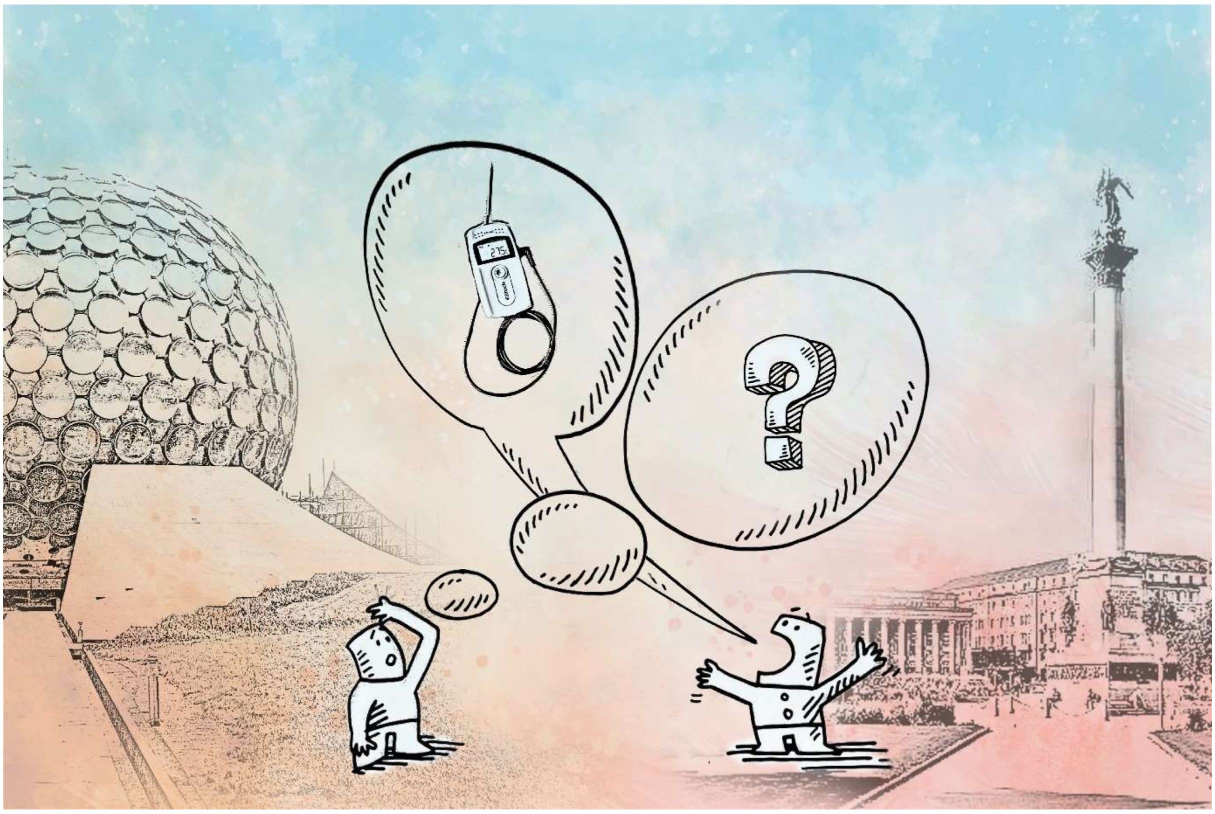
A Remote Data Collection Journey: The Auroville Language Laboratory



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Abstract:

A remote data collection process is described, carried out for an operational but unfinished building located in the city of Auroville, India: the Auroville Language Laboratory and the Tomatis Research Centre. Coordination work was performed remotely by Transsolar KlimaEngineering staff, based in Stuttgart, Germany, while installation of devices and measurements were performed by building staff.

The selected equipment was efficient in recording data containing ambient temperature, relative humidity and surface temperature values at relevant locations on the site, both indoors and outdoors. In this way, the data collected have proven to be valid for the purposes of supporting computational simulations; as part of Transsolar engineers' assessment of the proposed climate concept for the building. Selection criteria for the devices is also explained in detail.

An applied work plan, containing specific instructions on measurement methodologies and techniques, is also well documented. The Auroville Language Lab staff had no prior knowledge of the use of this equipment. Therefore, the planning process contributed significantly to the accomplishment of the main task.

Finally, a list of common problems and how to solve them is described, together with practical recommendations, aiming to be useful for anyone conducting a similar task.

Table of content:

Introduction:

This report documents the process of climate data collection within an operational, yet unfinished building located in the town of Auroville, India: the Auroville Language Laboratory and Tomatis Research Centre.

With the aim of gathering useful information for the evaluation and validation of the climate concept proposed for this building, a work plan was drawn up to record values of ambient temperature, relative humidity and surface temperature in relevant locations of the site, both indoors and outdoors. The data collected is intended to support future computational simulations made by Transsolar engineers.

It is important to mention that the collection tasks have been performed by the staff of the Auroville Language Laboratory, which did not have any previous knowledge in the use of this equipment. This, together with the limited availability of equipment to carry out the measurements, constituted a technical challenge from the initial stages. For this reason, it was necessary to implement an adequate planning to make the most of the available hardware, as well as to maintain a constant communication and supervision over the process by both parties.

This report should not be considered a standard methodological manual to be implemented. The methods described in it correspond exclusively to the specific characteristics of the building under study, as well as to the available equipment; factors that can vary significantly from one case to another.

It is the author's intention to document mainly issues, situations and doubts identified during the measurement process, which may be useful for anyone carrying out a remote data collection process.

1 - Getting started:

1.1 Devices selection criteria

From the beginning, it was defined that air temperature values and Relative Humidity levels were key elements to be measure, in order to satisfy our purpose in the project. Consideration was also given to the acquisition of equipment to measure wind direction and speed, which would complement the assessment of the proposed ventilation system, intended to provide dehumidified fresh air, as part of the climate concept. However, the elevated cost of this equipment was not worth the benefits.

Due to limitations on the available budget, the cost of the devices constituted one of the main criteria to consider for their selection. This, also combined with their availability for delivering either to India or Germany, required a prior market study.

It is well known that the technological advancements associated to climate data measurements have been a process in constant expansion, making it possible to find, nowadays, a great variety of this equipment with dissimilar advantages. One of the most innovative and useful features present in current data logger models is the possibility of transferring the collected information wirelessly. This eliminates the need to implement annoying cable assemblies, while reducing costs and increasing the applicability of the system.

However, a peculiarity of the building under study is its operation under strict rules to ensure electromagnetic compliance, being the reduction of electromagnetic pollution one of the fundamental aspects to be considered in any intervention. For this reason, and respecting the customer's requirements, it was decided to acquire wired devices instead.

Consistently with the above mentioned, the Auroville Language Lab staff was able to purchase six Elitech branded devices, model RC-4HC. In addition, a FLUKE 59 MAX Thermal Gun was acquired to analyze the thermal performance of surfaces within the building.

A request for support made to the Auroville Scientific Research Center (CSR) was not ignored. The CSR kindly lent eight HOBO Onset data loggers, model U12-013, technologically superior compared to Elitech devices. The possibility of connecting two external sensors, in addition to the default ones, as well as the user-friendly interface for their configuration are key reasons to validate this affirmation. This institution also provided seven surface temperature sensors, model TMC6-HE, of great importance to collect a larger volume of data.

1.2 Equipment comparison:

The equipment comparison task represented the practical starting point of the process. It consisted of two fundamental stages: measurements in a controlled environment, performed by Auroville Language Lab personnel on August 1st -2nd, 2019, and the subsequent analysis of results, carried out by the author.

Contrary to an equipment calibration, which can be defined as the process of comparing a reading on one piece of equipment or system, with another piece of equipment that has been calibrated and referenced to a known set of parameters, in this case no validated reference was available.

Thus, the main objective to be achieved was to obtain and compare data to identify possible deviations between the equipment, given that the available devices corresponded to different typology and model. Secondary, to get the building personnel familiar with the tasks of collecting and exporting data.

It is important to mention that, prior to the results shown below, four attempts were made to complete this task between the days 22nd and 31st of July 2019. For different reasons, these attempts were invalidated. However, this process of trial and error led to a final success. A detailed explanation of the encountered problems and the applied solutions can be found at the troubleshooting section.

Below is a list of the equipment used:

- 5 Elitech (RC-4HC) air temperature / humidity data loggers
- 8 HOBO Onset (U12-013) air temperature / humidity data loggers; 2 extra ports for sensors
- 7 Surface temperature sensors (TMC6-HE)
- 5 air temperature sensors (For the Elitech devices)
- 1 FLUKE (59 MAX) Thermal gun for surface temperature measurements.

Figure 1 Elitech (RC-4HC) and air temperature probe (left)

Figure 2 FLUKE (59 MAX) thermal gun

Figure 3 HOBO Onset (U12-013) air temperature / humidity data logger and (TMC6-HE) surface temperature sensor

By the time the measures were being taken, the following equipment was still pending to arrive:

- 1 Elitech (RC-4HC) air temperature / humidity data logger
- 1 Air temperature sensor

1.2.1 Applied methodology:

The comparison measurements were made according to the following instructions:

1- Set up all data loggers close to each other, leaving space between the probes (20cm-30cm), in the same room at the same time; approximately 1m – 1.2m above the ground.
2- Avoid direct sun and areas under ceiling fans for the location.
3- Set the surface temperature sensors on the wall.
4- Once everything is setup, send pictures to Transsolar indicating the position of the sensors and a description mentioning their serial number for identification purpose.
5- After receiving Transsolar approval, start measuring for 24 hours on a 15 minutes interval.
6- Parallel to this process, use the thermal gun to collect data hourly, for at least 8 hours. Use a white paper sheet as a surface target for the measurements. Take care to hold the sheet somewhere close to the sensor's location, and collect data according to the manual and Transsolar instructions (close to the surface, perpendicularly, etc.) Write down the results on the specified template (Auroville_STR).
7- After the 24 hours cycle is completed, download data (Excel format) and send it to Transsolar for checking.


Figures 4-5 *Final distribution of the equipment on the room. (1 HOBO device was added after this picture was taken)*

1.2.2 Data analysis:

The collected data corresponded to a 24 hours rate, starting from 17:00 (01/08/2019) to 17:00 (02/08/2019) As indicated on the methodology, measurements were done every 15 minutes; resulting on a total of 97 data points. All the devices worked properly, so no interruptions were recorded during the process.

As for the surface temperature. readings, using the thermal gun, they were made on an hourly basis starting from 9:00 to 17:00 (02/08/2019) That leads to a total of 18 data points between the two indicated targets (wall and white paper sheet)

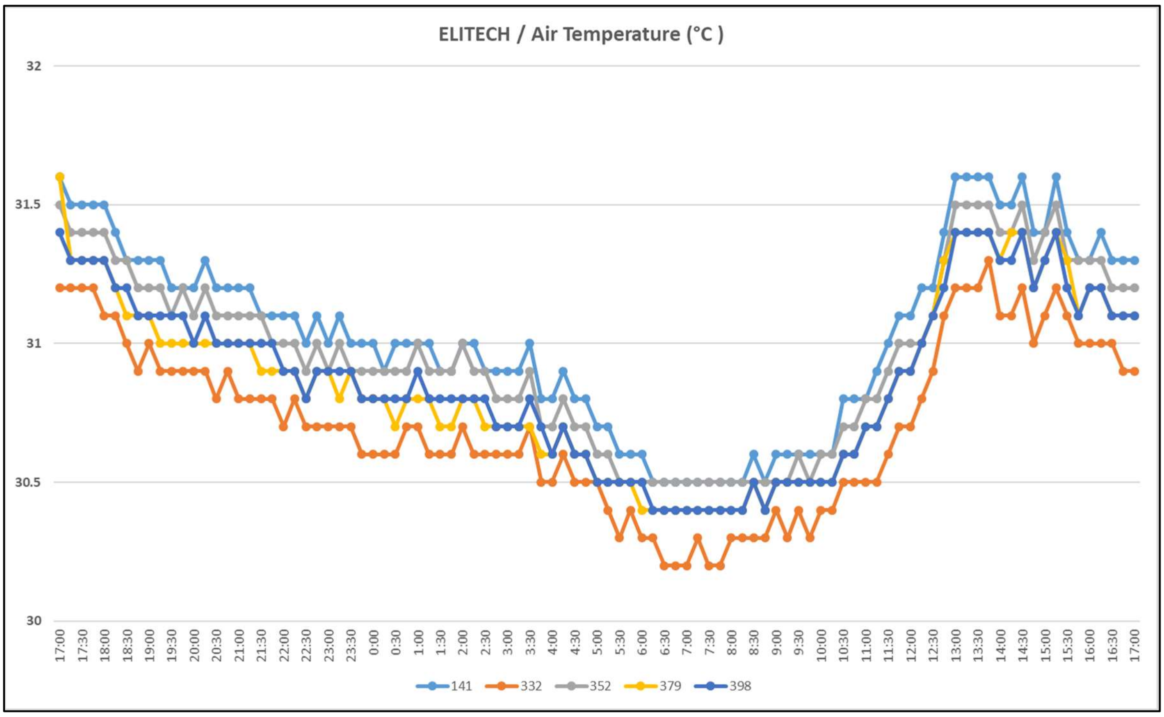
Collected data was analyzed considering the following aspects:

- Comparison between all Elitech devices (air temperature, relative and absolute humidity values)
- Validation of Elitech average air temperature results
- Comparison between all HOBO devices (air temperature, relative and absolute humidity, surface temperature values)
- Validation of HOBO average air temperature and surface temperature results

- Comparison between Elitech and HOBO devices (air temperature and relative humidity average values)

Elitech devices - Data comparison

The chart (*Graph 1*) shows the air temperature values collected by the five Elitech devices during the studied period. Despite some small fluctuations between devices, less than 0.4°C, it can be concluded that their results present a similar pattern. Variation on the data can be caused by small differences on the external conditions, due to the position of the equipment, and/or technical particularities.



***Graph 1** Elitech devices air temperature values*

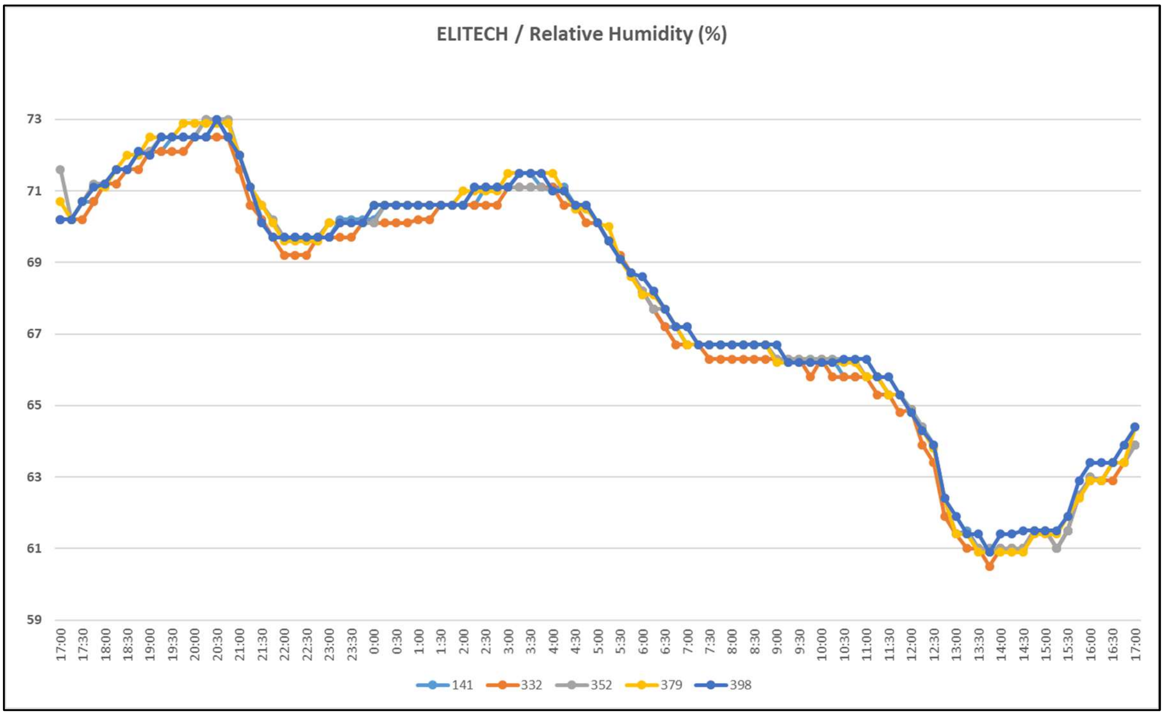
A similar situation occurs for the relative humidity results (*Graph 2*) with a more similar behavior between the data series. The absence of significant deviations on the data leads to the conclusion that, for the previous study (*Graph 1*), differences were caused mainly because of the location of the thermal probes, and not so much because of technical deviance on the data loggers. Moisture levels are measured through the integrated sensors on the equipment case, and not by external sensors, reason why this hypothesis may be valid.

Since none of the applied equipment can measure Absolute Humidity levels, the following conversion method was utilized to obtain approximate values; taking into consideration the specific air temperature and relative humidity values at every data point:

$A = C * Pw / T$ (g/m3)

Where:

- A (Absolute humidity)
- C (Constant 2.16679 gK/J)
- Pw (Vapor pressure in Pa)
- T (Temperature in K)



***Graph 2** Elitech devices relative humidity values*

For calculating the vapor pressure (Pw) values, the following formula was used:

Pw = Pws * RH/100

Where:

- Pws (Saturated vapor pressure in HPa)
- RH (Relative humidity in %)

Also, saturated vapor pressure (Pws) was calculated using:

Pws = 6.11 * 10^ [(7.5 * Tn) / (237.3 + Tn)]

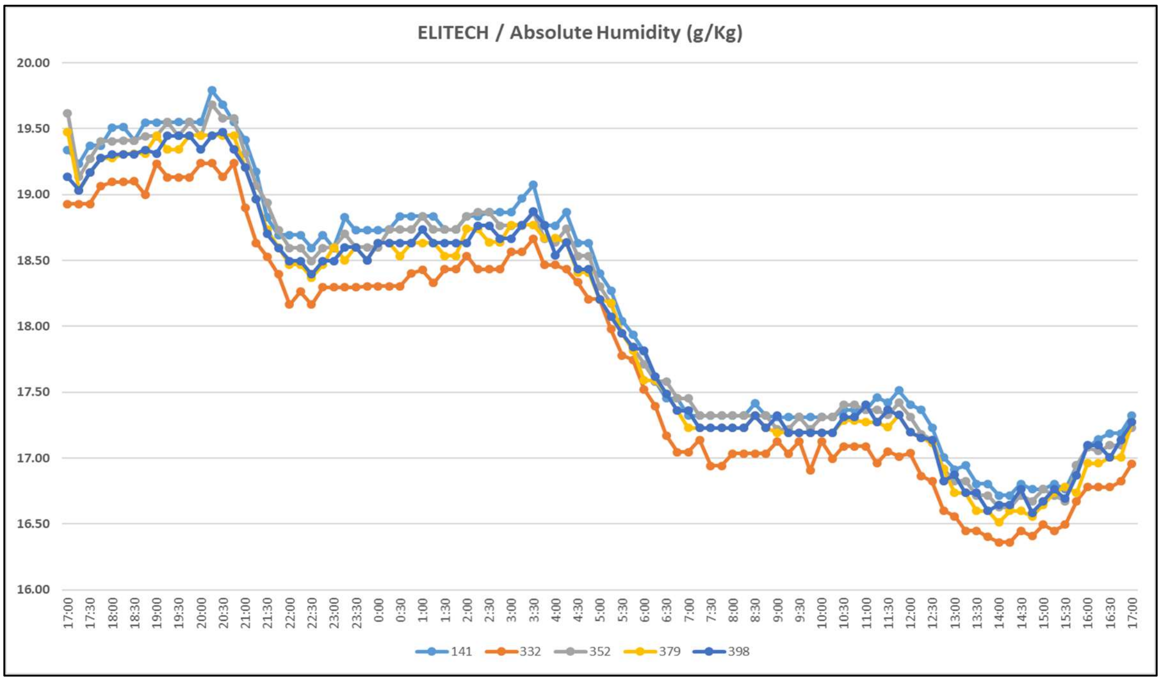
Where:

- Tn (Temperature in °C)

Finally, the obtained absolute humidity (g/m3) values were converted into (g/kg) by assuming a standard air density of 1.204 Kg/m3 and a stable air pressure value of 1013 hPa. As a result, the following general formula was applied on the excel tool:

<u>A = ((2.16679*((6.11*10^((7.5*Tn)/(237.3+Tn)))*(RH/100))/(Tn+273.15))*100) / 1.204</u>

Absolute humidity results are plot on (*Graph 3*) presenting a similar pattern, with small deviations due to the influence of the air temperature values.

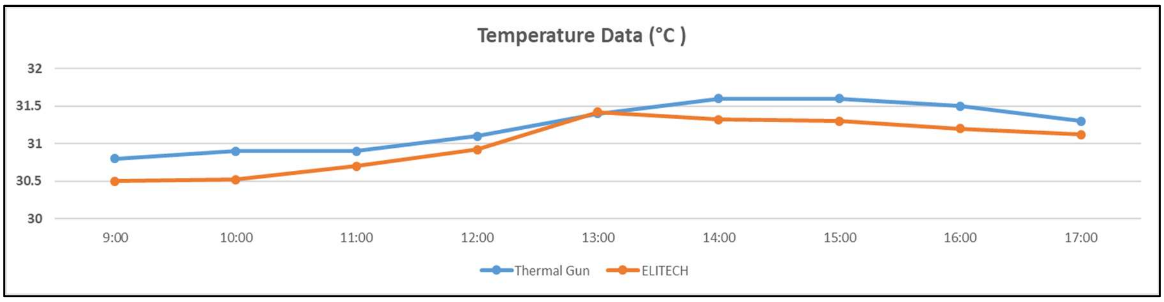


Graph 3 *Elitech devices absolute humidity values*

Elitech devices – Air temperature data validation

With the intention of verifying the accuracy of the equipment readings, a comparison was made between average air temperature values, from the Elitech devices, and data collected with the thermal gun, on a paper sheet located close to the sensors. A white paper sheet demonstrated to be an efficient surface to obtain readings with high similarity to air temperature values; according to previous experimentations made by the author.

The chart (*Graph 4*) shows the relationship between this two sets of data, demonstrating a similarity between their deportment. An average deviation of 0.23°C was noticed. This validates the usability of data collected by the Elitech devices for the purposes of the project. However, the deviation on the results should be considered in future analysis.

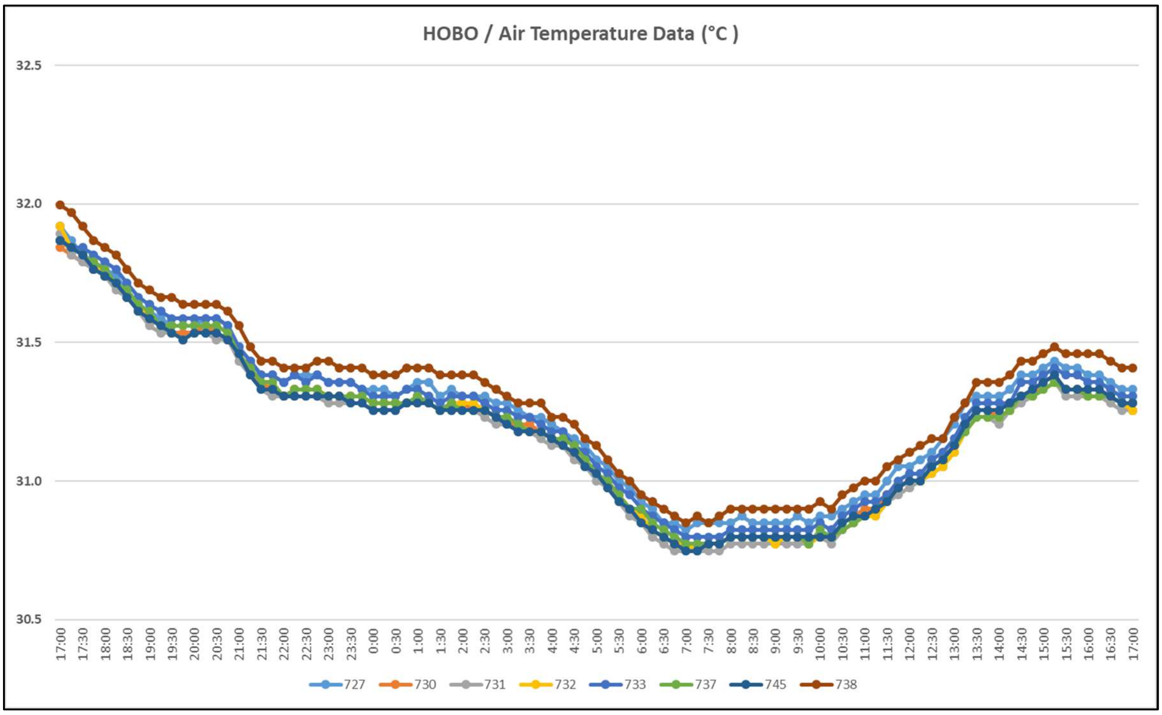


Graph 4 *Surface temperature (paper sheet) and Elitech air temperature values comparison*

HOBO devices - Data comparison

In a similar way as for the Elitech equipment, air temperature data series collected by the HOBO devices present a similar behavior (*Graph 5*) It is important to mention that results are more uniform with very little deviation between the equipment, which validates their similarities and proves their functioning is correct.

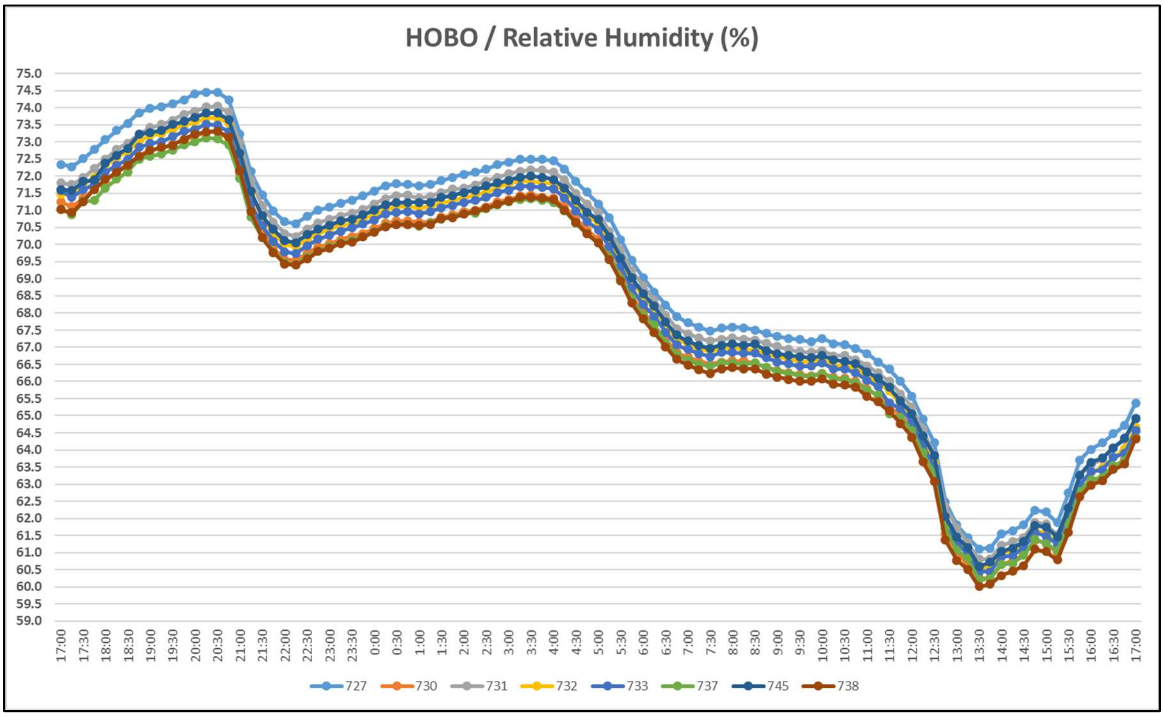
The deviation presented by device #738 is approximately +0.1°C. This value is considered negligible for the purposes of the current analysis.



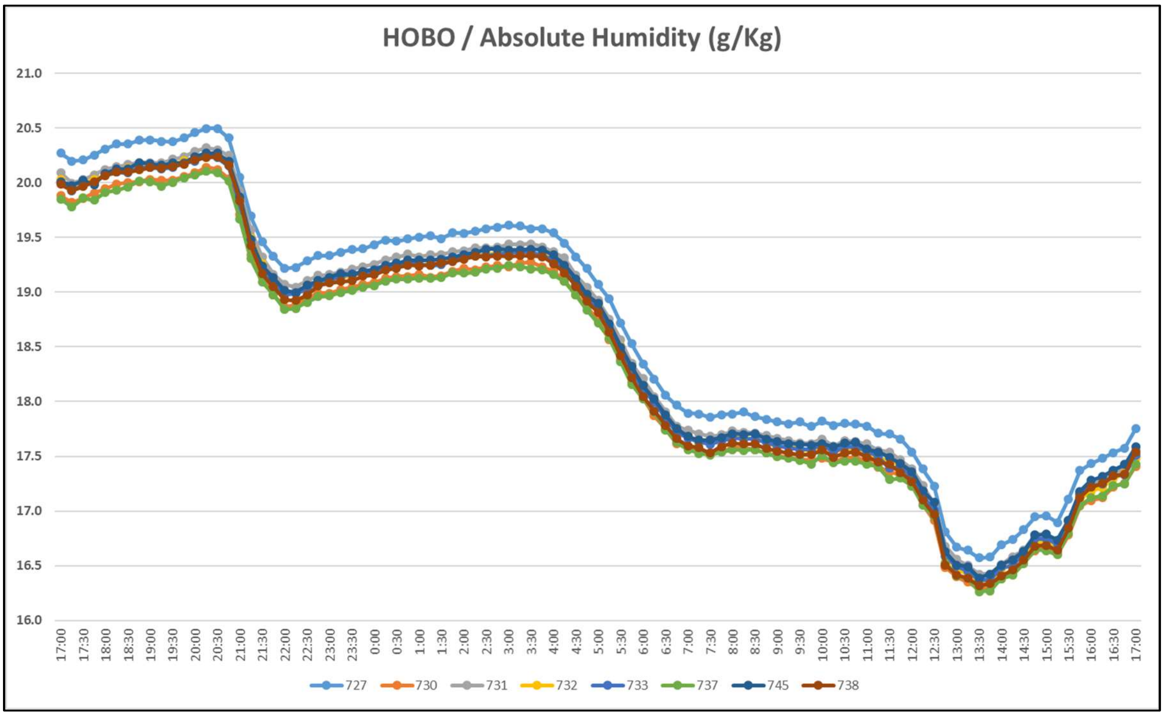
Graph 5 *HOBO devices air temperature values*

As for the relative humidity levels, results are shown on (*Graph 6*) It should be noted that some deviations appear between devices, in the range of 1-2.5%, which is again not a significant difference, thus it will not be taken into consideration.

Same methodology as before was applied for obtaining absolute humidity values (*Graph 7*) As expected, small variations are noticeable within the range of 0.1-0.5 g/kg. However, data sets show a very similar pattern, so this range of error is assumed.

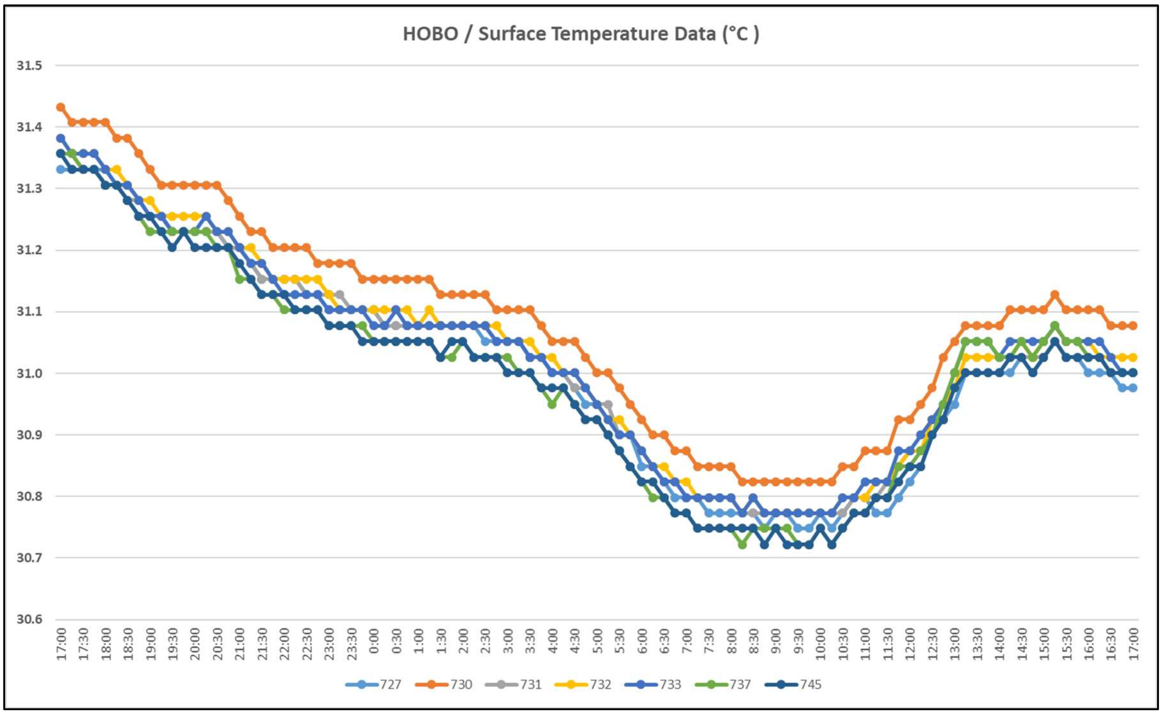


Graph 6 *HOBO devices relative humidity values*



Graph 7 *HOBO devices absolute humidity values*

Surface temperature values were collected on one of the interior walls of the room, as shown in (*Figures 4-5*) It is important to note that only 7 of 8 devices collected data, due to the limited availability of sensors. Minimum and maximum surface temperatures recorded are 30.7°C and 31.4°C respectively. In general, all data sets show a similar trend (*Graph 8*); the highest margin of error between them is only ±0.1 Celsius degrees.

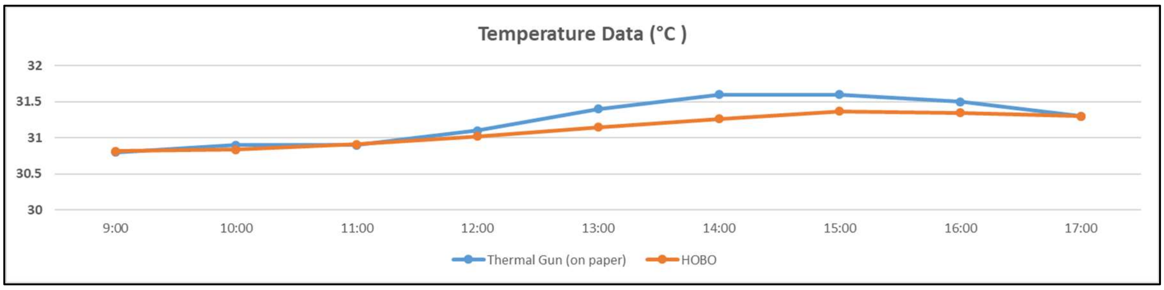


Graph 8 *HOBO devices surface temperature values*

HOBO devices – Air temperature data validation

In the same way in which the check was carried out for the Elitech devices, air temperature values collected by the HOBO equipment were compared with the thermal gun readings. As can be seeing on (*Graph 9*) the results coincide several times, showing a very similar behavior. The average deviation recorded between them is of only 0.12°C; 50% lower compared to the 0.23°C deviation presented by the Elitech equipment.

This not only validates the obtained data, but also confirms the superior accuracy of the HOBO devices with respect to the Elitech. For this reason, they will be used as a reliable reference for future comparisons and measurements.

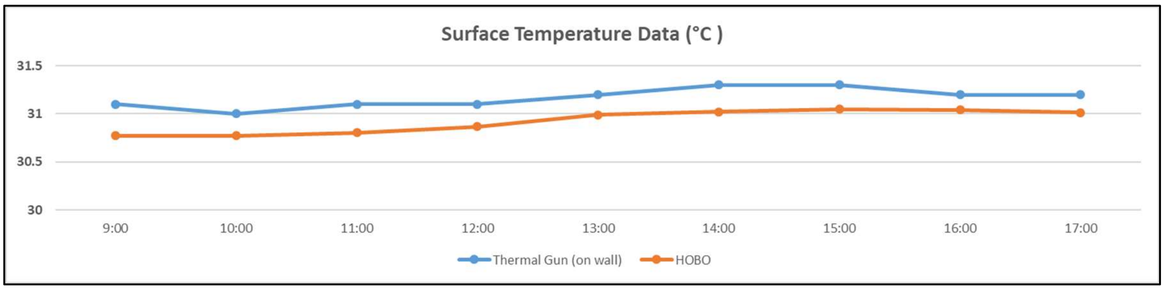


Graph 9 *Surface temperature (paper sheet) and HOBO air temperature values comparison*

HOBO devices – Surface temperature data validation

As explained above, in the description of the working methodology, surface temperature values were obtained using the thermal gun on the inner wall in which the sensors were installed.

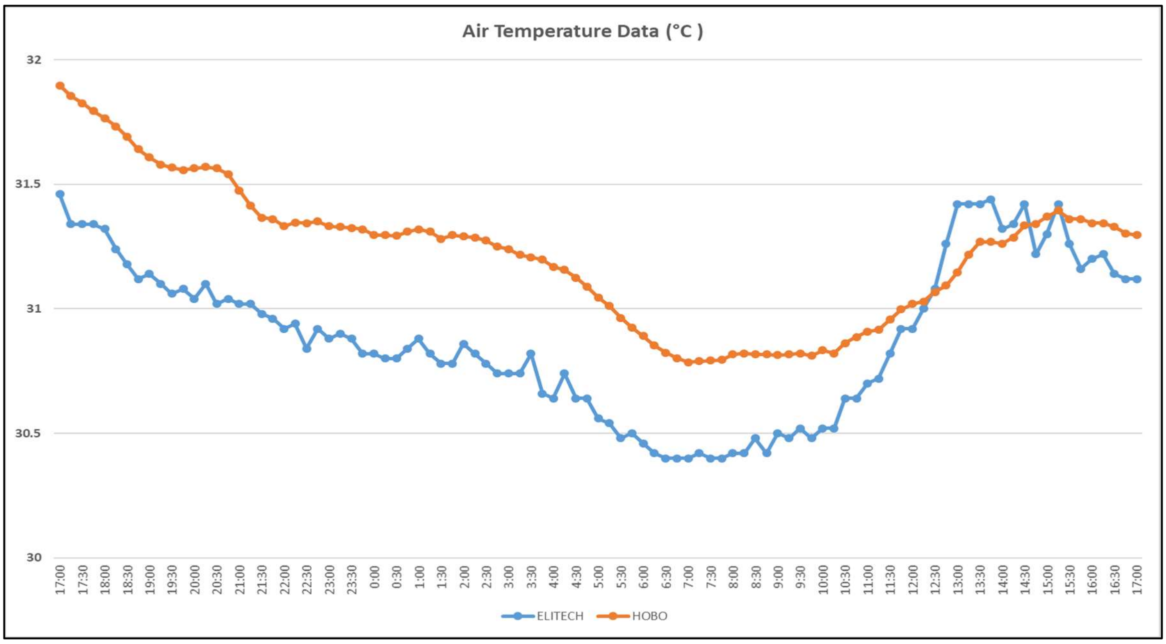
The chart (*Graph 10*) shows the comparison between these results, with the same pattern being appreciable for both data series. The average recorded deviation is -0.24 degrees of the HOBO devices with respect to measurements with the thermal gun. It is important to note that although this difference is significantly small, it can be considered for future calibrations. This demonstrates the precision of the used surface temperature sensors, as well as the efficiency of the method applied for indoor placement.



Graph 10 *Comparison between thermal gun and HOBO sensors surface temperature values collected on the wall*

Elitech and HOBO results comparison

In order to evaluate how similar results are, obtained by both equipment models, data was averaged to simplify the process and achieve a better graphic understanding. The comparison between air temperature values shows a similar trend in both data series. However, results corresponding to HOBO devices show minor fluctuations between data points; not being so for the other case, in which variations can be appreciated between short time intervals (*Graph 11*)



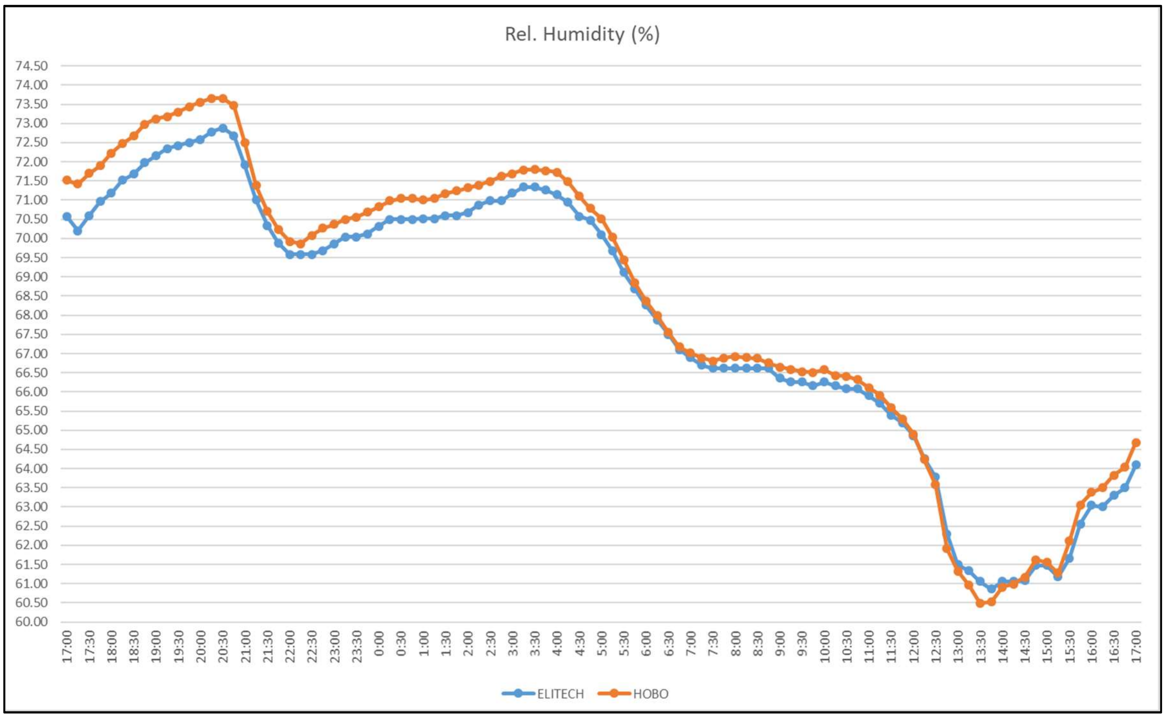
Graph 11 *Air temperature values comparison between equipment models*

Being consistent with previous partial conclusions, data acquired by the HOBO equipment is assumed as the most accurate reference. An average deviation of ±0.33°C was identified for the Elitech devices, therefore this will be considered for processing results in future measurements.

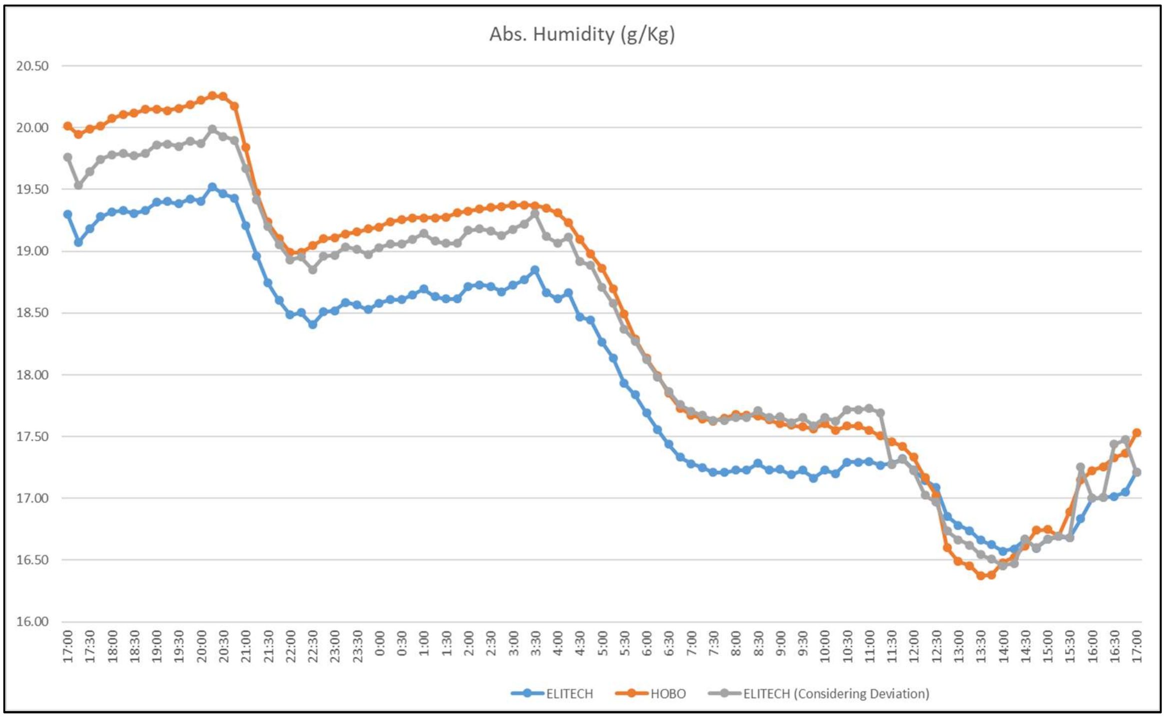
On the other hand, the comparison made for relative humidity values (*Graph 12*) also shows similar behaviors between both data series. In the case of Elitech devices, data shows a smaller number of fluctuations between time intervals, compare to air temperature values. This may be due to humidity data being measured in the body of the data logger and not through external sensors.

The calculated average deviation on the Elitech devices is ±0.40%. Despite being a small difference, the influence of these values, together with the air temperature ones, on calculating absolute humidity, condition this fact to be considered for future results analysis.

In order to support this conclusion, (*Graph 13*) was plotted, evidencing an average deviation on the Elitech devices of ±0.44 g/kg compared to the HOBO equipment. At the same time calibrated results for the Elitech devices, considering the deviation previously identified, are also shown. It should be noted that the formula to correct these results remains a work in progress, reason why aberrations can be observed on the data curve. However, it is appreciable how much it is possible to calibrate the results to bring them closer to more correct values.



Graph 12 *Relative humidity values comparison between equipment models*



***Graph 13** Absolute humidity values comparison between equipment models (Elitech calibrated results are also shown)*

1.2.3 Equipment comparison conclusions:

As a result of the previous analyzes, the following was concluded:

1- Devices collected data for all the planned points in time, and within a negligible margin of error between equipment of the same model, thus the equipment is adequate for the purposes of future measurements.

2- Devices belonging to the HOBO model proved to be most accurate for measuring air temperature and relative humidity values, compared to the Elitech equipment.

3- Auroville staff, in charge of data collection on the site, has the necessary knowledge about the equipment and required software for data extraction.

It was then determined to proceed with distributing the devices within the building to begin the general data collection process. To this end, a work plan was drawn up containing the necessary instructions for the staff of the Auroville Language Laboratory to follow. The plan was prepared for use as a consultation document, however, it should be noted that slight modifications were made to the original throughout the process, so a final version will be presented below.

2 - Measurement plan:

2.1 Goals:

As mentioned above, the main objectives to be achieved with the data collection process at the site are the following:

1- To collect air temperature, surface temperature (HOBO sensors) and relative humidity values on strategical spaces of the building. This site measured data will be use farther to validate Transsolar´s thermal analysis (calculations, simulations), which will be used to evaluate thermal comfort and to support explanation and/or design of climate-responsive measures.

2- To collect surface temperature values (thermal-gun) for validation purposes. This data will help to verify the accuracy of the results obtained by the rest of the equipment.

3- Understand local climate conditions around the building.

In this extend, and subsequent to internal discussions among Transsolar staff for finding the best possible distribution, locations for the equipment were suggested together with specific procedures.

2.2 Procedure - Data loggers:

- Place the loggers and sensors on the indicated locations (See below: Equipment suggested locations), ~1.2 m above the floor.
- Check that no direct sunlight is hitting the equipment and to avoid strong air flows coming from windows or fans. In case it is needed, protect the sensor according to specifications (See below: Equipment protection)
- Air temperature probes cannot be in touch with any surface.
- Send pictures of data loggers in their locations for Transsolar´s final checking. Do not start collecting data before having the approval.
- Prepare a laptop with all the software required for setting up the devices and reading results. These can be downloaded from the following links:

  - HOBO: https://www.hobodataloggers.com.au/hoboware-free-download

  - Elitech: https://www.elitech.uk.com/software.html

- Configure the loggers to collect data every 15 minutes.
- The starting and ending times should be set also considering a 15 min – ratio basis, e.g. Start at 11:15 instead of 11:13
- Start collecting data. The process will remain unstopped, unless important issues or malfunctions are detected. Thus, check the devices at least once per week to verify they are working correctly.
- Twice per month, ideally every two full weeks, download and compile data and send it to Transsolar for post-processing.

2.3 Procedure – Thermal Gun:

- Measure the surface temperature for walls, both internal and external, ceiling and floor on the following rooms: Mediatheque, Class Indian and Class Tomatis.
- Measure the inner surface temperature of the Courtyard metallic roof. Make sure to take the readings close to the existent HOBO surface temperature sensor.
- Collect data on an hourly basis, for 2-3 day in a row, every week. For more accurate results, it is required to collect data also during night, in order to complete a 24h cycle. **However, this is completely optional due to the extra work required for the task.
- Readings must be done on the same spot and taking into consideration the specifications listed on the equipment manual. (Close and perpendicular to the surface)
- Write down the results using the designated table (Auroville_STR) In case the measurement times does not match, because of the distance between the spots, approximate them to the closest.
- Send files to Transsolar for post-processing together with the information from the rest of devices.

2.4 Equipment suggested locations:

The following (Table 1) compiles the number of items and their location within the building. As mentioned before, many aspects were taken into consideration for the distribution, including some of the previous conclusions from the equipment comparison. Thus, HOBO devices were located at some of the most important rooms for the study and selected as well for the outdoors location.

SPACES	HOBO (U12-013)	Elitech (RC-4HC)	Surface Temp. Sensors	Air. Temp. Sensors (Elitech)
Atrium	2	1	1	1
Mediatheque	2		2	
Class Indian	1		2	
Class Tomatis	1		2	
Childrens place		1		1
Adults Passive		1		1
Mita´s office		1		1
Meditation Room	1			
Outdoors	1			
Underground Tunnel		2		2
TOTAL	**8**	**6**	**7**	**6**

Table 1 *Equipment distribution within the building*

Specific guidelines for the rooms were given as follows:

- **Courtyard**

- Place the sensors on the north side, following the details shown in (Fig. 6) and (Fig. 8). Given the volume of this space, it was decided to maintain the distances specified for better coverage, in order to obtain detailed information to validate the corresponding thermal simulations.

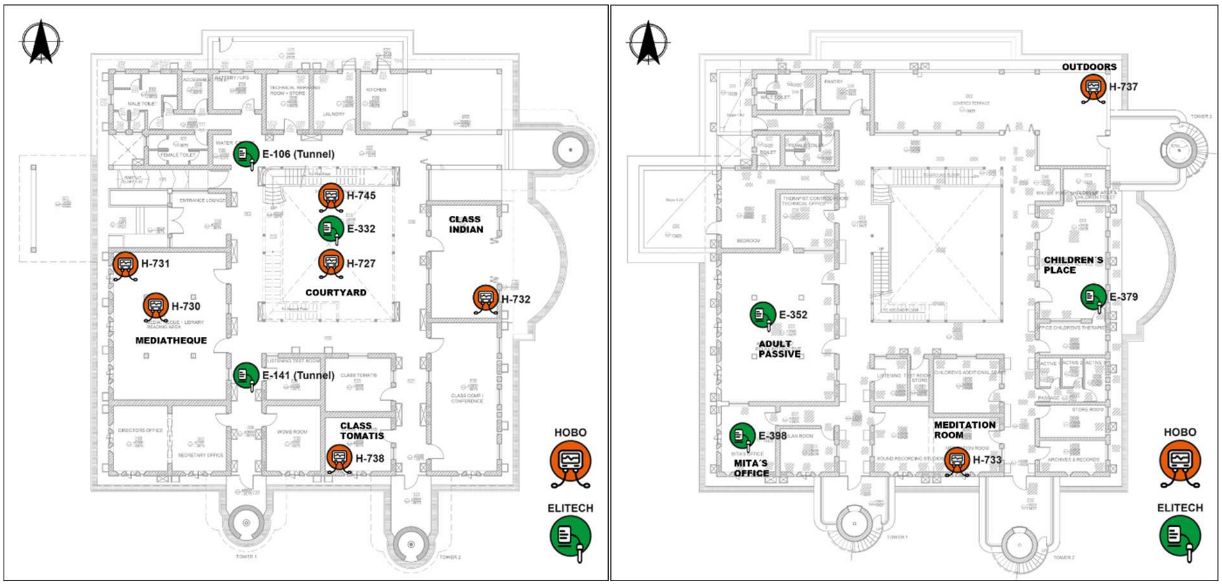


Figure 6-7 *Layout showing equipment distribution within the building on Ground (left) and First floor*

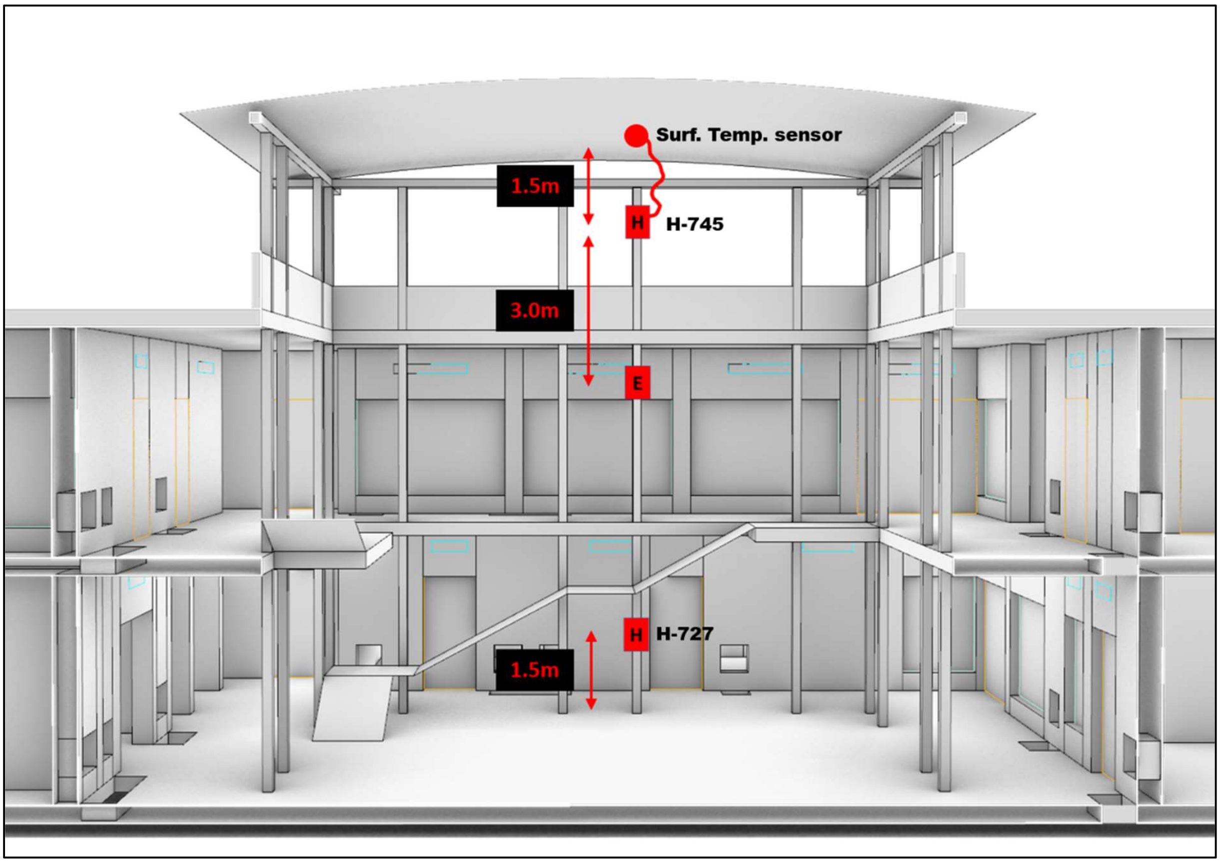


Figure 8 *Sketch showing the suggested distribution for the Courtyard equipment.*

- **Mediatheque**

- Place the sensors on the area close to the west façade, as indicated (See Fig. 9). Take care to choose the adequate side of the column, while placing the second device, in order to reduce the effect of ceiling fans over it. It is important to locate the surface temperature sensors, both inside and outside, at the same level. For the outside one, check the recommendations for its protection listed later.

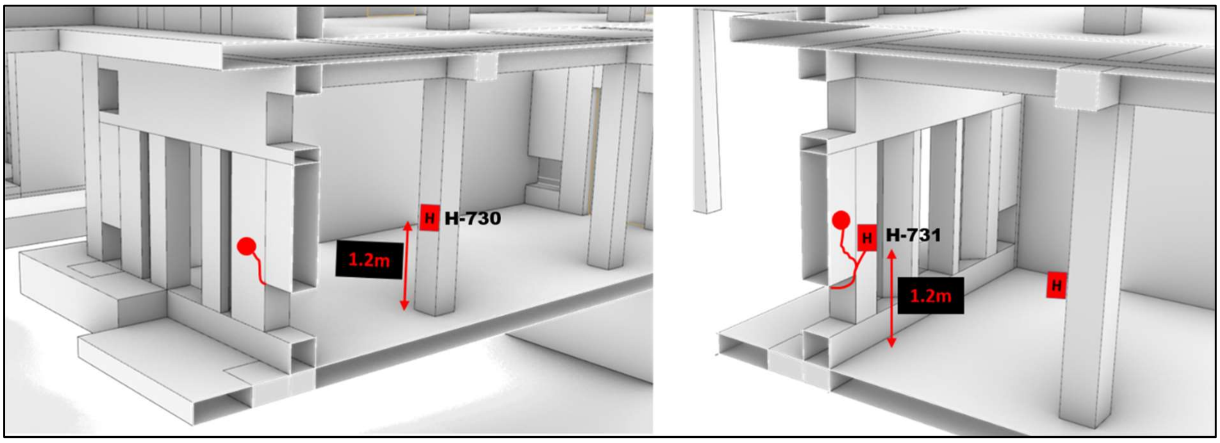


***Figure 9** Suggested distribution for the Mediatheque equipment.*

- **Class Indian and Tomatis**

- Place the devices on the corresponding façade, as shown on the distribution layout. As previously indicated for the Mediatheque, situate them at the height of 1.2m and respect the same conditions for the surface temperature sensors.

- **Children´s place**

- Choose a location for the data logger on the surface opposite the facade. Observe the height and general protection requirements of the device and its probe. Also consider a place where children cannot accidentally remove or interact with the equipment.

- **Adults passive, Meditation room and Mita´s office**

- Find a proper surface towards the inside of the building, for wind and direct sun light protection. General conditions remain the same as for previous rooms.

- **Outdoors**

- Place sensor to the inner side of the corner column, located on the north-east covered terrace, on the first floor. As indicated on (Fig. 10)

- **Underground tunnel**

- Place sensors at least 1m above the floor and separated as much as possible from the tunnel walls. The suggested locations are shown at (Fig. 11)

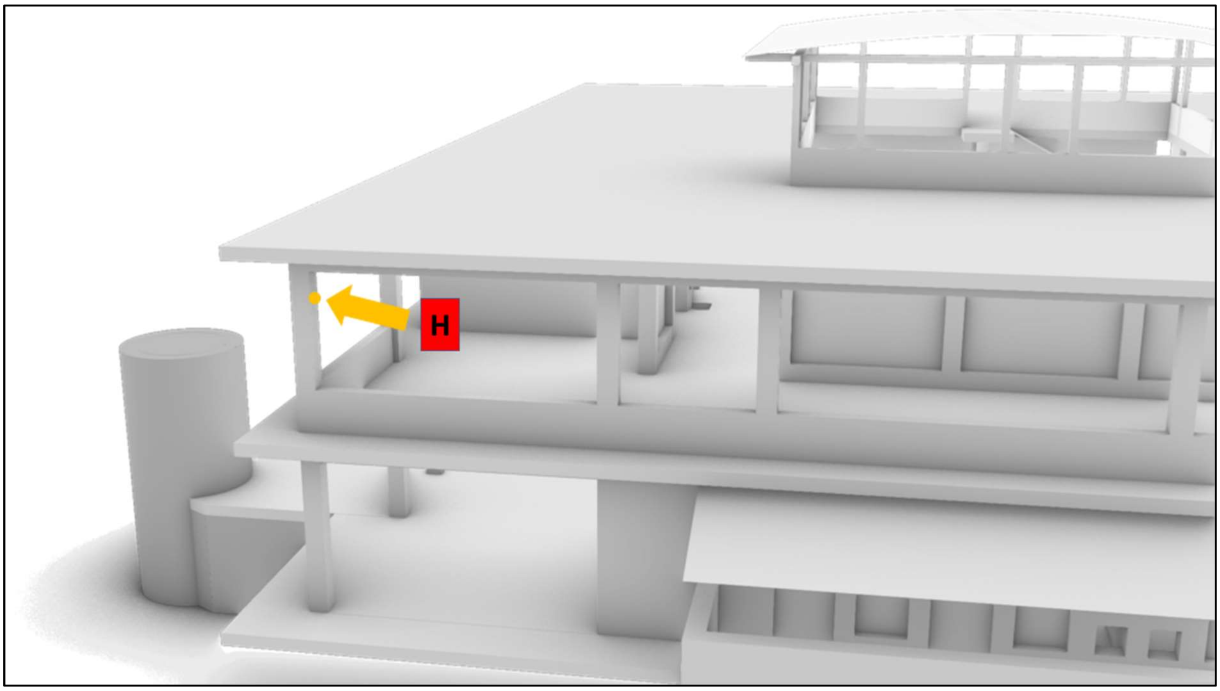


***Figure 10** Suggested location for the Outdoors HOBO device (view from the North side)*

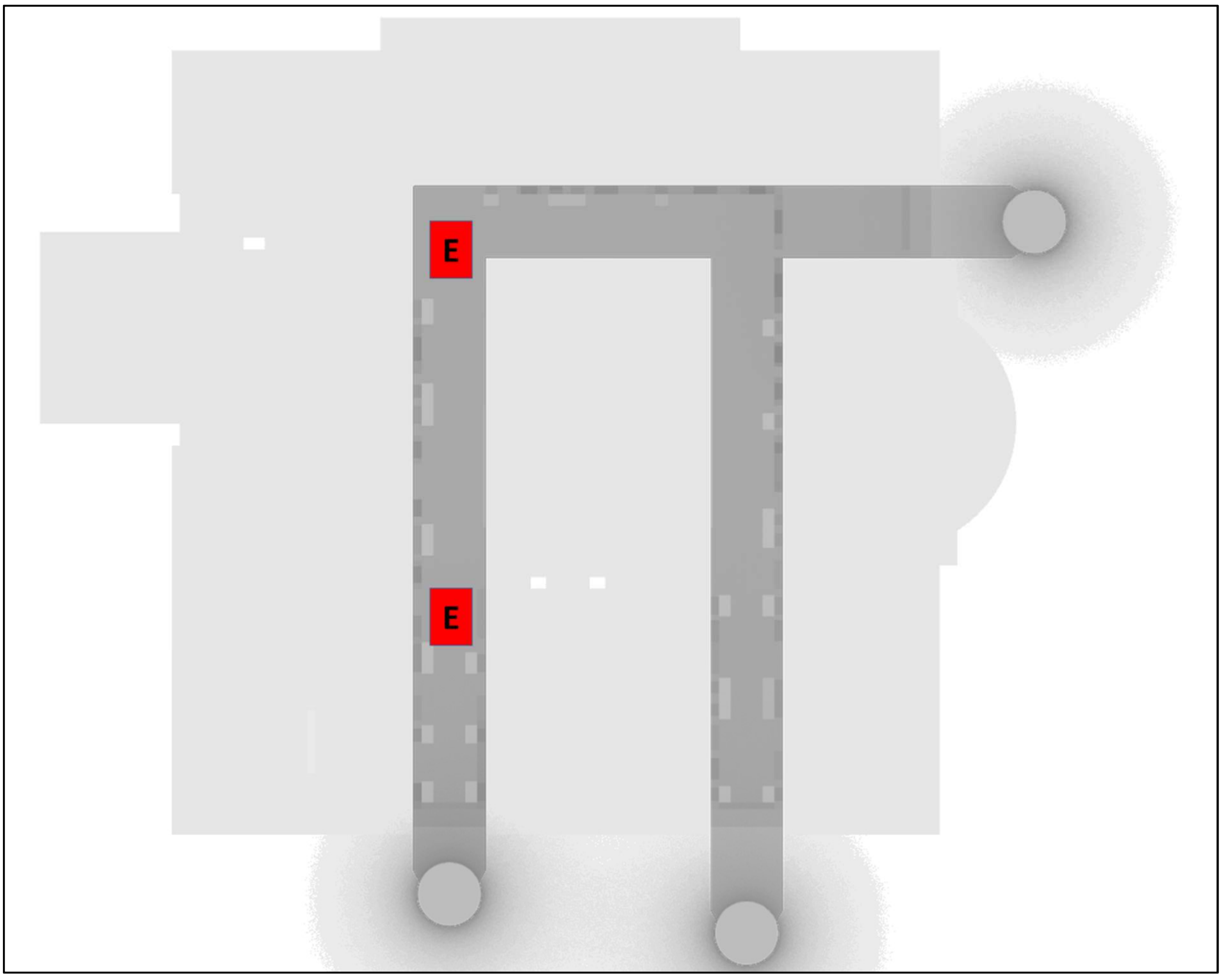


***Figure 11** Sketch showing the ventilation tunnels and the position for the devices*

2.5 Equipment protection:

Due to the operating characteristics of these devices, one of the key factors to consider during the planning process is the protection of the equipment against external factors that may alter the measurements. Considering this, any object or surface that is sufficiently close to or in direct contact with the sensors constitutes a source of cold or heat radiation, which means that the obtained values would be erroneous. Direct solar radiation and considerable air flows, such as from a fan or ventilation system, are also a problem that should be avoided at all costs.

For this reason, two methods to protect the devices were developed and implemented. These will be detailed below.

2.5.1 Self-made protection case:

One of the common issues that were found while using the Elitech devices was the vulnerability of its external probe, used for gathering air temperature values. An easy to assemble protection case was designed by the author to provide an inexpensive solution to protect this sensor, conceived to be printed on a thin sheet of cardboard (A4) and built in a few simple steps.

Once assembled, the cylinder provides sufficient space to place the probe, and a constant air flow is allowed thanks to the ventilation openings located at the top and bottom. Covering the outer surface of the case with a thin layer of aluminum foil, which can be found in any kitchen, adds additional properties of light reflectivity.

Auroville Language Laboratory personnel was able to build all the needed prototypes, which demonstrated the applicability of the idea. However, it is important to mentioned that only theoretical assumptions were considered for its conception, thus an analysis of its real performance remains a work in progress. In addition, its use is recommended only for indoor spaces as the materials and the design are not suitable to offer protection against rain or strong winds. The template can be found as an annex at the end of the document.

Figure 12-13 *Prototype built by the author, notice the probe inside (left), and its application in the building*

2.5.2 Lime paint:

Surface temperature sensors, placed on the exterior areas of the building, were a concern from the outset, especially those located on the south and west facades. These sensors are very sensitive to direct solar radiation, so their protection was crucial.

Initially, the possibility of placing them in a shaded area under the overhangs was considered. However, the length of the cables and the fact that this location was not optimal for our measurement purposes were major drawbacks that led to the rejection of the idea.

As the predominant material in the building is lime, it was decided to fix the sensors to the surface using layers of masking tape, which were subsequently covered with a solution of lime plaster. The masking tape has a high thermal transfer, so its insulating properties are relatively low especially compared to other adhesive materials. This, together with the applied lime paint, allowed to obtain a coating similar to that of the façade.

Figure 14-15 *External surface temperature sensors before and after applying the lime paint protection layer*

2.6 State of art:

Once the comparison process was completed, all equipment was placed in the building according to the indications shown above. It is important to mention that the distribution task was carried out entirely by the building staff, mostly using the work plan as the main guide. This demonstrated the importance of having such a document, as it helped to save considerable time for both parties. Transsolar's advice was only necessary at specific moments of the process, mainly to clarify or give solution to minor problems that were not contemplated in the planning stage.

Once Transsolar's approval was given, the general data collection process began. At the beginning, it was determined to modify the delivery times of the data collected, in order to check that they were correct and identify errors. Therefore, the information was exported and sent for review on a weekly basis, and not every two weeks as indicated in the work plan.

As feared, inconveniences of various kinds were found after the review, resulting in the partial invalidation of data. This process of identification and rectification of errors unfortunately took place from the end of August to the middle of November, which represented a delay in the measurement task and the loss of some relevant data for the investigation. Details about the main encountered problems and how they were solved can be found in the Troubleshooting section.

Fortunately, not all the information was damaged, so much of it was qualified as valid. It has been used by Transsolar engineers to validate thermal simulations carried out for relevant rooms in the building, such as the Mediatheque, the Indian classroom and the ventilation tunnels. At the time this report has been drafted, measurements are being made smoothly and new data is expected to be sent.

Figure 16-18 *Final setup for equipment. From left to right: Adults Passive, Indian Class and Outdoors*

3 - Troubleshooting:

3.1 Equipment comparison:

First attempt (22/07/2019)

Description: Elitech devices were placed in the same room and set to collect data for the same amount of time.

Encountered problems:

- Transsolar received only three data files (five should have been received, one for each device) It was concluded that the results were overwritten from one device to another when imported into the computer.

Applied solution:

- It was identified that the cause of the problems was the lack of knowledge in the handling of the software used to calibrate the devices, as well as to carry out the readings of the recorded data. A video call was made between Transsolar personnel and the staff in charge of carrying out the measurements in situ, showing step by step how to carry out the process correctly.

Second attempt (23/07/2019)

Description: The location of the devices remained the same.

Encountered problems:

- The data loggers were not configured correctly, which means the starting/ending time and date on the devices were incorrect.
- After analyzing the results, an erratic behavior was identified among devices.

Applied solution:

- A detailed explanation was given to clarify how to set the basic parameters of the data loggers in the software.
- Photographs showing the position of the equipment were requested. These showed that the cause of the incoherent behavior between devices was due to a bad positioning of their external sensors. These had been placed on a table, very close to its surface, contrary to what was specified in the methodology. Instructions were given on how to properly place the sensors.

Third attempt (25/07/2019)

Description: The location of the devices remained the same. Time and date settings were corrected. The position of the sensors was modified according to the previous instructions.

Encountered problems:

- The results remained significantly different between the devices. After reviewing the new photographs of the installation, it was concluded that the location of the sensors within the room had been done incorrectly. Contrary to what was specified in the methodology, the equipment was unprotected from direct sunlight and placed under a ceiling fan, factors that unevenly influenced the results.

Applied solution:

- Instructions were given to move the devices into an unoccupied room, with the objective of minimizing external factors that could influence their performance.

Figure 19-20 *Setup used for the first three attempts. Previously mentioned issued can be easily recognized*

Fourth attempt (31/07/2019)

Description: Equipment was moved to a new room as required. In addition to the Elitech devices, the recently acquired HOBO equipment was placed. Photographs of the installation were sent prior to the measurements start.

Encountered problems:

- A review of the photographs showed that the external sensors of the Elitech devices had been incorrectly positioned (Fig. 21). As was the case during the second attempt, the probes were resting on the table surface.

Applied solution:

- A new video call was arranged to explain in detail the proper way to place the equipment.

Figure 21 Incorrect placement for the Elitech devices external sensors

3.2 General measurement process:

First attempt (22/08/2019 – 26/08/2019)

Encountered problems:

- Start and stop times for two devices, HOBO #730 (Mediatheque) and HOBO #737 (Outdoors). The collected data corresponded to old measurements according to the registered dates: 17/08/2019 – 19/08/2019
- Some hours were missing from the surface temperature values (thermal gun). Also, floor and ceiling surface temperature was not measured for any room.

Applied solution:

- Instructions were given to stop the recording of each device and to reset its configuration in the software. In addition, the old data stored in the system was requested to be deleted.
- A call was established to highlight the importance of maintaining consistency in the times when measurements were to be taken.

Second attempt (13/09/2019 – 25/09/2019)

Encountered problems:

- The data collected by the outdoor surface temperature sensor corresponding to HOBO #732 (Indian class) showed erratic behavior. Temperature values were extremely high for a few hours only to drop drastically again.

Applied solution:

- It was assumed that the sensor protection was not well implemented, thus direct sun light was causing the problem. Therefore, instructions were given to carefully check the outside setup, documenting the process with photographs.

Third attempt (18/10/2019 – 28/10/2019)

Encountered problems:

- No data was received corresponding to device HOBO #745 (Courtyard)
- Values obtained from device HOBO #732 remained showing the same erratic behavior as identified before.

Applied solution:

- The personnel in charge of sending the information was asked about the missing device. It turned out to be a human error when exporting the file.
- It was assumed that a malfunctioning on the sensor could be the cause of the remaining issue for device HOBO #732, thus instructions were given for replacing it. Luckily, a meeting between the building staff and engineers from CSR, shed some light on the subject. It turned out that the hardware did not present any problem. Instead, as a result of tensions made to the sensor cable during its installation, the probe had been slightly disconnected from the corresponding port in the data logger. Therefore, the high values recorded corresponded to the internal sensors of the equipment, reason why erroneous results were obtained.

Conclusions:

Considering the totality of the aspects that have been approached throughout the present work, as well as the personal experiences of the author during the development of the described task, the following is concluded:

- The selected devices are efficient for measuring air temperature, surface temperature and relative humidity values within the building under study. Thus, collected data is valid for the aims of supporting Transsolar engineers work.

- The planning process, in the form of a work plan, led to an adequate distribution of the available equipment, and supported the staff of the building while completing the task.

- A list of common problems and how to solve them was obtained, together with practical recommendations applicable for anyone carrying a similar process.

Recommendations:

This document should be understood as an example of how to carry out the remote climate data collection process. Therefore, the following is recommended:

- To use the described equipment in buildings located at similar climate contexts.

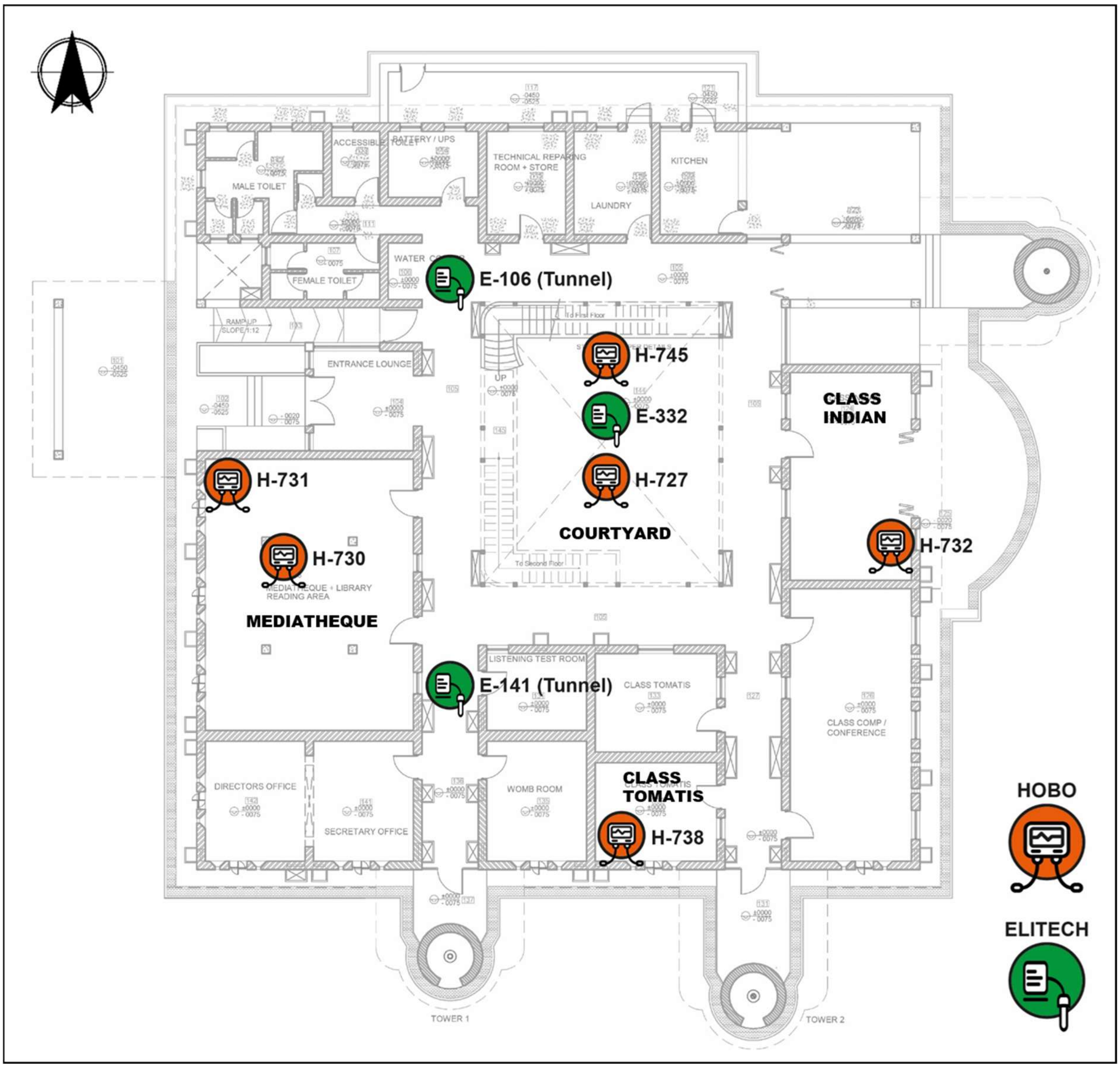
- To maintain a strict organization during data management, especially considering the magnitude of the same, in order to avoid confusions or information losses.

- To keep a constant communication between the parts involved, using more dynamic communication channels compared to emails, as is the case with video calls.

In addition, it is recommended that additional studies be carried out on some of the methodologies described in this work, fundamentally those related to equipment protection.

Annexes:

Equipment distribution within the building (Ground floor and tunnels)



Equipment distribution within the building (First floor)