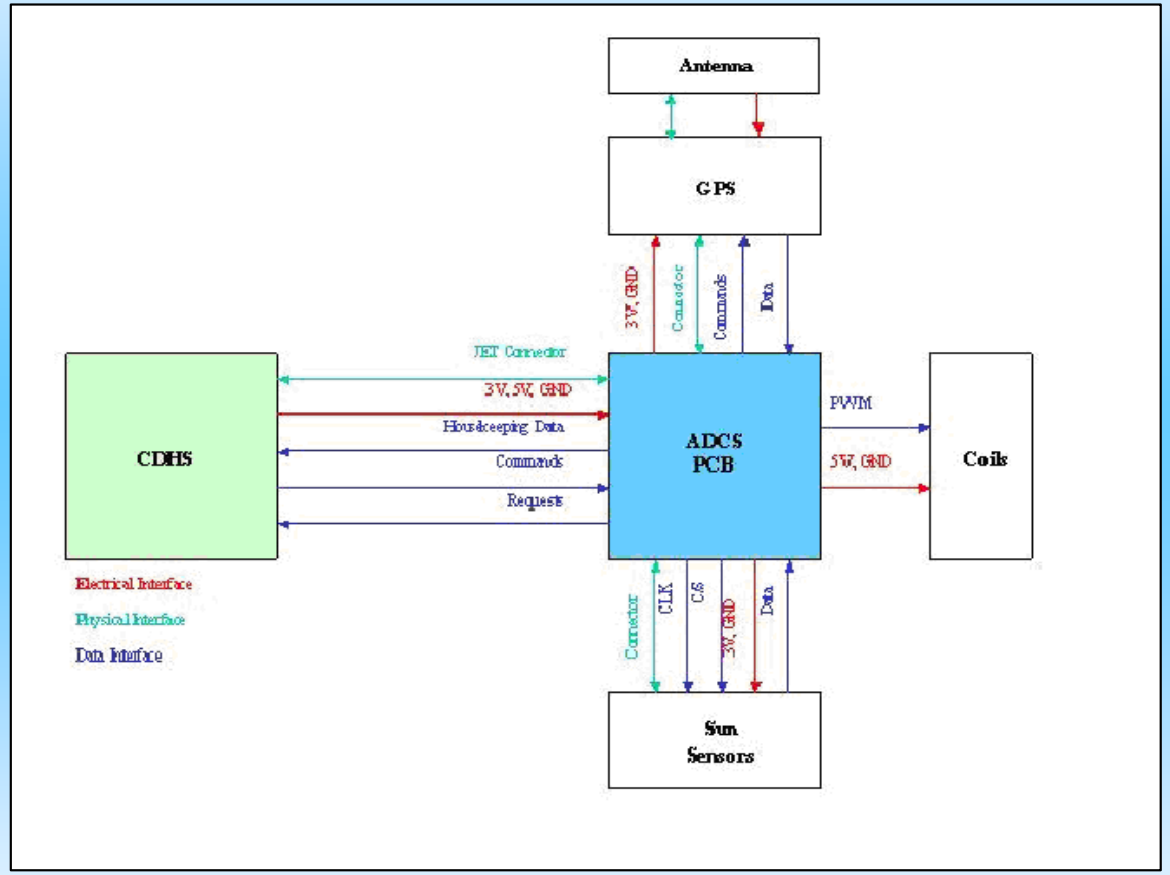
  - **Low costs**

  - **Feasible for university projects**

COMPASS-1 System Overview



ADCS System



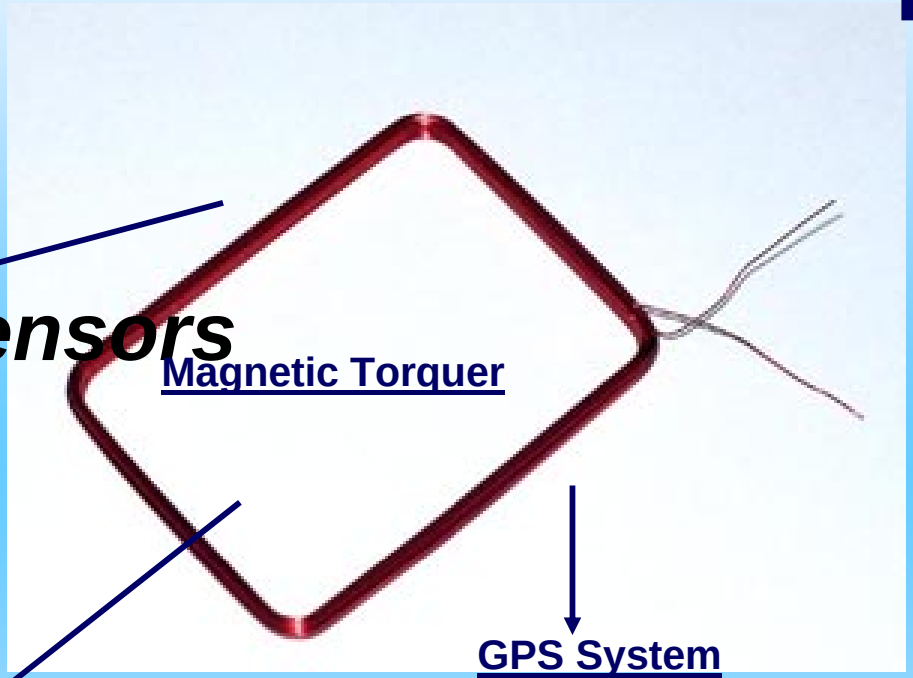
Stabilize the spacecraft

Point the camera (payload) towards a predetermined point on the earth's surface

ADCS Hardware Components

MOEMS Sun Sensors

Sensors



Magnetic Torquer

Actuator

GPS System

AMR magnetometer

(Anisotropic magneto resistive)

- produces

- allows an

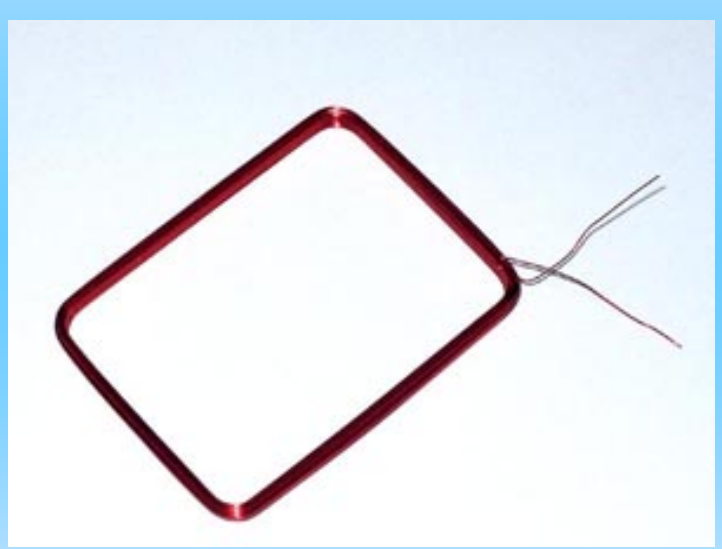
Commercial-off-the-shelf board

&

active patch antenna

Magnetic Torquers / Coils

Cooper wire winded into a loop



Produces a magnetic moment in the earth magnetic field

$$M = m \times B$$

magnetic dipolmoment vector of the coil

magnetic field vector of the earth

M = 1 µ Nm

m = 4,26E-02 Am^2

B = 2,35E-05 T
Minimum earth intensity by 600km altitude

Coil Requirements

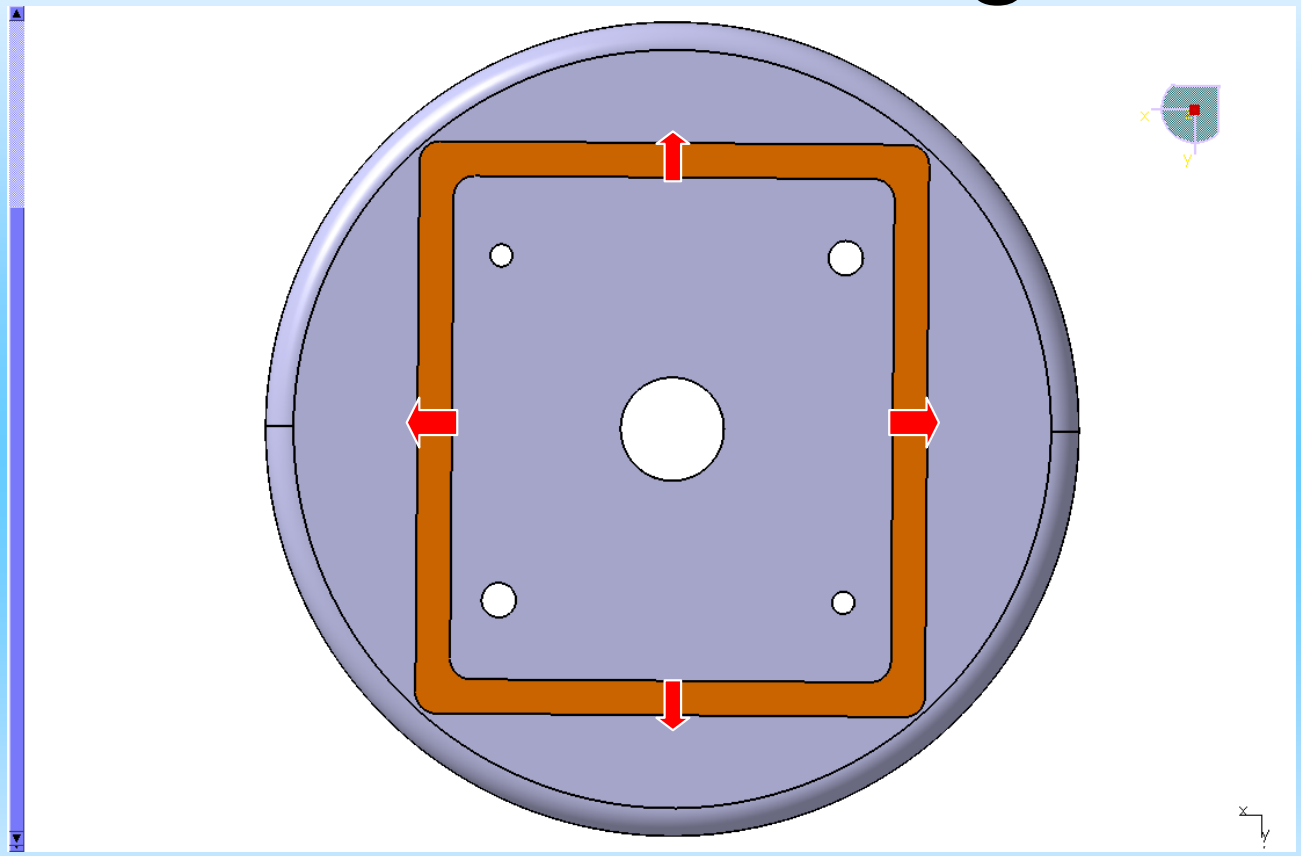
- **Available space in the spacecraft**
- **Power limits P = 250mW**
- **magnetic moment M = 1,0 µNm**
- **Mass limits**
- **Thermal limits**

Parameter	Symbol	Value	Unit
Maximum breadth	b	74	mm
Maximum altitude	h	83	mm
Maximum cross sectional breadth	d	2,1	mm
Maximum cross sectional altitude	sh	5	mm
Face of coil	A	6142	mm^2
Cross sectional area	Acmax	10,5	mm^2
average Amount	C	294	mm
Total Mass limit	Mges	60	g
Mass of coils each axes	Mc	20	g
Minimum temperature	T min	-100	°C
Nominal temperature	T Nominal	20	°C
Maximum temperature	T max	100	°C

Development

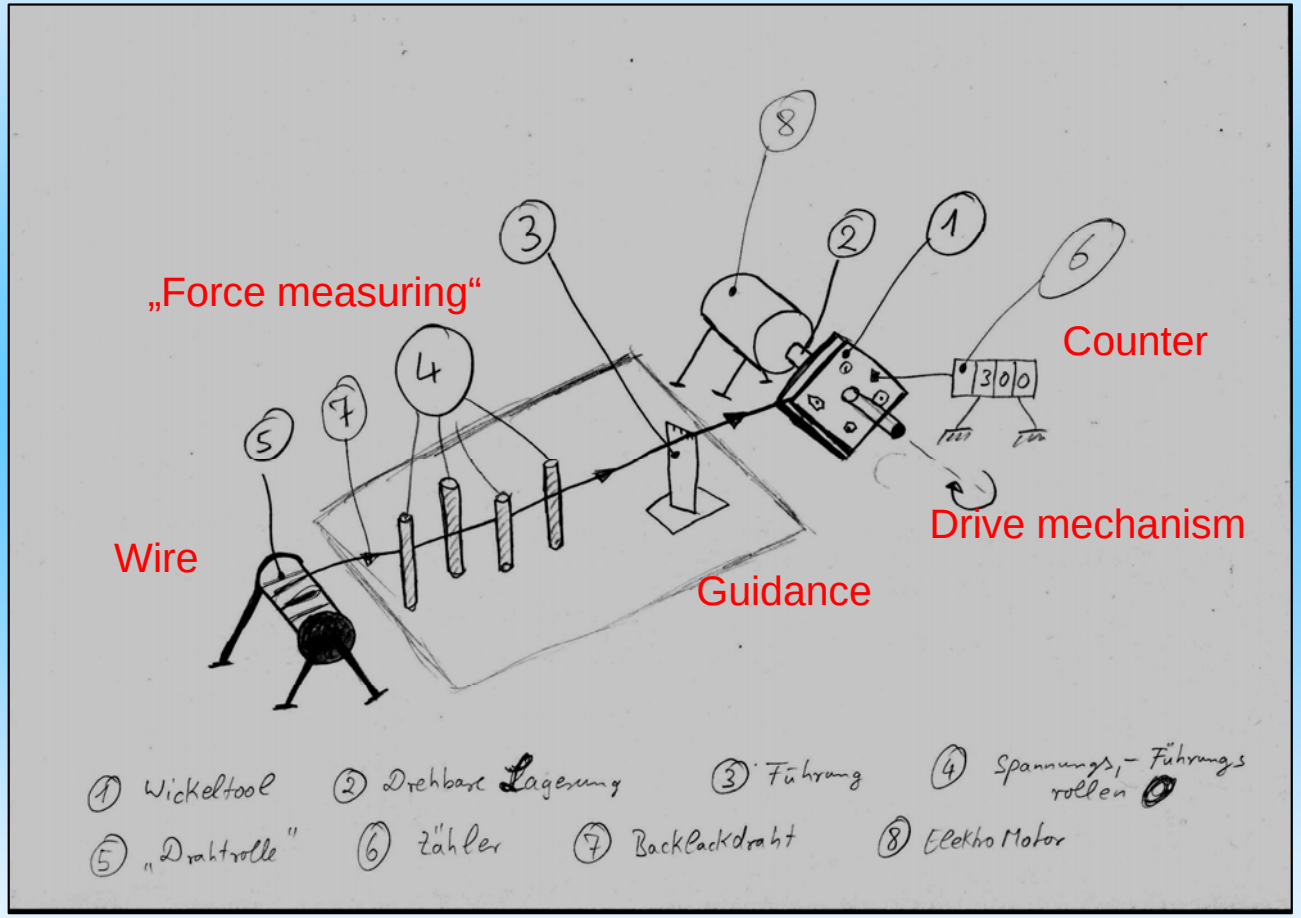
Parameter	Symbol	Value 7	Value 8	Value 9	Unit
Wire diameter	D	0,106	0,13	0,15	mm
Number of turns	N	830	553	416	
Mass of one coil	Mc	19,969	19,995	19,968	g
Total Mass incl. insulation	M	59,907	59,986	59,904	g
Current through coil nominal	I(293K)	9,222	20,817	36,842	mA
Magnetic dipole moment	m	4,86 E-02	7,31 E-02	9,73 E-02	Am^2
Needed cross section area	Ac	10,179	10,139	9,988	mm^2
Power consumption (173K)	P	0,08148	0,18394	0,32554	W

Manufacturing



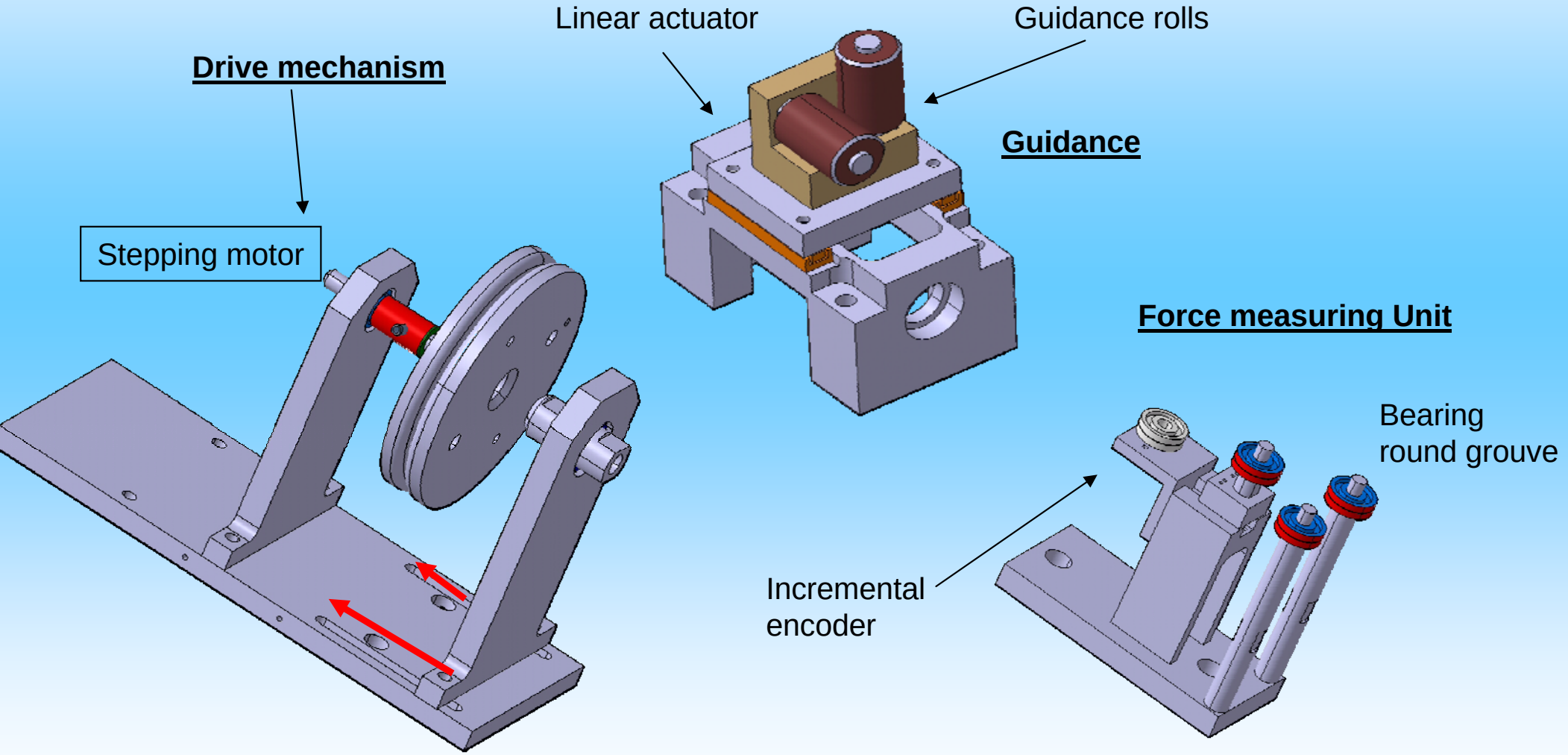
Coil Mould

Coil Winder

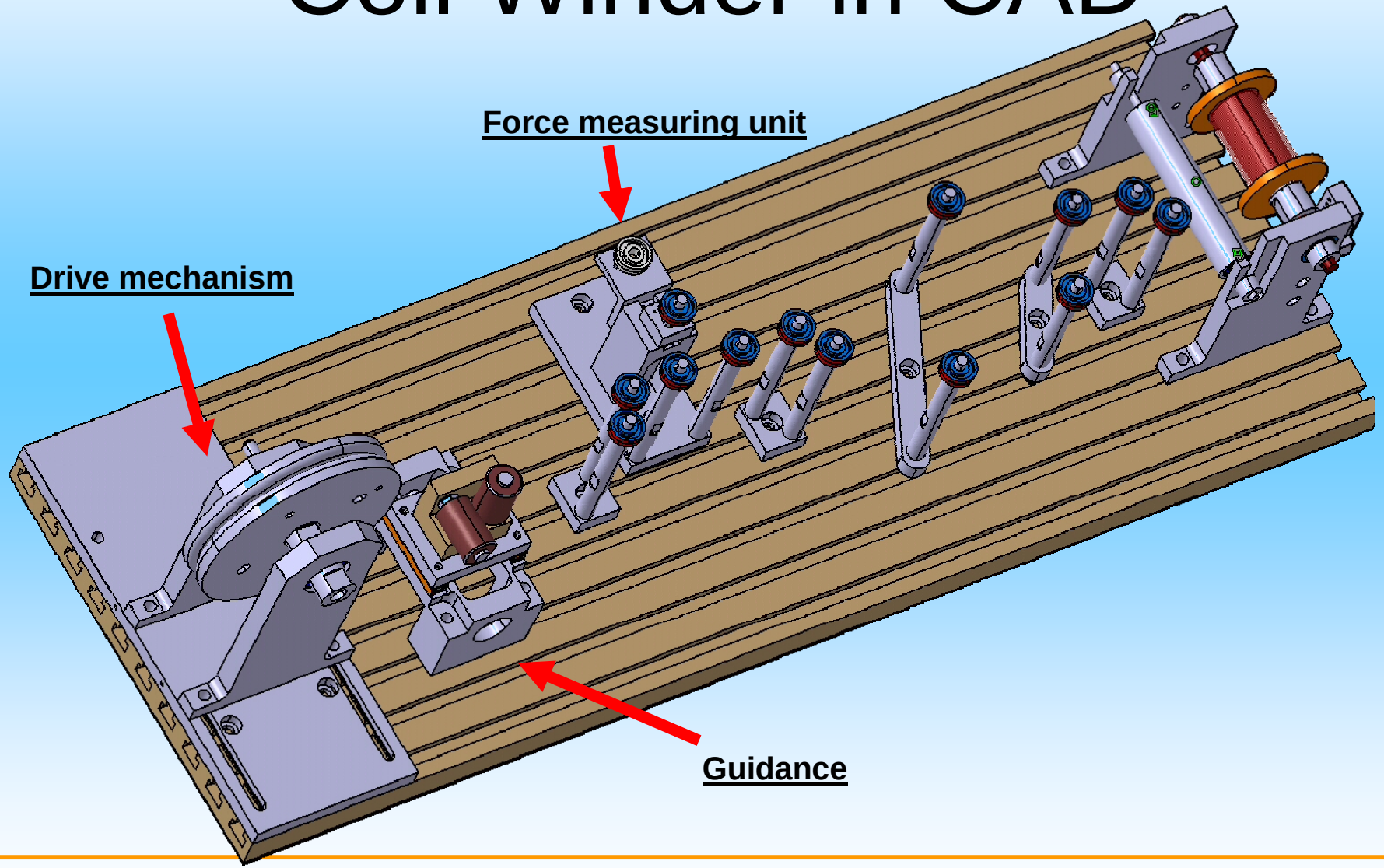


First hand drafting

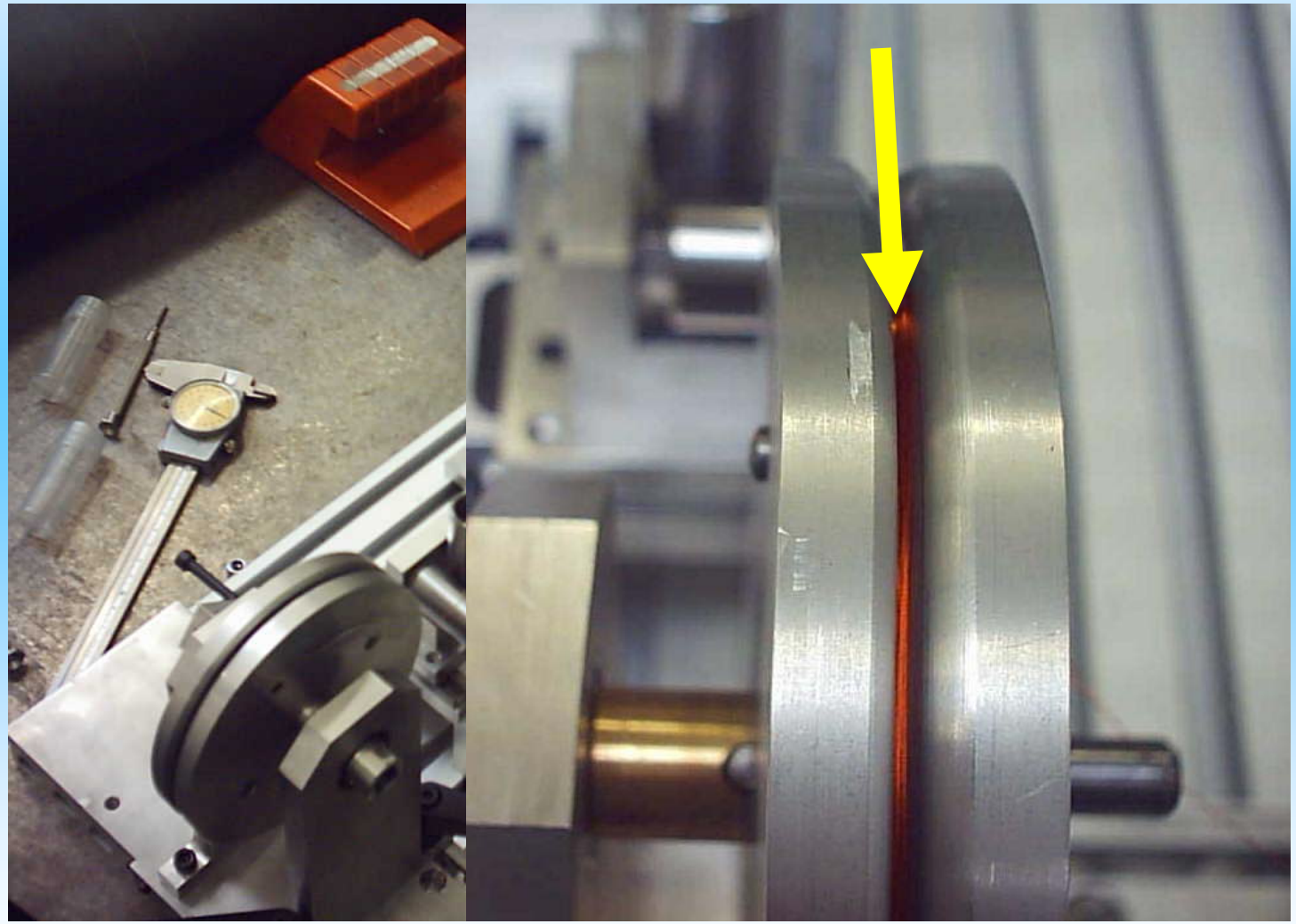
Coil Winder


Linear actuator
Guidance rolls
Drive mechanism
Guidance
Stepping motor
Force measuring Unit
Bearing
round grouve
Incremental
encoder

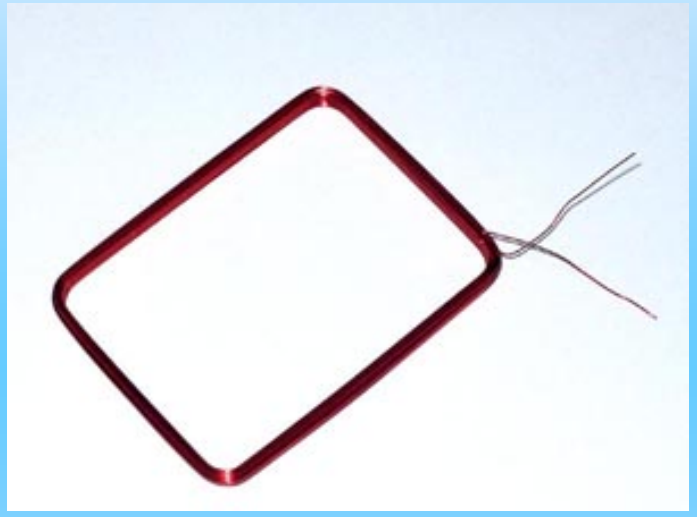
Coil Winder in CAD



Coil Winder in Real



Connection



Magnetic torquer

Connection itself

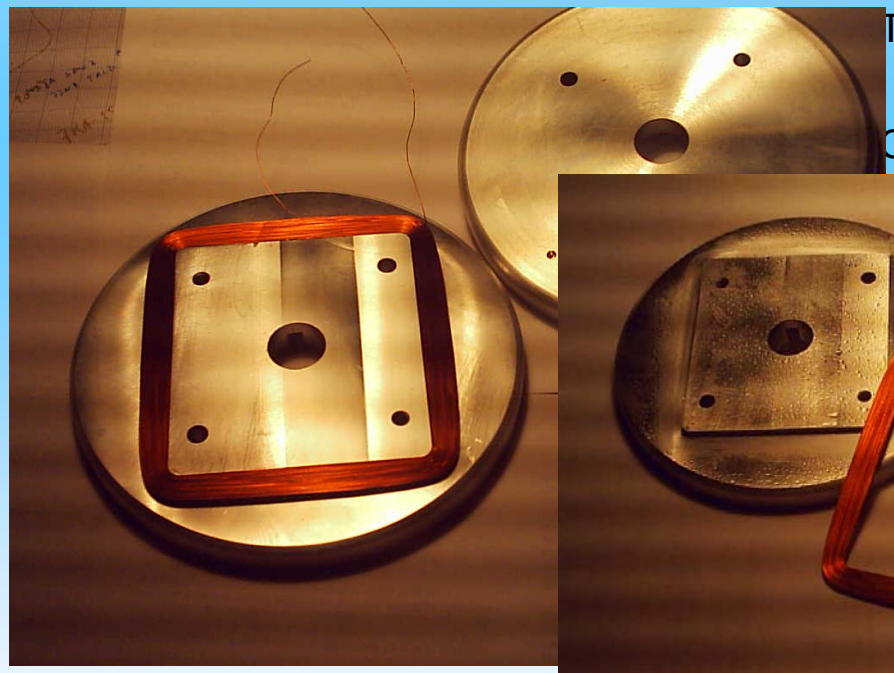
Current bonding method

Connection with the ADCS Board

Equiped with special connectors (JST)

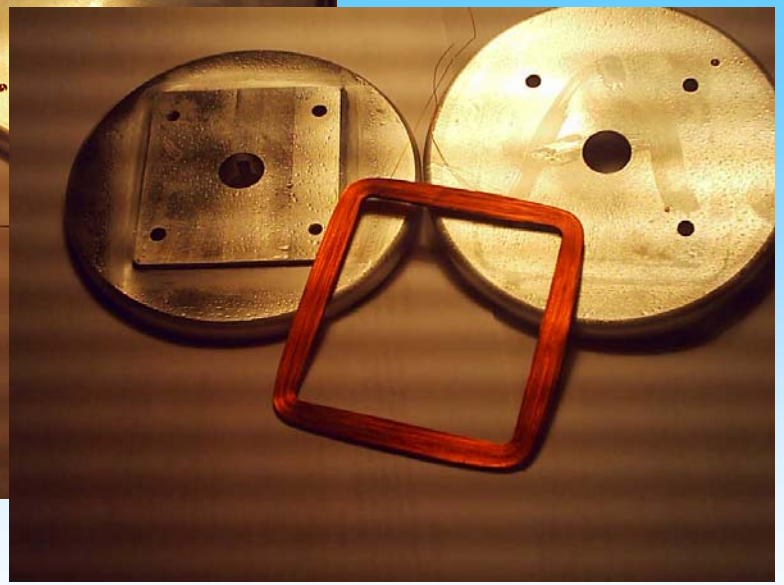
1st Coil

After the bonding the coil mould must cool down →



The mould is reducing its volume

Coil is easyer to remove

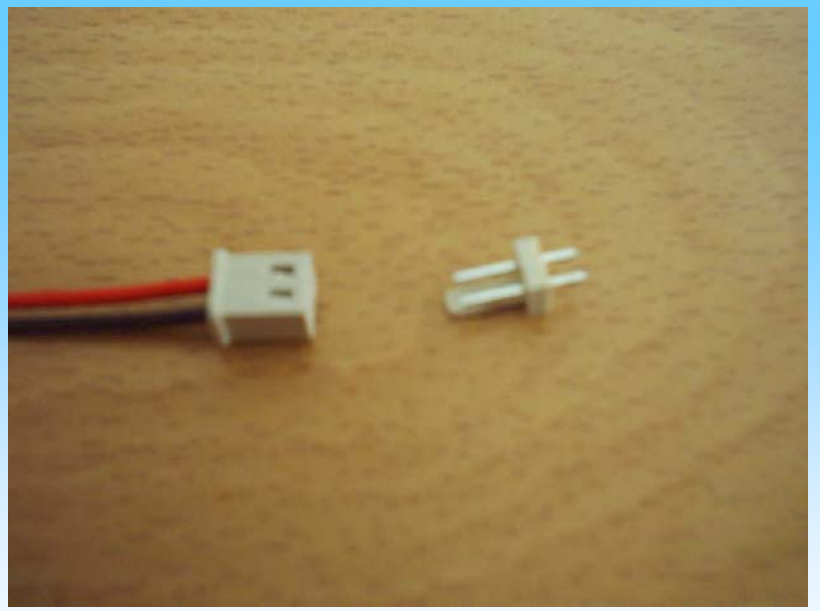


Size: 83 x 74 x 2,1 mm³

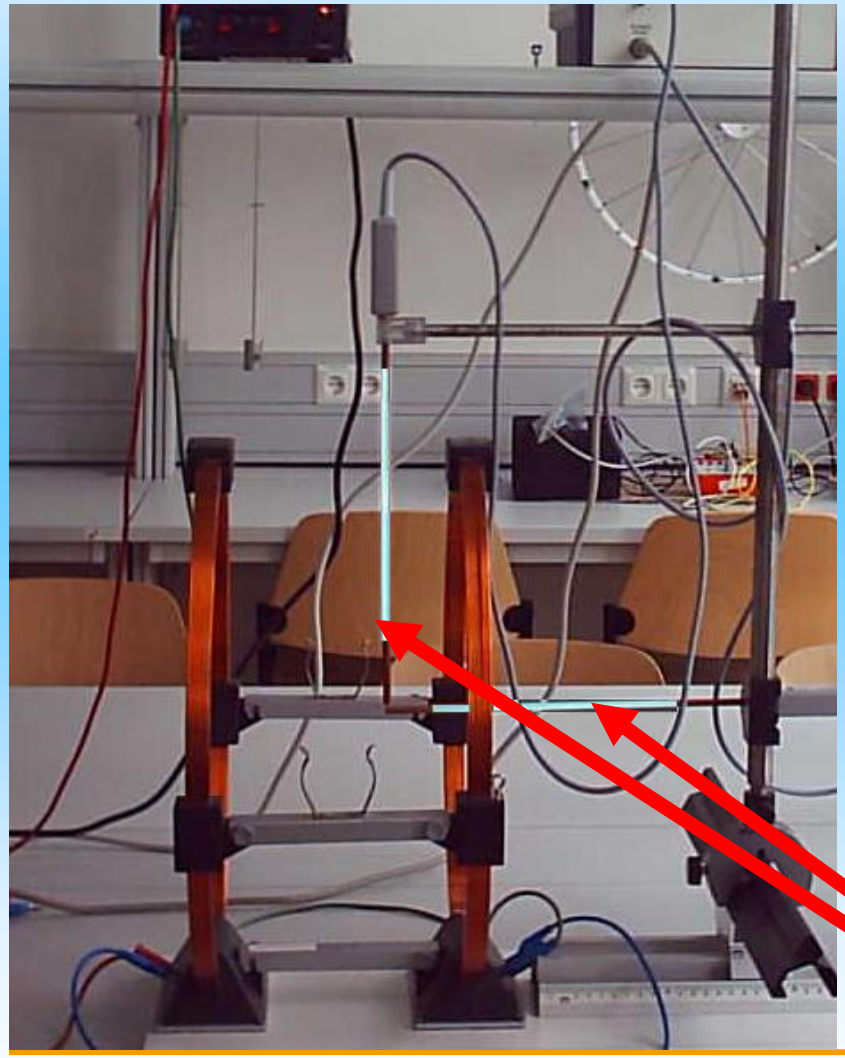
Diameter: d = 0,15 mm

Turns = 400

Mass = 19,8 g



Test



Helmholz coils. Radius R=200mm

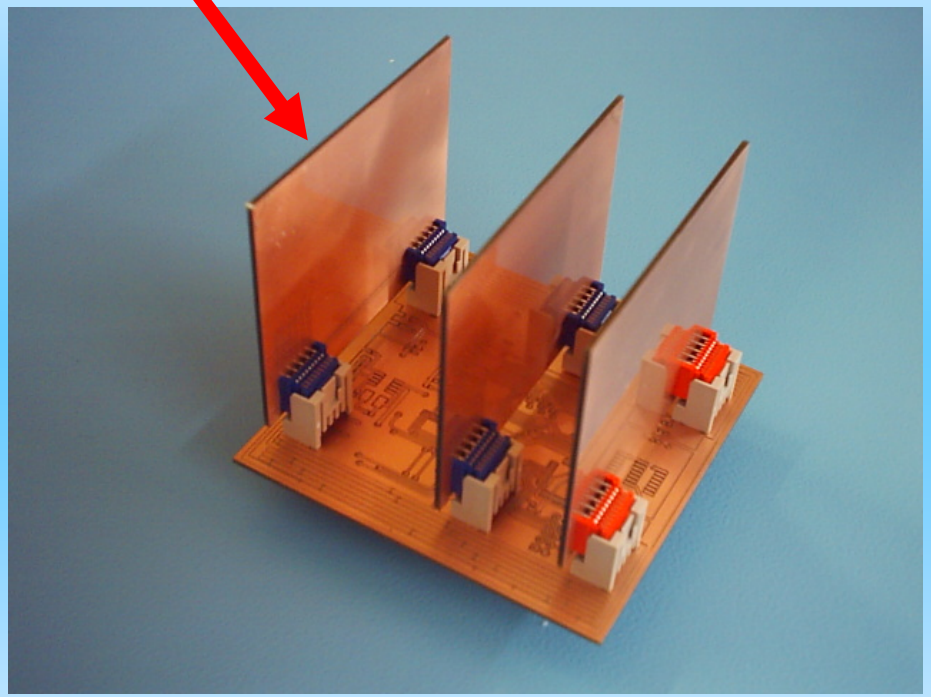
Teslameter

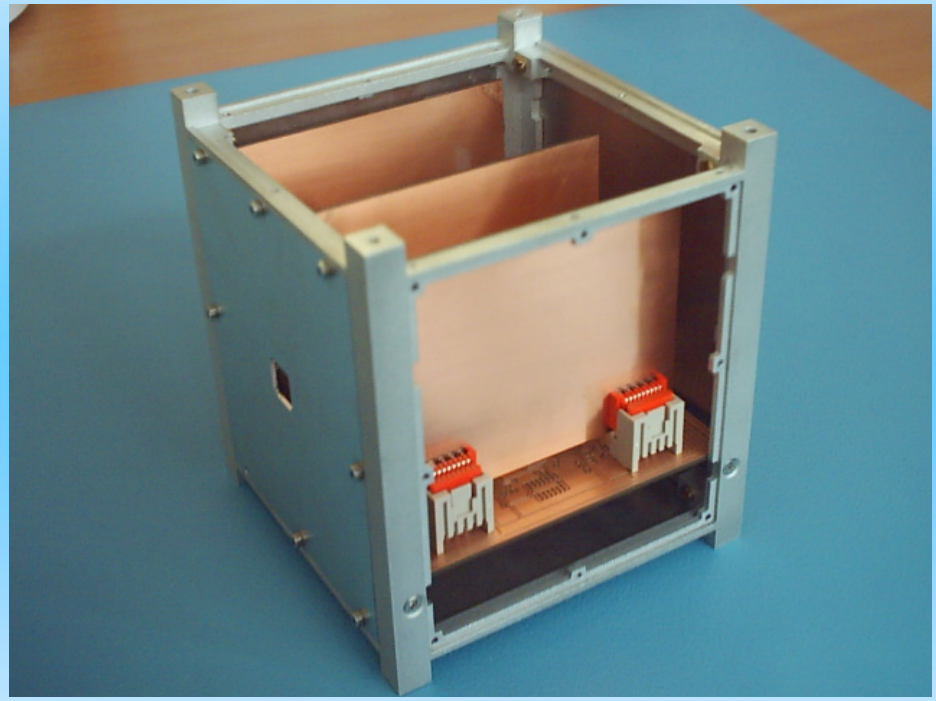
The test results will describe:

The generated forces of the each coil in a homogeneous magnetic field

↳ Dependency between the magnetic moment and the current

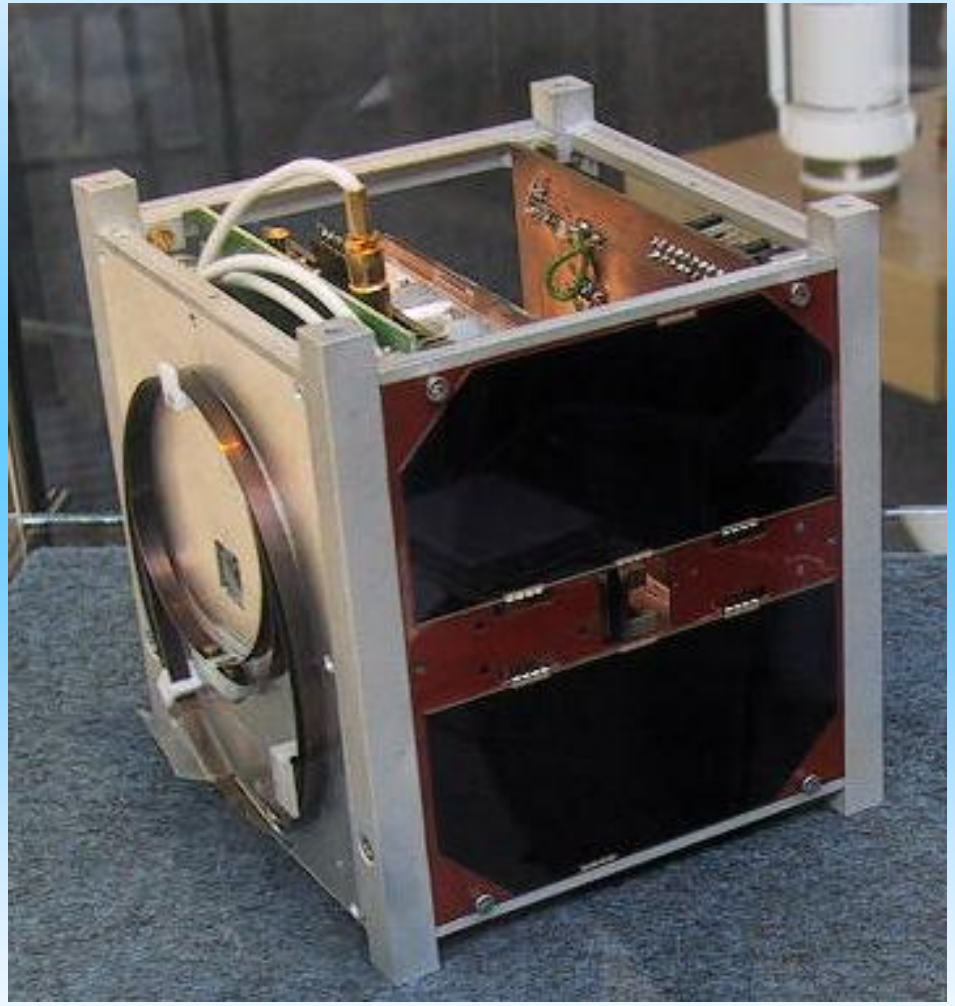
ADCS Board





Compass model without coils

Summary



Only Coils for an active control

Design and Development aspects

Connection methods

Test Equipment

THANK YOU

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CHK Wickeltechnik GmbH