

Will the future of high-rell components be  
Pure SCOTS or only SCOTish

**LENS** R&D

FOCUS ON INNOVATION



# The difference between SCOTS and SCOTish (1)

## SCOTish

- Produced before (build to print)
- Qualified (for a specific project)
- Rebuild after project grant

### Advantage:

- Low risk for supplier
- Low to Medium risk for buyer

### Drawbacks:

- Will take months to complete
- No sharing of NRE so high cost per unit
- Generally a delta qualification is needed adding risk of failure and costs

### Result:

Exactly what you want but slow and expensive

# The difference between SCOTS and SCOTish (2)

## Pure SCOTS

- Produced before sales
- Qualified to an envelop specification
- NRE recouped on batch produced

## Advantages:

- Low risk for supplier
- Low risk for buyer
- No delta qualification required
- Sharing of NRE over multiple devices and projects

## Drawbacks:

- Will need a high level of qualification to be able to serve multiple projects
- Will require up front investment from supplier

## Result:

Exactly what you buy, fast and cost effective (once qualified)

# When do you want to go SCOTish

1. If you want to make money on engineering and qualification.
2. If your product is not expected to be sold at medium to high volume
3. If you are satisfied with your market share and don't expect competition
4. ...

# When do you want to go pure SCOTS

1. If you feel there is a market need for a recurring product
2. If your product is rigid enough to sustain an envelop qualification
3. If you don't want to spend your life doing delta qualifications.
4. If you are interested in enabling high volume small satellite applications.

# Is COTS new?

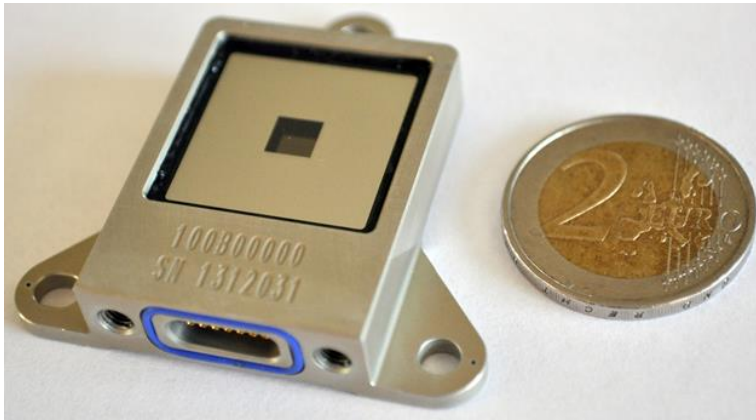
- **NO**

- ISIS qubesatshop is full of COTS devices
- Similar initiatives have popped up all over the world
- Cubesat's are mainly build using COTS devices.

# So why bother presenting ?

- There is a difference between SCOTS and COTS
- Smallsats are getting more mature
- Reliability requirements are increasing
- Nanosat electronics is generally not designed to be ultimately reliable but to be small and affordable.
- **Pure SCOTS** approach is needed for various **true high-rell components** in order to enable cost effectiveness for high-rell constellations.

# Lens R&D contribution

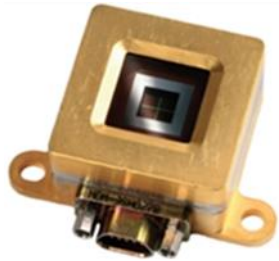


± 64 degrees FOV (in diagonal)  
± 0,5 degree accuracy  
Virtually indestructible

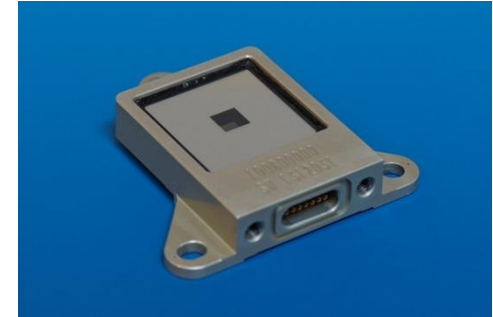
## BiSon 64



# History of a sunsensor in a nutshell



ESA-BIC



TNO mini-FSS

- True high rel
- High cost

BiSon 6

- high rel
- Terrestrial
- Low cost
- €225@5000pcs

BiSon 64

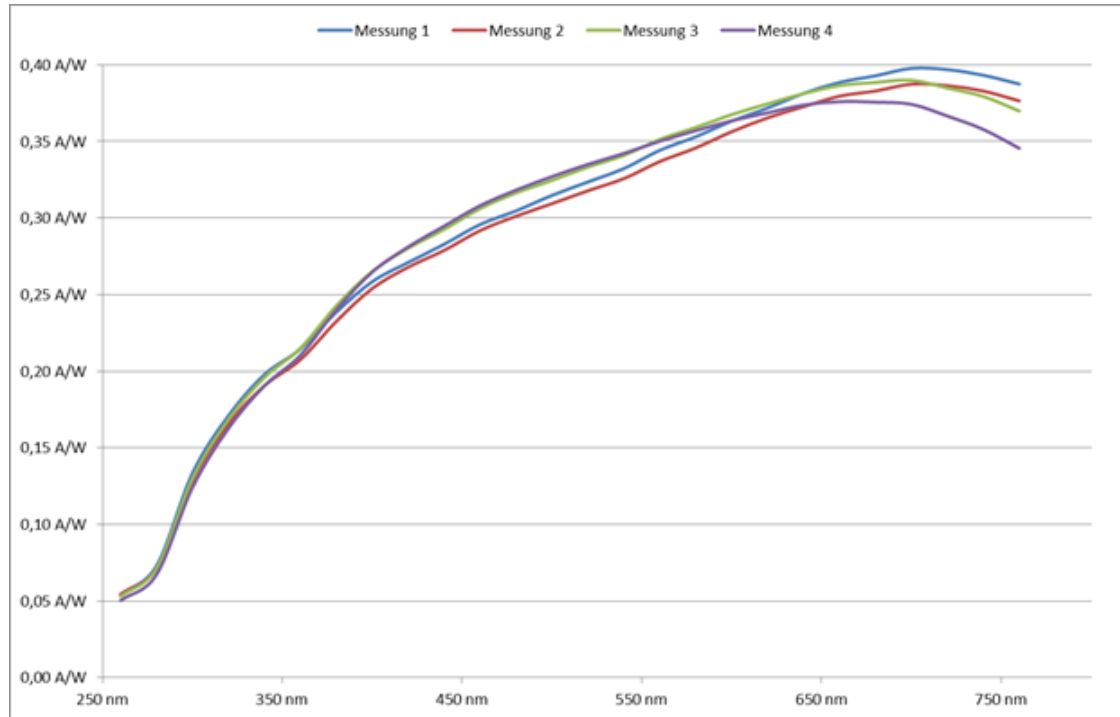
- True high rel
- Space
- Low cost
- €3750 EXW @6pcs

The (high-rell) world according to Lens

Pure SCOTS

?

# Radiation tolerance



First Sensor

## Tested to high dose

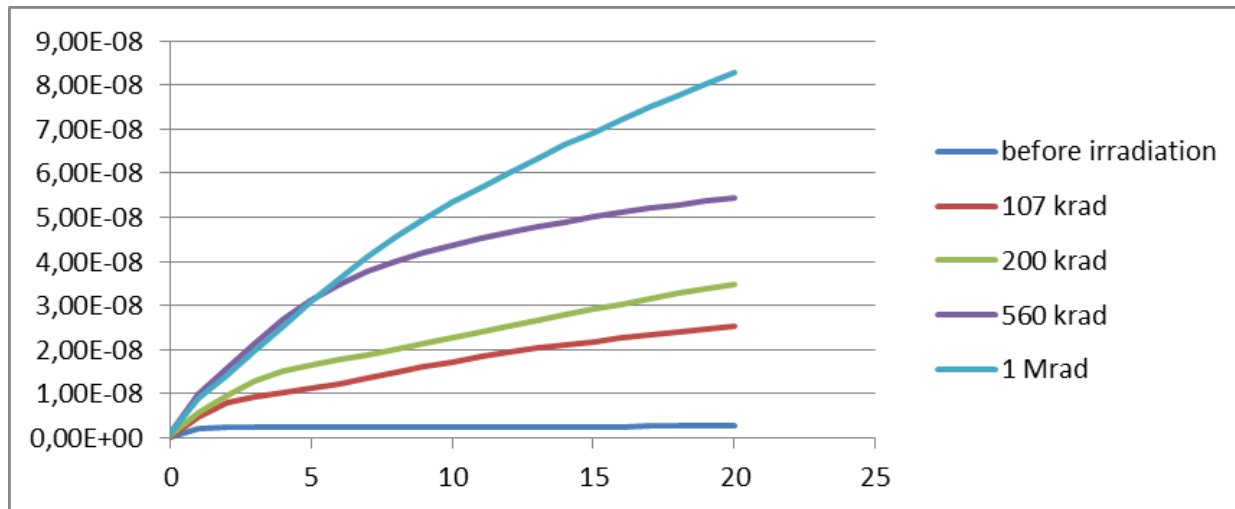
- Messung 1 = reference
- Messung 2= after  $1 \cdot 10^{15}$  1 MeV electrons
- Messung 3= after  $3 \cdot 10^{15}$  1 MeV electrons
- Messung 4= after  $1 \cdot 10^{16}$  1 MeV electrons

## Radiation insensitive algorithm

$$S_A = \frac{Q_3 + Q_4 - Q_1 - Q_2}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\alpha)}{\tan(\alpha_{MAX})} \quad \text{and} \quad S_B = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\beta)}{\tan(\beta_{MAX})}$$

# Radiation tolerance (2)

- Total dose testing performed at ESTEC
- Excellent dark current performance
- No change in quantum efficiency measurable

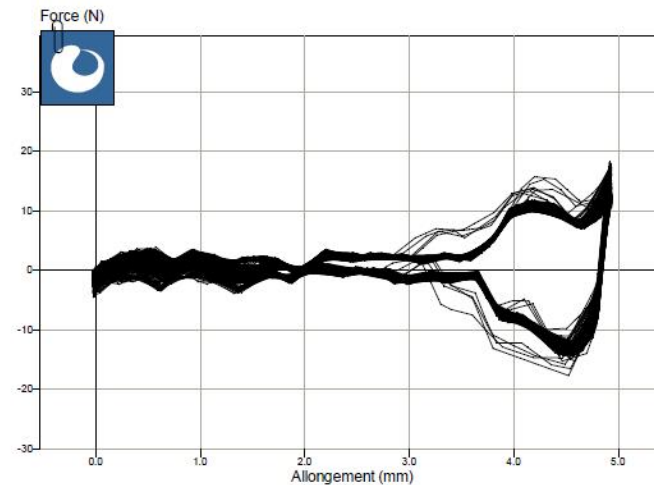
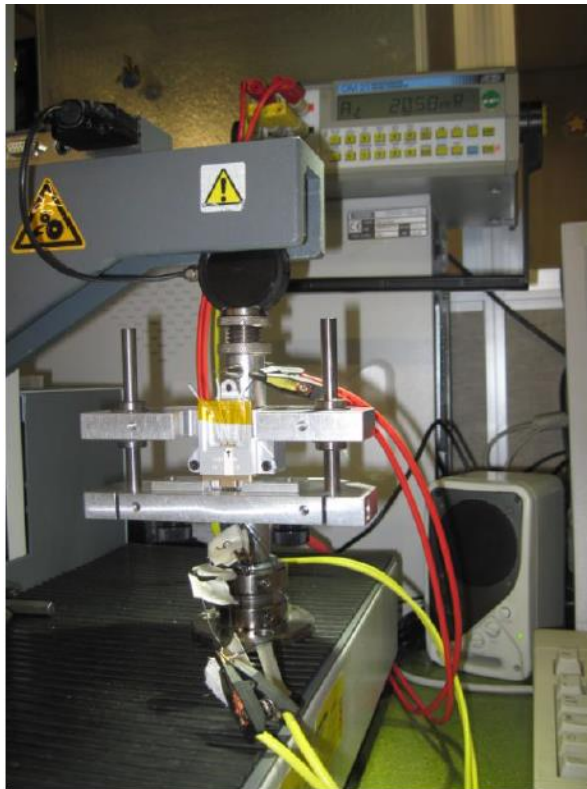


# Liquid Nitrogen dip-testing



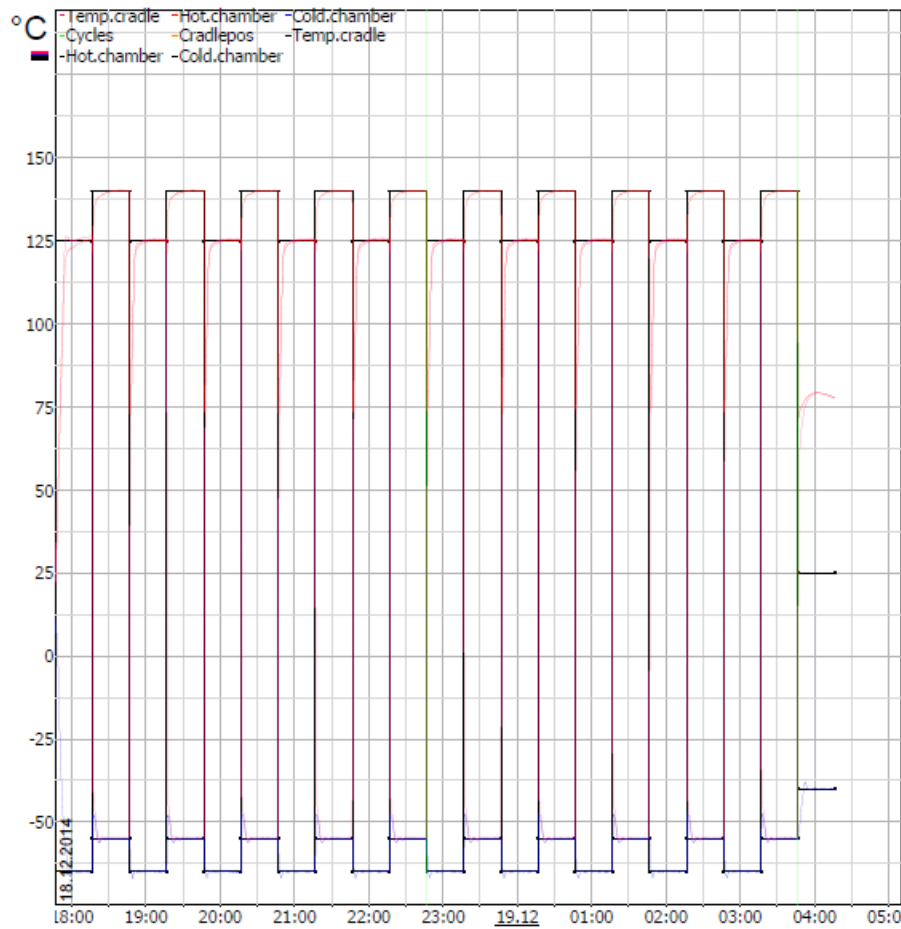
pure SCOTS or only SCOTisch

# 3000 mate/de-mate cycles



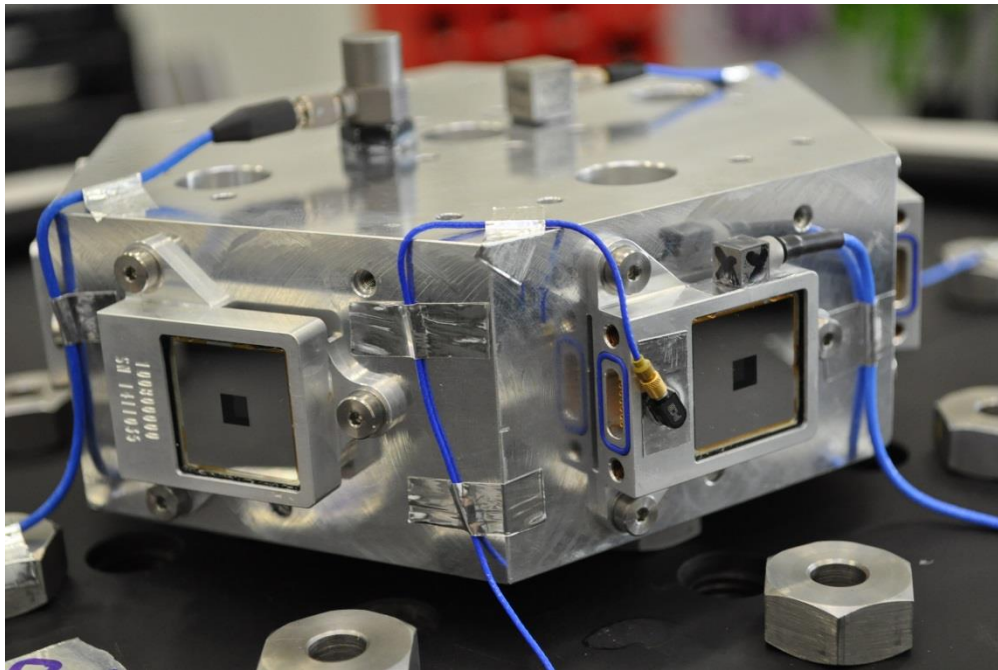
Grphe des 1000 à 1500 cycles

# Thermal testing



- 10 thermal cycles on each unit (MIL-STD-883 Method 1010B)
- 1000 cycles -45°C..+85°C planned Q2 2015
- 30.000 cycle test range TBD planned Q4 2015

# Vibration qualification at ESTEC



30g sine

37.9g random

N.B. 6 units tested instead of only 1

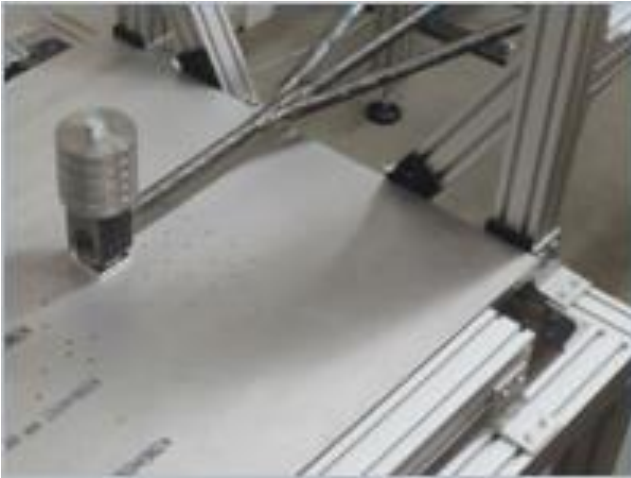


# Particle Induced Noise Testing

- On each unit
- According to MIL-STD-883 method 2020A
  - 4 times three 1000g shocks
  - 4 times 20g random for 3 seconds

# Pyro shock testing

- To be performed at ISIS Q4/2015

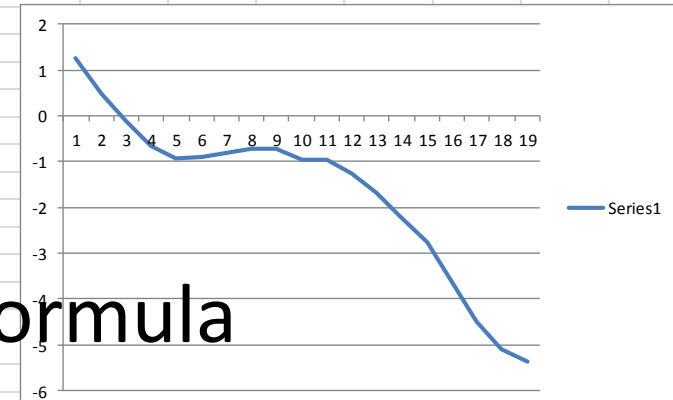
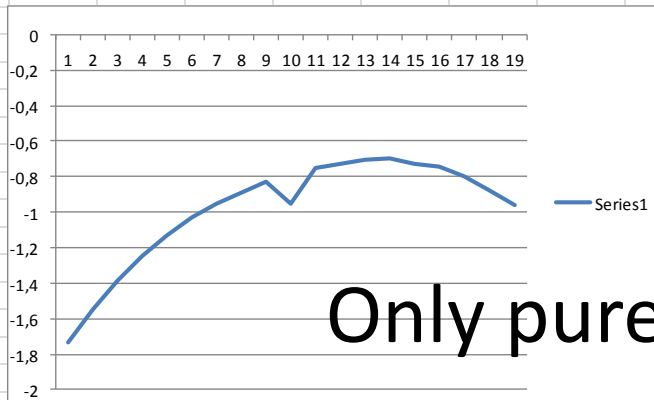
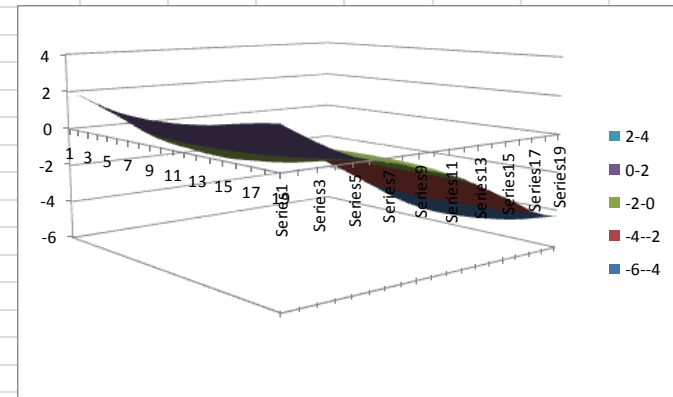
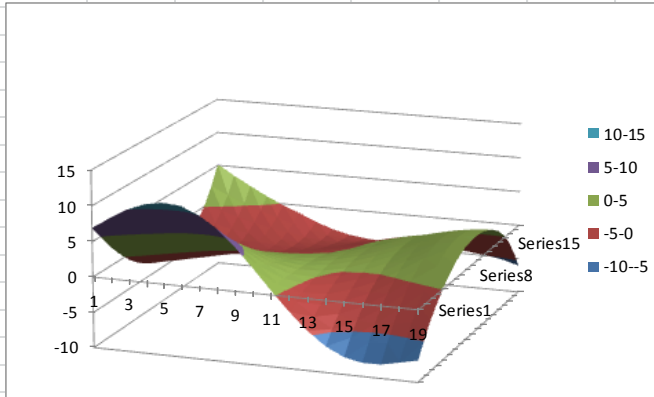


# Result

# Confidence

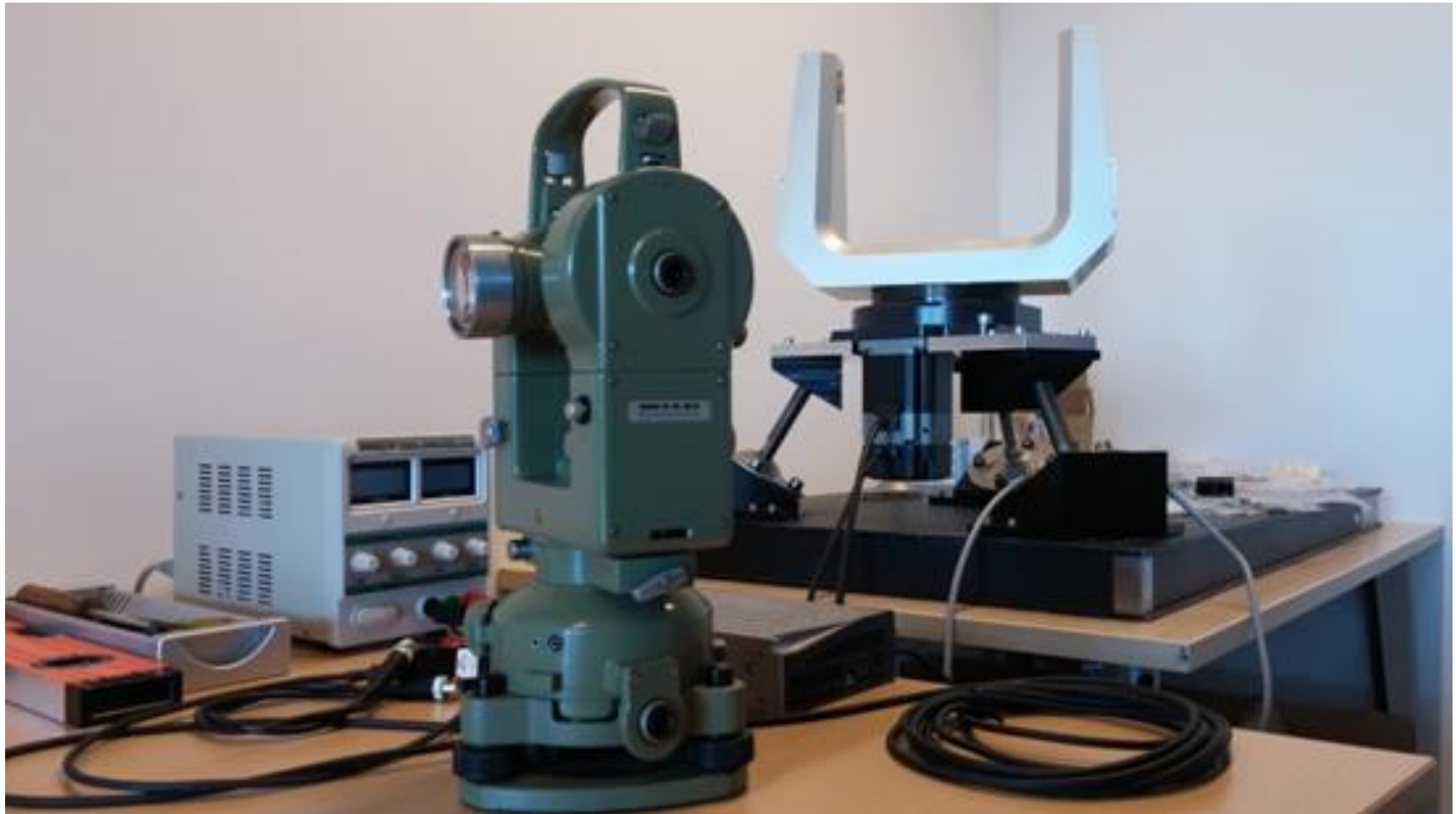
# Calibration at ESA (SN44) (Q2 2014)

max angle	55,2
offset alfa	0
offset beta	0
offset x	0
offset y	0
0 gain	
Q1	0 1
Q2	0 1
Q3	0 1
Q4	0 1
cos alfa	
cos beta	
Q1raw(0,0)	0
Q2raw(0,0)	0
Q3raw(0,0)	0
Q4raw(0,0)	0



Only pure formula

# Calibration setup under construction



pure SCOTS or only SCOTisch

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# Sales and prospects (1)

- 12 units sold to Luxspace for the ARTES21 Sat-AIS program (6 breadboard and 6 flight units)
- 6 units in option for second satellite (satellites 3/4/5 to be discussed)
- !!! Listed on ESA harmonisation roadmap !!!

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Netherlands

Miniature quadrant sun sensor – in final development

- Selected by the Dutch chamber of commerce and Shell as one of the five most innovative companies of the Netherlands



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# Sales and prospects (2)

- Taking orders
- Delivery within Q4 2015
- After this, Space grade COTS (SCOTS)
- 100% pre-payment but instant delivery of flight quality hardware

## Pure SCOTS

# Other parts that could go SCOTS

- Startrackers
- Earth sensors
- Reaction wheels
- Propulsion components
- SADM's
- Batteries
- TR modules
- Antennae
- .....

All parts which are needed on the majority of satellites.  
(or on several satellites in high volume)



# Conclusions

- Going pure SCOTS is needed to bring even more maturity to small satellites while increasing cost effectiveness.
- Although the risk is on the manufacturers side in first instance there are large gains to be expected for both manufacturer and customer.
- Large constellations of small satellites (like Oneweb) will largely depend on pure SCOTS components as otherwise they will either not be affordable or not reliable enough.

# The future will be pure SCOTS

## BiSon 64

Is there as a start



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# Thank you for your attention

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