

# Real Time Line Sag Detection

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## Need

- Extensive line sag causes short circuits in power distribution networks. It also causes damages to the wirings and poles.
- Disturbances and damages in electricity distribution networks are very expensive and hard to locate and repair
- The line sag detection system will help to prevent damages and speed up the repairing tasks
- Only in Finland there are about 150 energy distribution companies which can use this system in order to prevent damages and save resources

## Approach

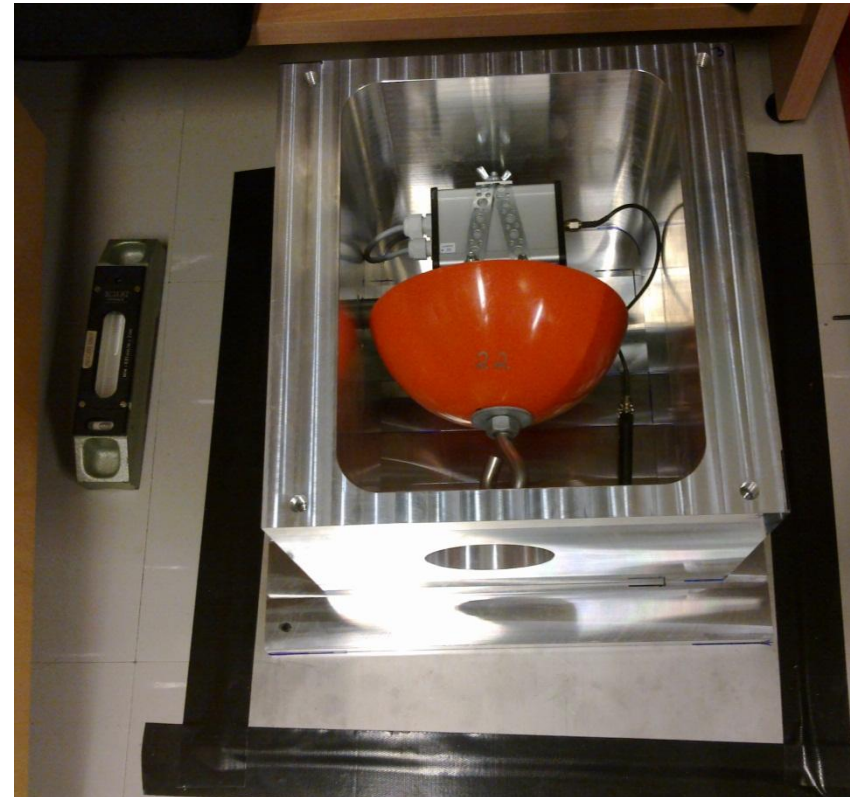
- The Power Line Monitoring system measures , analyses and achieves power line sag information
- This information can be used to create alarms or propose measures when the power line sag exceeds a certain limit (this can be caused by ice, snow or mechanical incidence liketrees, wind etc.).
- The system reduces on-site inspection work, prevents further damages and shortens power outages bringing cost savings for the power line maintaining companies.

## How does it work?

- The project has developed a neat calibration and verification system for line sag detection system.
- The line sag detection algorithms have been tested and verified by a test system in VTT.
- VTT has got patents pending on the key technology in the following countries:
  - Canada, USA, Russia and EU
- Sensors used in instrumentation need to be calibrated. Without calibration the accuracy is not adequate for sag detection system

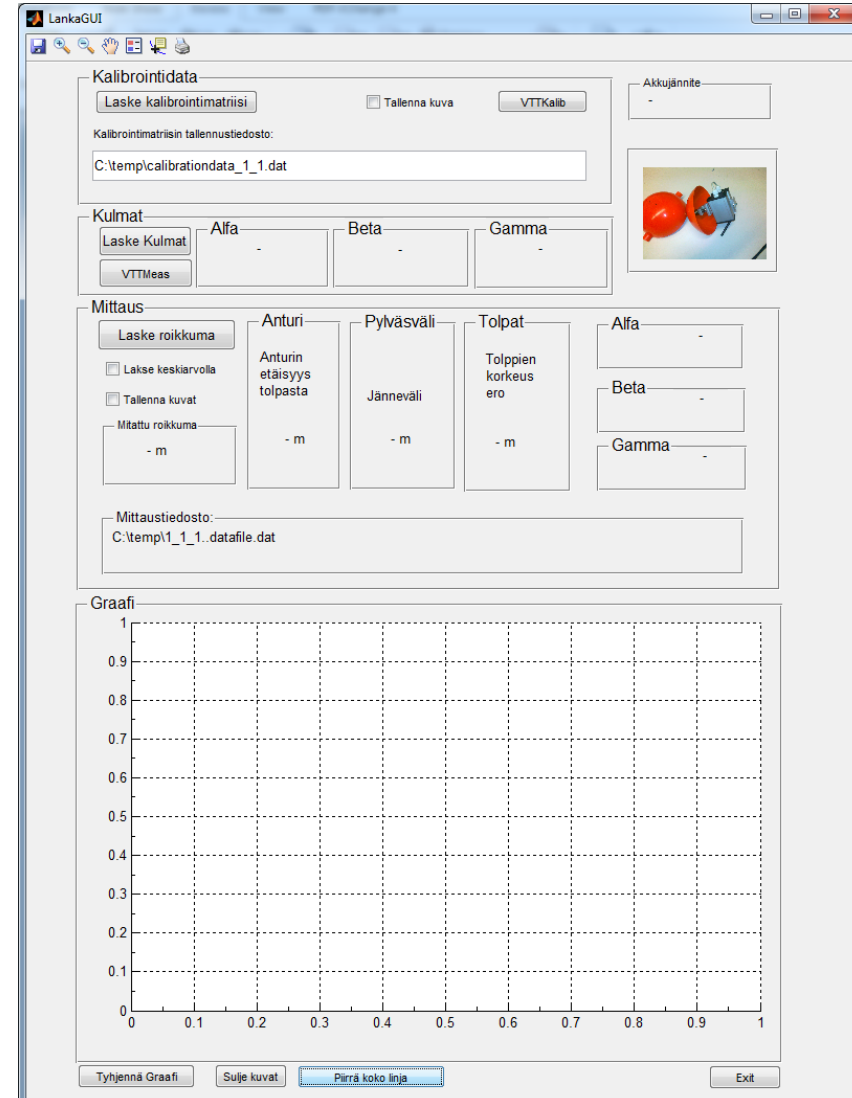
## Calibration setup

- The calibration measurements are done by installing the measuring unit (sensor unit) into a precision machined calibration cube
- The cube is rotated (6 DoF rotation) on a highly accurately leveled plate with 3 adjustable support legs
- Data sampled with 100Hz sample rate and sent wirelessly to PC



## MATLAB UI

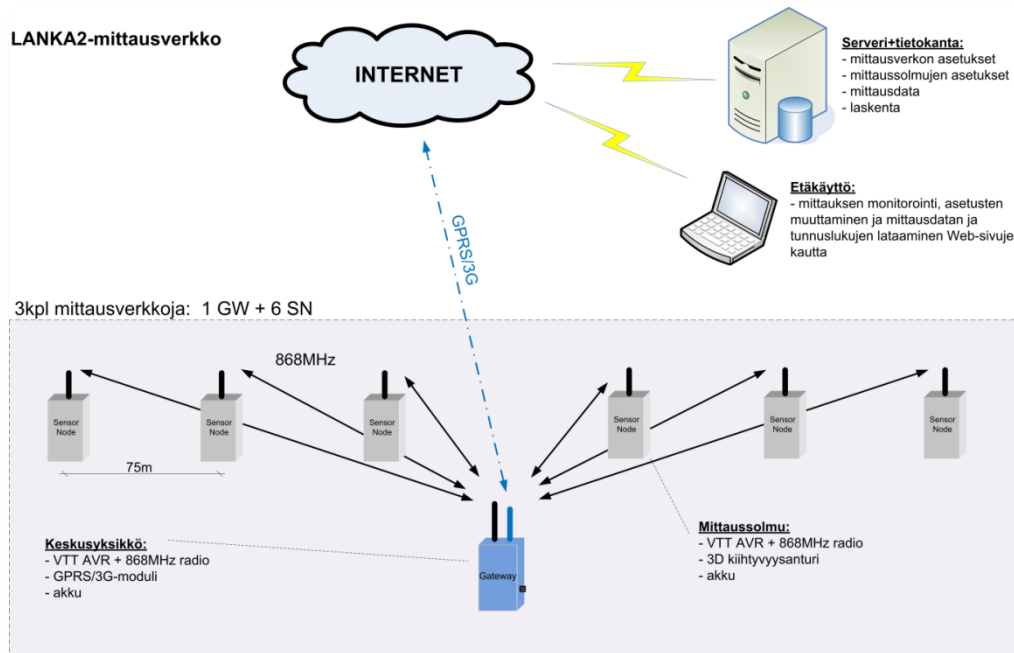
- The calibration matrix calculation is done with a MATLAB coded software.



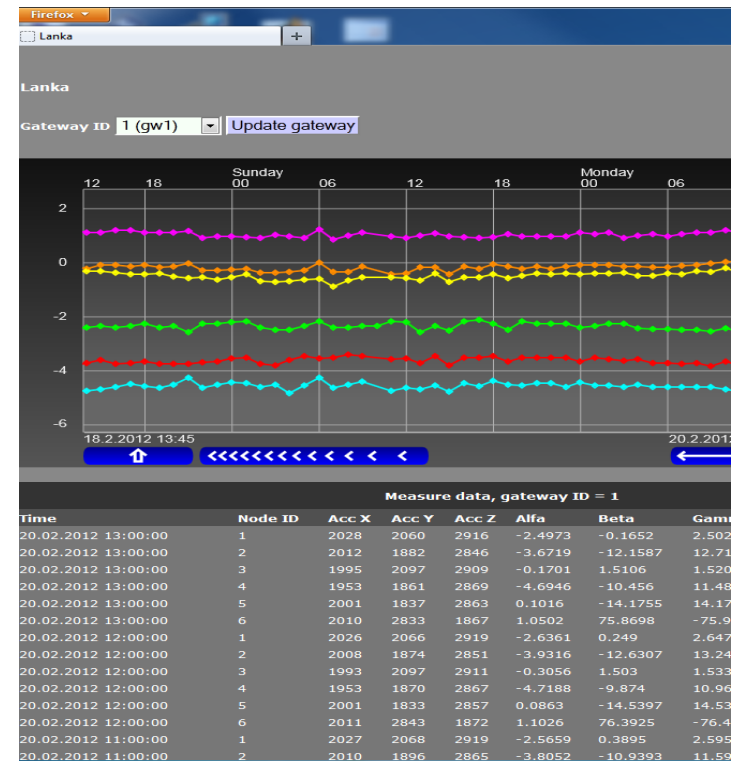
## On-site demonstrator setup

- Long term real on-site power line sag detection system tests are on-going and will be finalized during this winter (2014)
- The test system is based on wireless implementation with battery power supply in the units (including temperature measurement for verification)
- In addition to line sag monitoring the system can be utilized also for dynamic measurements (e.g. time- and frequency domain analysis)

### Sensor Network Architecture



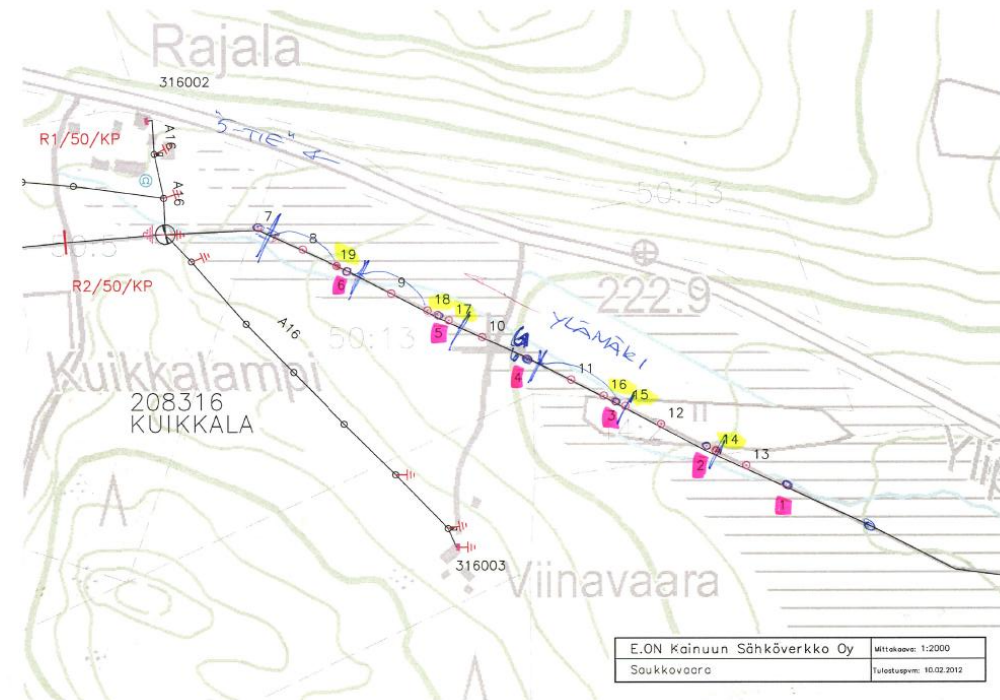
### WEB UI for data visualization





## On-site test setup installation

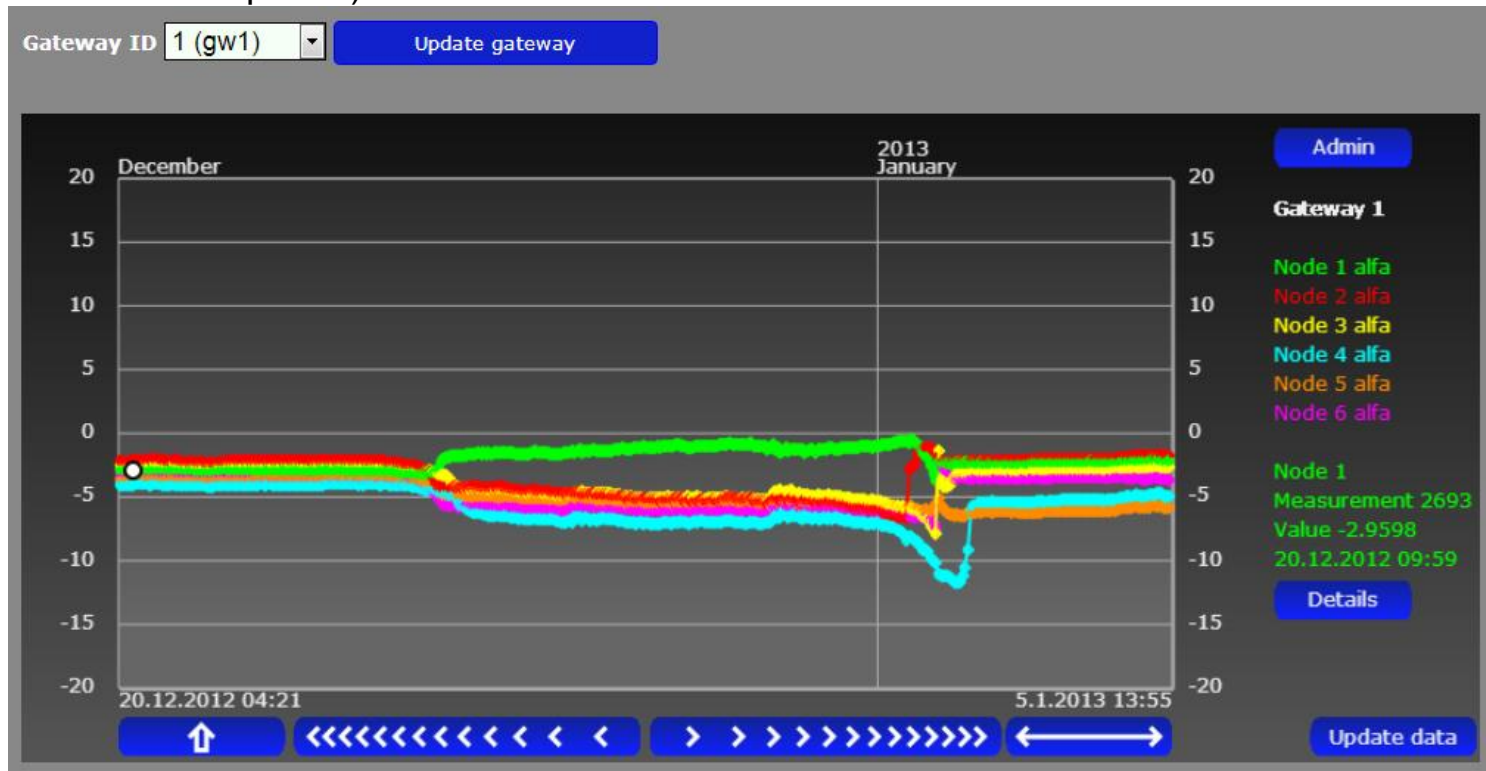
- A six sensor unit setup was installed in E.ON. Kainuun Sähköverkko Oy power lines at Saukkovaara
- All the electronics are packed into 'bird warning ball'
- Data is acquisitioned and sent to the Internet server by using a embedded gateway





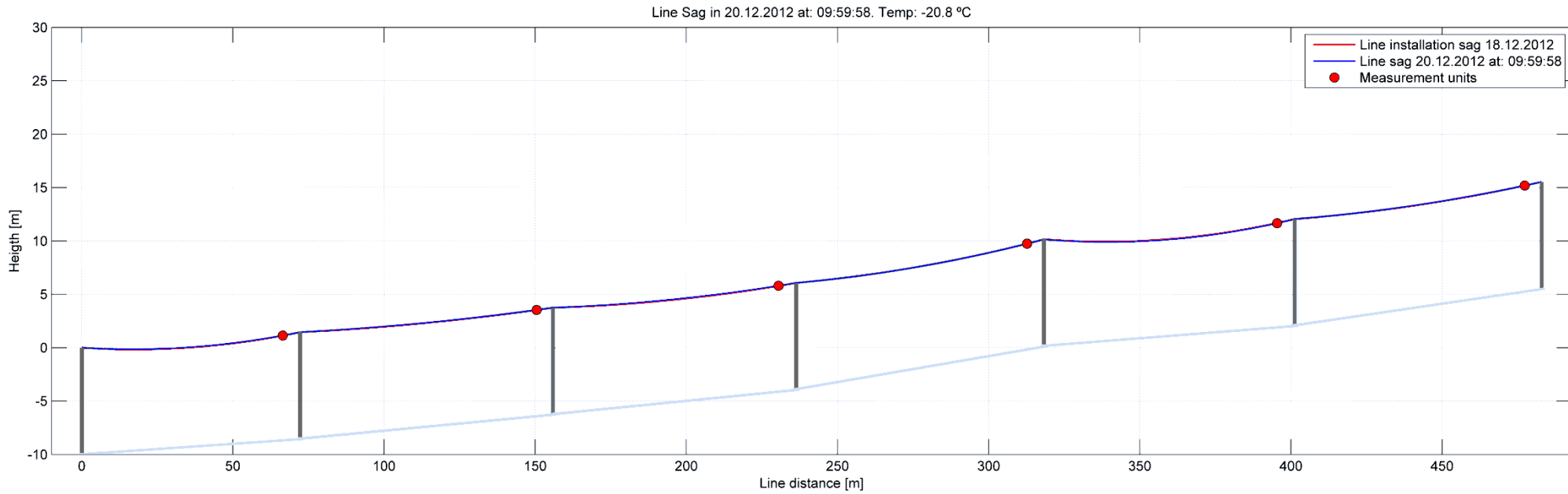
## Measurement results

- Server data of the Power line sag measurements during 20.12.2012-5.1.2013
- 6 unit data including power line sag angle
- Sag angle data is post processed with MATLAB to obtain sag information (see next slides)
- It can be seen from the results that sag has increased during 24.12.2012-1.1.2013 because of snow load and then again decreased during 2.1.2013 (most probably snow fell off because of warmer period). See next slides



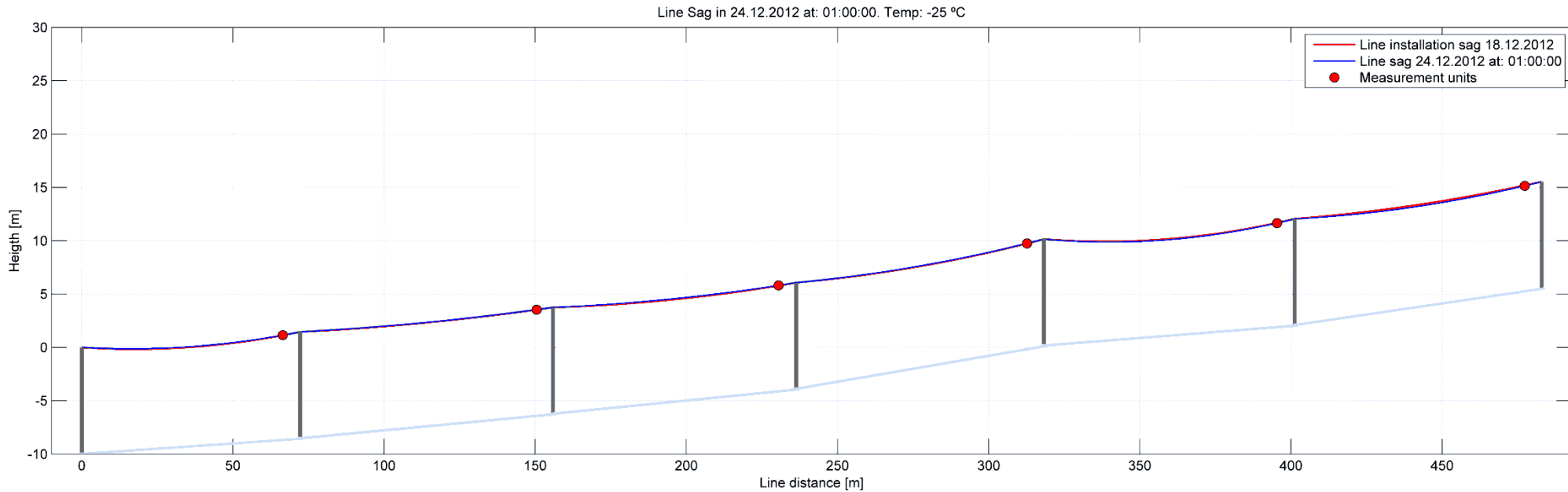
# Measurement results

- Matlab visualization of the Power line sag measurement 20.12.2012



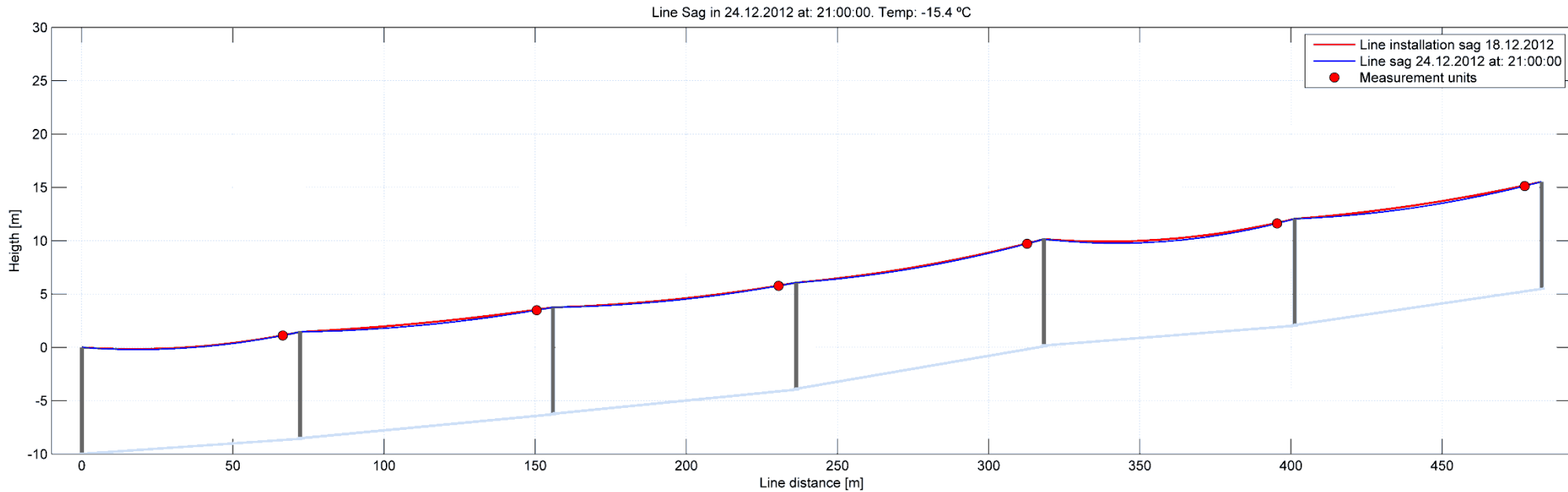
## Measurement results

- Matlab visualization of the Power line sag measurement 24.12.2012 at 1:00



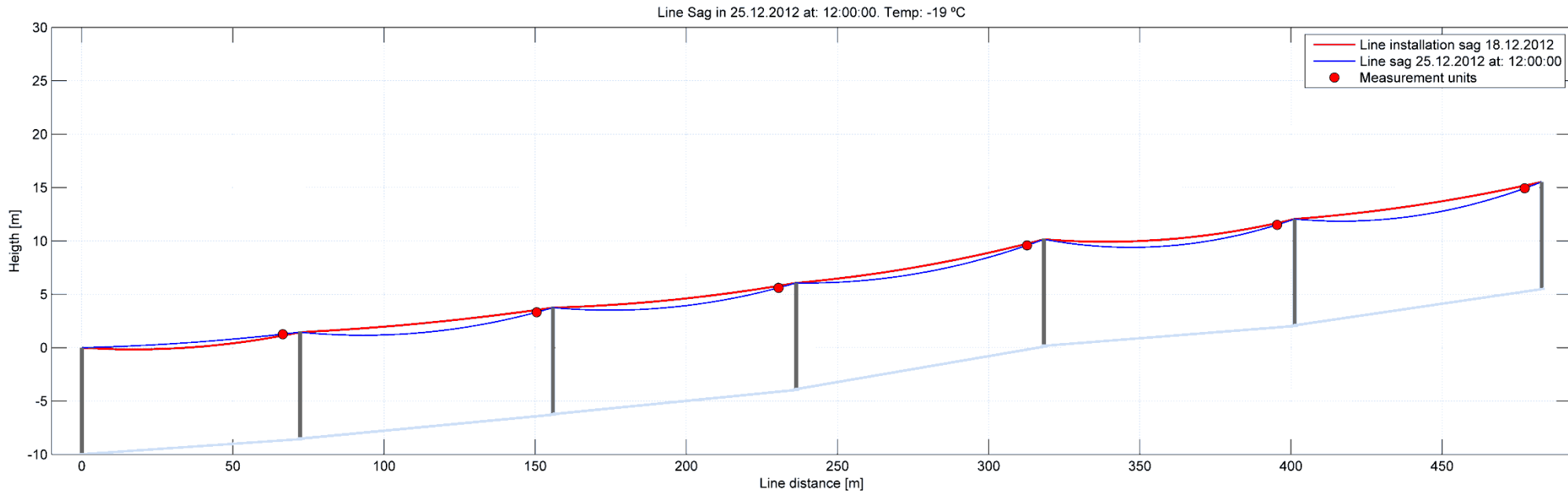
# Measurement results

- Matlab visualization of the Power line sag measurement 24.12.2012 at 21:00



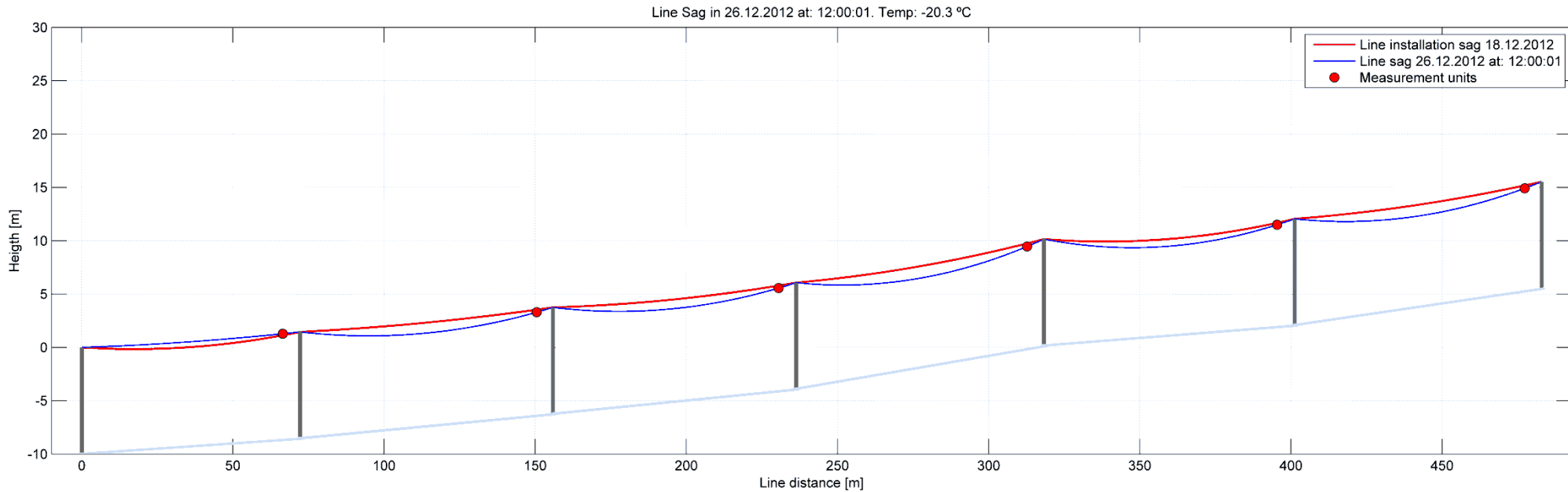
# Measurement results

- Matlab visualization of the Power line sag measurement 25.12.2012



# Measurement results

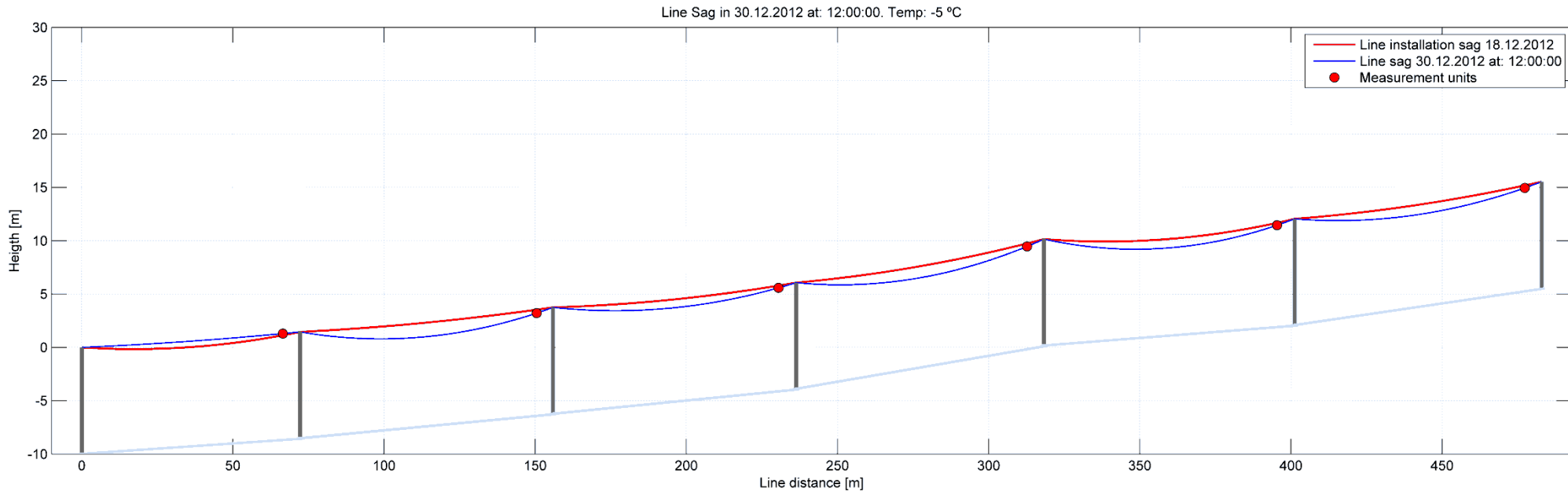
- Matlab visualization of the Power line sag measurement 26.12.2012





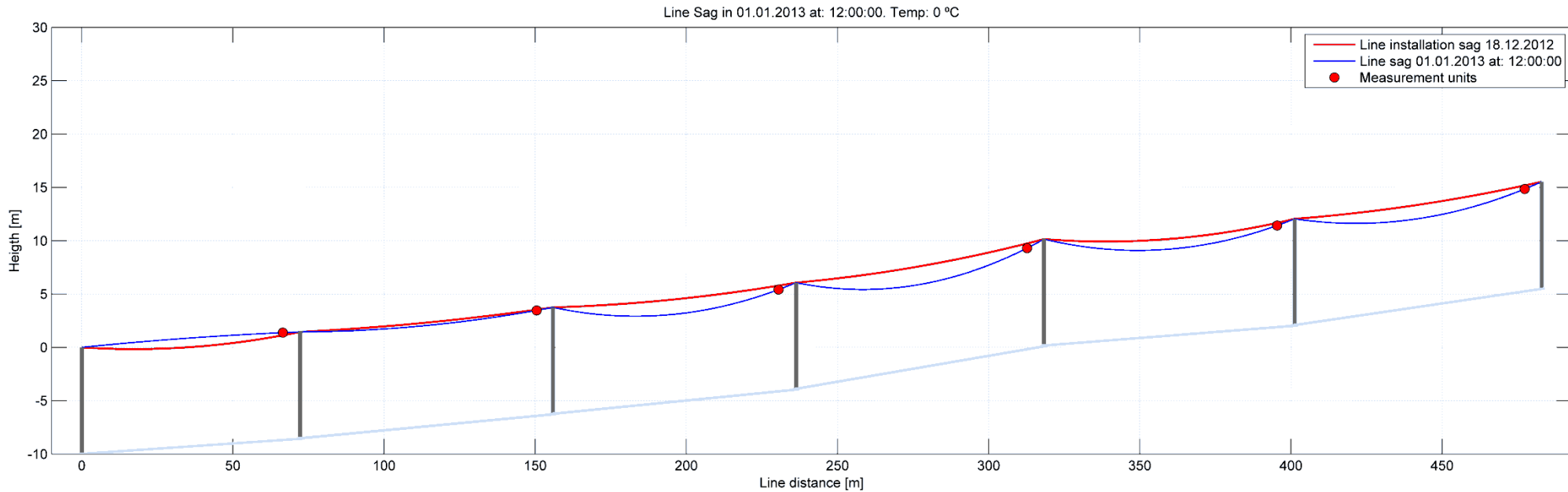
# Measurement results

- Matlab visualization of the Power line sag measurement 30.12.2012



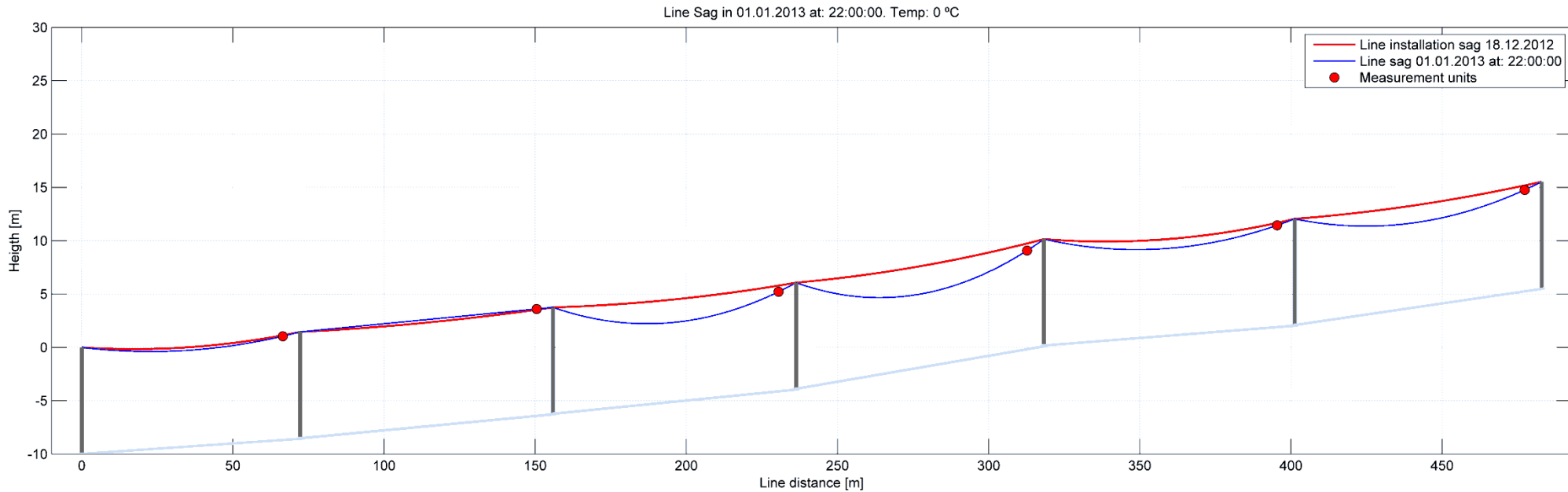
# Measurement results

- Matlab visualization of the Power line sag measurement 1.1.2013 at 12:00



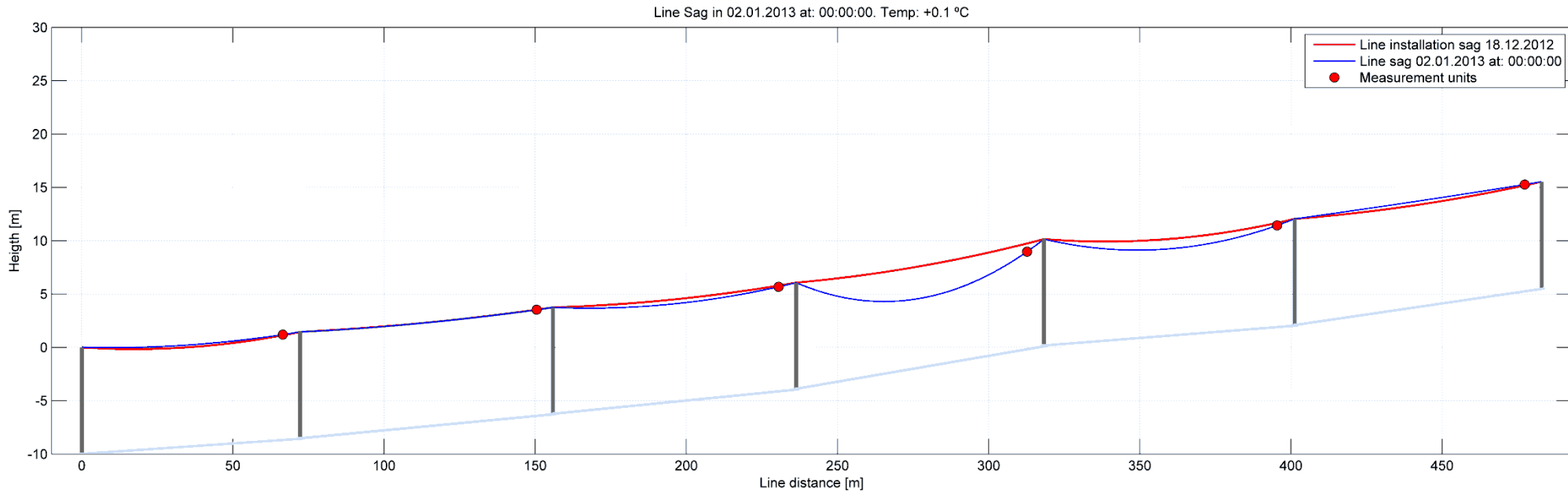
## Measurement results

- Matlab visualization of the Power line sag measurement 1.1.2013 at 22:00



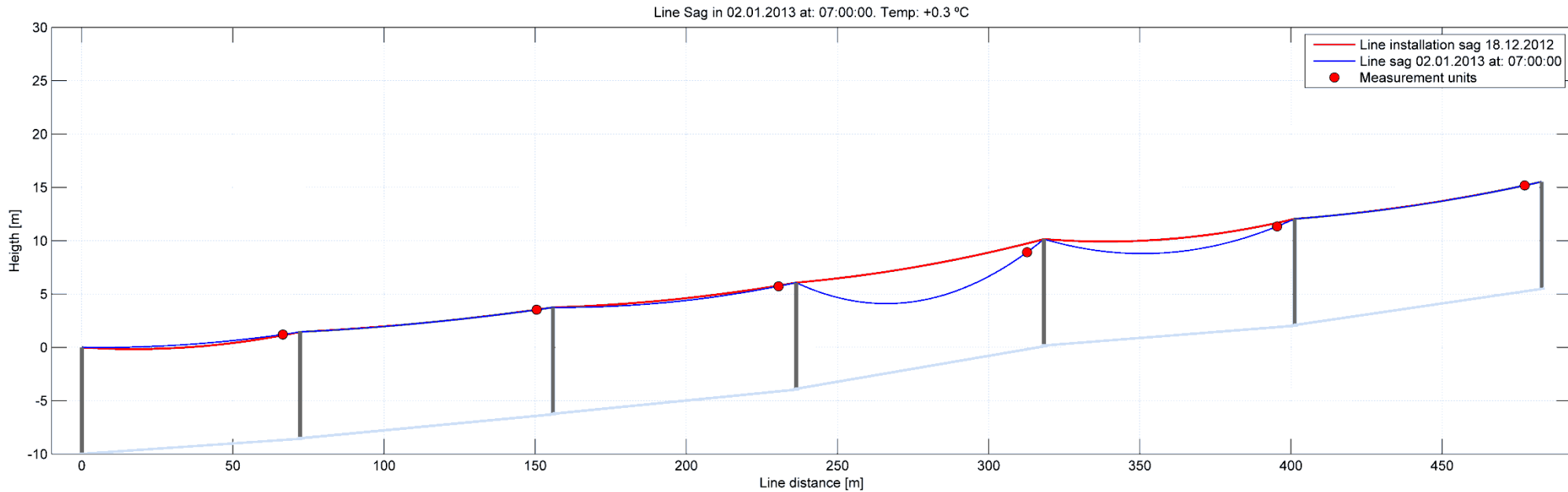
## Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 24:00



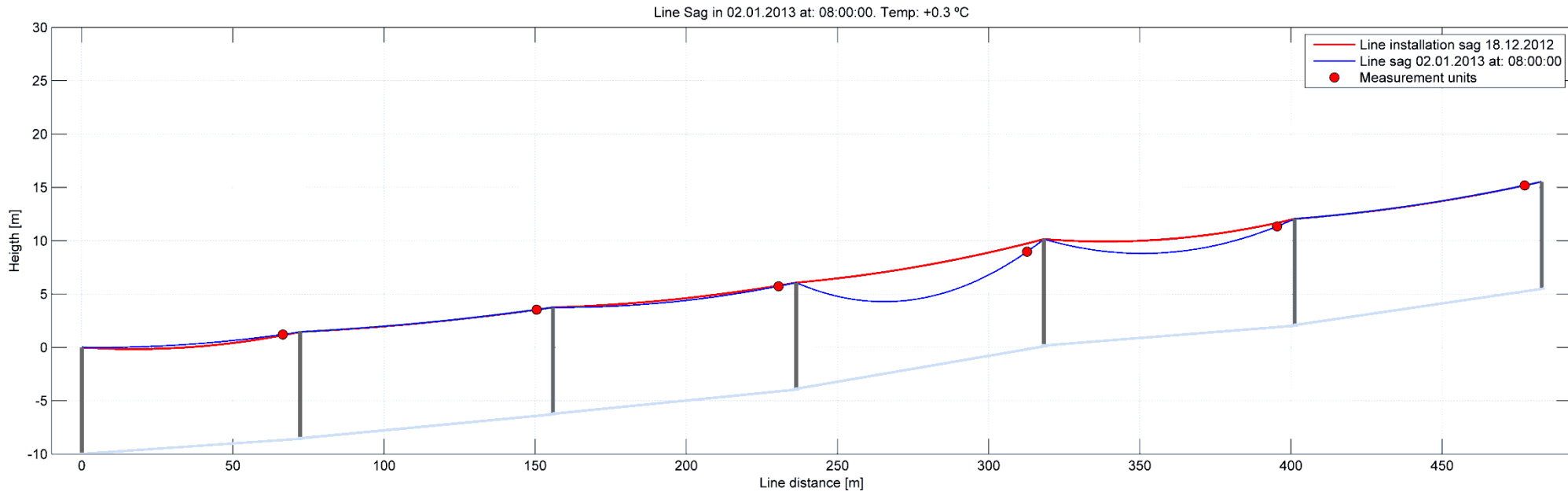
## Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 7:00



# Measurement results

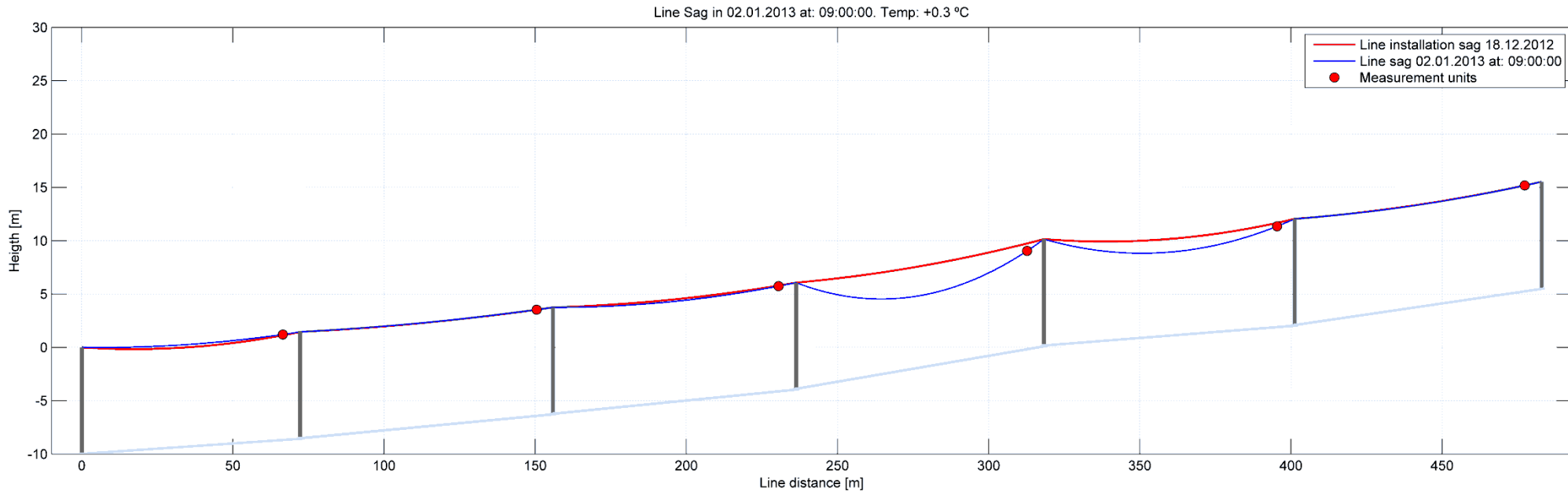
- Matlab visualization of the Power line sag measurement 2.1.2013 at 8:00





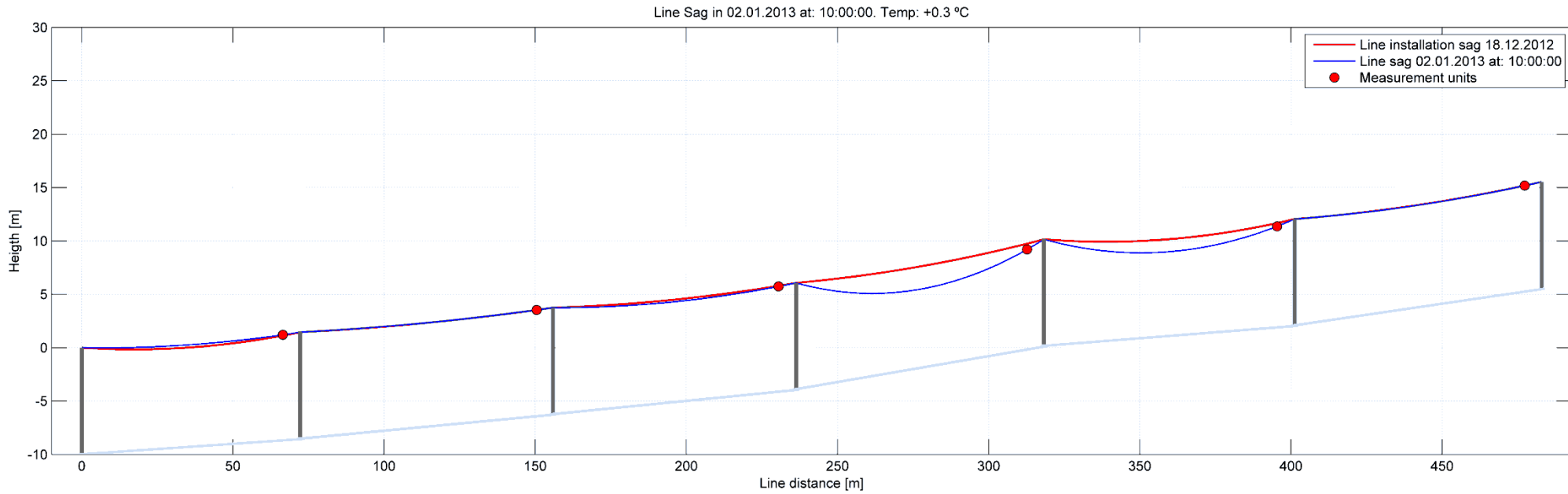
# Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 9:00



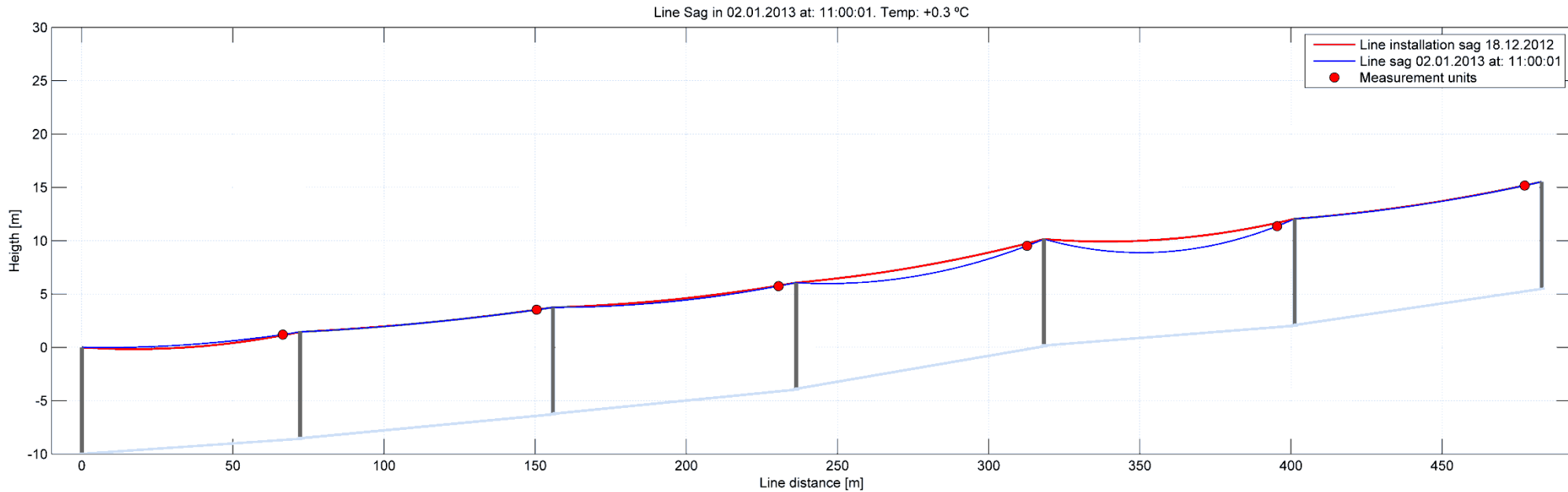
# Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 10:00



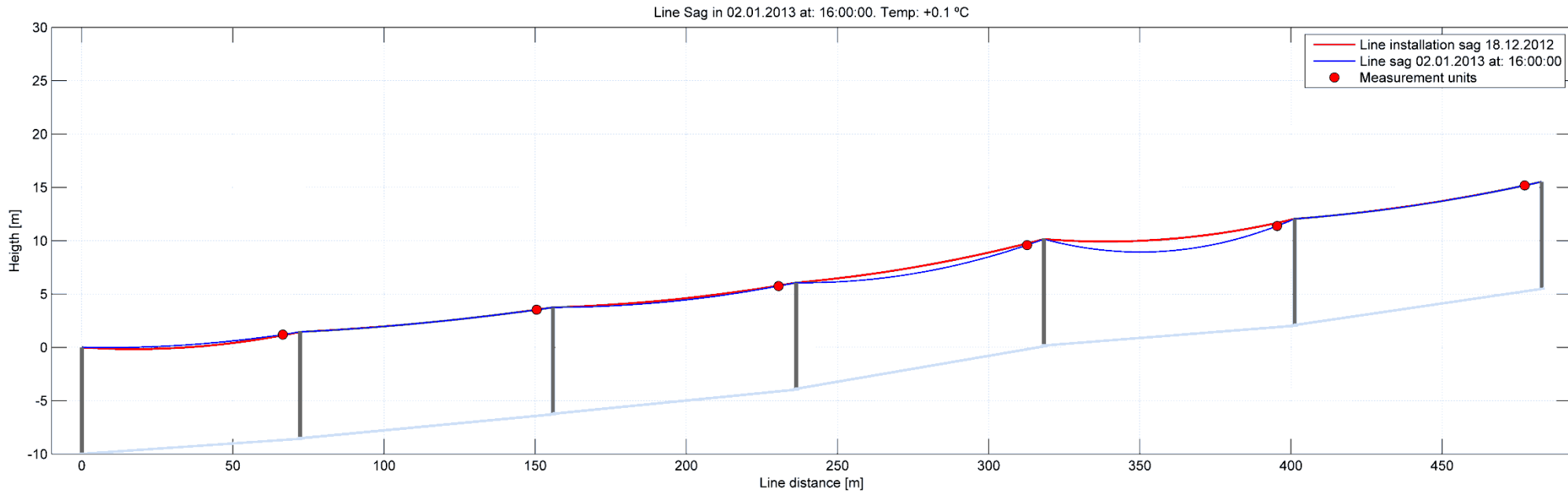
## Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 11:00



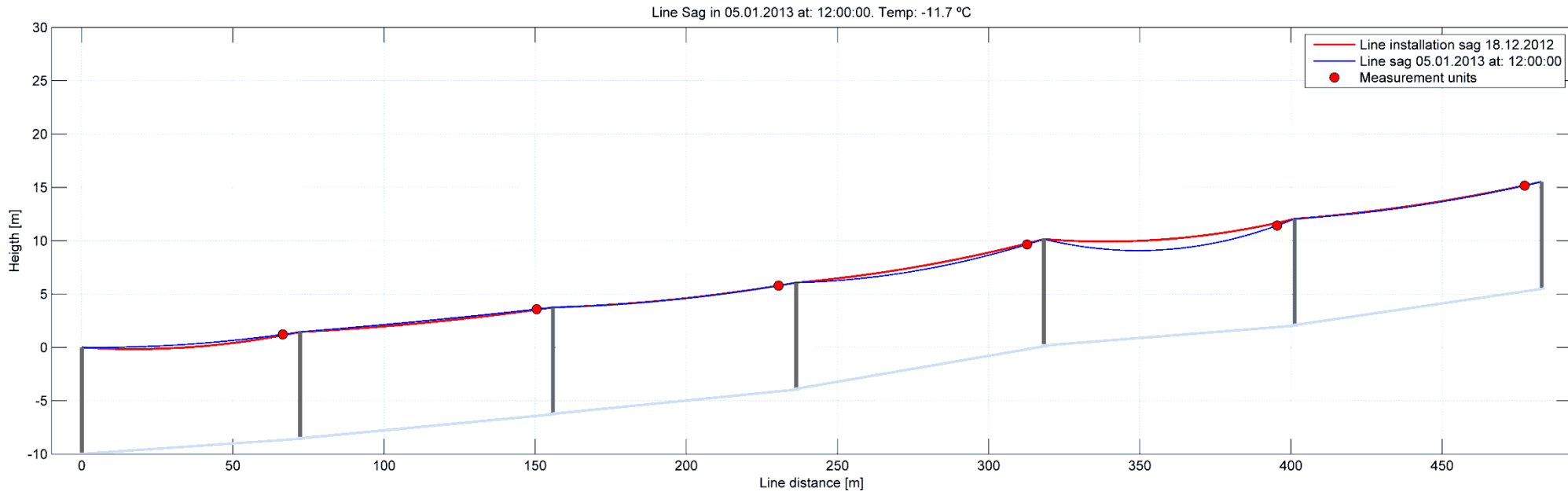
## Measurement results

- Matlab visualization of the Power line sag measurement 2.1.2013 at 16:00



# Measurement results

- Matlab visualization of the Power line sag measurement 5.1.2013 at 12:00



## Future steps to be taken

- Improvement of the measurement unit HW (more accurate sensor element)
- Development of the Web-UI: integrating the algorithms to the server software
- Energy harvesting in for the line units (photovoltaic or inductive) to extend lifetime to >6 years
- ADD on sensors for environmental monitoring (temperature, humidity, wind, (speed directions))
- New applications in vibration and fatigue analysis on power lines
- Commercialization: collaboration on manufacturing (OEM), licensing and product development ongoing



Thank You; Any Questions?