Micro Laser Beam Scanner

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Goal of the Project

- Future space missions with rovers need a 2D image and distance information for safe navigation, independend from surrounding light and with long range resolution
- 3D imaging LIDAR, an active optical system uses time of flight datas from a moving laser beam
- A scanner directs the laser beam with a resolution of 0.025° over the Field of View (22°x 22°)
- During this 2 year activity one main component, the micro scanner was developed and tested
- Specifications are based on EXOMARS Rover requirements

Scanner Development (MEMS)

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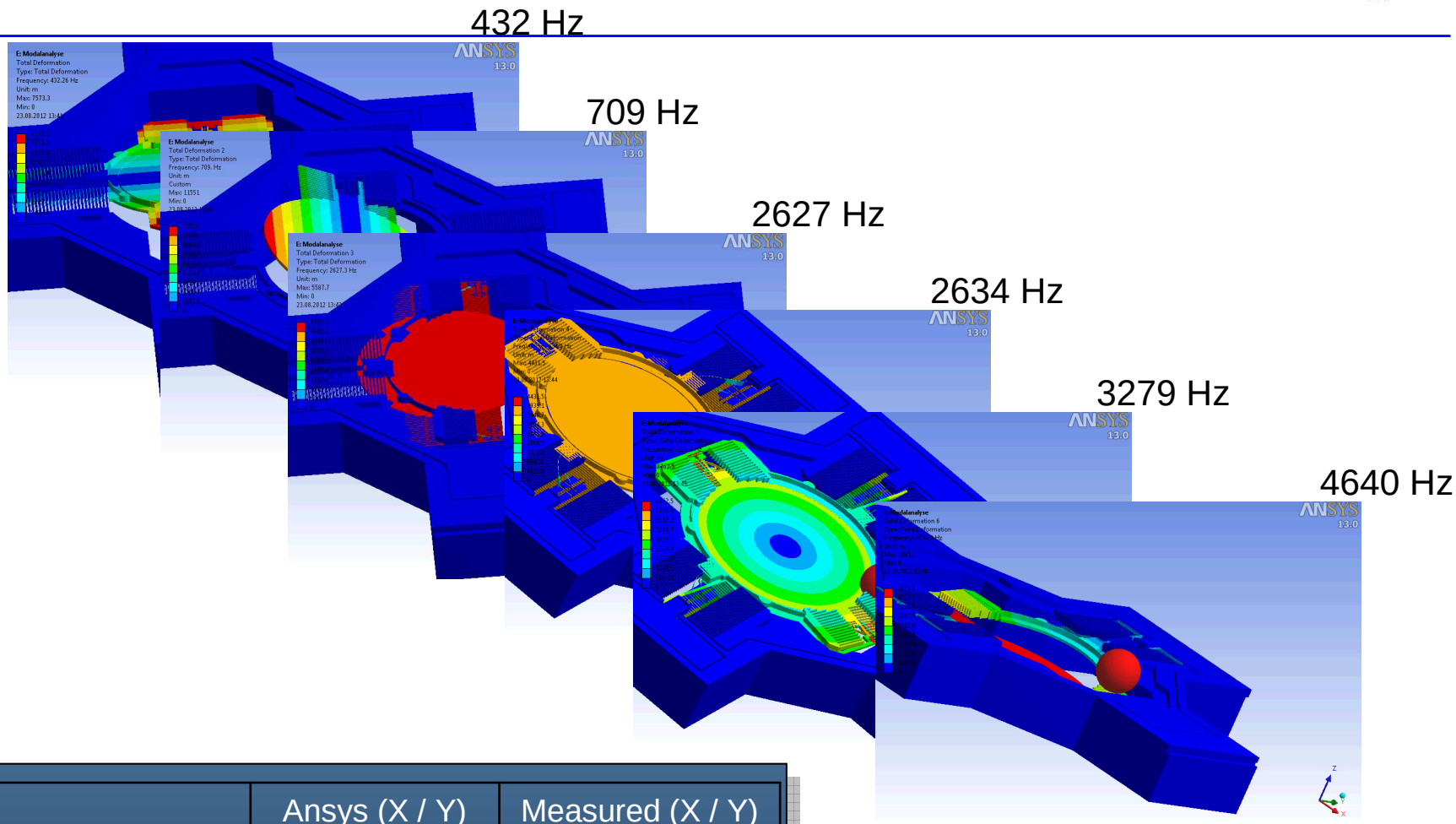
Characteristics:

- Mirror Size: 1mm
- Tilt angle optic.: two axis +/- 11°
- Resonance frequency: >400Hz
- ROC: >1.8m
- Feedback: capacity sensing
- Driving: vertical comb drives
- Actuation: non resonant
- Actuation Voltage: 0-110V
- Resolution: 12bit (0.02V)

ANSYS Modal Analysis



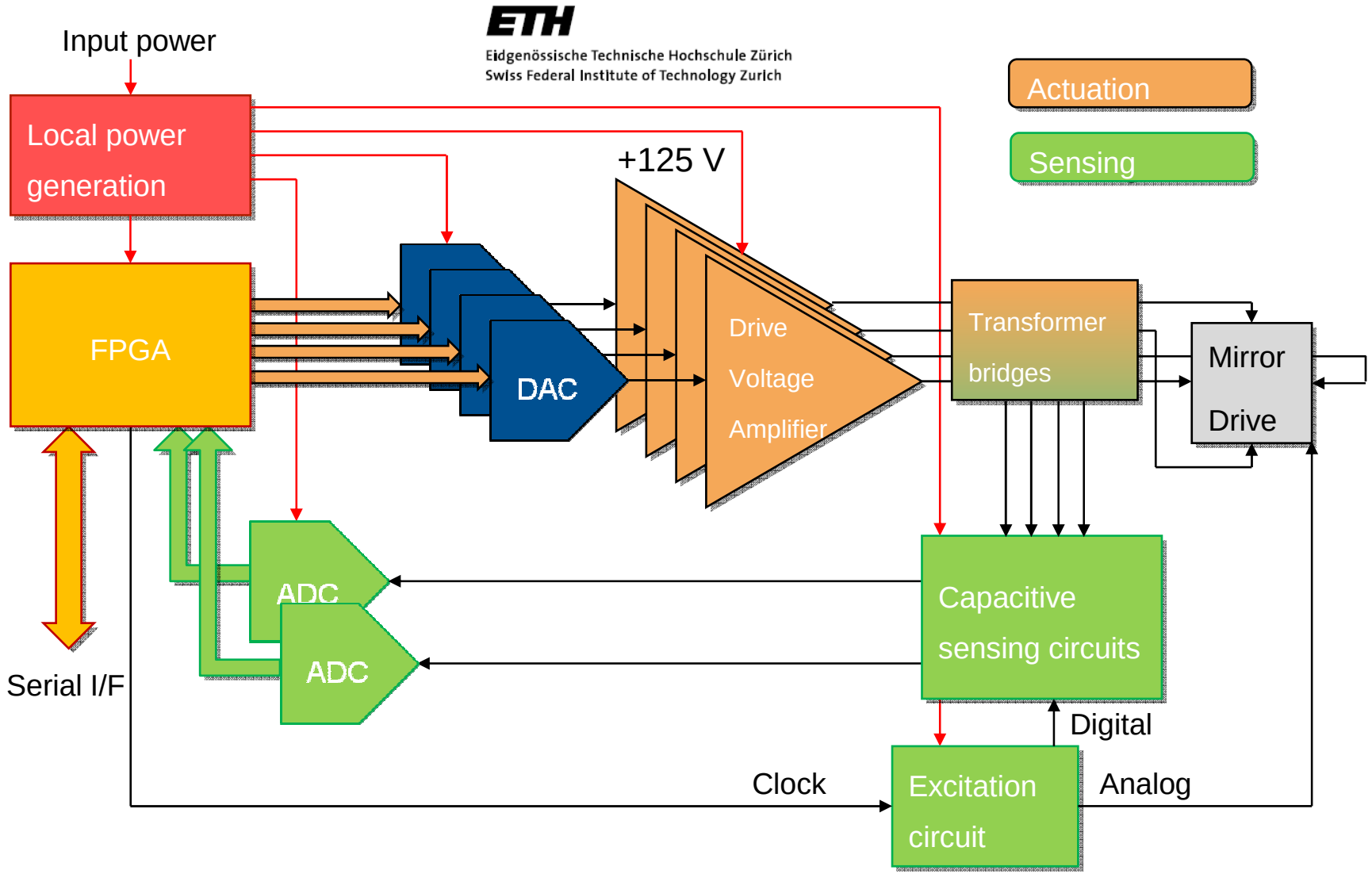
	Ansys (X / Y)	Measured (X / Y)
Resonace frequencies [Hz]	**432 / 709**	**480 / 880**

Ansys Simulation Thermal Effects

Characteristics:

- Temperature Range: -130°C to + 80°C
- Max. Displacement: ~0.4µm
- Max. Stress: 0.26 GPa < 2GPa

Driver Electronics (1)



Driver Electronics (2)

Characteristics:

- All used components are exchangeable with space qualified equivalents
- Feedback: capacity sensing for function verification
- Driving Voltage: up to 120V DC
- Resolution: 12 bit (0.03V)

Mirror Actuation

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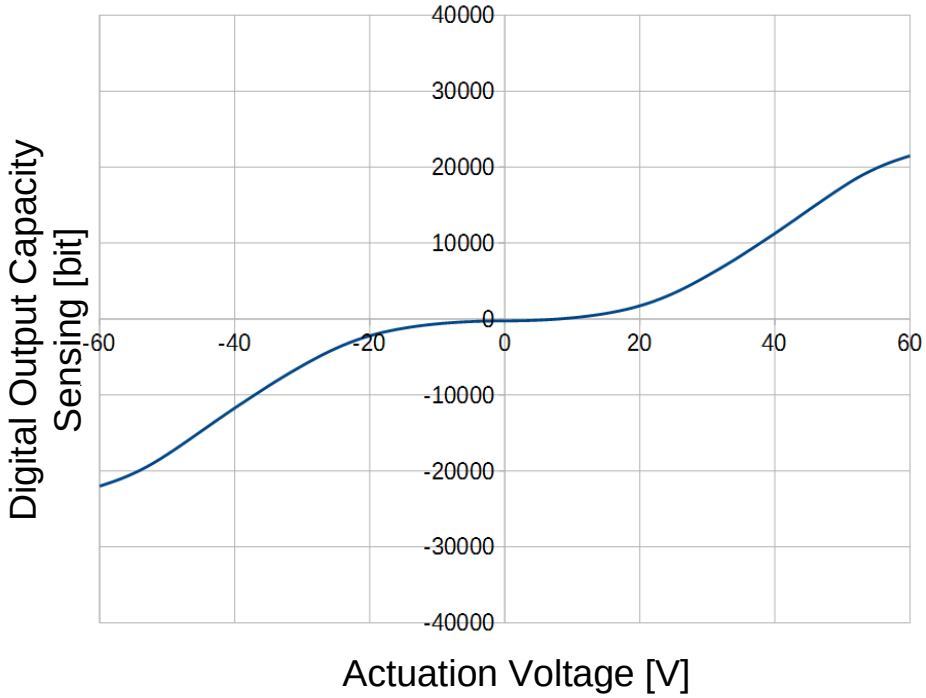
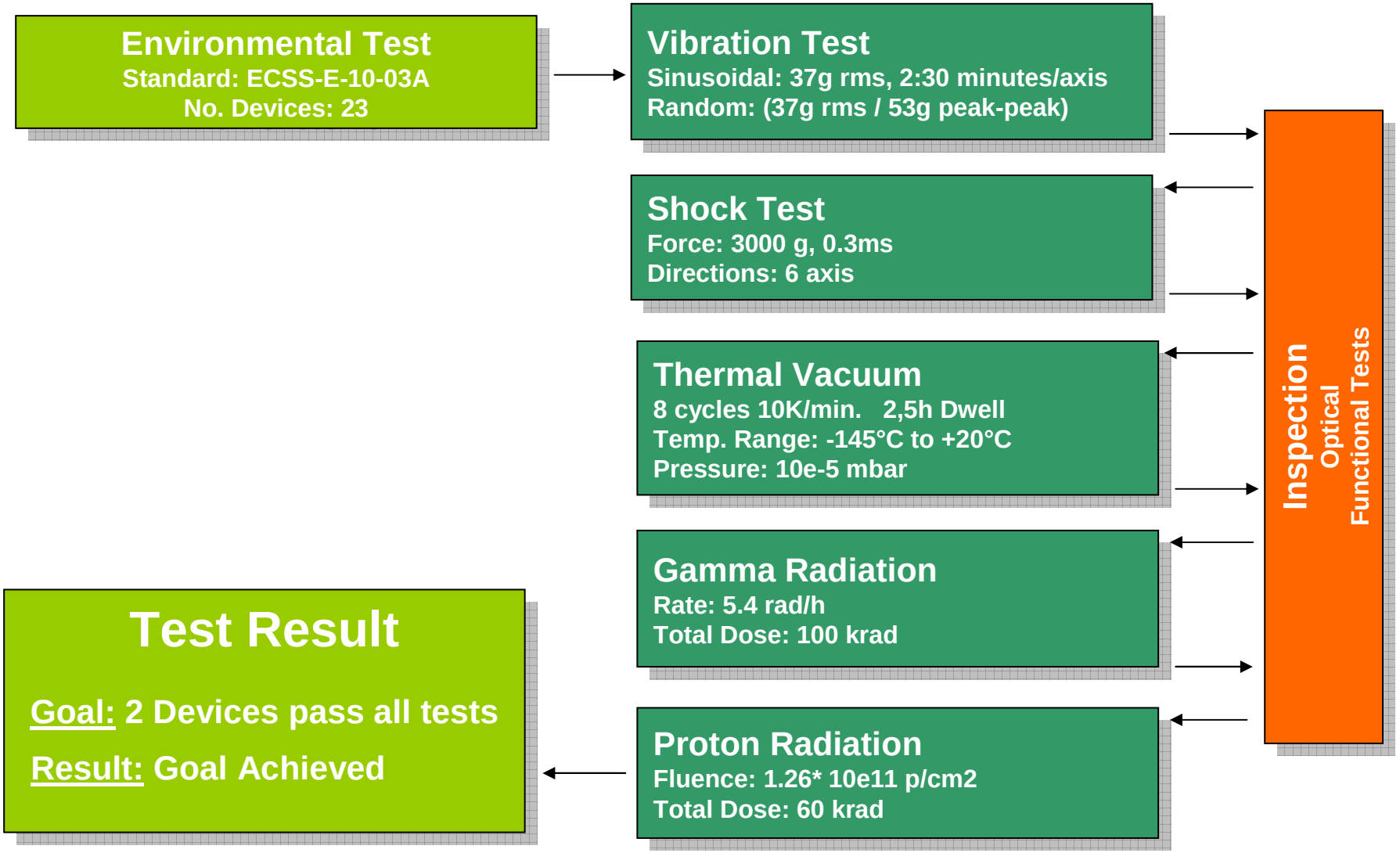
Capacitive Sensing:

- Capacity converter output level as a function of the voltage applied on one mirror axis
- Full Scale: <300 fF
- Resolution: ~14aF
- Usage: Only for function verification



Environmental Tests (1)

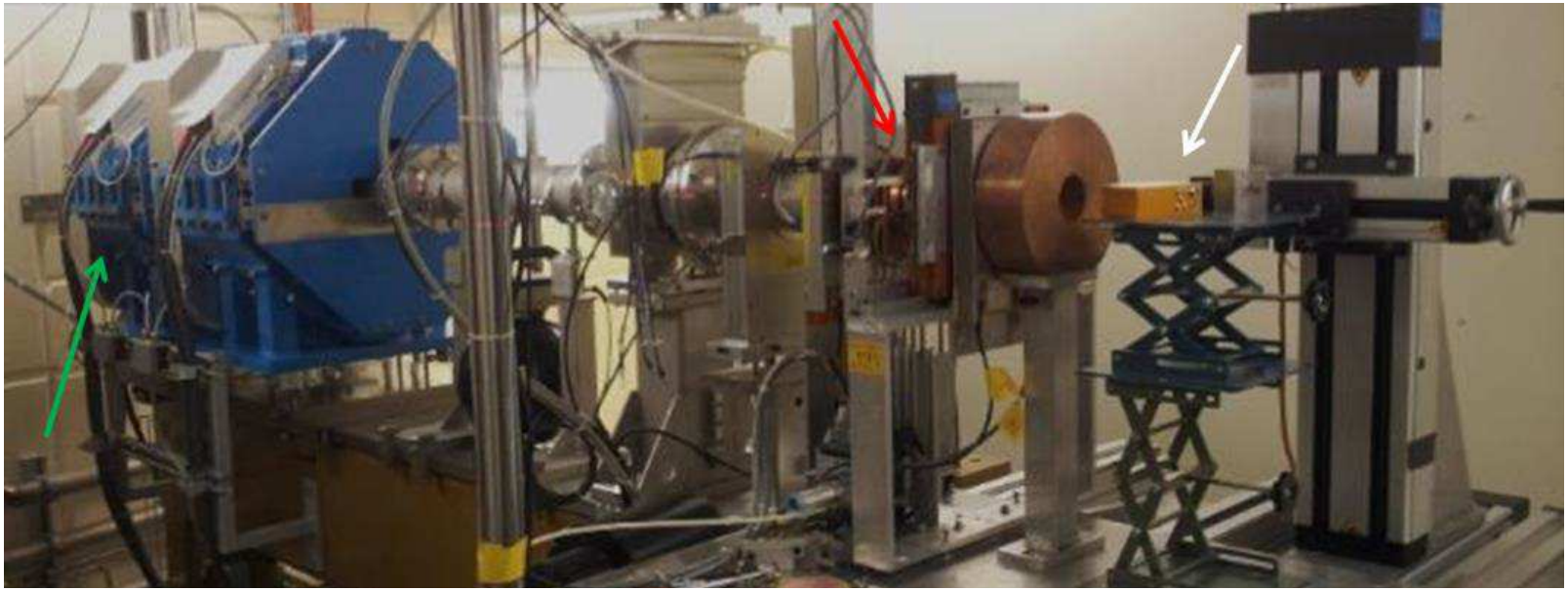


Environmental Tests (2)

Test conditions:

- Based on SRIM simulations:
- Proton energy: **50 MeV**
- Total fluence 1.26 * 1011 p cm-2 which corresponds to **20 krad (Si)**
- Due to shielding the effective dose was 10-30% higher

Due to elevated radioactivity the devices were not directly released by the radiation facility.



RESULTS (Performance)

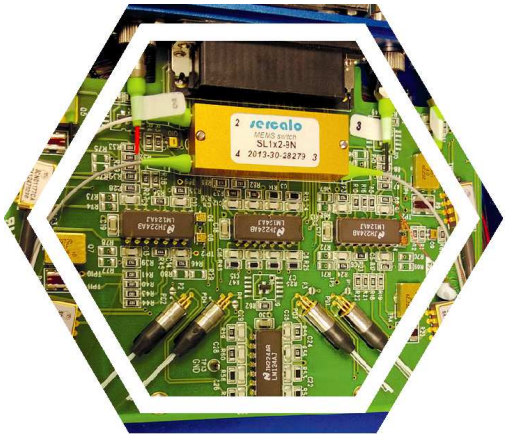
Requirement object	Required specification	Compliant	Achieved Performance
Field of Regard	22° horizontal 22° vertical	C	24.3° ± 0.4 horizontal 24.7° ± 0.4 vertical
Scene coverage	>90%	C	>90% when using 0.5° divergence and 100x100 points
Scan time ts for the whole FoR	FoR/ α^2*10µs<ts<1s	C	1s
Mirror flatness	< λ /10	C	0.155µm over R=500µm mirror --> ROC>0.806m Measured ROC>1.8m
Resonance frequency	>160 Hz	C	>300 Hz
Peak Power consumption	<5W	C	3,45 W
Avr. Power consumption Standby	<1W	C	0.72 W
Optical Pointing Stability	@ any angle for 10s ± 4mrad	C	<0.6mrad (± 0.2 mrad)

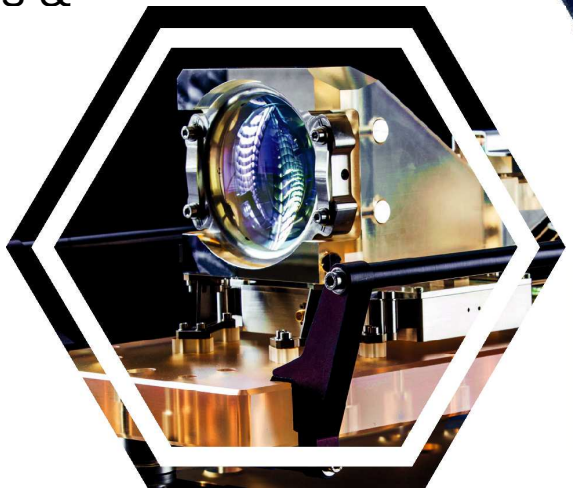
RESULTS (Environmental)

Requirement object	Required specification	Compliant	Achieved Performance
Temp operational SU	-70° C to +20° C	C	-70° C to +20° C
Non operational Temp. SU	-130° C to +70° C	C	-130° C to +70° C
Temp operational EU	-20° C to +40° C	C	-20° C to +40° C
Non operational Temp. EU	-20° C to +70° C	C	-20° C to +70° C
Mechanical Vibration	Sinusodial 37,7 g	C	37,7g
Mechanical Vibration	Random Noise 37,7g	C	37,7g--$_{rms}$
Mechanical Shock	3000g	C	3000g
Thermal Vacuum Test	8 cycles -130° C to +20° C in 10e-5 mbar	C	-145° C to +20° C
Gamma Radiation Co60	Total Dose 100krad	C	100krad
Proton Radiation	Target fluence of 1.26*a0e11 p/cm2 Total dose 60 krad	C	1.26*10e11 p/cm2 Total dose 60 krad

Lessons learned

- We could demonstrate that MEMS scanner are robust against vibration, radiation and thermal vacuum cycles.
- Dynamic and Static Operation without feedback is possible in given accuracy for small mirrors.
- For better SNR or bigger mirrors, the use of feedback is necessary
- Mirror sizes in the low cm range could be interesting in short range Rendez-vous & Docking, applications

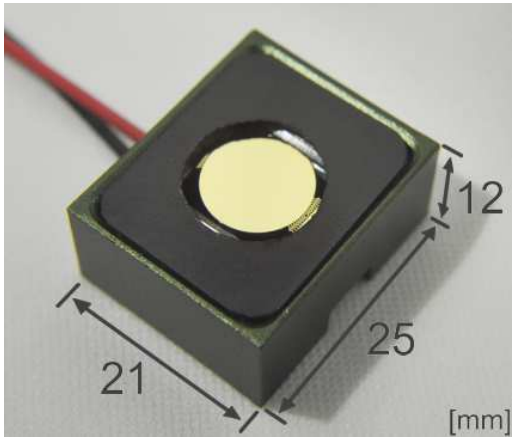




Gooch & Housego

Future Activities

- Mirror sizes in the range of ~1cm needs a feedback loop and different actuation principle
- Mirrors that size can be used for sending and receiving
- A demonstrator scanning unit was realized at sercalo as a follow-up to this project.



Acknowledgements

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csem centre suisse d'électronique et de microtechnique

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Thank You !