

# Smart sensor for schools

heat stroke, lightning strike, PM2.5 monitoring and alerting

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# The problems

- Real **life-threatening**<sup>1</sup> risks to students during outdoor activities from:
  - **Heat stroke**<sup>2</sup> (especially, during heat wave) .
  - **Lightning strike** injuries<sup>3</sup>.
- **Lack useful information** to effectively plan outdoor activity, which may lead to unnecessary event cancellation.
- Hard to design and **manage heat policy scientifically** based on unclear data.



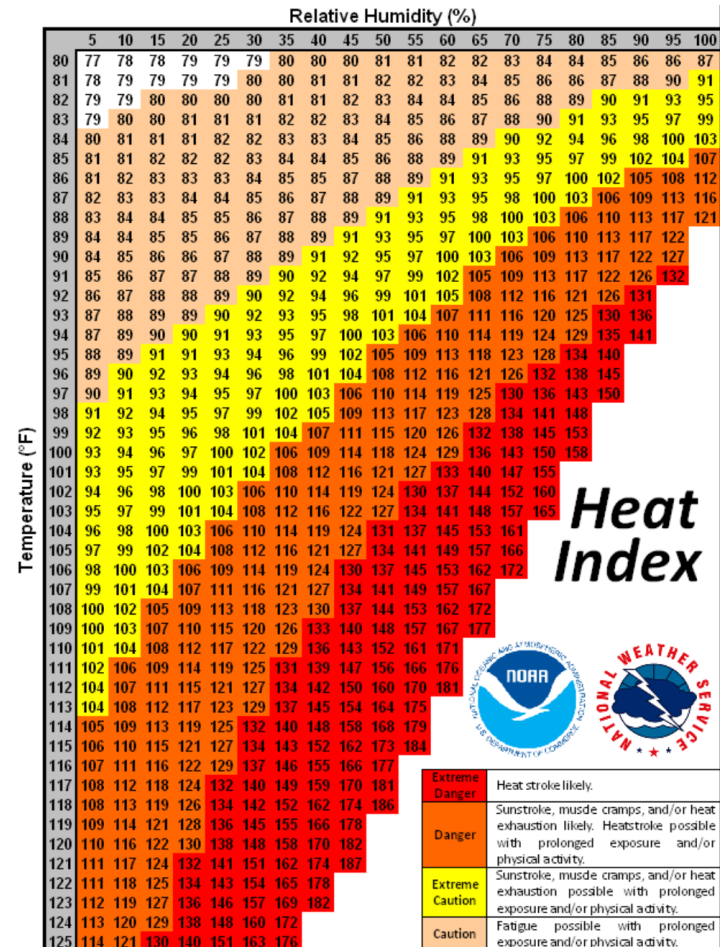
1. National Athletic Trainers Association **BEAT THE HEAT**, [https://www.nata.org/sites/default/files/hydration\\_heat\\_illness\\_handout.pdf](https://www.nata.org/sites/default/files/hydration_heat_illness_handout.pdf)  
“Exertional heat stroke is one of the top three killers of athletes and soldiers in training.”  
“Currently, 13 states have heat acclimatization policies, for secondary school athletics”

2. เด็กหญิง ป.5 ถูกทำโทษวิ่งรอบสนาม 4 รอบจนเป็นลม สุดท้ายเสียชีวิต <https://www.sanook.com/news/5236858/>

3. พ้าผ่ากลางโรงเรียน จ.ตาก เด็ก-ครูเจ็บระนาว 35 ราย สลด นร.ป.6 เสียชีวิต <https://www.youtube.com/watch?v=Vk1BaRFirb0>

# System objectives

- Save students (using preventive measures) from:
  - Heat stroke.
  - Lightning strike injuries.
- Help analyze and plan outdoor activities.
- Help manage heat policy.



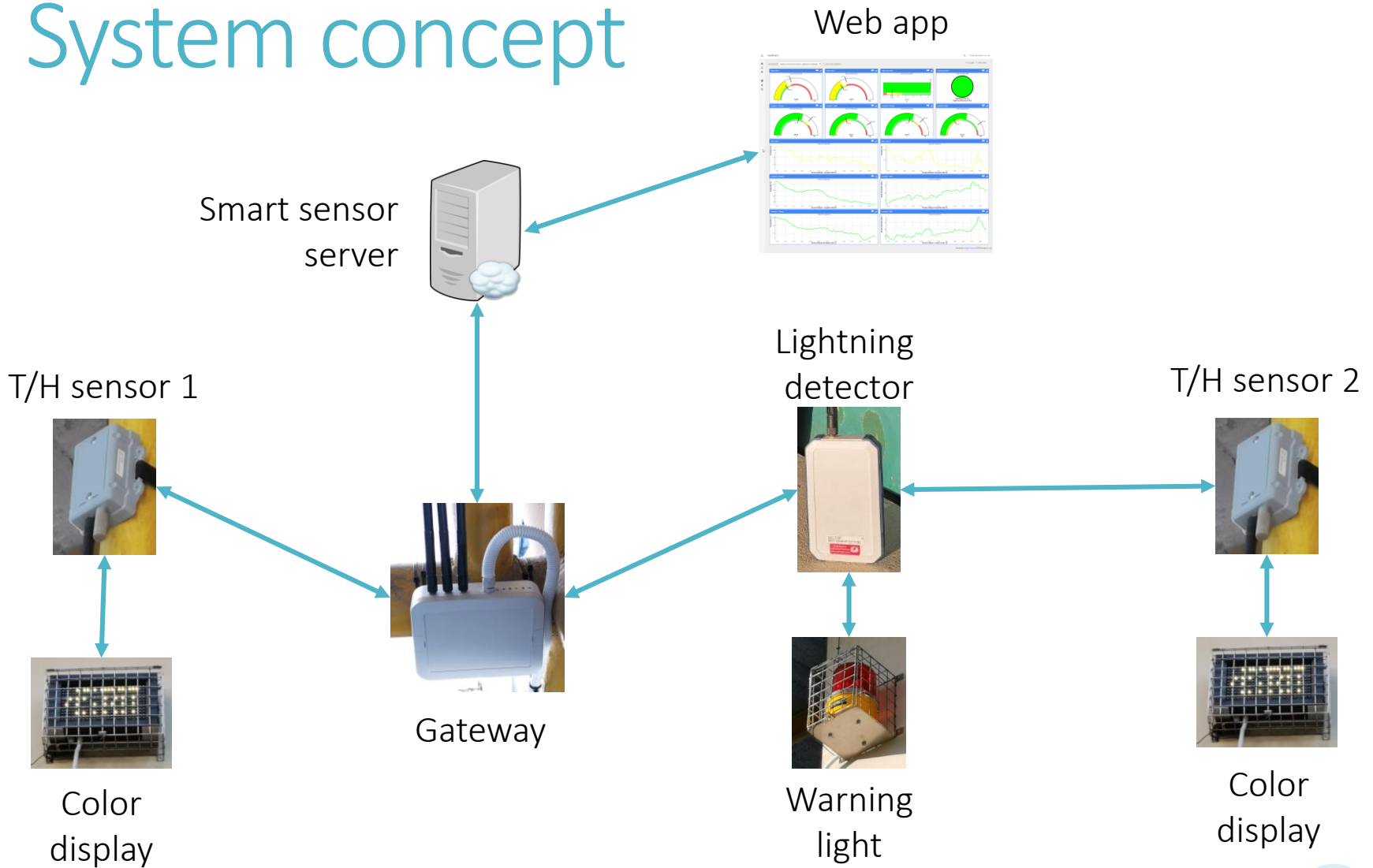
# Why Aimagin Smart sensor?

- **Versatile** hardware & software
- **Accuracy**
- **Reliability** and availability
- **Flexibility**
- **Easy & low-cost** installation and maintenance

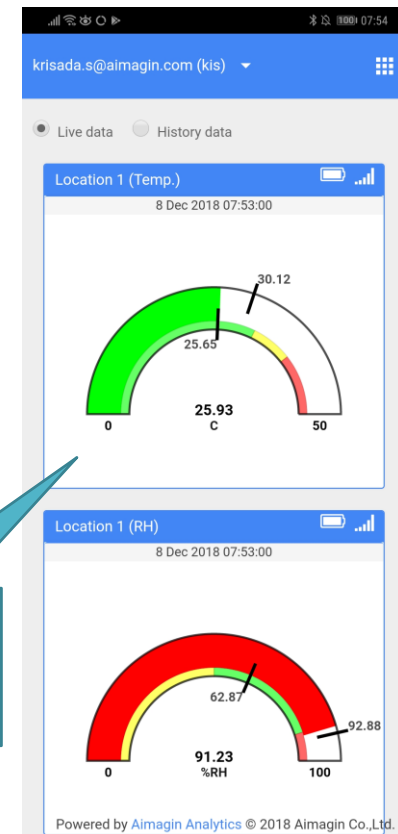
# Versatile hardware & software

- Secure **cloud** server with **responsive web application**.
- Gateway **3G / WIFI / BLE** (with **12 hours backup battery**) acts as a **master node** that gather and sent sensors data to the cloud server.
- In-the-field waterproof wireless **color digital display** that changes data and color according to real values and alert threshold in real-time (require 220VAC)
- Wireless **warning light** (require 220VAC)
- **Temperature / humidity / heat index** sensor (require 2xAA battery)
- **Lightning detection** sensor (require 2xAA battery)
- **Repeater node** for extending wireless range (require 2xAA battery)

# System concept



# Smart sensor web app



# Reliability and availability

- More than one sensor of the **same type** affords **redundancy**:
  - Temperature / humidity sensor 1
  - Temperature / humidity sensor 2
- More than one type of the **same data** affords **cross-checking**:
  - Sensor data (Heat index)
  - Weather forecast (WBGT)
- Gateway with **automatic switch** between (available Feb 2019):
  - WIFI and
  - 3G
- **Multiple alert channels**:
  - Email
  - Naver line
  - SMS





# What is WBGT?

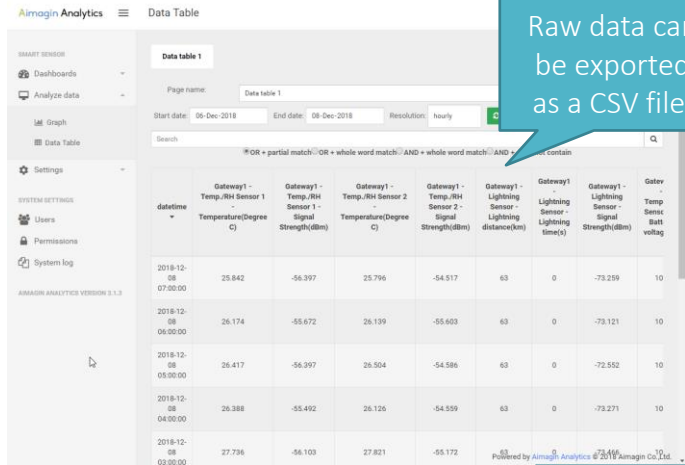
	Heat Index	Wet Bulb Globe Temperature (WBGT)
Purpose	1950s Control serious outbreaks of heat illness in training camps of the United States Army and Marine Corps	
Effects	Effective but had entailed excessive compliance costs in the form of lost training time	Reduced heat illness and also lost fewer training hours
Parameters used	Temperature Humidity	Temperature Humidity Wind Speed Sun Angle Cloud Cover
Implications	Both must be tailored to suit local climate and people.	

<https://blog.weatherops.com/forget-heat-index-wet-bulb-globe-temperature-is-where-its-at>  
<https://www.weather.gov/tsa/wbgt>  
<https://www.weather.gov/safety/heat-index>

# Accuracy

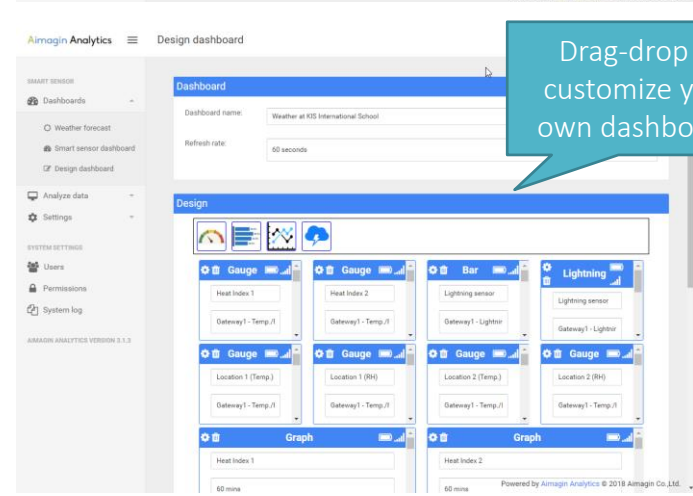
- Temperature / humidity sensor
  - Temperature: range **-40 – 85C**, accuracy **±0.2 C typical**.
  - Relative Humidity: range **0-100%**, accuracy **±2%**
  - **Heat index**: derived from temperature and relative humidity measurements
  - Sample time: **1 minutes typical**
- Lightning detector
  - Lightning activity: cloud to ground and cloud to cloud
  - **Maximum detection distance: 40 km.**
  - **Time of last strike**: resolution 1 second,
- Weather forecast
  - Forecast time: next 36 hours and next 10 days.
  - **Heat index**: estimates from weather forecast data
  - **Wet Bulb Globe Temperature (WBGT)**: estimates from weather forecast data
  - **Precipitation forecast**

# Sample software features



Sensor group settings for alert management.

Select	Sensor group name	User roles	Alert methods	Alert status	Smart filter (mins)	Group threshold
<input type="checkbox"/>	Temperature group	admin	Email, Line	Enable	1, 10	Disable 15 38
<input type="checkbox"/>	Relative humidity group	admin	Email	Disable	1	Disable 0 0
<input type="checkbox"/>	Heat index group	admin	Email	Disable	1	Disable 22 24
<input type="checkbox"/>	Lighting distance	admin	Email, Line	Enable	1, 10	Disable 0 0
<input type="checkbox"/>	Teacher Temperature	Teacher Group	Email	Disable	1440	Disable 0 0



# Weather forecast

Next day hourly forecast delivered to your email everyday.

Weather forecast daily report for 13-12-2018 >

## Data Center Environment Monitoring System

to weatherstationaler

Company :

Gateway :

Check online status

Time	Label	Type	Value	Note
2018-12-13 0:00:00	Heat Index	Heat index forecast (C)	28.6	-
2018-12-13 0:00:00	Heat Index	Probability of precipitation (%)	0	-
2018-12-13 1:00:00	Heat Index	Heat index forecast (C)	27.6	-
2018-12-13 1:00:00	Heat Index	Probability of precipitation (%)	0	-
2018-12-13 2:00:00	Heat Index	Heat index forecast (C)	26.8	-
2018-12-13 2:00:00	Heat Index	Probability of precipitation (%)	0	-
2018-12-13 3:00:00	Heat Index	Heat index forecast (C)	25.4	-
2018-12-13 3:00:00	Heat Index	Probability of precipitation (%)	1	-
2018-12-13 4:00:00	Heat Index	Heat index forecast (C)	24.7	-
2018-12-13 4:00:00	Heat Index	Probability of precipitation (%)	2	-
2018-12-13 5:00:00	Heat Index	Heat index forecast (C)	24.3	-
2018-12-13 5:00:00	Heat Index	Probability of precipitation (%)	2	-

Weather 36-hours and 7-days forecast dashboard with heat index, WBGT and precipitation estimates.

**Now**

Ban Laem Nuea, Thailand Sat, 08 Dec 2018 08:03:18

Conditions	Temp.	Feels Like	Dew Point	UV	Humidity	Precip today	Wind	Visibility	Solar radiation	Pressure	Heat Index	WBGT indoor
Partly Cloudy	24.6 °C	24.6 °C	24 °C	0.0	96%	6 mm	0 km/h NE	6.0 km	16 W/m <sup>2</sup>	1012 hPa	25.6 °C	24.3 °C

**For the next 36 hours**

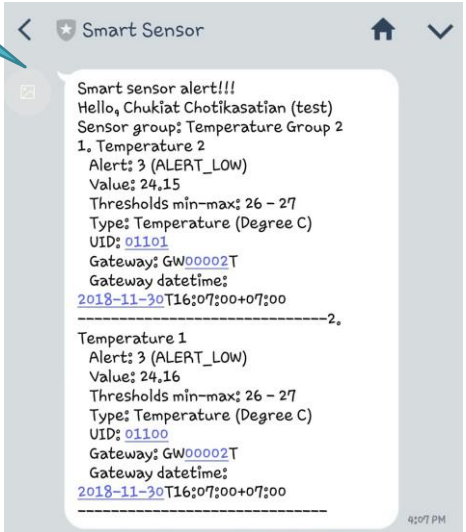
Time	Conditions	Temp.	Feels Like	Precip	Amount	Cloud Cover	Dew Point	UVI	Humidity	Wind	Pressure	Heat Index
9:00 AM	Partly Cloudy	26 °C	26 °C	1 %	0 mm	56 %	25 °C	3	91 %	13 km/h NNE	1014 hPa	28. °C
10:00 AM	Mostly Cloudy	26 °C	26 °C	0 %	0 mm	62 %	24 °C	5	89 %	13 km/h NNE	1014 hPa	29. °C
11:00 AM	Overcast	27 °C	27 °C	1 %	0 mm	80 %	24 °C	6	85 %	13 km/h NNE	1014 hPa	30. °C
12:00 PM	Overcast	28 °C	32 °C	9 %	0 mm	97 %	24 °C	4	79 %	13 km/h NE	1013 hPa	31. °C
1:00 PM	Overcast	28 °C	32 °C	9 %	0 mm	97 %	24 °C	4	79 %	13 km/h NE	1012 hPa	31. °C

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# Alert functions

- Possible alert threshold settings
  - Temperature
  - Relative Humidity
  - Probability of precipitation
  - Lightning detection distance

Naver line alert



Example email alert.

Smart sensor alert for Temperature group (Company ID: [REDACTED])

SMART SENSOR <smartsensor@aimagin.com> to me  
 Fri, Dec 7, 1:26 PM (6 days ago)

Hello,

Sensor group: Temperature group								
Sensor label	Gateway	UID	Type	Value	Min	Max	Alert	Gateway datetime
Temperature #2	GW00000G (Gateway1)	01101 (Temp./RH Sensor 2)	p3:Temperature (Degree C)	38.01	15	38	2 (ALERT_HIGH)	2018-12-07T13:26:00+07:00

\*You received this alert because you are in role:'admin' which is a part of sensor group: 'Temperature group' for company id: [REDACTED]

Next alert checking will be performed on Fri Dec 07 2018 13:27:00 GMT+0700 (Indochina Time)

Thank you,  
 Aimagin team.

# Flexibility

- Dashboard available in **2 modes**
  - Real-time
  - Recorded historical data
- **Highly flexible configurable alert management** by:
  - **User roles** combined with
  - **Sensor group**
- Built-in **analytic tools for in-depth analysis**
  - Graphs
  - Data table with advanced filter
- **Upgradable firmware** both
  - Gateway
  - Sensor

# Easy & low-cost installation and maintenance

- **Wireless network** for easy installation no need for data cables
  - Distance: indoor 30m, outdoor **upto 400m** (line of sight, depending on antenna)
- **Repeater node** available to extend wireless range.
- **Ultra low power** for easy maintenance
  - A typical sensor requires **2AA battery last for at least 1 year.**

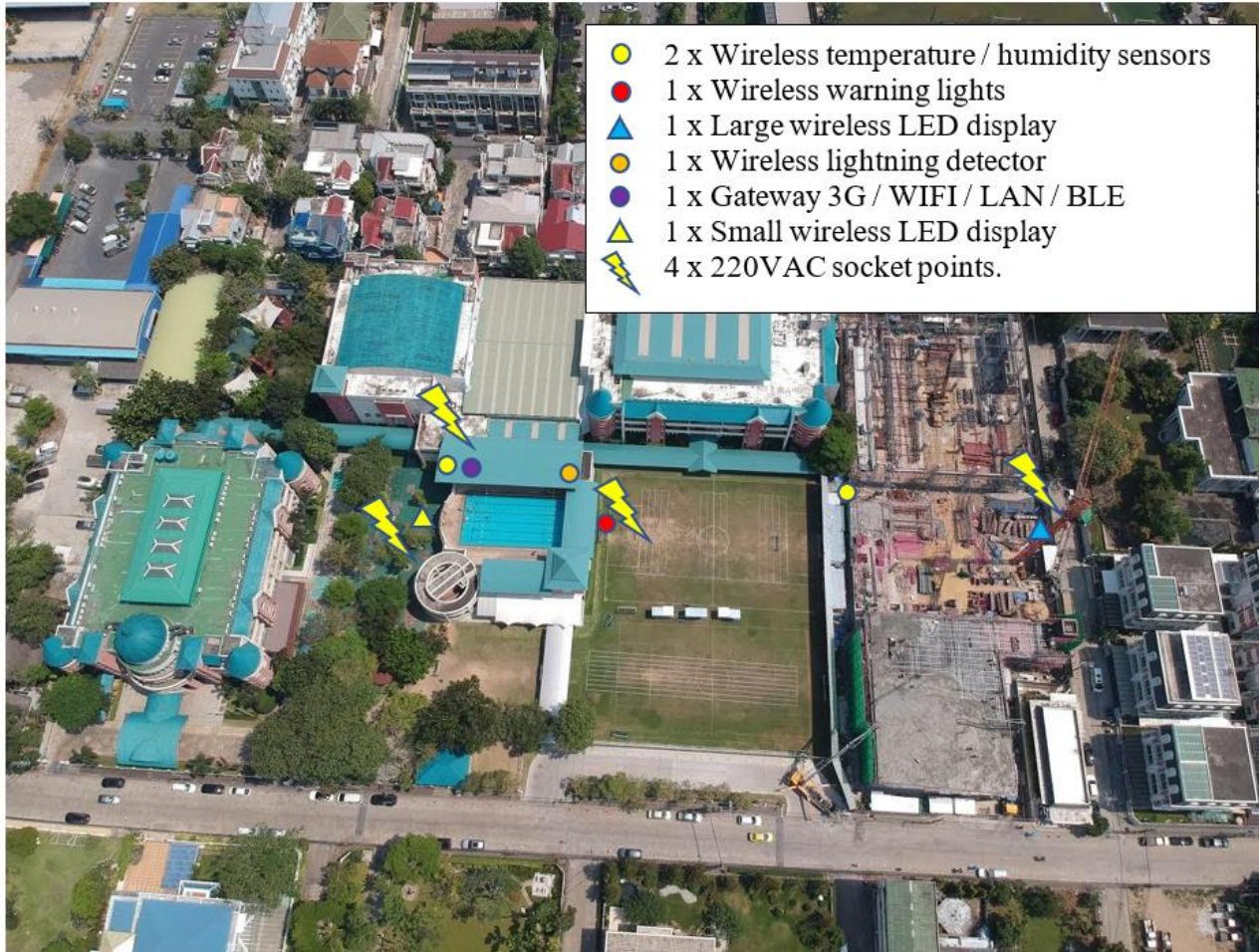


# NIST International School (Phase 1)

- 2 x Wireless temperature / humidity sensors
- 1 x Wireless warning lights
- ▲ 1 x Large wireless LED display
- 1 x Wireless lightning detector
- 1 x Gateway 3G / WIFI / LAN / BLE
- ▲ 1 x Small wireless LED display
- ⚡ 4 x 220VAC socket points.







# Other features

- **Working hours (active alert period) settings:** Allow alerts to be issued only during specified period (ON: school time, OFF: non-working hours and holidays). There is also a manual override for special events.
- **Map dashboard:** Display top view of sensors' locations and status.
- **Custom widgets:** Allow data to be added to your own website.
- **Custom email content:** Allow your own content, such as heat policy reminder, to be added to alert email.
- **Snooze button** in email alert message.
- **Back to normal** notification.

# Planned software features (Jan 2020)

- **Global alert settings:** Allow simple setting for the same type of sensors across the board with automatic redundancy management.

# Smart sensor wireless particle matter sensor

- 2.4GHz BLE 5 wireless connectivity
- Measure particle matter: PM1, PM2.5 and PM10
- Effective range: 0 - 500  $\mu\text{g}/\text{m}^3$
- Accuracy: +/- 10%
- Resolution: 1  $\mu\text{g}/\text{m}^3$
- Dual sensors for higher accuracy and reliability
- Update rate: 1 minute
- 220VAC power supply (socket) required

# Why Aimagin Smart sensor particle matter (PM) sensor is worth it?

## Best cost – performance balance

“PurpleAir PA-II is a PM sensor evaluated by the Air Quality Sensor Performance Evaluation Center<sup>1</sup> as having the highest accuracy from a range of PM sensors available on the consumer market (30+). PurpleAir PA-II uses PMS5003 sensors. Aimagin Smart sensor PM sensor uses PMS7003 sensors which are produced by the same manufacturer as PMS5003, but a newer and smaller model. Aimagin Smart sensor output is compared against PurpleAir PA-II for performance assurance.”

“Commercial PM sensors can be affected by temperature and humidity.<sup>2</sup>

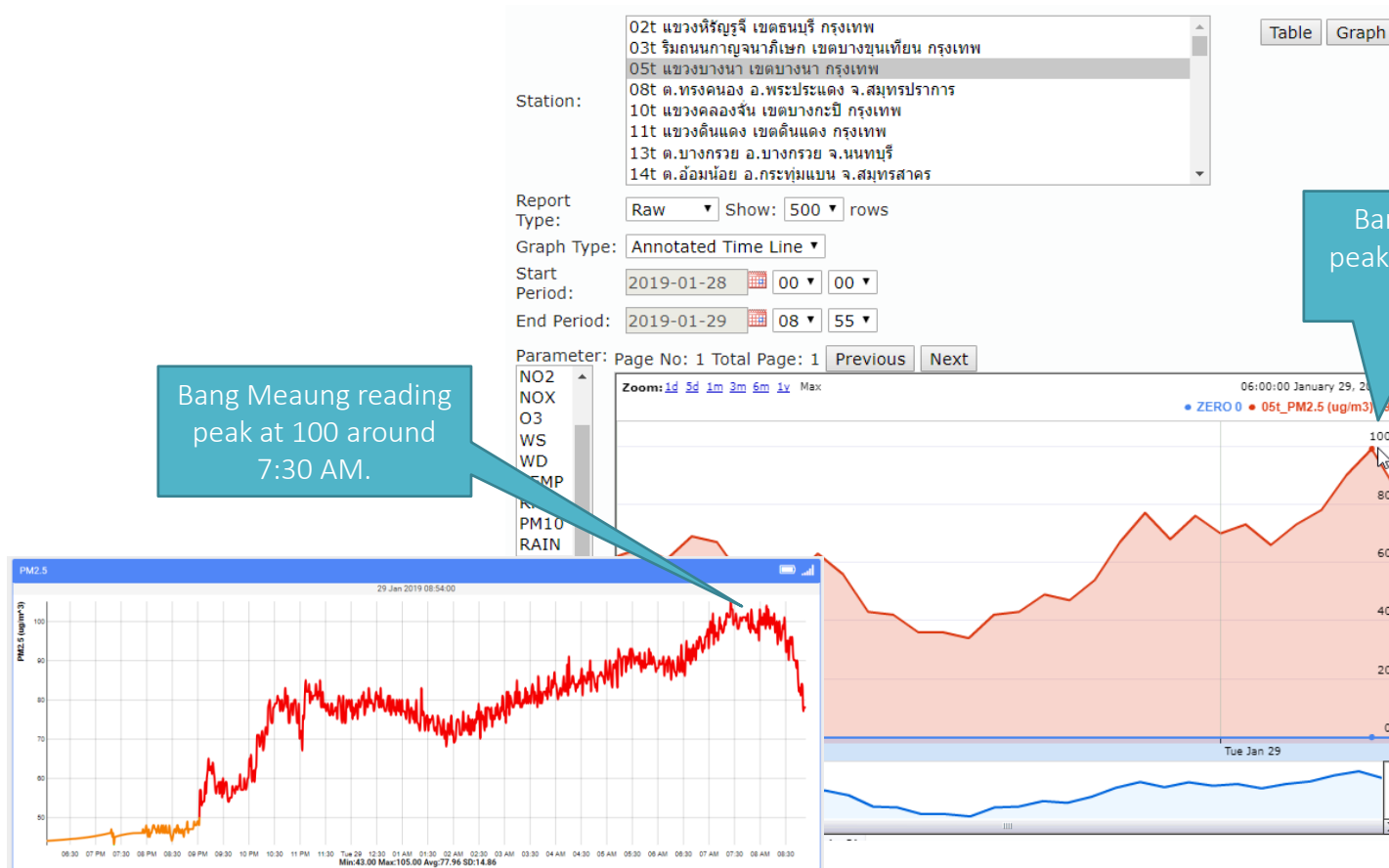
PMS7003 has been selected for evaluation by the US Environment Protection Agency (EPA), whose initial observation states that PMS7003 is accurate, highly correlated ( $r^2 > 0.9$ ) between sensors with no significant bias and highly correlated ( $r^2 > 0.9$ ) with reference instruments for all size fractions but measure roughly twice the measured reference and exhibits no notable temperature or RH influences.”

<sup>1</sup> <http://www.aqmd.gov/aq-spec/evaluations/summary-pm> as of 23 Jan 2019.

<sup>2</sup> Evaluation of Low-Cost Sensors for Ambient PM<sub>2.5</sub> Monitoring, [https://www.researchgate.net/publication/328631397\\_Evaluation\\_of\\_Low-Cost\\_Sensors\\_for\\_Ambient\\_PM25\\_Monitoring](https://www.researchgate.net/publication/328631397_Evaluation_of_Low-Cost_Sensors_for_Ambient_PM25_Monitoring)

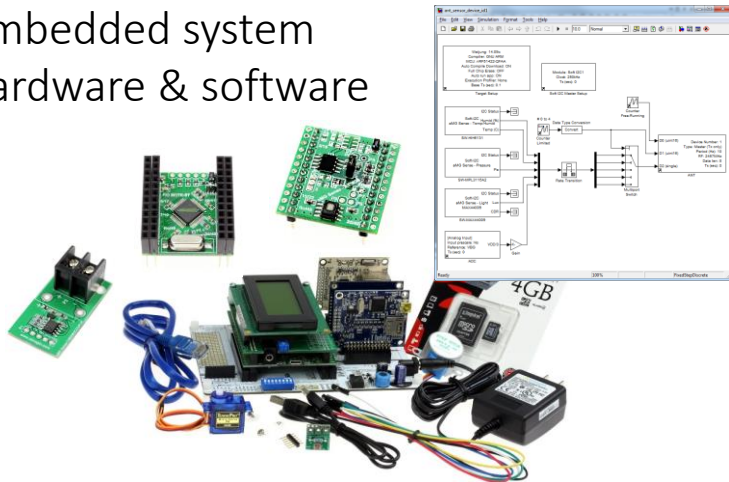
<sup>3</sup> [https://www.epa.gov/sites/production/files/2018-03/documents/final\\_em-3\\_master\\_slide\\_set.pdf](https://www.epa.gov/sites/production/files/2018-03/documents/final_em-3_master_slide_set.pdf) page 37

# Compare Smart sensor PM2.5 readings with aqmthai.com readings



# Who is Aimagin?: Embedded system expert

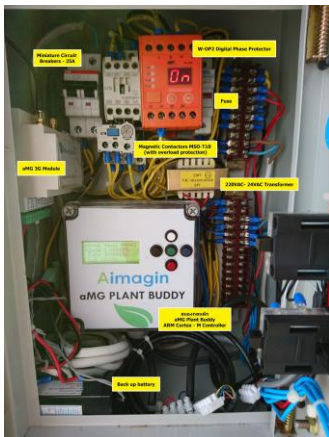
Embedded system hardware & software



Custom embedded system design service



Advanced embedded system R&D



Electronics control system implementation



# Aimagin IoT solution & customers

Monitor server room, freezers, etc.

