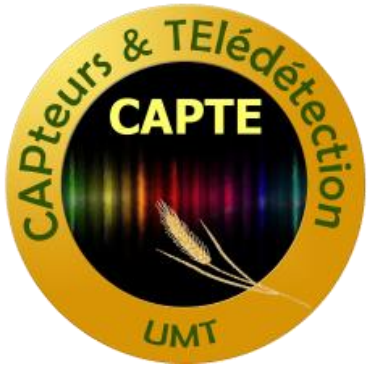
PHENOMOBILE for High-throughput Phenotyping in Field Conditions



Two main time scales for crop monitoring

Short term crop reaction

Monitoring the diurnal course of some crop state variables

- Surface temperature
- Leaf rolling
- PRI
- fluorescence

The diurnal course of these variables is driven by (at least!):

- stomatal conductance
- photosynthesis
- leaf water potential

} Radiation, VPD, T°, Wind …

Need to complete observations of the whole experiment within few minutes

Integrated crop reaction

Impact of water stress on growth:

- Plant Height
- Green Fraction
- Green Area Index
- Senescence
- FIPAR (Fraction of Intercepted Radiation)
- Organ Size (leaves, flower, stem diameter)

Importance of the seasonal time course to understand the establishment of the stress for each microplot

Need repeated observations with strong temporal consistency
Fine resolution (organ size & height)

UAV

UGV

Several (U)GV SYSTEMS

Boom
<300 plots
Small payload-autonomy

Phenotypette
<500 plots
Small payload-autonomy, height

Tractor based
<1000 plots
Non automatic, height

Several (U)GV SYSTEMS

Pulled system (Osnabruk)
Height
Manoeuvre
Semi-automatic

Buggy (CSIRO)
Height
Semi-automatic

Bonny-rob (Osnabruk)
Height
Autonomy
fully-automatic

Several UGV SYSTEMS

Gantry system (rails or wheels)

Weight: 2-6 t
Height: ≈ 4 m
Mobility: limited
Pressure soil: very high
Width <15 m
Interplot ≈1 m

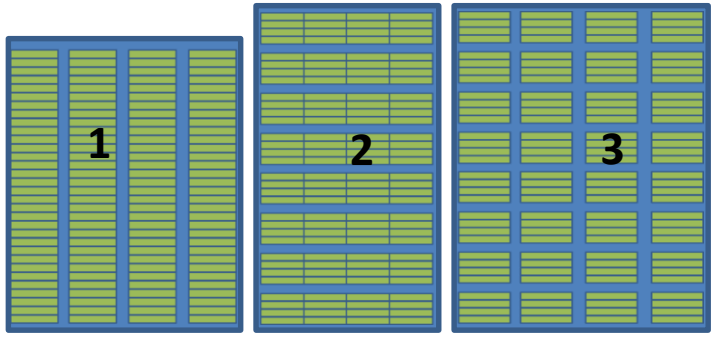
PHENOMOBLE V1

Weight: <1 t
Height: <1.35 m
Mobility: good
Pressure soil: high
Width: ≈ 2 m
Interplot: 30-40 cm

PHENOMOBLE V2

Weight: 8 t
Height: ≈ 4 m
Mobility: good
Pressure soil: low
Width: 10 m
Alleys: ≈ 2.5 m

Several UGV SYSTEMS

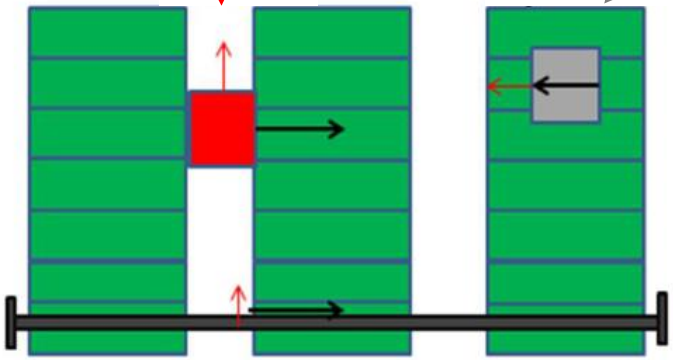


The 3 main Experimental plot design

Gantry (wheels or rails)

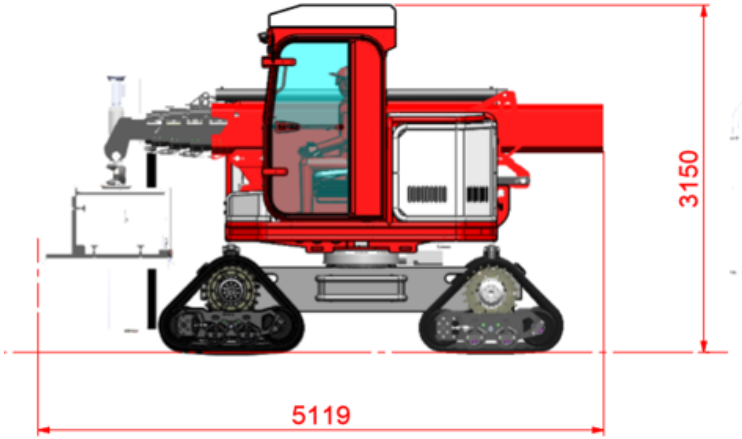
PHENOMOBILE V2

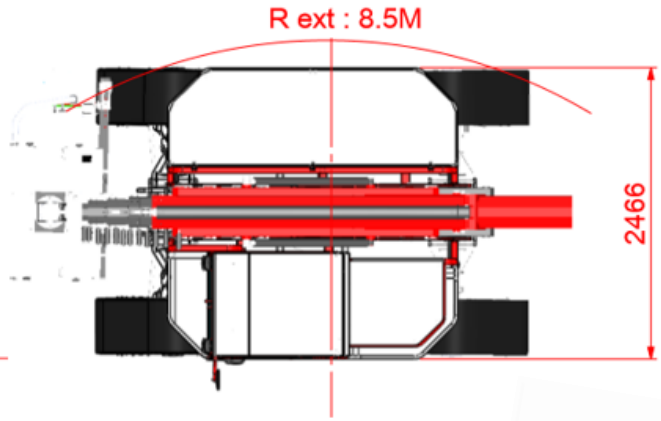
PHENOMOBILE V1



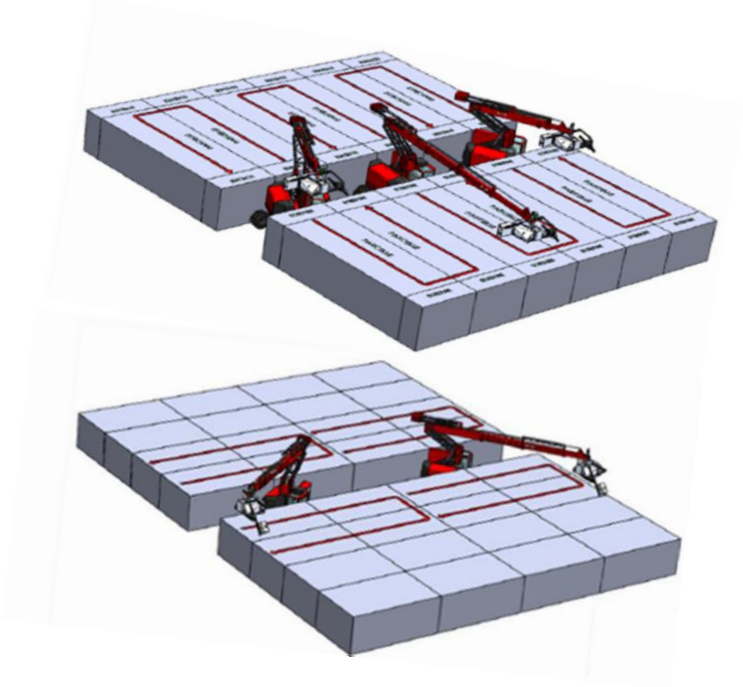
Great interest of PHENOMOBILE V2
Height 4 m

PHENOMOBILE V2





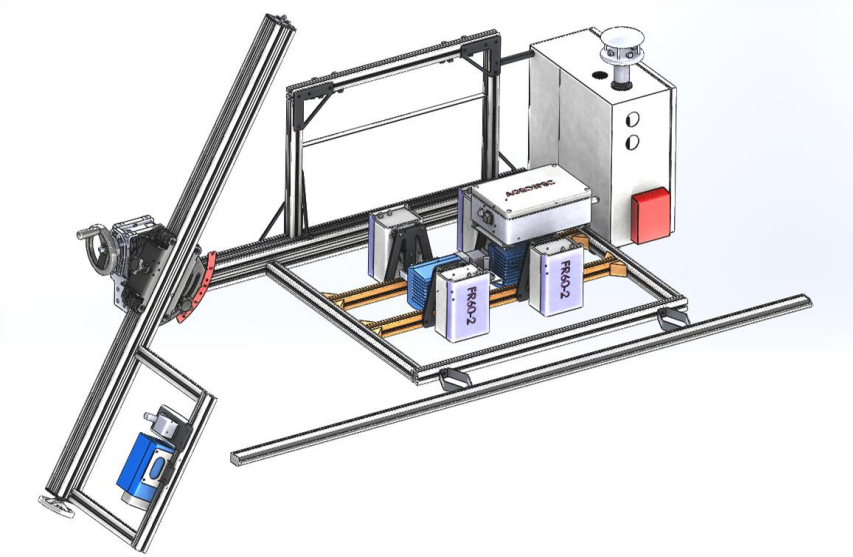
- Weight: 7.85t
- Turning radius: 8.5m
- Width: 2.46m
- Length: 5.2m
- Height: 3.15m
- Diesel engine powering the hydraulic and electric systems
- Autonomy: 10h
- 4 steering-powered caterpillars
- Airconditioned cabin
- Maximum speed: 12 km/h
- Throughput: >180 microplots/hour

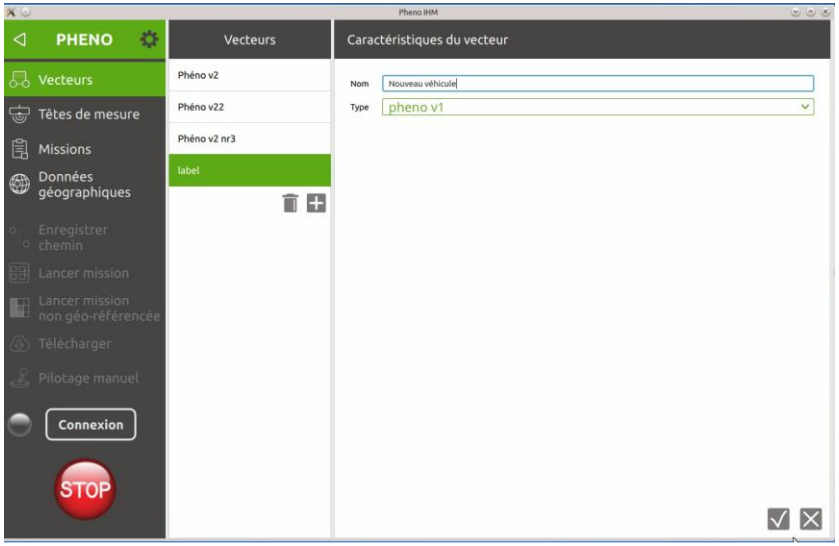


PHENOMOBILE V2

Just delivered to Avignon!!

A universal measurement head and command system



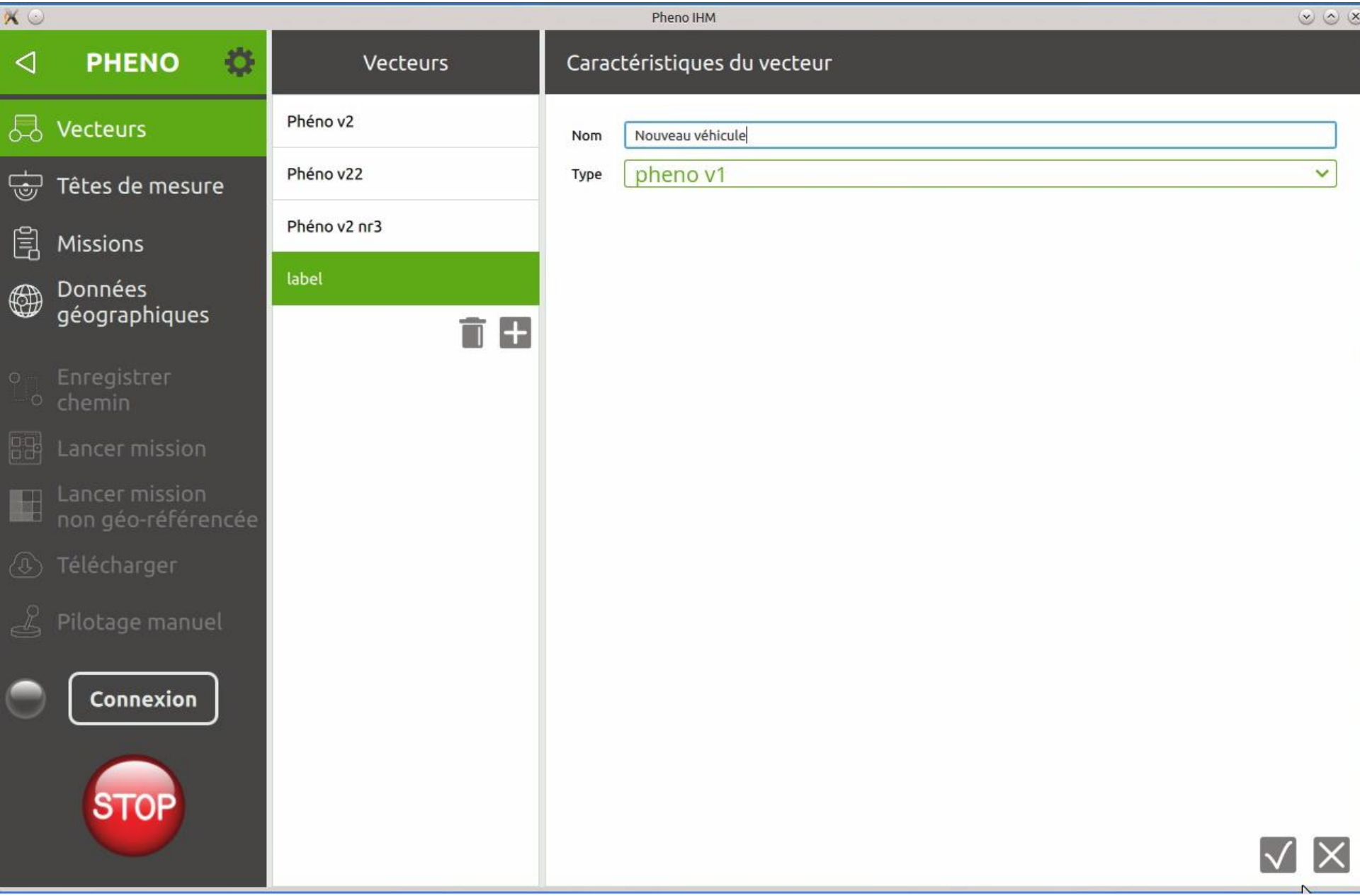


Measurement head that can

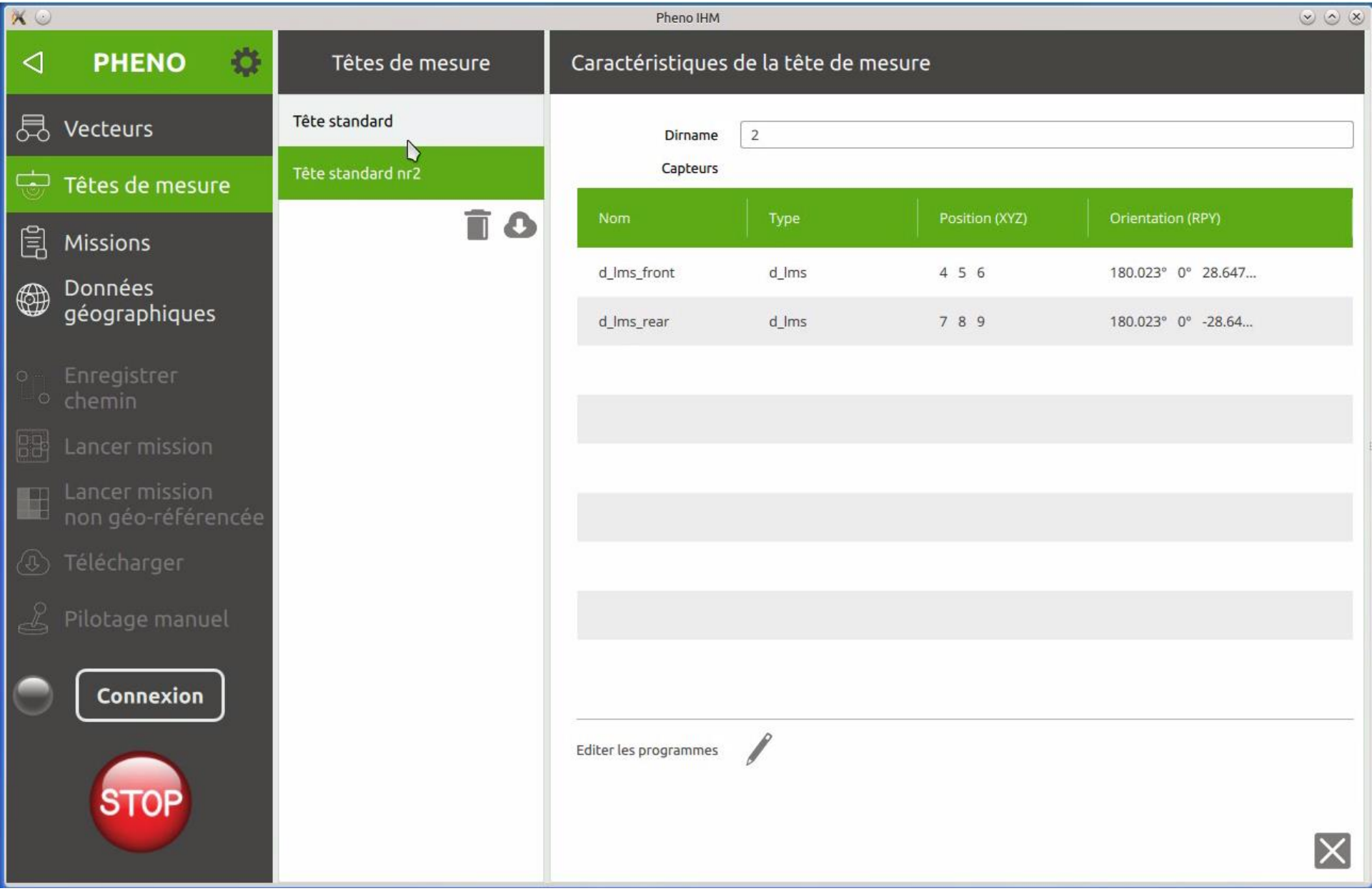
- **be mounted on several vectors**
- **host any sensor**

A flexible and user friendly interface

Command system



Command system



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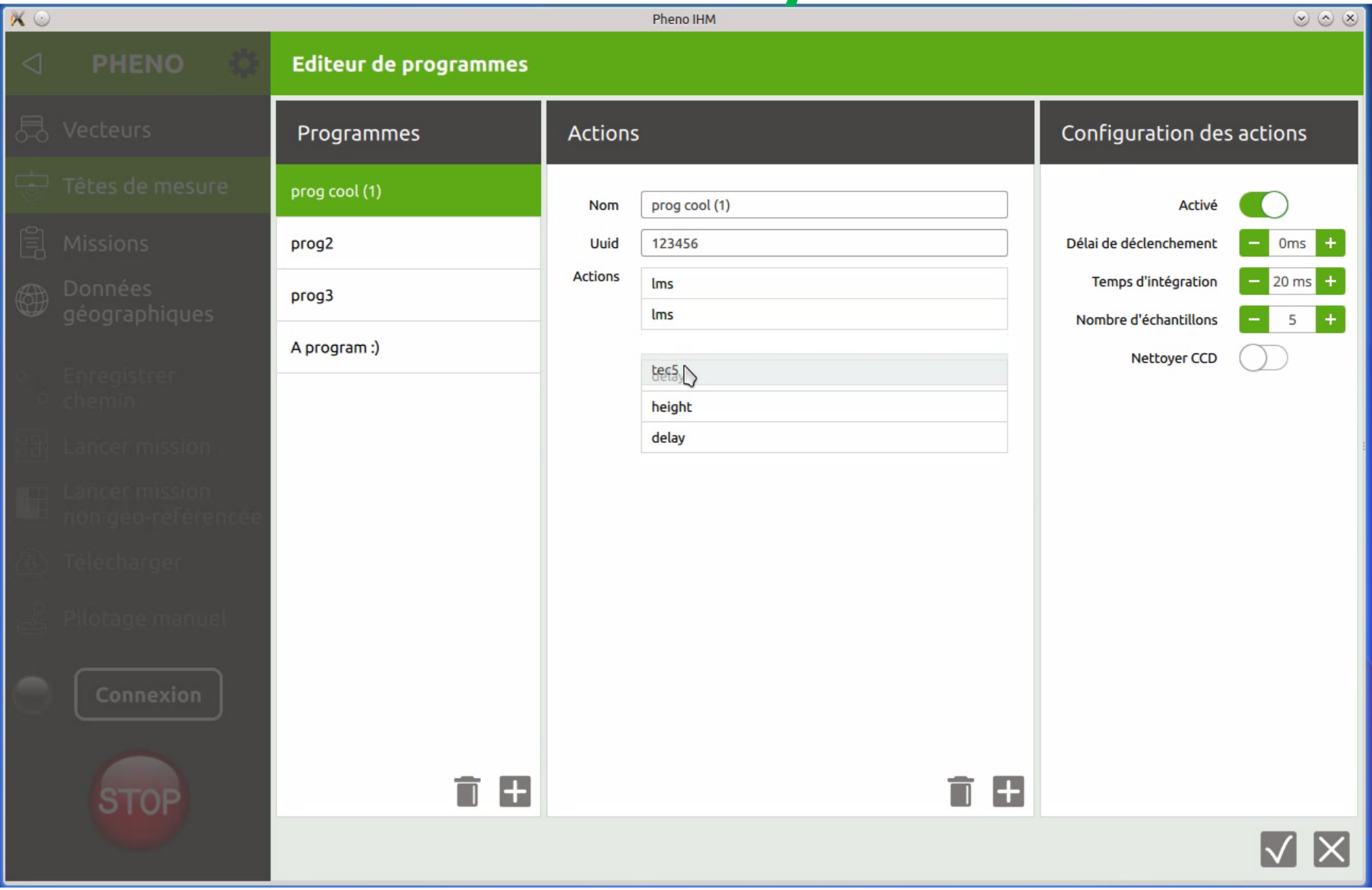

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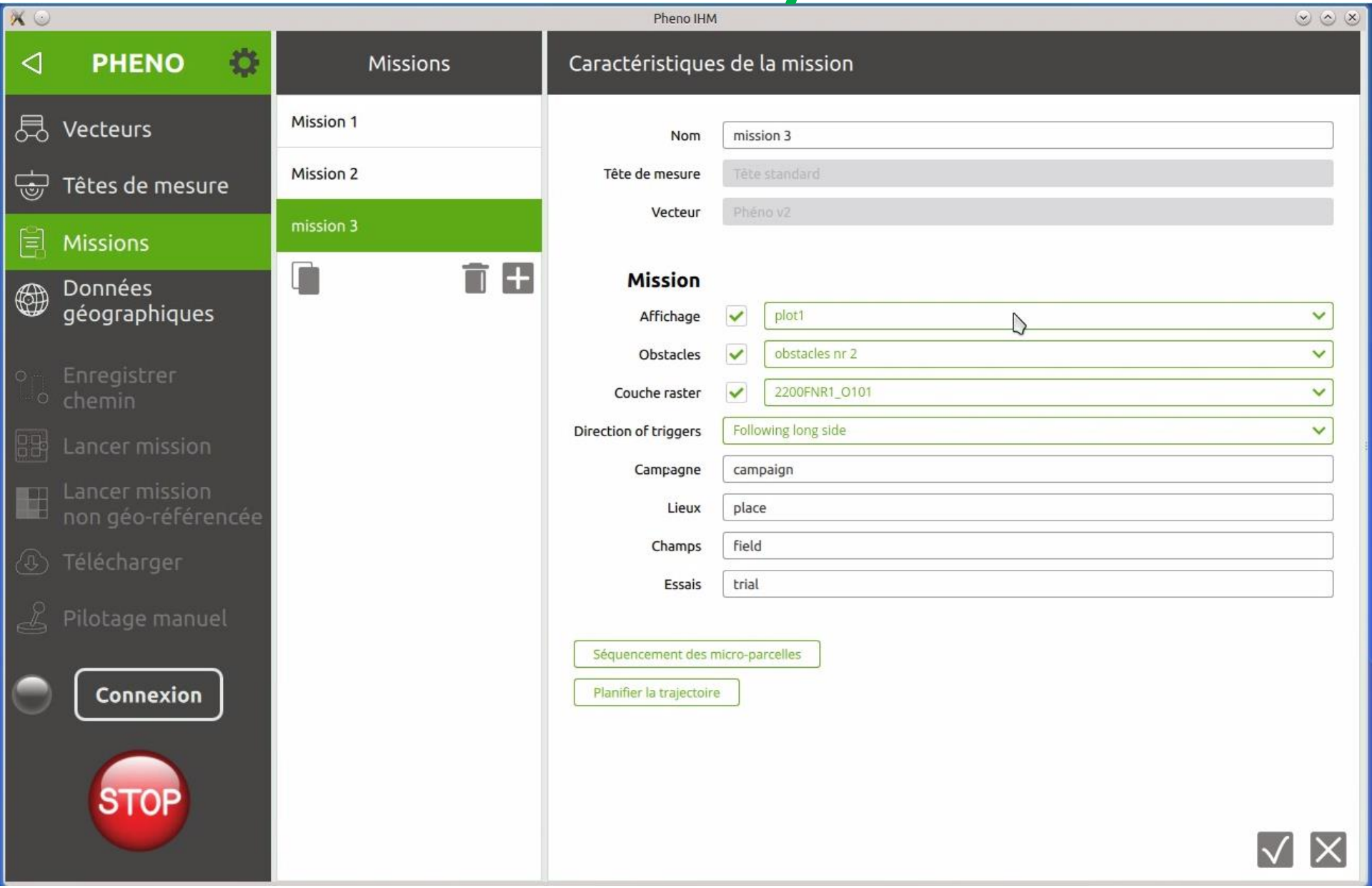

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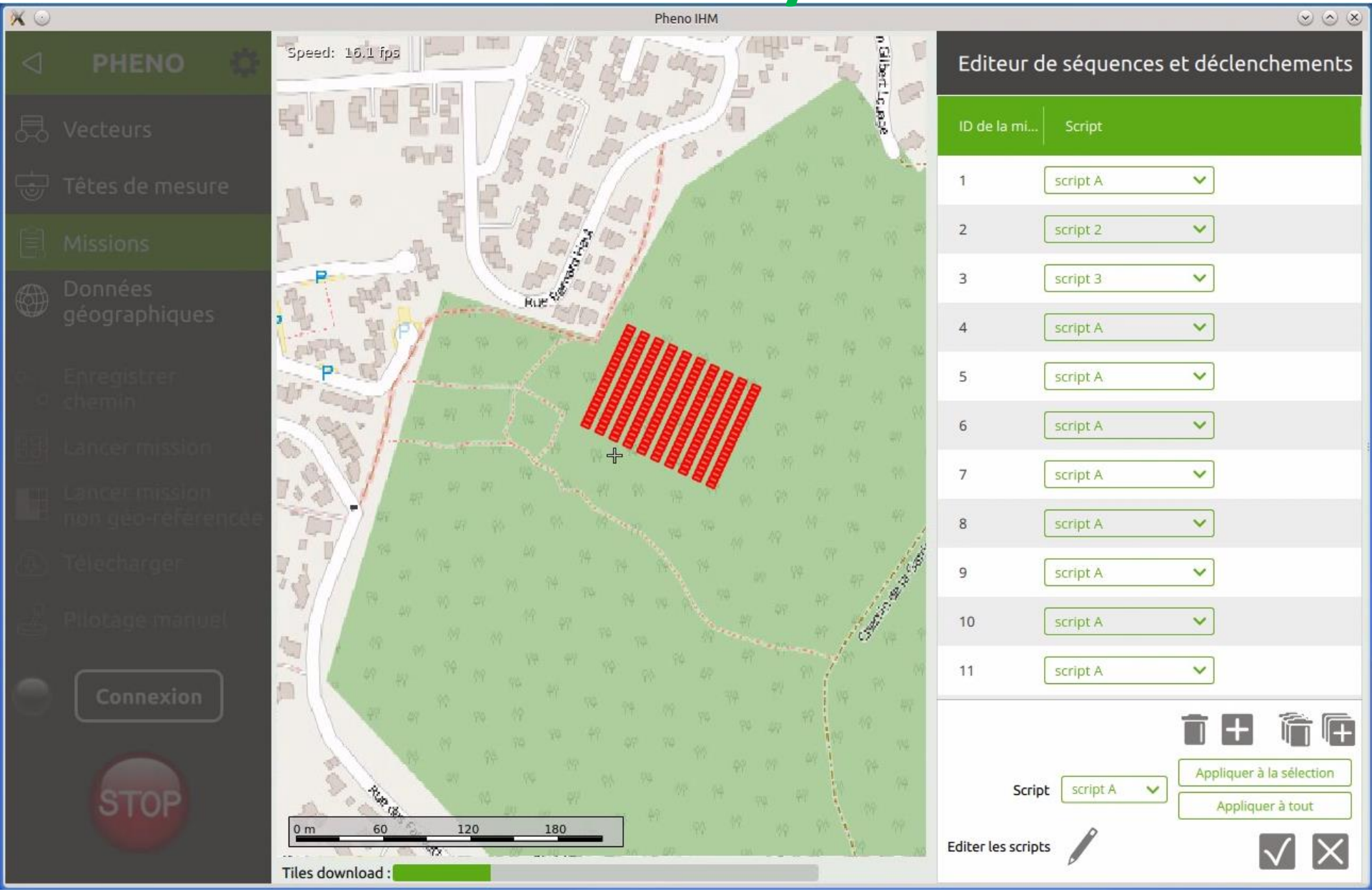

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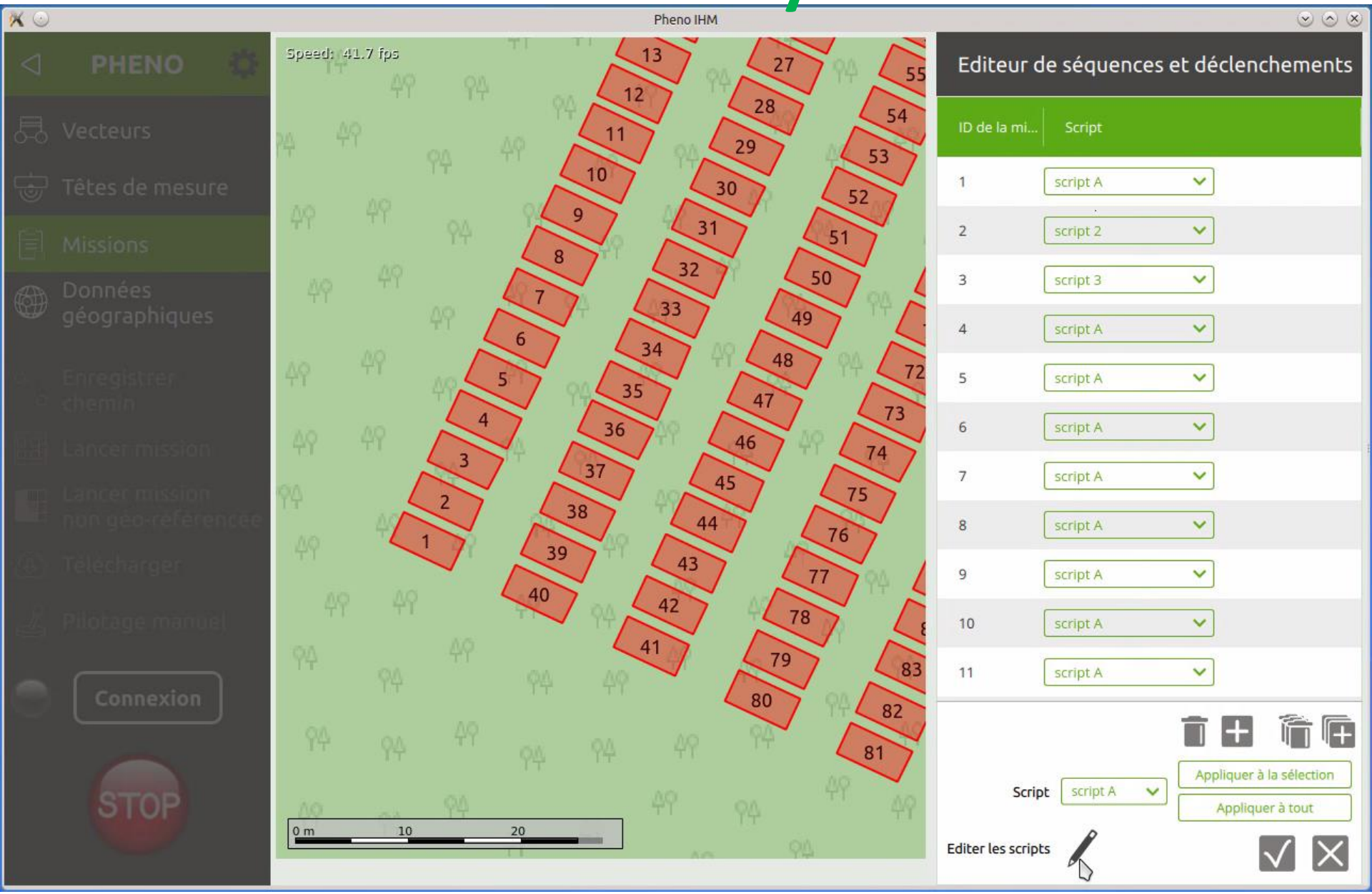

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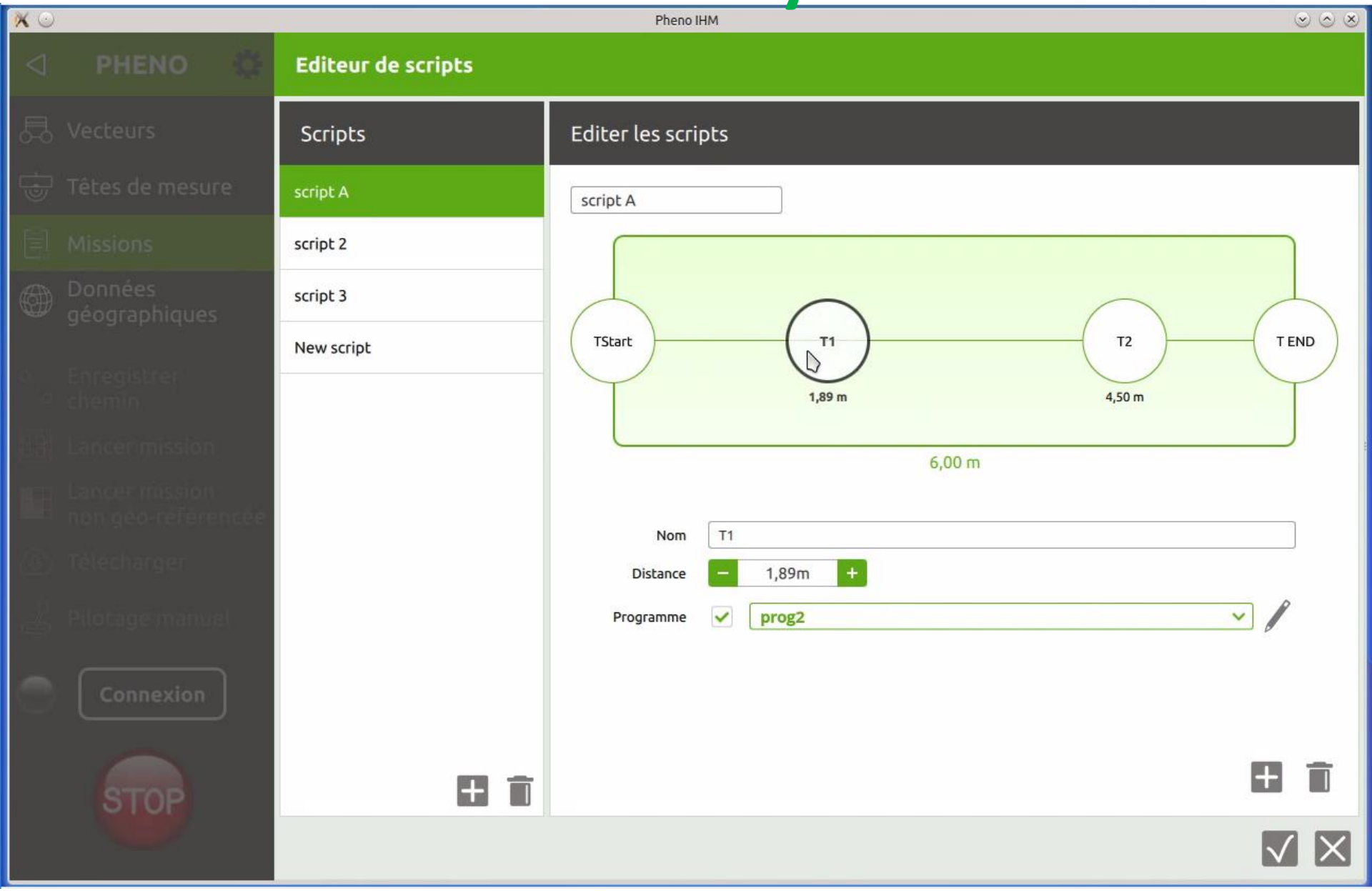

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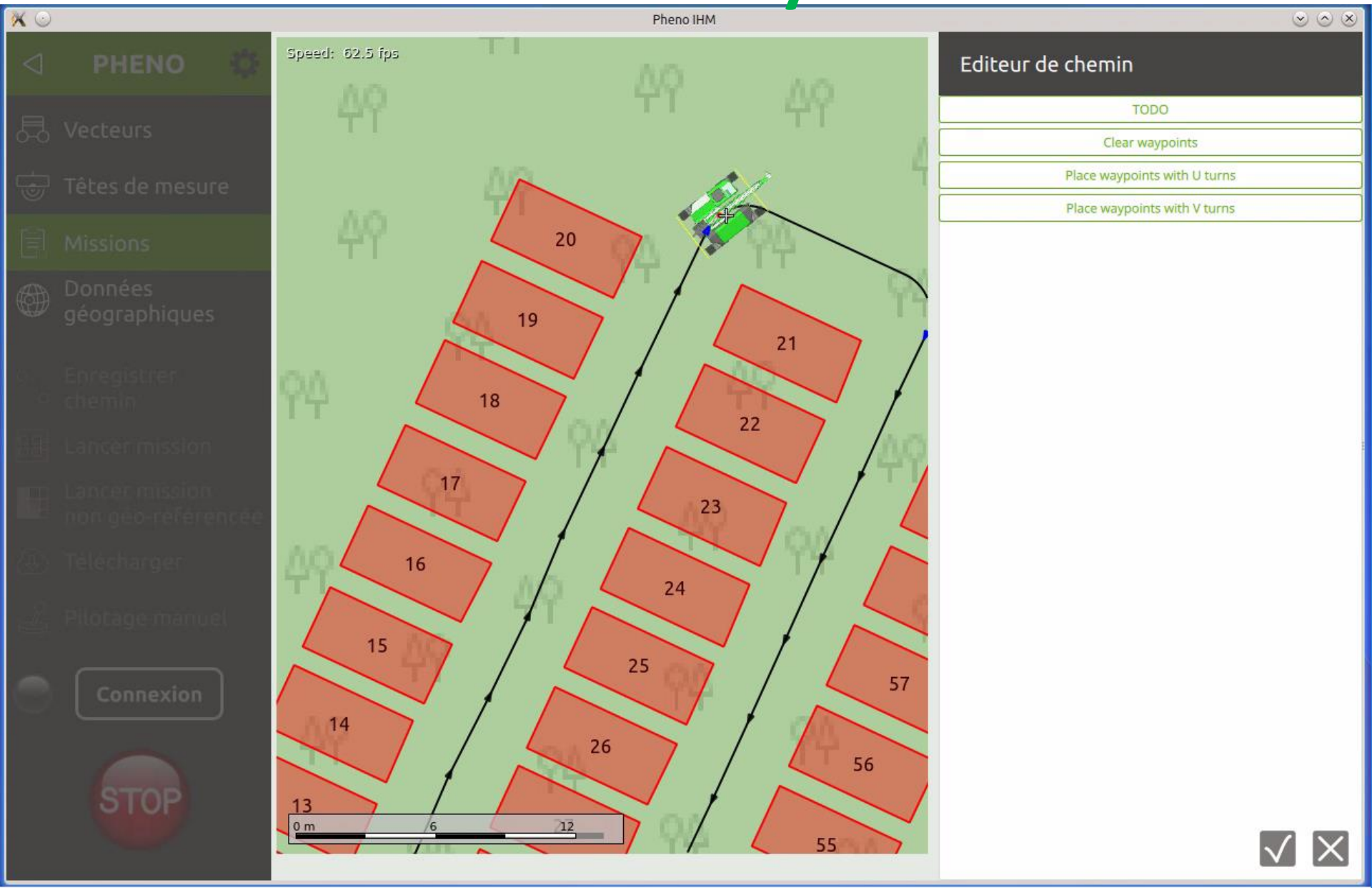

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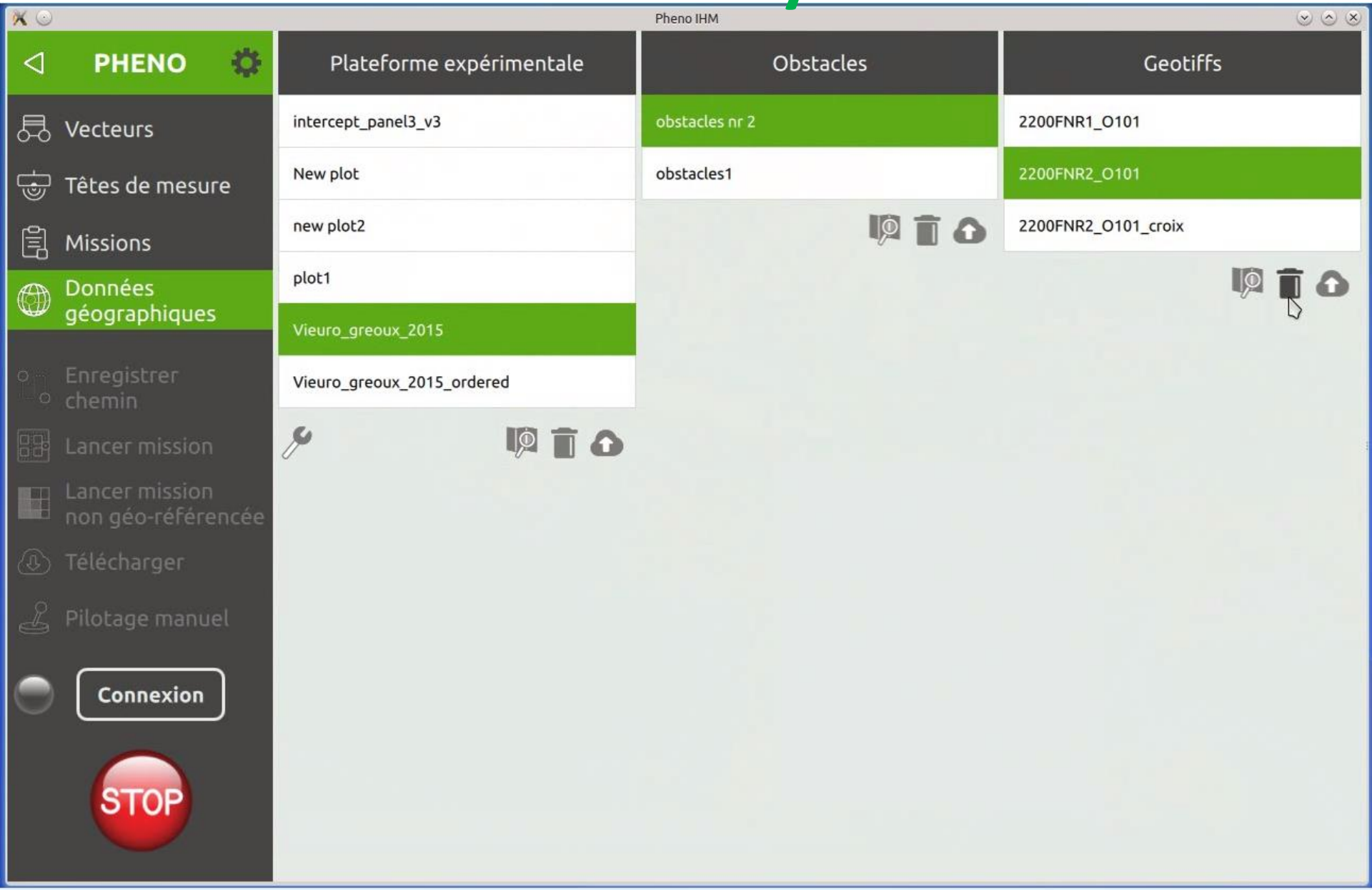

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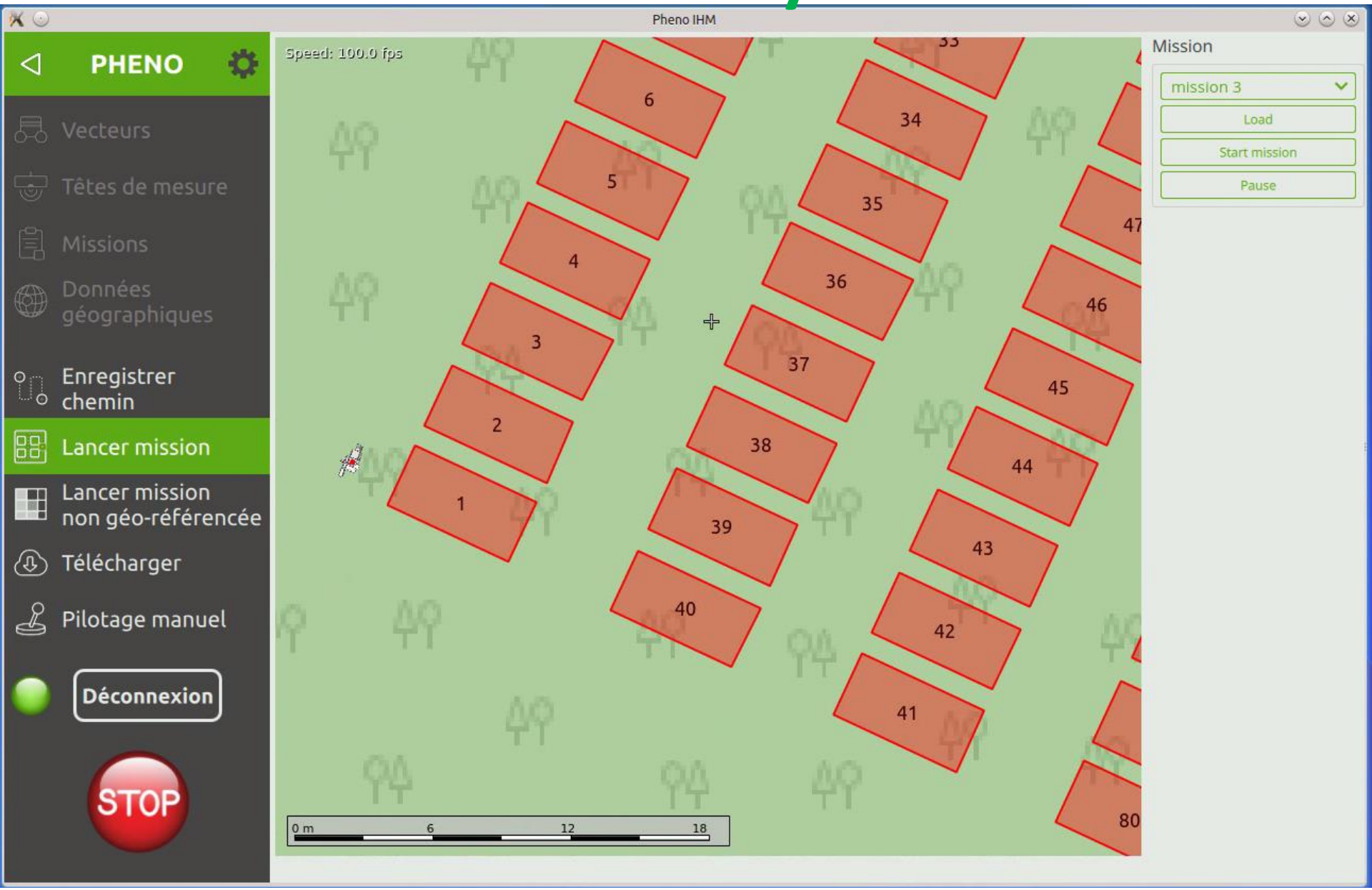
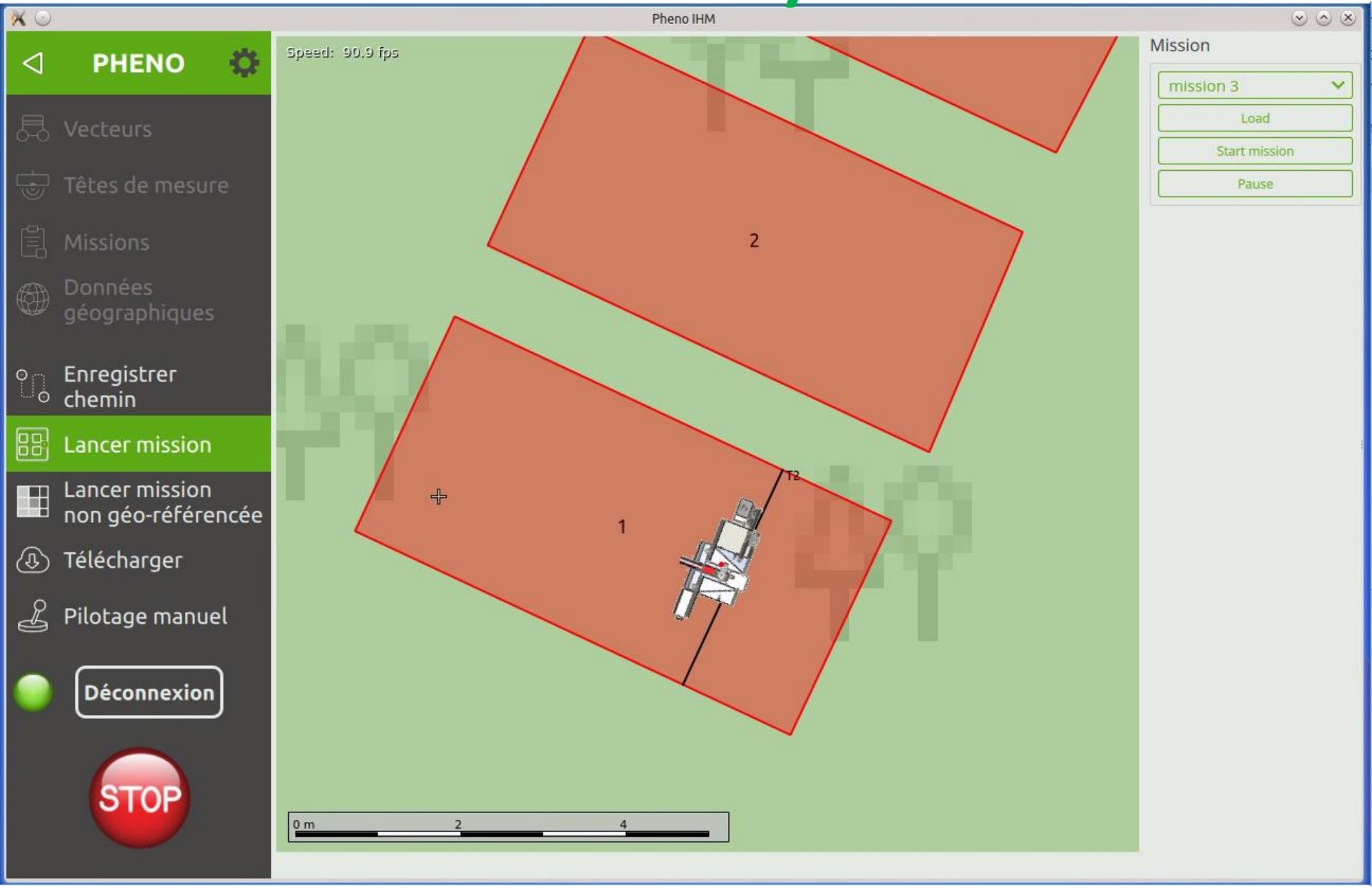
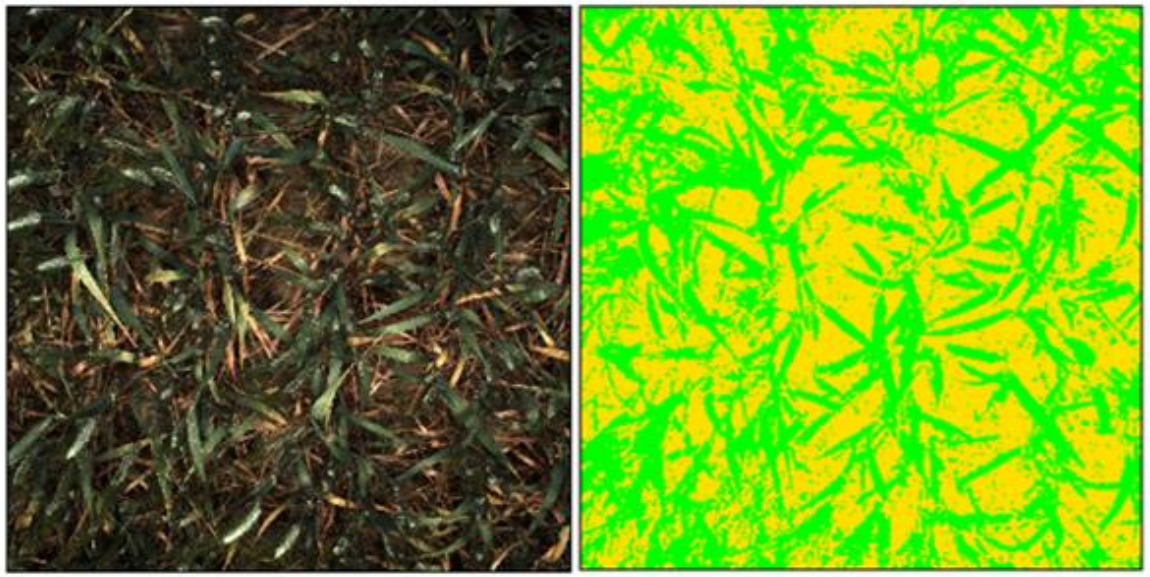


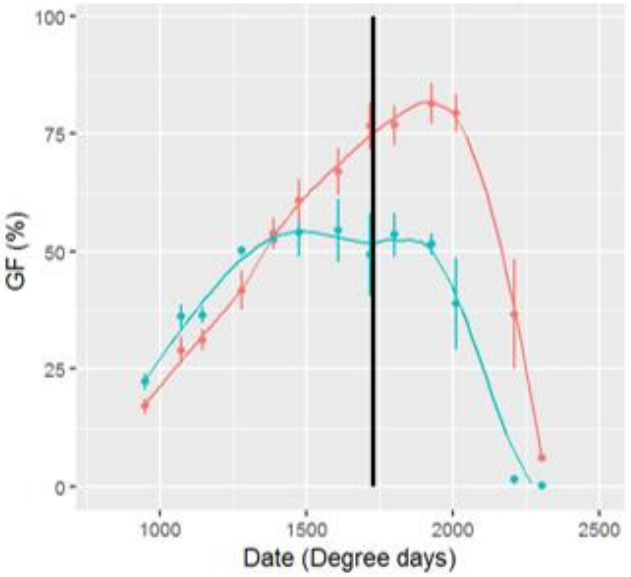
Command system



Sample results

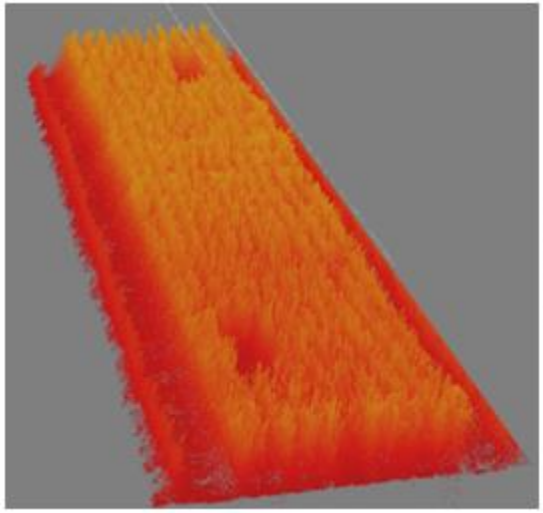
Green fraction from RGB camera working in active mode

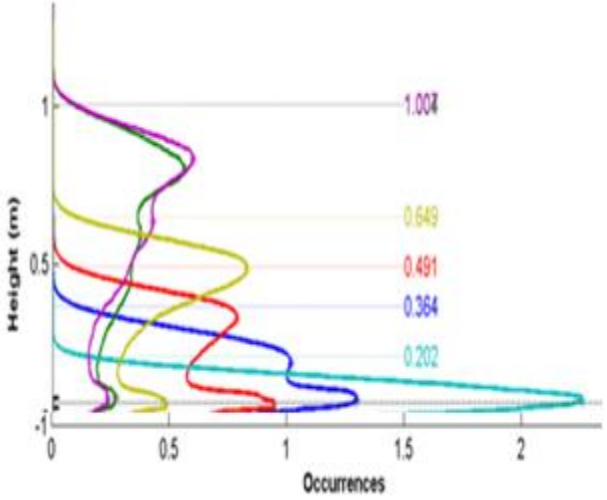


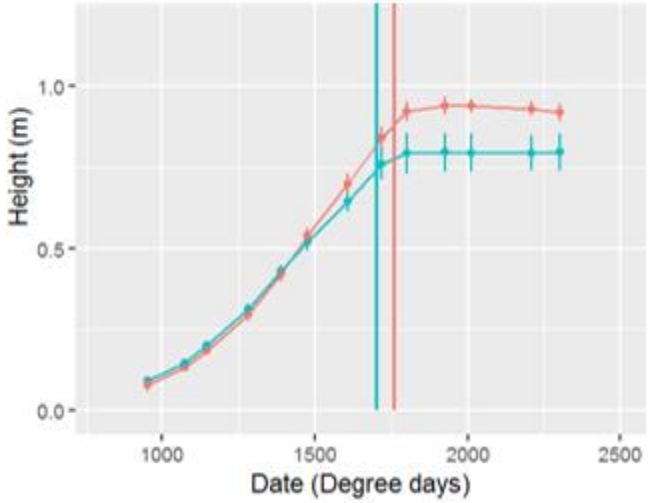


Sample results

3D point cloud from LiDAR

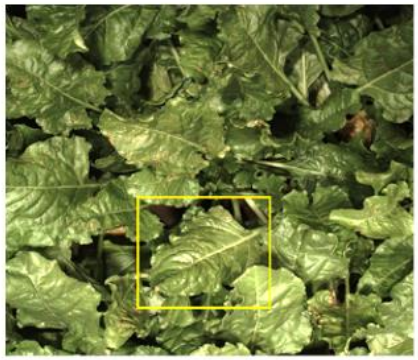




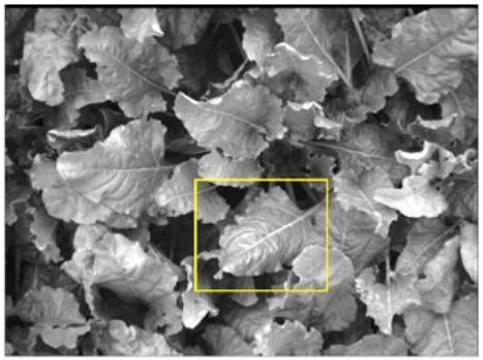


Sample results

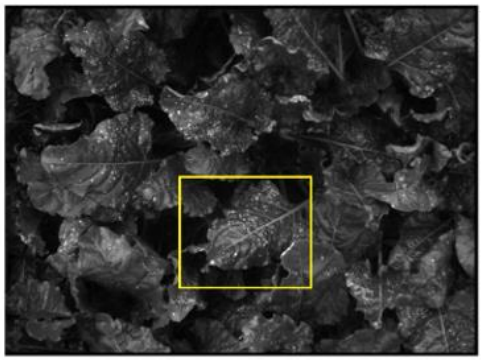
Disease symptom quantification from RGB and AIRPHEN multispectral camera



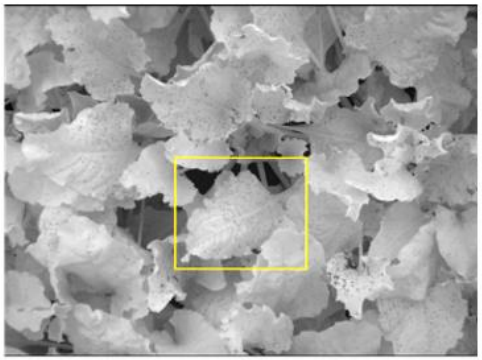
RGB



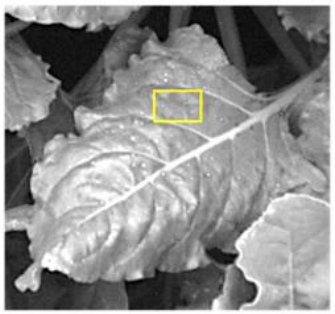
Airphen – 530 nm

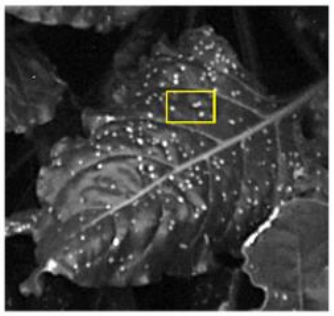


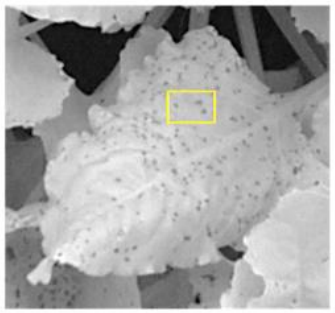
Airphen – 675nm

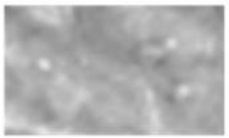


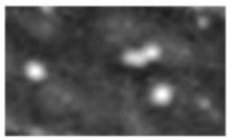
Airphen – 730 nm

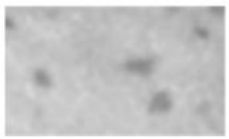












CONCLUSIONS

- **Technology is maturing very fast:**

  → PHENOMOBILE V2 provides an advanced solution allowing
  - Easy integration of new sensors
  - High repeatability (heritability)
  - Active measurements
  - Autonomy (automatic, more than 10 hours autonomy)
  - Flexibility (height, experimental design, soil conditions)

- **The Bottleneck[2]:**

  → the phenotyping bottleneck is data interpretation!

→ **Need to integrate repeated measurements into functioning models**
- **Combining several observations and dates**
- **Accounting for environmental variability**
- **Exploiting knowledge accumulated on processes**
- **Providing higher level traits**


Thanks for your attention