

# FUTURE INTERIOR AIR QUALITY MONITORING SYSTEMS

A REAL TIME TOOL TO MONITOR ONBOARD AIR QUALITY

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Public

# AGENDA

1 AQS (“AIR QUALITY SENSOR”) CONCEPT

2 USE CASES

3 THE PROJECT

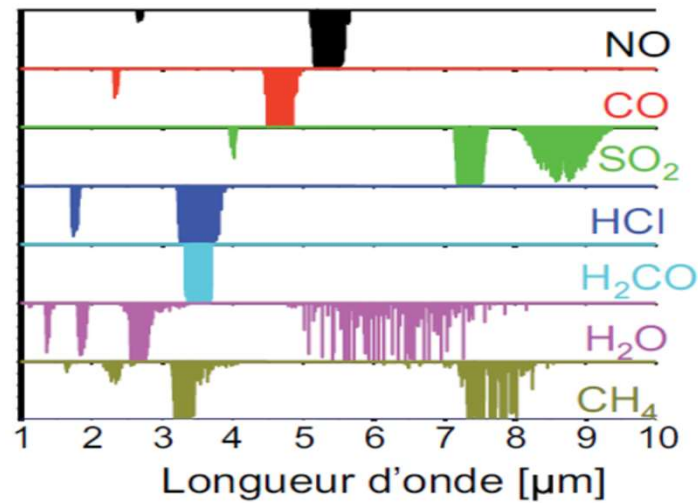
4 “STAGE 4” OPEN POINTS

# AQS

## THE CONCEPT

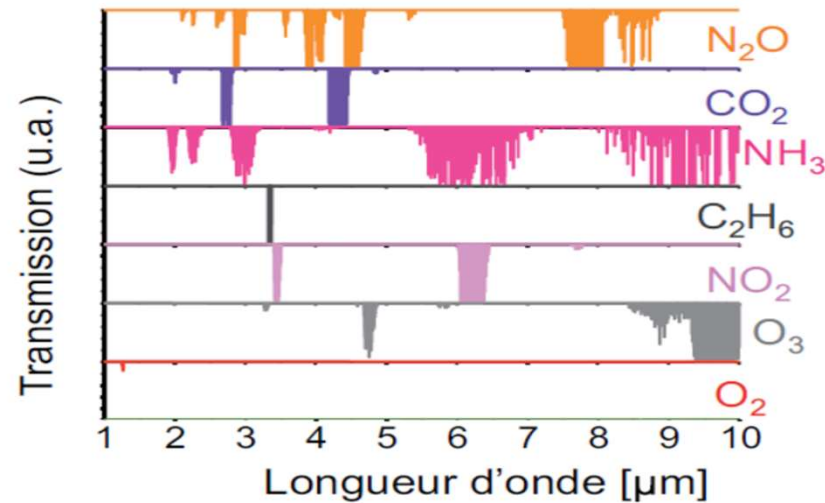
### Optical spectroscopy

- ✓ molecular absorption spectroscopy based on Beer Lamber law
- ✓ absorption bands specific to target gas



### Mid Infrared range (from 2.5um)

- ✓ relies on molecule “fundamental” vibration
- ✓ exhibits strongest absorption level: X10 to X100 vs NIR



- ✓ **Multi gas measurement capabilities**
- ✓ **Specific measurement: system optical design / concept related**

# AQS

## TARGET SPECIFICATION (ANALYTICS)

Gas	Range		Sensitivity (LLD)	Accuracy
CO (ppm)	2	500	2	+/-1
CO2 (ppm)*	250	15000	250	+/-125
NO2 (ppb)	20	400	20	+/-10
NO (ppb)	20	800	20	+/-10
Formaldéhyde (ppb)	40	500	40	+/-20
O3 (ppb)	30	150	30	+/-15
H2O* (%)	0.1	5	0.1	TBD

\*: Absolute concentration

LLD: Lower Limit of Detection

- ✓ Sensitivity values derived from Health WW recommendation related to long term exposure (1 year)
- ✓ \*: VITESCO suggestion

# AQS

## TARGET SPECIFICATION (ANALYTICS) JUSTIFICATION

### Air quality guideline values

Pollutant	Air inside a vehicle	Air in populated areas										
	GOST 33554-2015*	RF*		WHO*		EU*		USA*		Korea*		
NO <sub>2</sub> , µg/m <sup>3</sup>	200	200	40	200	40	200	40	100	190	110	57	
NO, µg/m <sup>3</sup>	400	400	60	undefined	undefined	undefined	undefined	undefined	undefined	undefined	undefined	
PM <sub>10</sub> , µg/m <sup>3</sup>	undefined	300	60	50	20	50	40	150	100	50	50	
PM <sub>2.5</sub> , µg/m <sup>3</sup>	undefined	160	35	25	10	20	20	35	50	25	25	
O <sub>3</sub> , µg/m <sup>3</sup>	undefined	160	30	100	100	120	120	140	200	120	120	
CO, mg/m <sup>3</sup>	5	5	3	undefined	undefined	10	10	41	11	29	10	
SO <sub>2</sub> , µg/m <sup>3</sup>	undefined	500	50	500	20	350	125	200	200	400	130	53
<span style="border: 1px solid red; border-radius: 50%; padding: 2px;">VOC</span> CH <sub>2</sub> O, µg/m <sup>3</sup>	50	50	10	undefined	undefined	undefined	undefined	undefined	undefined	undefined	undefined	
Benzene, µg/m <sup>3</sup>	undefined	300	100	undefined	undefined	5	5	undefined	undefined	5	5	

\*Exposure time

Short term

Long term

- ✓ From VIAQ 8th: still valid or to be updated? Agreed within automotive community?
- ✓ Are those thresholds health and drowsiness related?

# AQS

## TARGET SPECIFICATION

Parameter	Number
Ambiant temperature	$-40^{\circ}\text{C} < T_{\text{amb}} < +85^{\circ}\text{C}$
Relative Humidity	$5\% < H_{\text{rel}} < 95\%$
Voltage	$9\text{V} < V < 16.5\text{V}$
Power	$< 1\text{W}$
Interface	LIN or CAN
Dimension	10cmX5cmX5cm
Response time	$< 1\text{s}$
Number of operating hours	10 000 H
Number of measurement	100 000
Lifespan	10 year

- ✓ Consistant with onboard automotive application
- ✓ Power and response time are correlated to measurement accuracy and sensitivity

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## REASON / MOTIVATION



- ✓ Visible Trend in awareness of in cabin-air-quality



- ✓ No reliable measurement to monitor and compute an AQI „Air Quality Index“

- ✓ Reliability means:

- ✓ Absolute
- ✓ Specific
- ✓ Sensitive

$$a_i = \left( \frac{MAC_{CO_{amb}} \times MAC_{CO_{w.zone}}}{MAC_{i_{amb}} \times MAC_{i_{w.zone}}} \right)^{\frac{1}{2}} = \sqrt{\frac{60}{(MAC_{i_{amb}} \times MAC_{i_{w.zone}})}}$$



- ✓ Opportunity to take care of both internal and external sources of pollution and adapt to pollution pattern
- ✓ Opportunity to combine onboard existing sensing functionality (CO2 + Humidity) together with extra measurement features (gaseous pollutants)



# AQS

## HARMFULNESS DIFFERENTIATION

### > Negative impact on:

#### Comfort / Safety

- › How: Short term exposure
  - › 10s to 1min
- › Effects
  - › Bad feeling
  - › Impair driver cognitive skills, drowsiness
  - › Impair vision (windshield fogging)
- › Relevant compounds / parameters:
  - › CO<sub>2</sub>
  - › CO
  - › NO
  - › O<sub>3</sub>
  - › Relative Humidity (fogging)
  - › Bad odors molecule (toluene, NH<sub>3</sub> and others??)

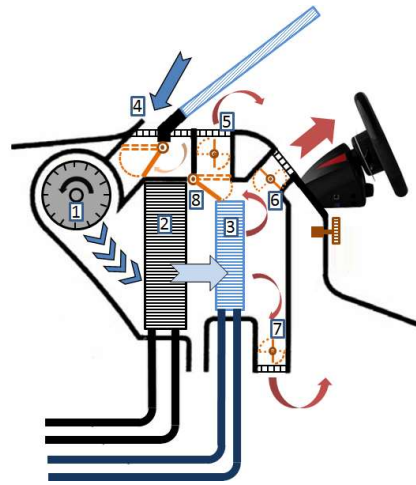
#### Health

- › How: Long term exposure and cumulative effect
  - › Hours
- › Effects:
  - › Asthma
  - › Cardio vascular disease
  - › Cancer
  - › Negative impact on central nervous system
- › Relevant compounds:
  - › CO<sub>2</sub>, CO, NO, O<sub>3</sub>
  - › NO<sub>2</sub>
  - › *PM<sub>2.5</sub> and smaller*
  - › Some VOC / HC (toluene, formaldehyde and others??)

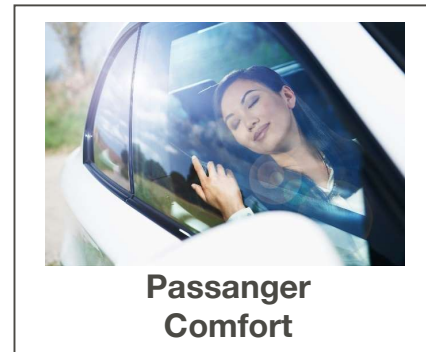
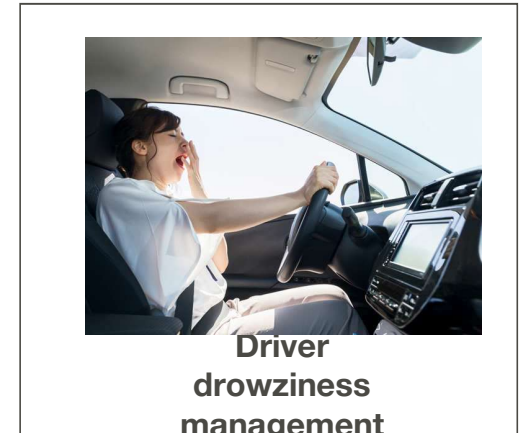
# AQS

## USE CASES

### « WHY USING A MULTI GAS SENSOR ? »



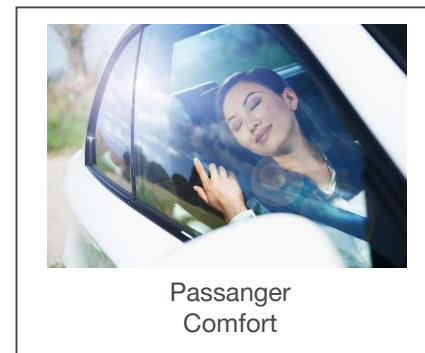
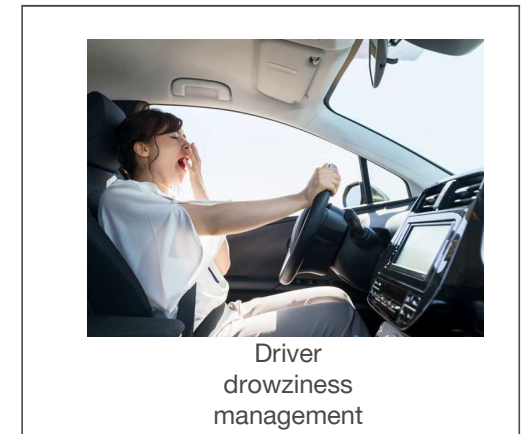
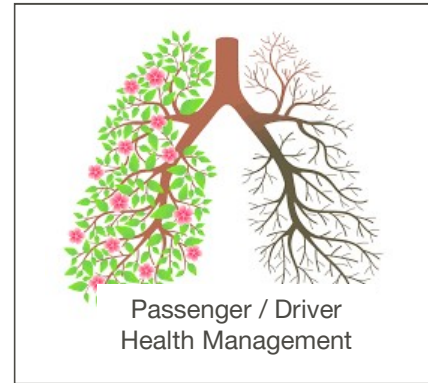
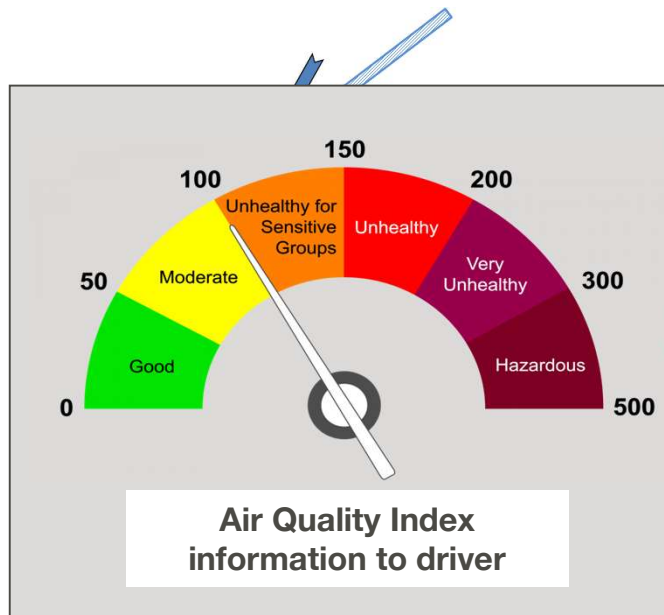
HVAC Control



# AQS

## USE CASES

### « WHY USING A MULTI GAS SENSOR ? »



# AQS

## USE CASES: DETAILS (SUGGESTION)

### « HOW USING A MULTI GAS SENSOR INFORMATION ? »

> Sensor information can be an **entry point** to close loop air cleaning devices (In cabin sensor):

> Air fractional recirculation:

> Air Exchange Ratio (AER)

> Purification devices:

> Ionizer

> Activated carbon filters

> Others ??

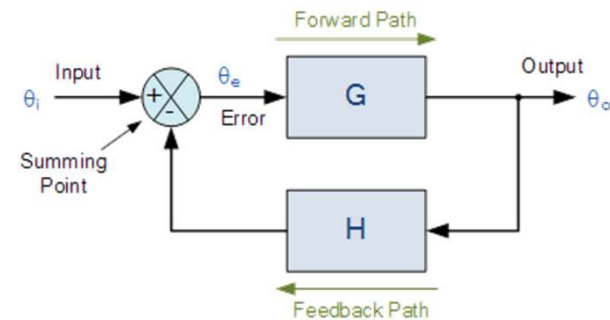
> **Close loop** on different output:

> Air Quality Index « Health » related

> Air Quality Index « Safety » related

> Power consumption (HVAC):

> HVAC compressor load vs circulation mode type (fresh air / recirculation)



# AQS

## USE CASES: DETAILS

### « HOW USING A MULTI GAS SENSOR INFORMATION ? »

- > Real time monitoring of air purification devices:
  - > Air filters (activated carbons and others ??):
    - > Efficiency (breakthrough)
  - > Ionizer:
    - > O<sub>3</sub> production
  - > Others: ??

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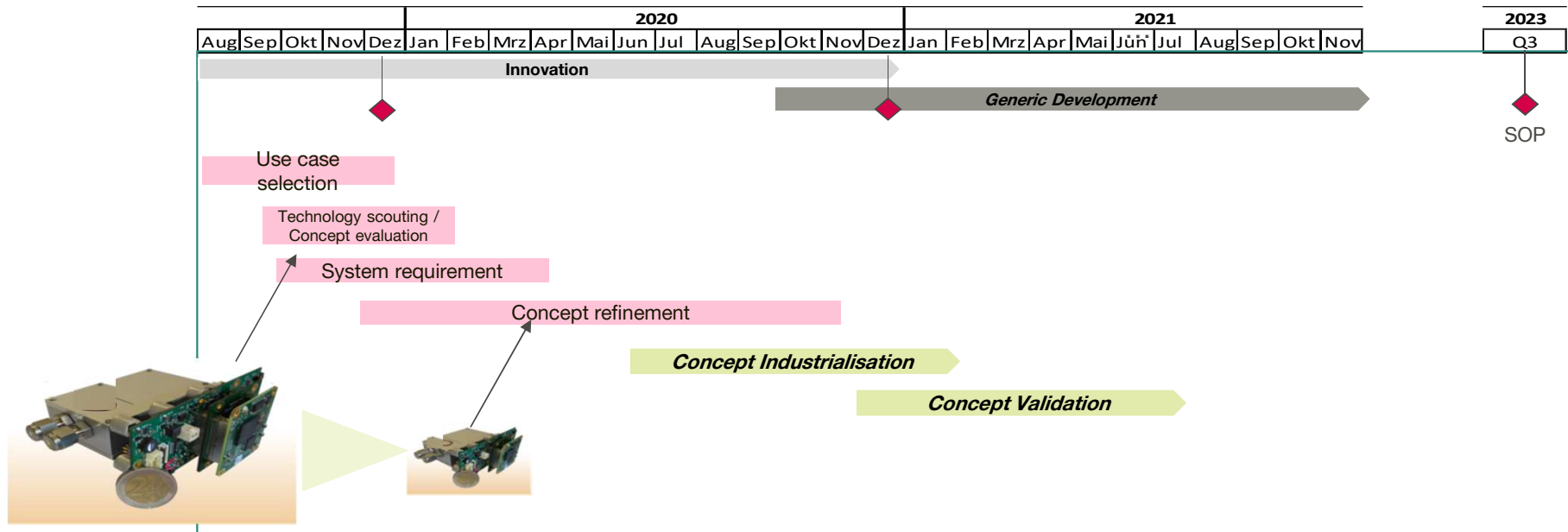
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# AQS

## DEVELOPMENT SCHEDULE



Available gases:  
NO, NO2, CO, CO2, NH3,  
Formadelhylde, Humidity

SOP: Start Of Production

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# AQS

## KEY QUESTIONS TO BE ADRESSED WITHIN STAGE4

> QUESTIONS ARE REQUESTED TO DRIVE SENSOR SPECIFICATION and DEVELOPMENT

> WHICH ARE THE MOST RELEVANT GASEOUS POLLUTANT TO BE CONTROLLED?

> WHICH ARE THE LOWEST CONCENTRATION TO BE CONTROLLED?

> DOES AQI (Air Quality Index) CALCULATION NEED TO BE UPDATED?

$$a_i = \left( \frac{MAC_{CO_{amb}} \times MAC_{CO_{w.zone}}}{MAC_{i_{amb}} \times MAC_{i_{w.zone}}} \right)^{\frac{1}{2}} = \sqrt{\frac{60}{(MAC_{i_{amb}} \times MAC_{i_{w.zone}})}}$$

> DOES AQI CALCULATION AGREED WITHIN SCIENTIFIC COMMUNITY AND BETWEEN VIAQ MEMBERS?

> IS AN AQI DIFFERENTIATION BETWEEN HEALTH AND COMFORT/SAFETY RELEVANT?

**LET'S  
DISCUSS!**