# Survey on air quality control in cultural heritage institutions and development of automated corrosion sensors for real time monitoring

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INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE

nke INSTRUMENTATION

Fraunhofer FEP

# Background

- Air quality control without any feedback may be either inadequate or excessive
- Real time corrosion monitoring allows taking immediate counter measures if the air aggressiveness is elevated

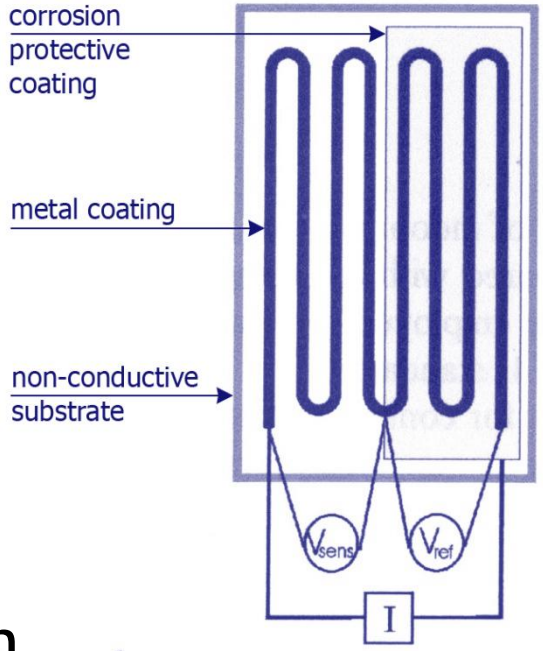




**Prototypes of loggers for measurement of air corrosivity developed** (CORRLOG project in FP6)

# AIRCORR prototype

- Precise measurement of changes in electrical resistance
- Small, battery driven, autonomy 3Y
- Exchangeable sensors
- Non-contact data reading, optional GPRS access
- Cu, Zn, Fe sensors, sensitivity in nm

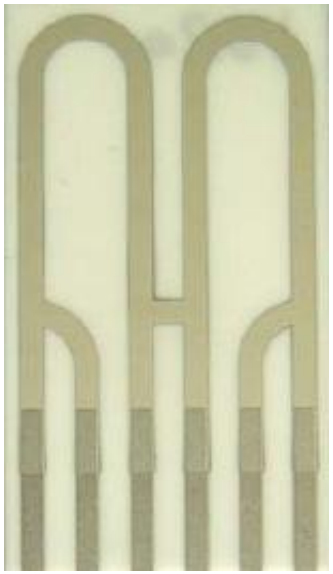



$$\text{Corrosion depth} = t_{init}\left(1 - \frac{R_{ref}}{R_{sens}}\frac{R_{sens,init}}{R_{ref,init}}\right)$$

$t_{init}$ *Initial metal track thickness*
$R_{sens}$ *Resistance of the sensor track*
$R_{ref}$ *Resistance of the reference track*
$R_{sens,init}$, $R_{ref,\ init}$ *Initial resistance*

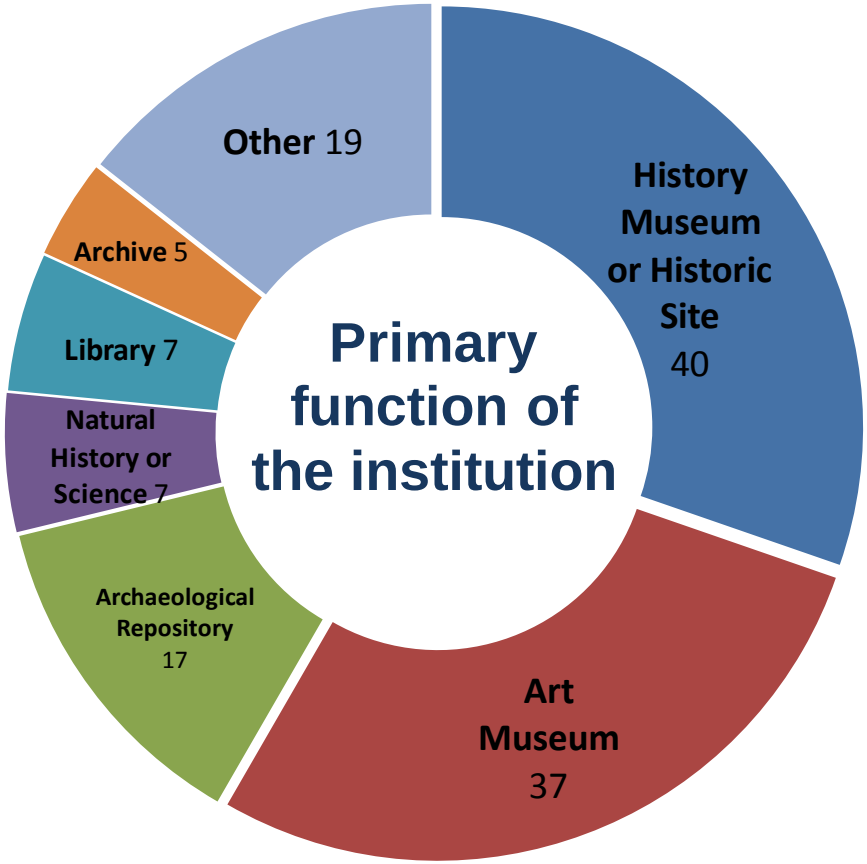
# MUSECORR project

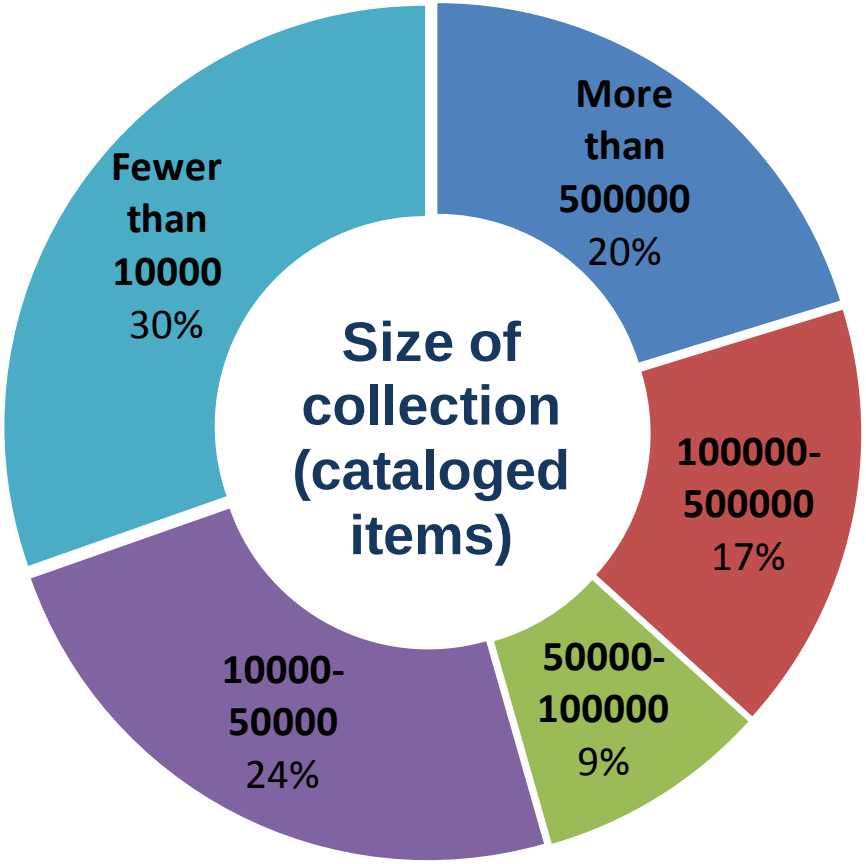
- 7th FP ‘Protection of cultural heritage by real-time corrosion monitoring’
- **Main goal: Adapt the prototype for monitoring in cultural heritage sphere** to get **useful**, **reliable** and **attractive** tool for professionals



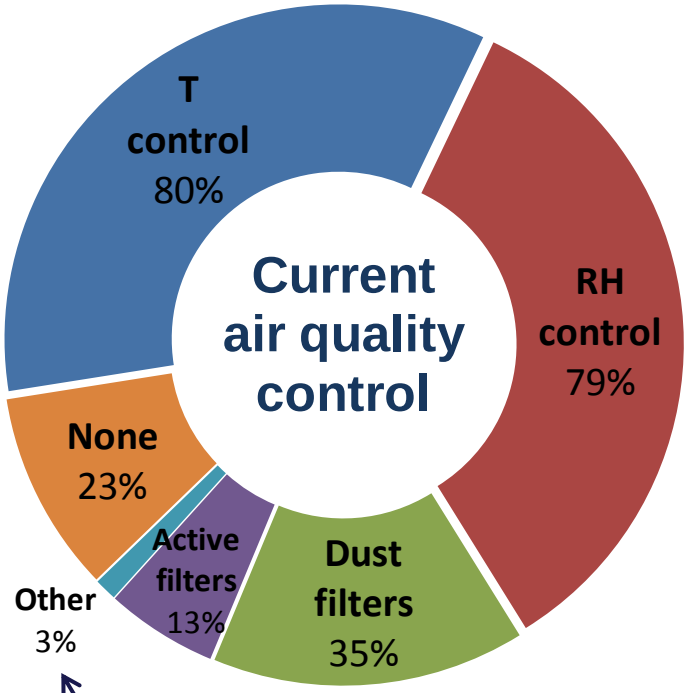
# Survey – Participants

- 22 questions
- 80 institutions from Europe and USA participated

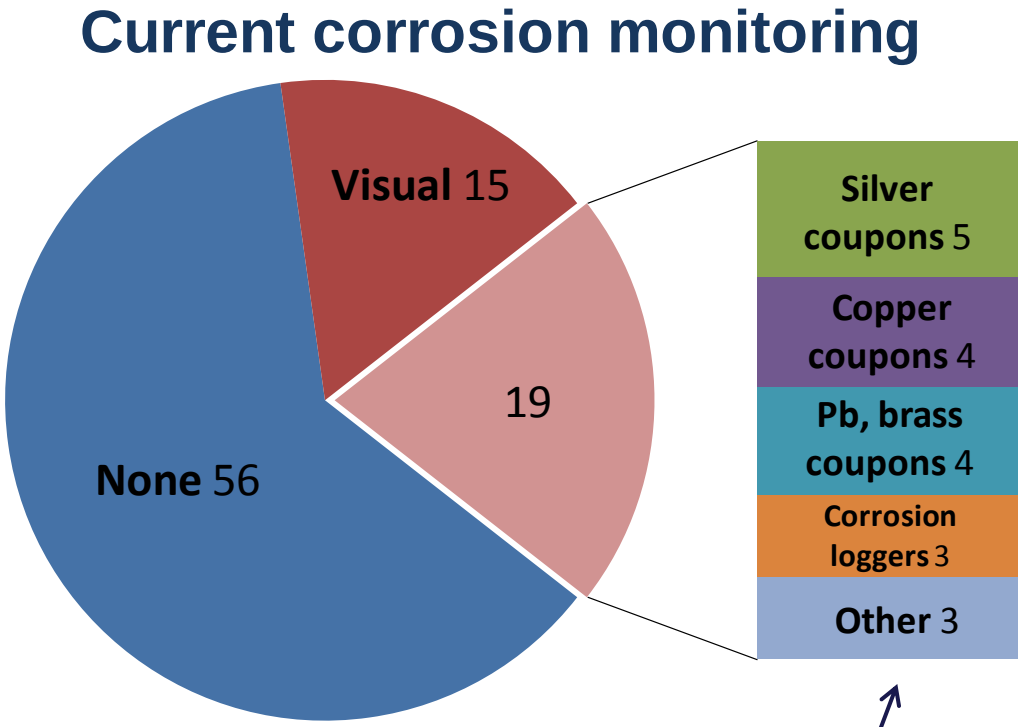


# Survey – Current state



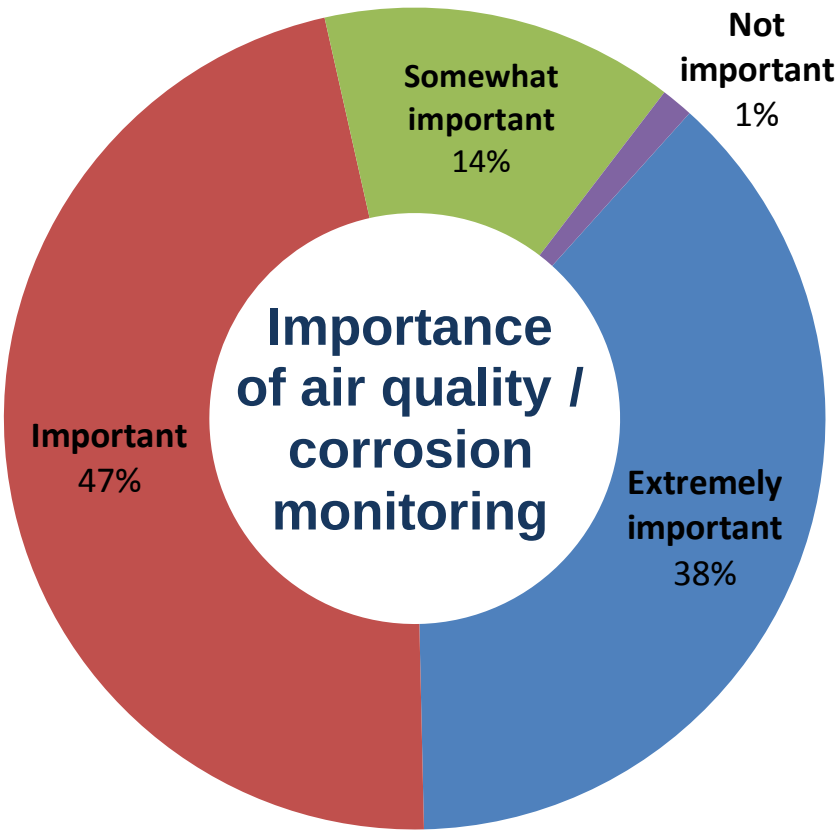

*Light filters (1)*
*Tarnishing protection fabric & zinc oxide (1)*




*Passive samplers (2)*
*Glass sensors (1)*

- Representative number and range of institutions

# Survey – Current state

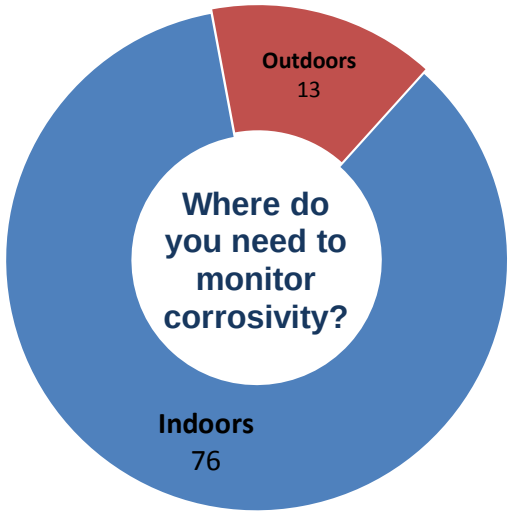


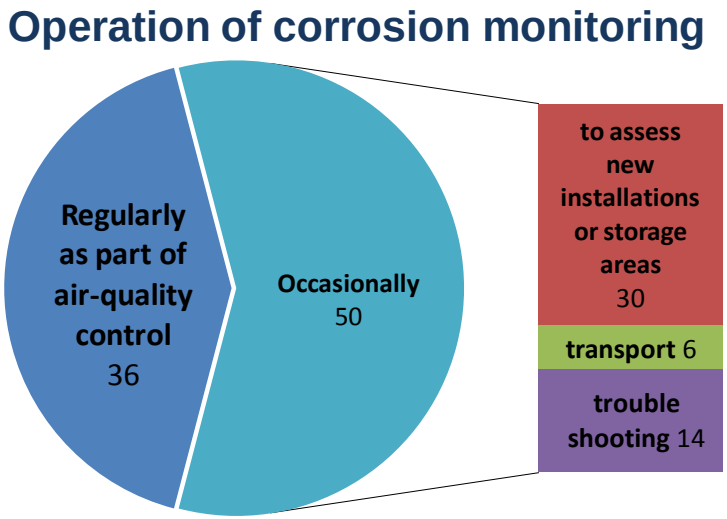


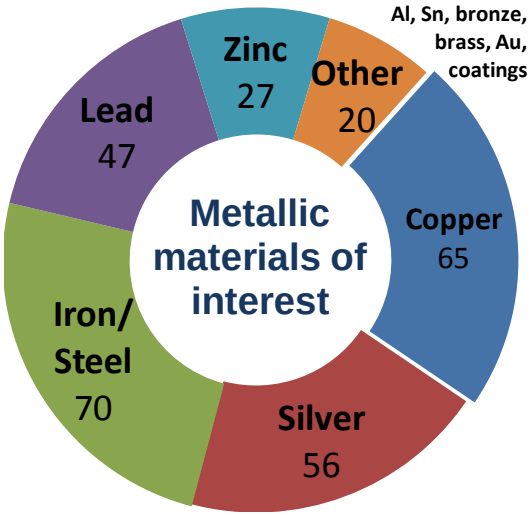
- **Current situation in air quality and corrosivity monitoring unsatisfactory ⇨ Strong need for new tools**

# Survey – Goals and needs

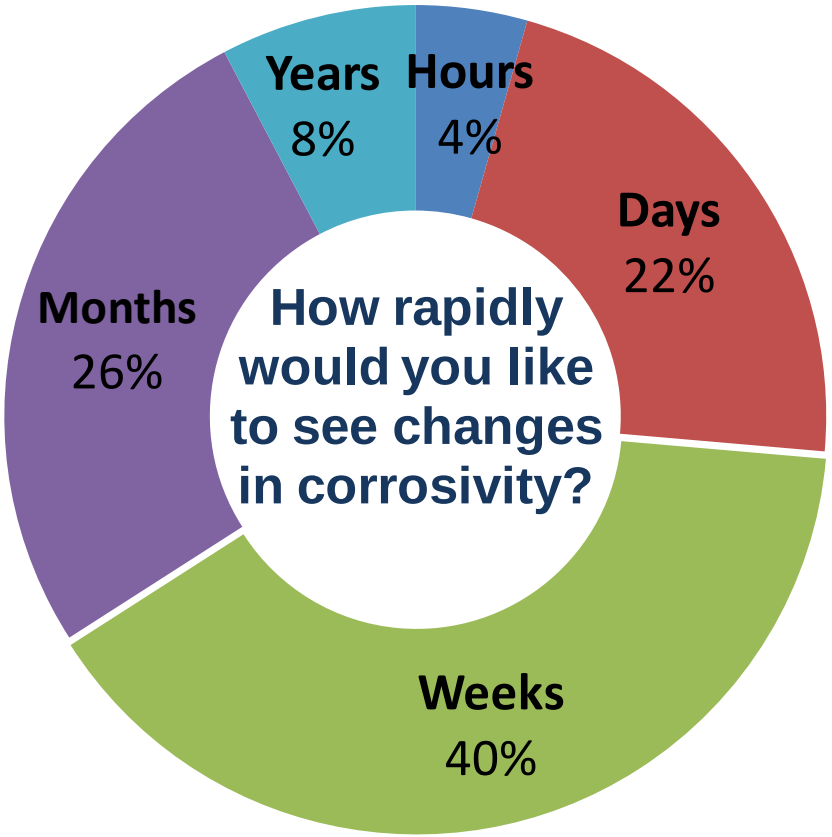
| What are the main goals of corrosion monitoring in your institution? | |
|---|---|
| Protection of materials of interest | 86% |
| Survey on general corrosivity of the environment | 33% |
| Problem solving | 30% |
| Assessment of exact corrosion rate of metals of interest | 26% |
| Verification of air control function | 19% |
| Assessment of air corrosivity classes according to standards | 11% |
| Monitoring is part of the institution's internal standards | 10% |

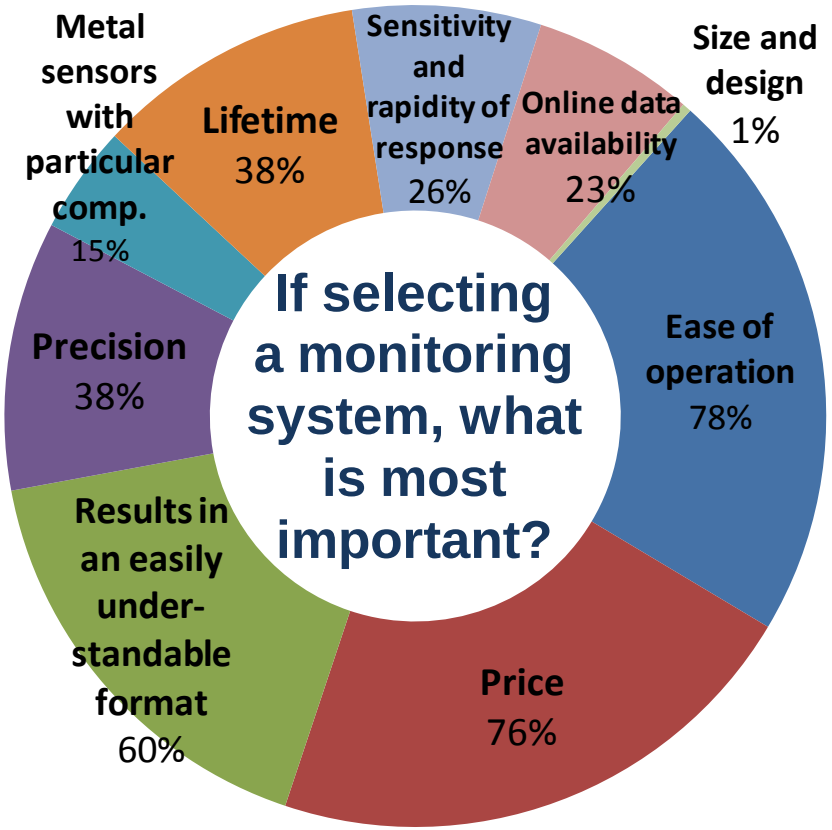


# Survey – Requirements

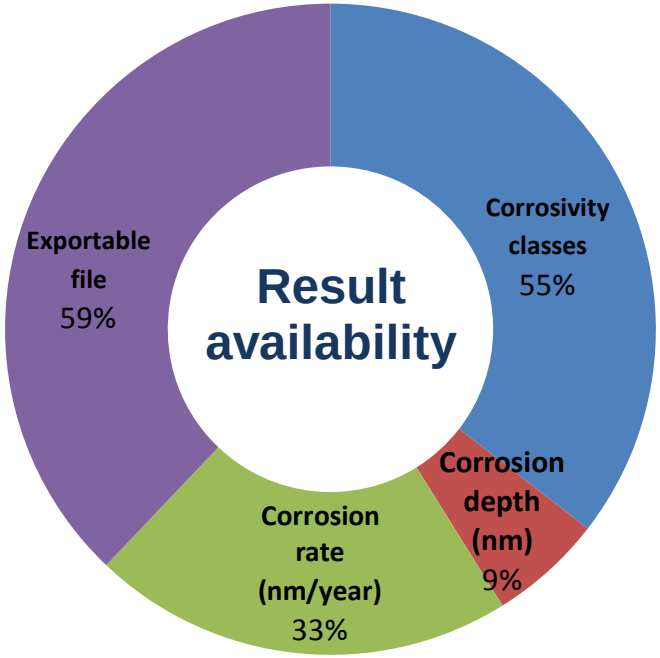


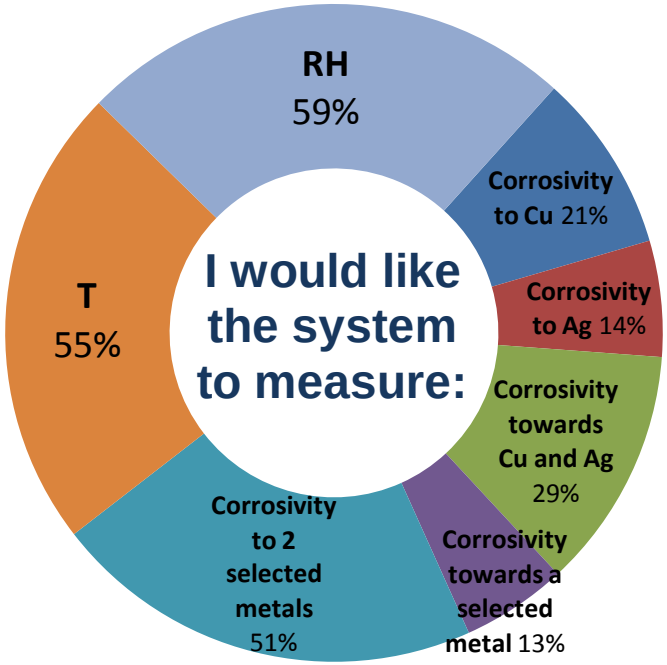




- **Ease of operation and easily-understandable data highly valued**

# Survey – Requirements

***Other results**: 59% of respondents preferred more costly device with exchangeable sensors and battery; 87% prefer to run measurements themselves; only 20% ready to pay for online data*

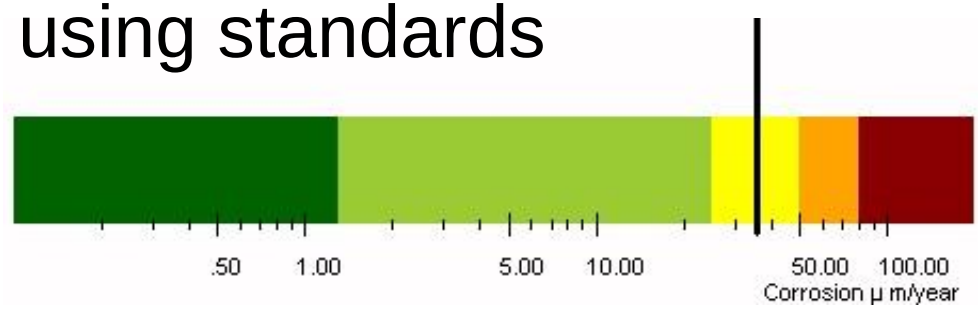



- Testing air corrosivity towards two metals of choice simultaneously preferred
- Incorporation of temperature and RH sensors might be desirable

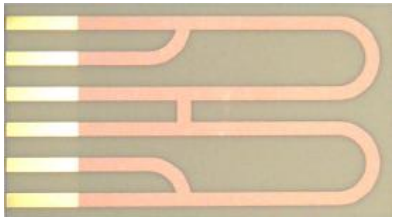
# AIRCORR logger concept

- All prototype features, more versions:
  - **I:** Indoor, 1 exchangeable sensor
  - **I Plus:** Indoor, 2 exchangeable sensors, T and RH sensors, LCD showing actual corrosivity, RH & T
  - **O:** Outdoor, water tight, fixed sensor
  - **GI:** Indoor/Outdoor, GPRS access
- New software: Easy operation, data treatment, interpretation using standards

# AIRCORR sensors

- New ultra sensitive sensors for low-corrosivity environments



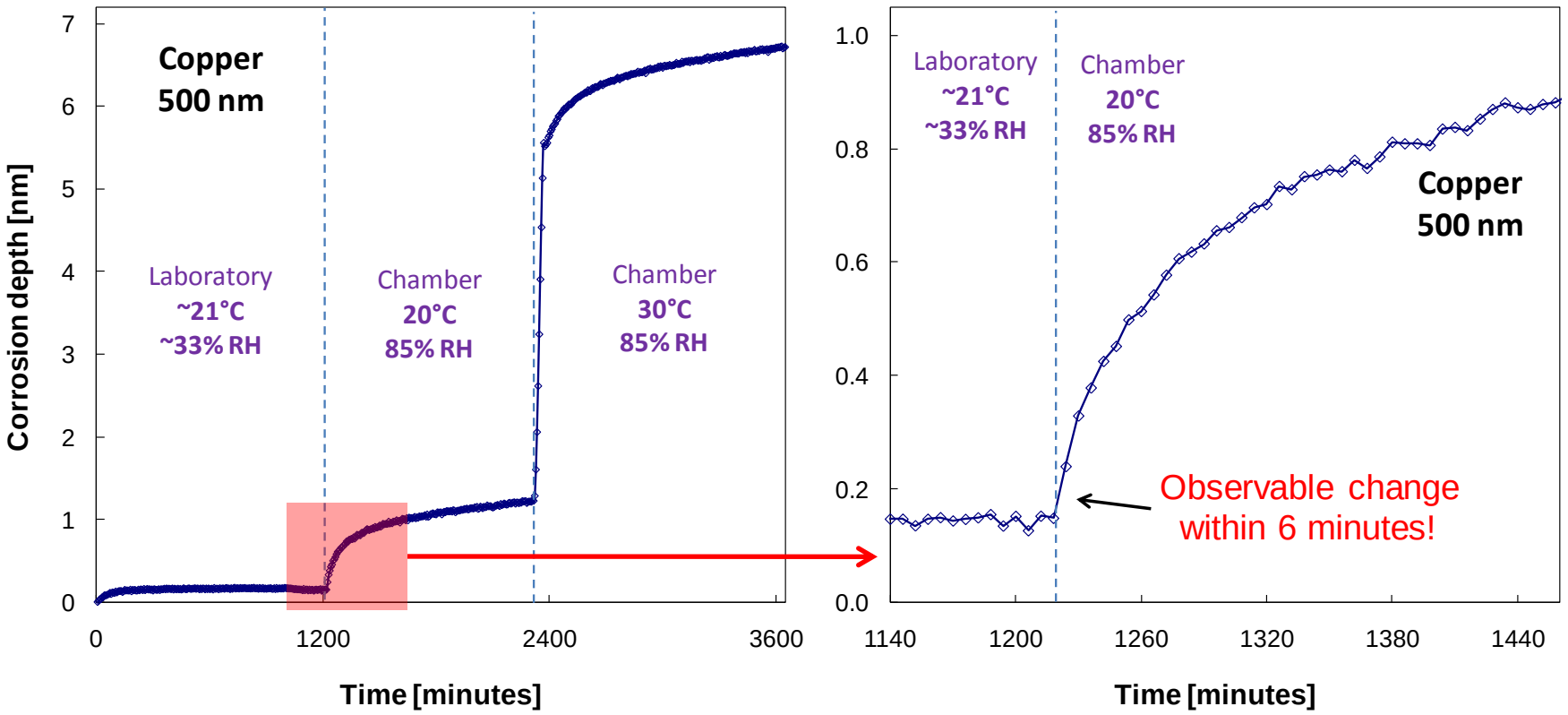
| Material | Indoor, high sensitivity | Indoor, long lifetime | Outdoor, high sensitivity | Outdoor, long lifetime |
|---|---|---|---|---|
| Copper | 50 nm | 500 nm | 5 µm | |
| Silver | 50 nm | 500 nm | | – |
| Lead | 200 nm | | 5 µm | |
| Iron/steel | 200 nm | | 25 µm | 250 µm |
| Zinc | – | 25 µm | | 50 µm |
| Tin | – | 5 µm | | |
| Bronze | 200 nm | | 5 µm | |
| Brass | – | 10 µm | | |

| *Ready* | *Under testing* | *To be developed* |
|---|---|---|

# AIRCORR sensors

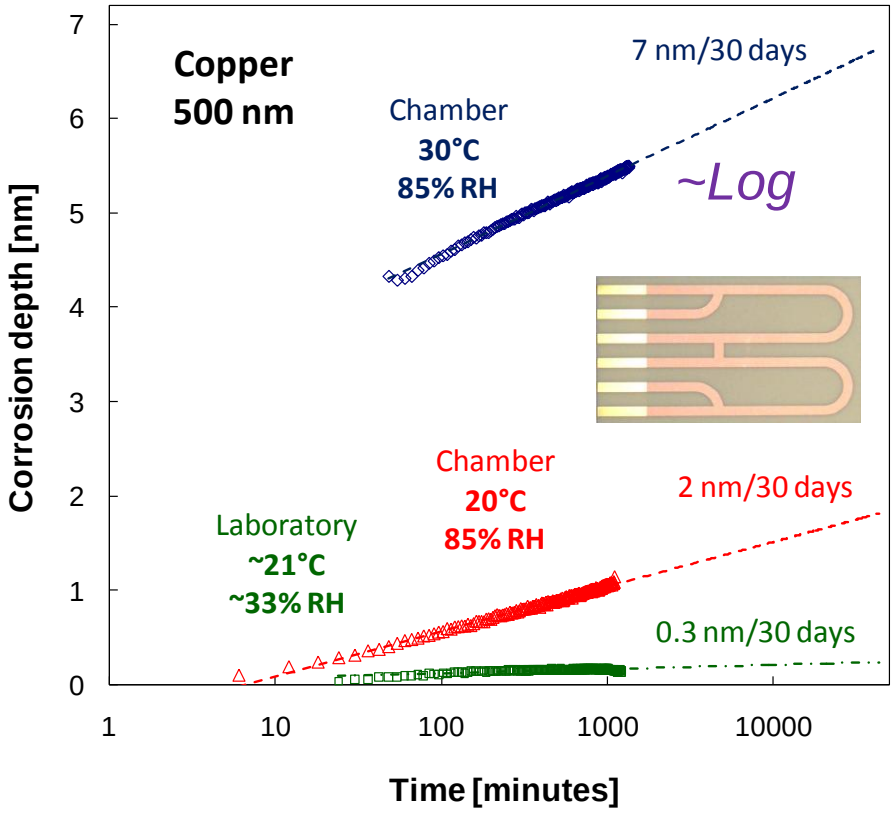
- Wide range of sensor materials ⇨ **Monitoring of air corrosivity for a given object / group of objects possible**
- Air corrosivity towards other materials may also be monitored by selecting appropriate sensor

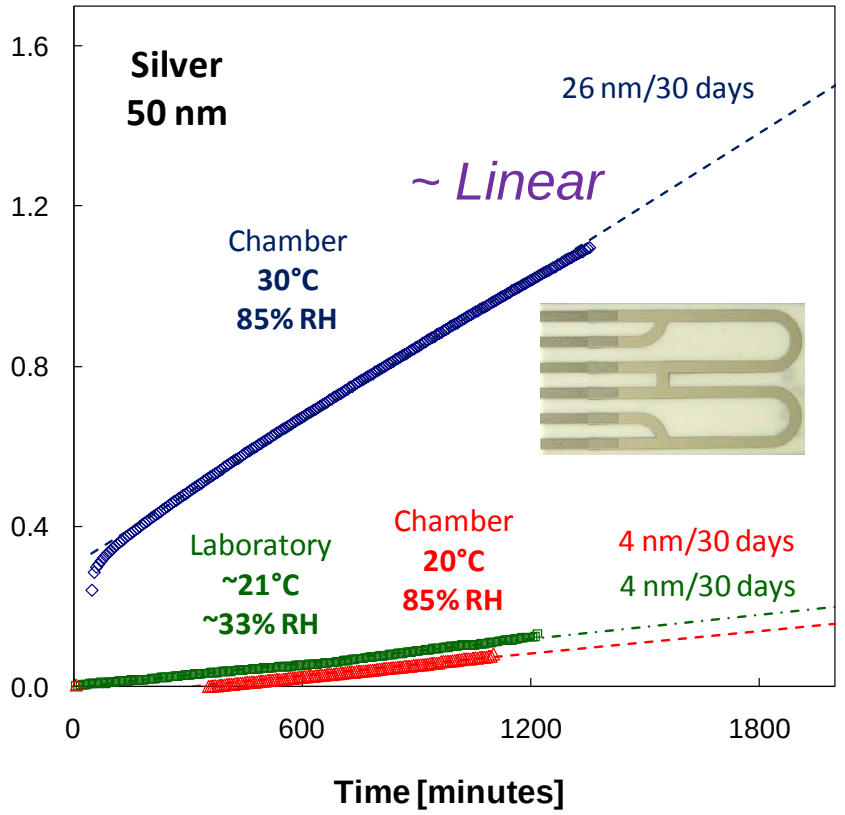
# Ultra sensitive sensors – tests




- 9-µm copper sensor cannot be used for monitoring in low-corrosive indoor environment
- **Very high sensitivity of 500-nm sensor**

# Extrapolation of metal loss




| | Extremely pure | Pure | Clean | Slightly contaminated | Polluted |
|---|---|---|---|---|---|
| Copper | C1 < 9 | C2 < 15 | C3 < 25 | C4 < 35 | C5 ≥ 35 |

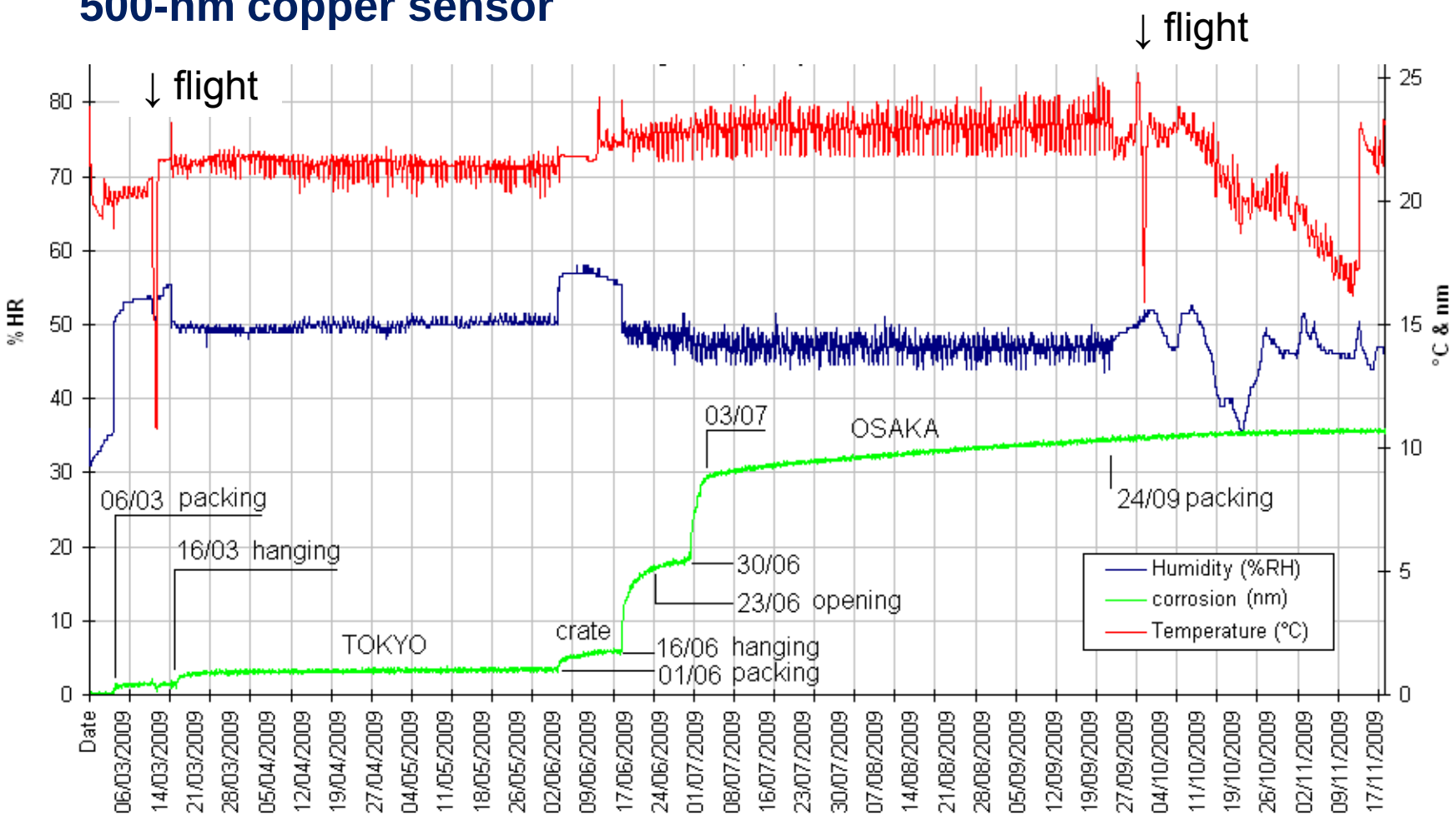
| | Extremely pure | Pure | Clean | Slightly contaminated | Polluted |
|---|---|---|---|---|---|
| Silver | S1 < 4 | S2 < 10 | S3 < 20 | S4 < 30 | S5 ≥ 30 |

*Classification of corrosivity of indoor atmospheres after Sacchi and Muller; in nm/30 days*

# Field data – transport

- Tapestry from Louvre collection loan to Japan

**500-nm copper sensor**

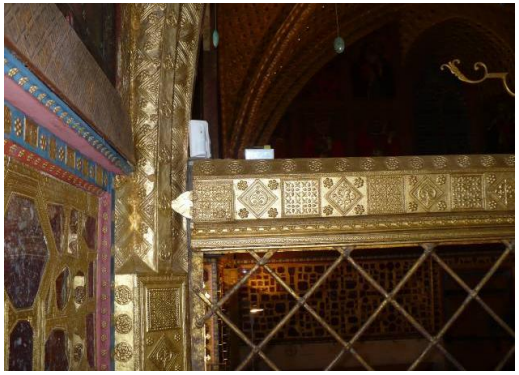


# Conclusions

- Current situation in air quality and corrosivity monitoring unsatisfactory
- **Need for simple, easy to operate tools for air quality / corrosivity monitoring**
- **Electrical resistance technique with ultra thin sensors provides very high sensitivity** and short response time even in low-corrosivity indoor environments (sub-C1/S1 class)
- Monitoring of air corrosivity for many different materials possible due to **wide range of available sensors**

# Next steps

- Laboratory testing: 2010 (HCOOH, $CH_3COOH$, $H_2S$)
- Internal testing in real environments: December 2010 – May 2011
- End-users testing: from June 2011
  - 50 institutions interested, but **further proposals of case studies still welcome**



In case of interest, contact *Vera Hubert, Michelle Taube, Milan Kouril* or *Michel Dubus*

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# Acknowledgement

**A research project supported by the European Commission under the Seventh Framework Programme**

Duration: **06/2009–05/2012** Contract number: **226539**

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**Special thanks to all participants of the survey**