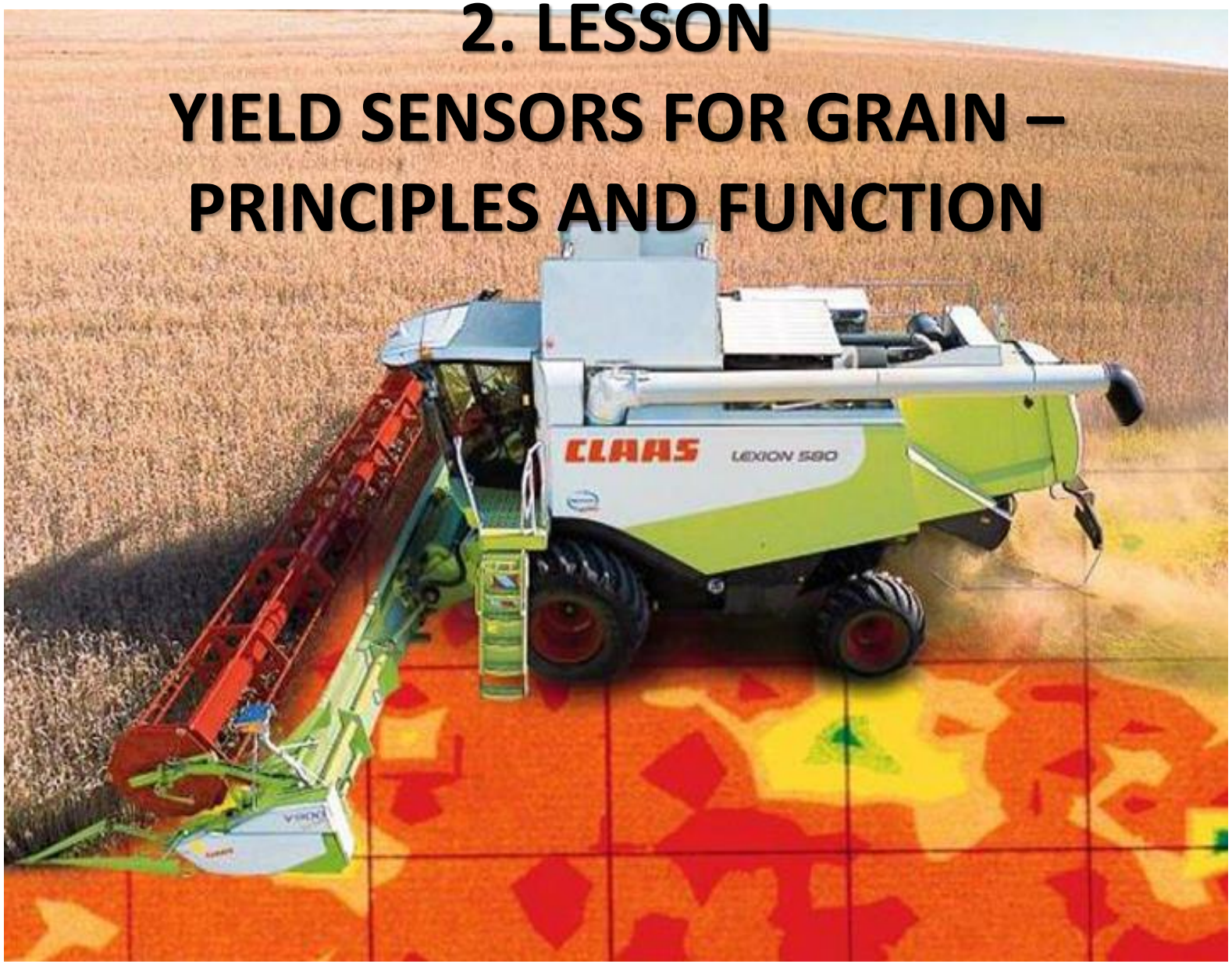
2. LESSON
YIELD SENSORS FOR GRAIN – PRINCIPLES AND FUNCTION



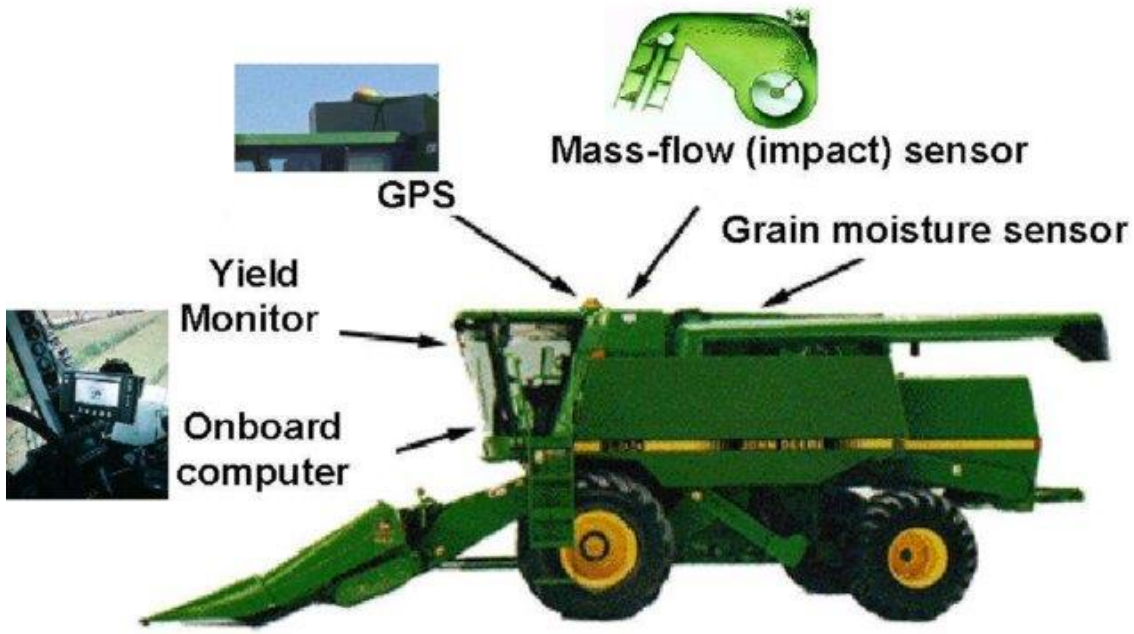
The idea of yield mapping was born in the US in the 1980s.

The GPS positioning system, developed by the US Army, started to be available also for civilian applications.

Someone thought that combining information about the machine's current position and immediate yield would result a yield map.

Yield mapping systems first appeared in combine harvesters because of two main reasons:

1. Combine harvester is an expensive machine, and the yield mapping system increases its price relatively little
2. Cleaned grain is very uniform material, which is very advantageous for the work of yield sensors



Two essential information are necessary for yield mapping:

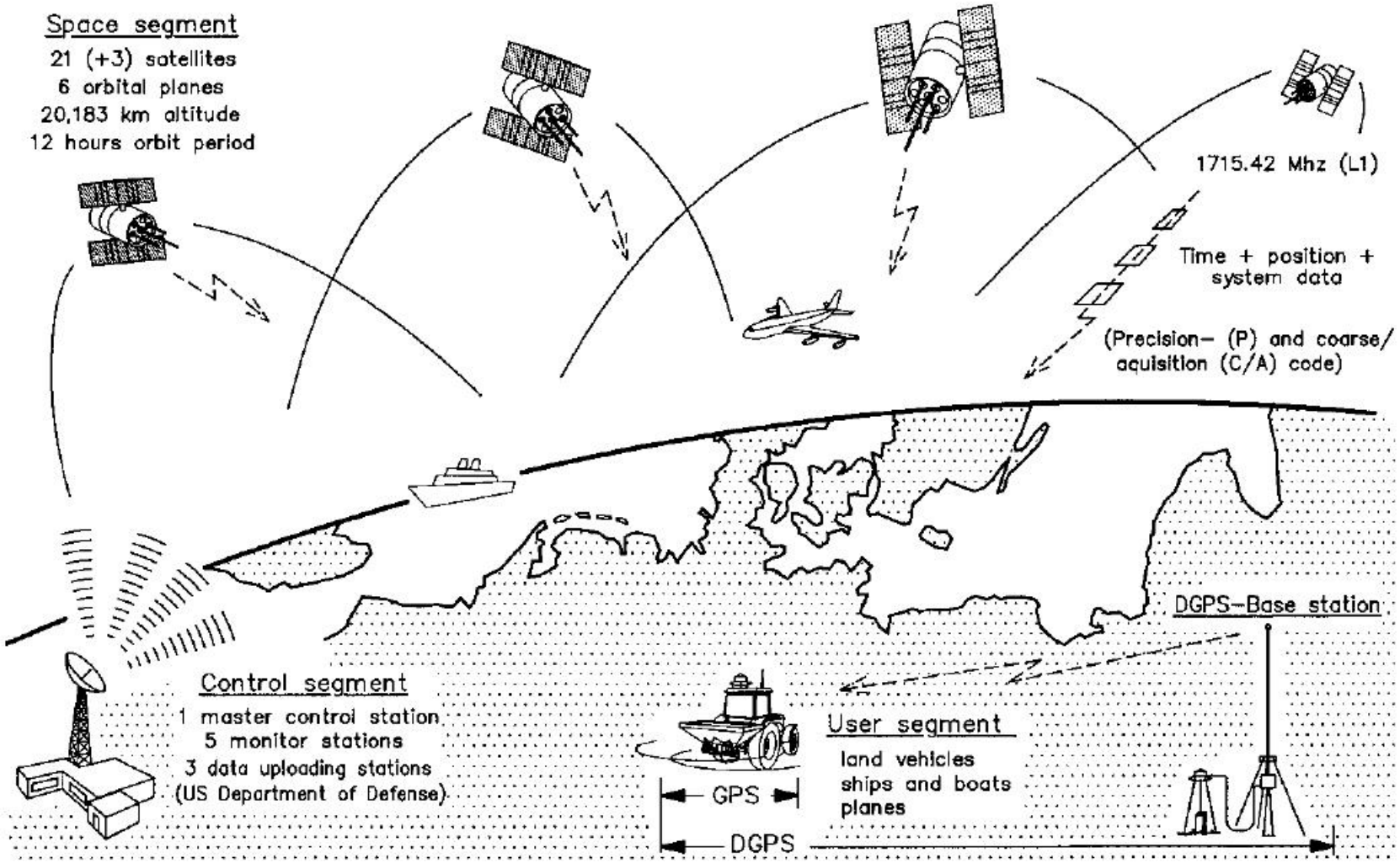
Information about instantaneous yield

Yield sensor

Information about machine´s current position

DGPS signal receiver

Information about machine´s current position



Also:
Glonass (Rus)
Galileo (EU)
Beidou (China)

Information about instantaneous yield – yield monitors

Combine harvesters

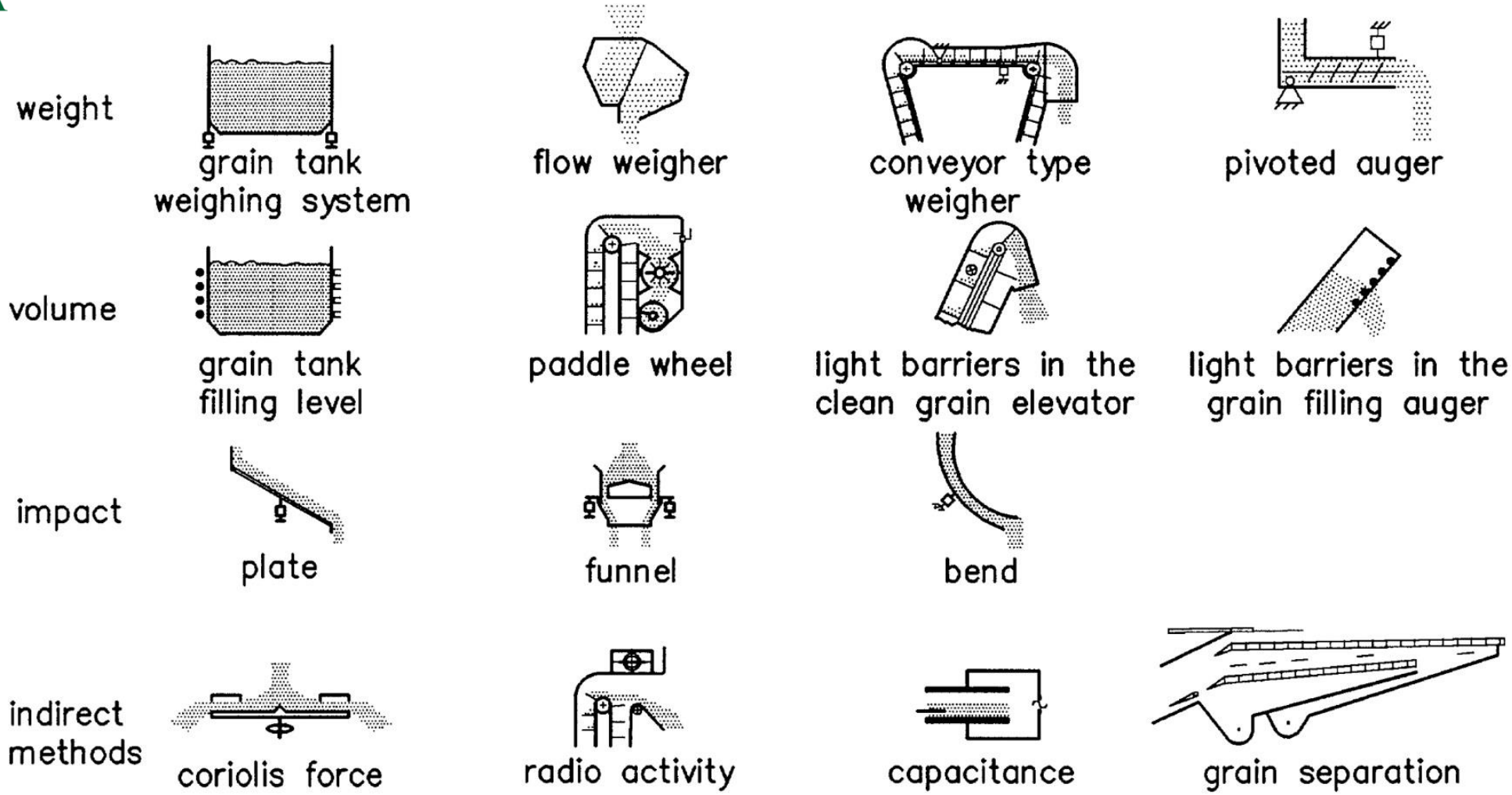
- Yield sensors are always placed in a clean grain conveyor to the grain tank
- The work of the yield sensors can be based on many different principles
- The data from the yield sensors should be supplemented with data on the instantaneous moisture of the harvested grain

In the past, a large number of principles for measuring yields during grain harvesting have been researched and tested.

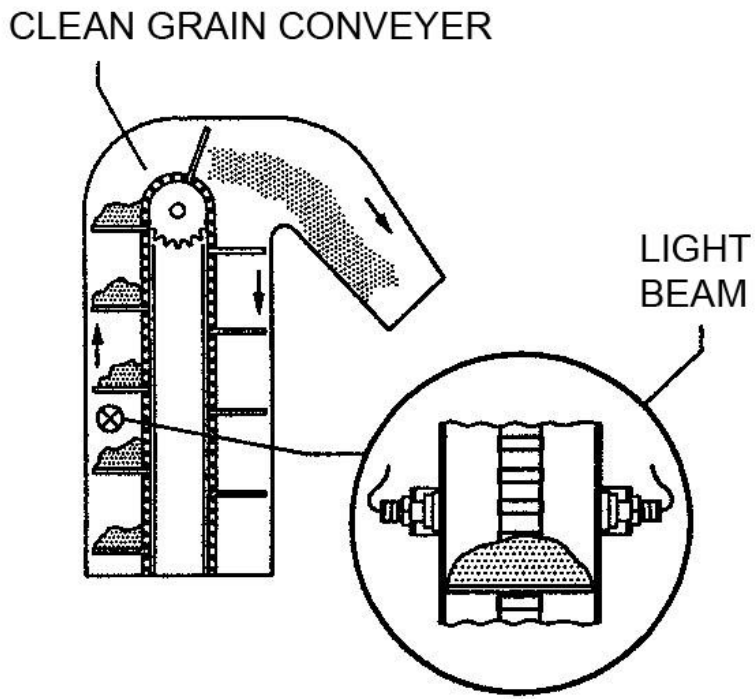
The individual methods were based on completely different physical principles. These were mainly methods based on determining:

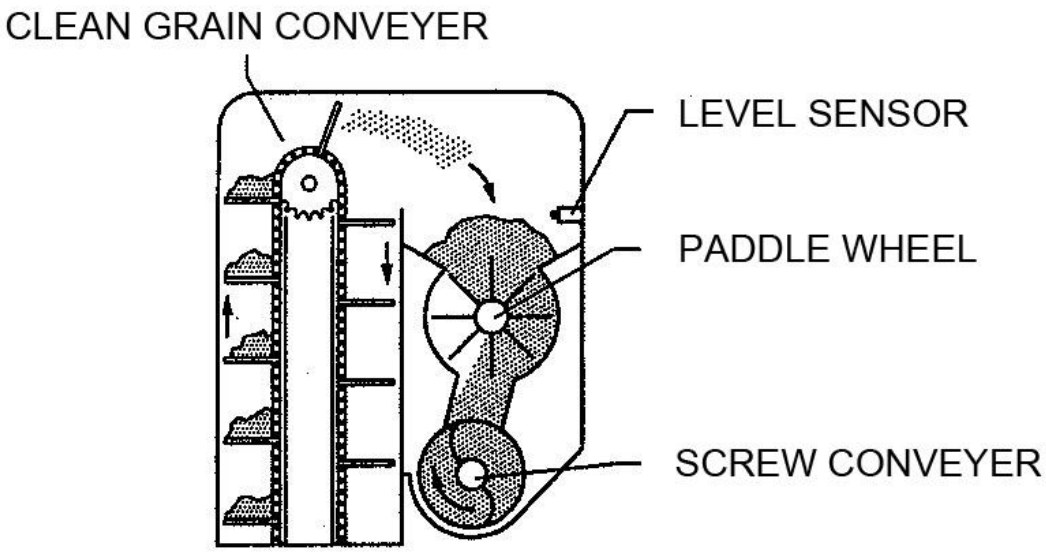
- the weight of the harvested grain,
- the volume of harvested grain,
- impact force caused by passing grain or
- on other indirect methods (e.g. X-ray, radio-activity, capacitive, coriolis force).

Only few of them are used now.



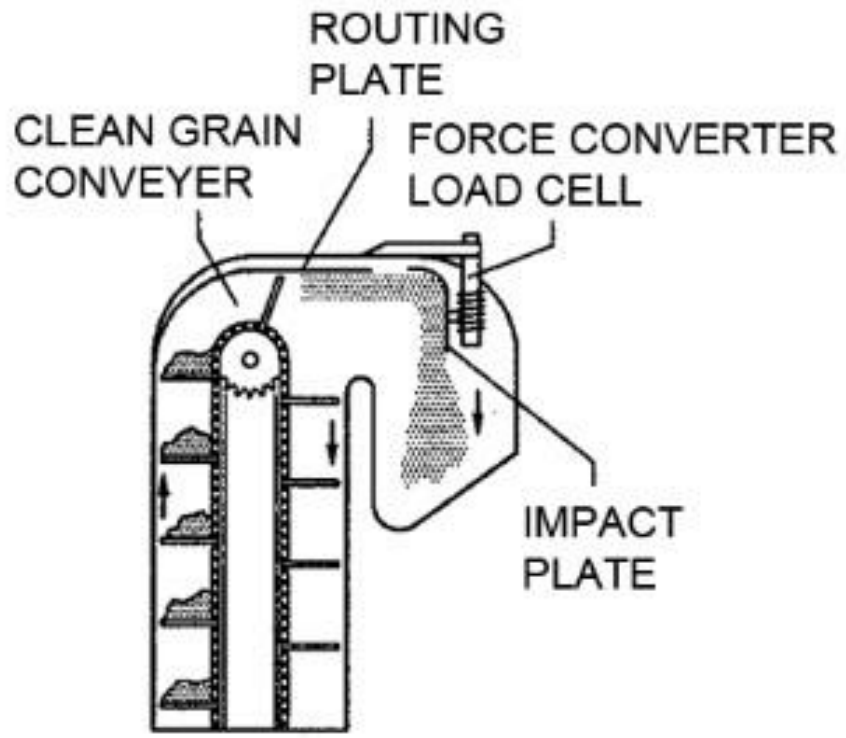
Different principles of grain throughput measurement studied and tested in combine harvesters

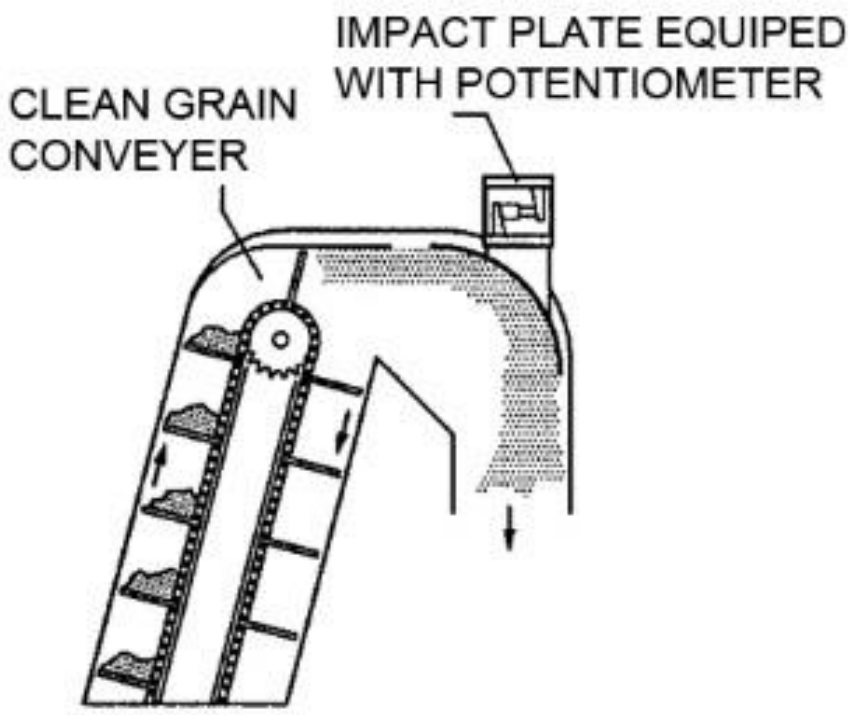




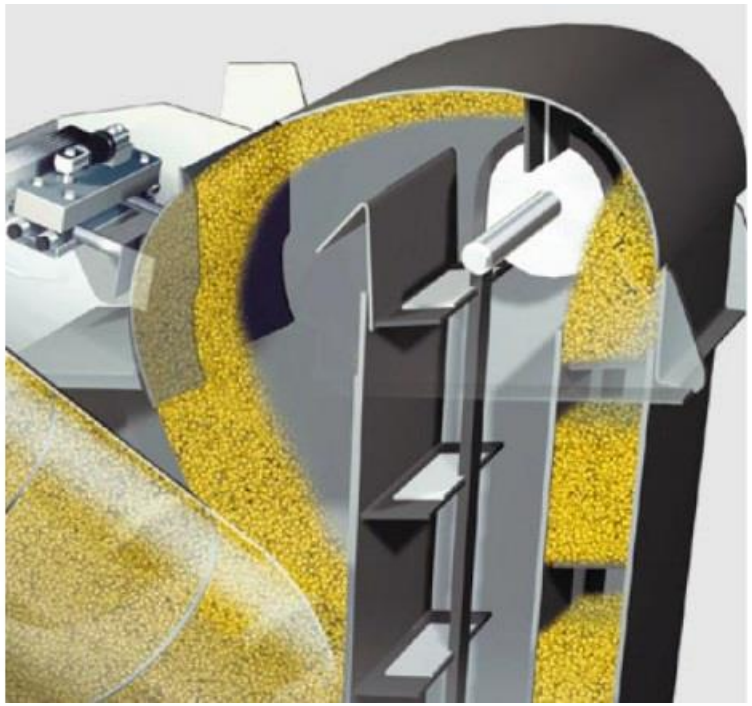
Two practically used grain-throughput measurement systems based on volume detection – left light beam, right paddle wheel

Practical solution of grain yield sensor working on light beam principle. *Its main advantage is that it can be easily mounted on the vast majority of older and new combine harvesters.*





Two practically used grain-throughput measurement systems based on weight detection – impact plate



Practical solution of grain yield sensor working on impact plate principle. *Left – impact plate used by CASE IH Company, centre – solution of impact plate used by John Deere Co., right – friction-compensated solution of impact plate by New Holland Co.*

Measurement of instantaneous moisture content of harvested grain

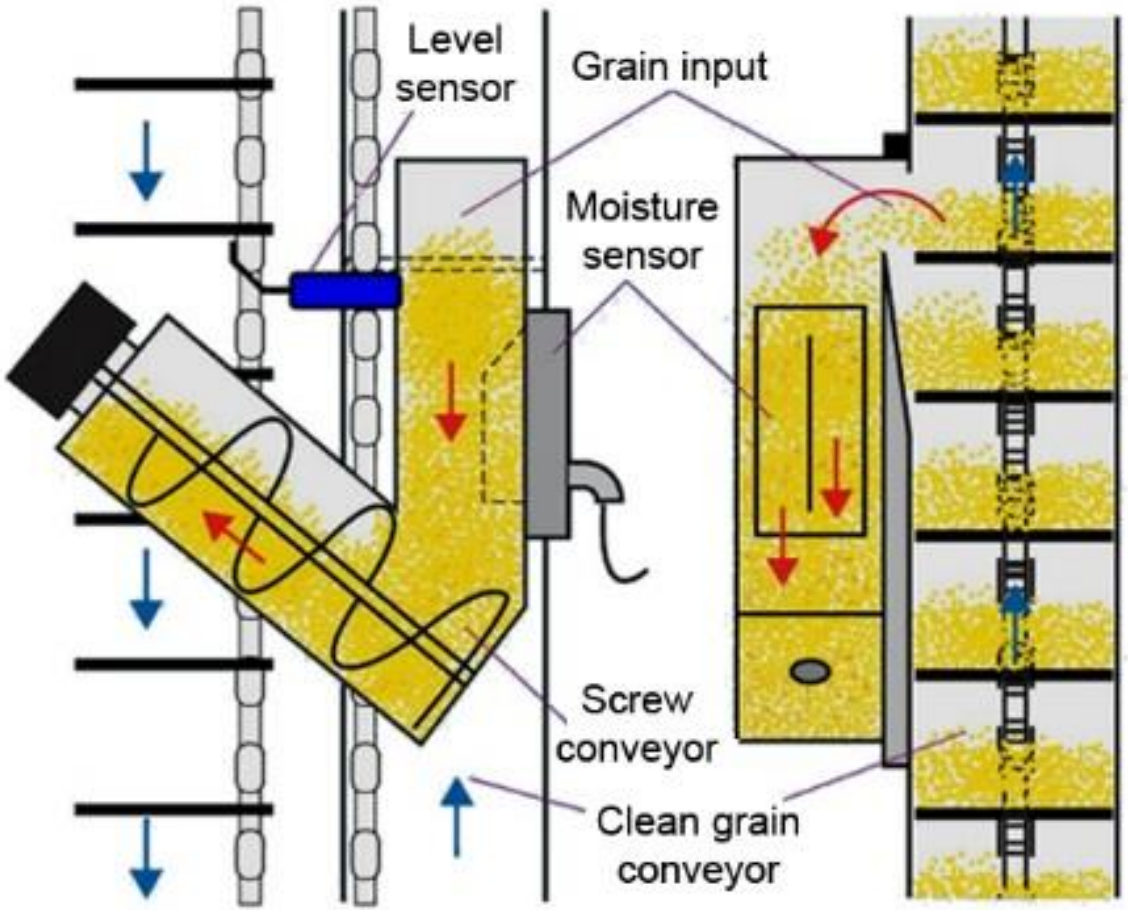
Grain moisture sensors are important feature of the yield monitors:

- Overview of the instantaneous moisture of the harvested grain (can vary from 10 to 15% during the day)
- Allow the grain weight to be converted to standard moisture (14%)

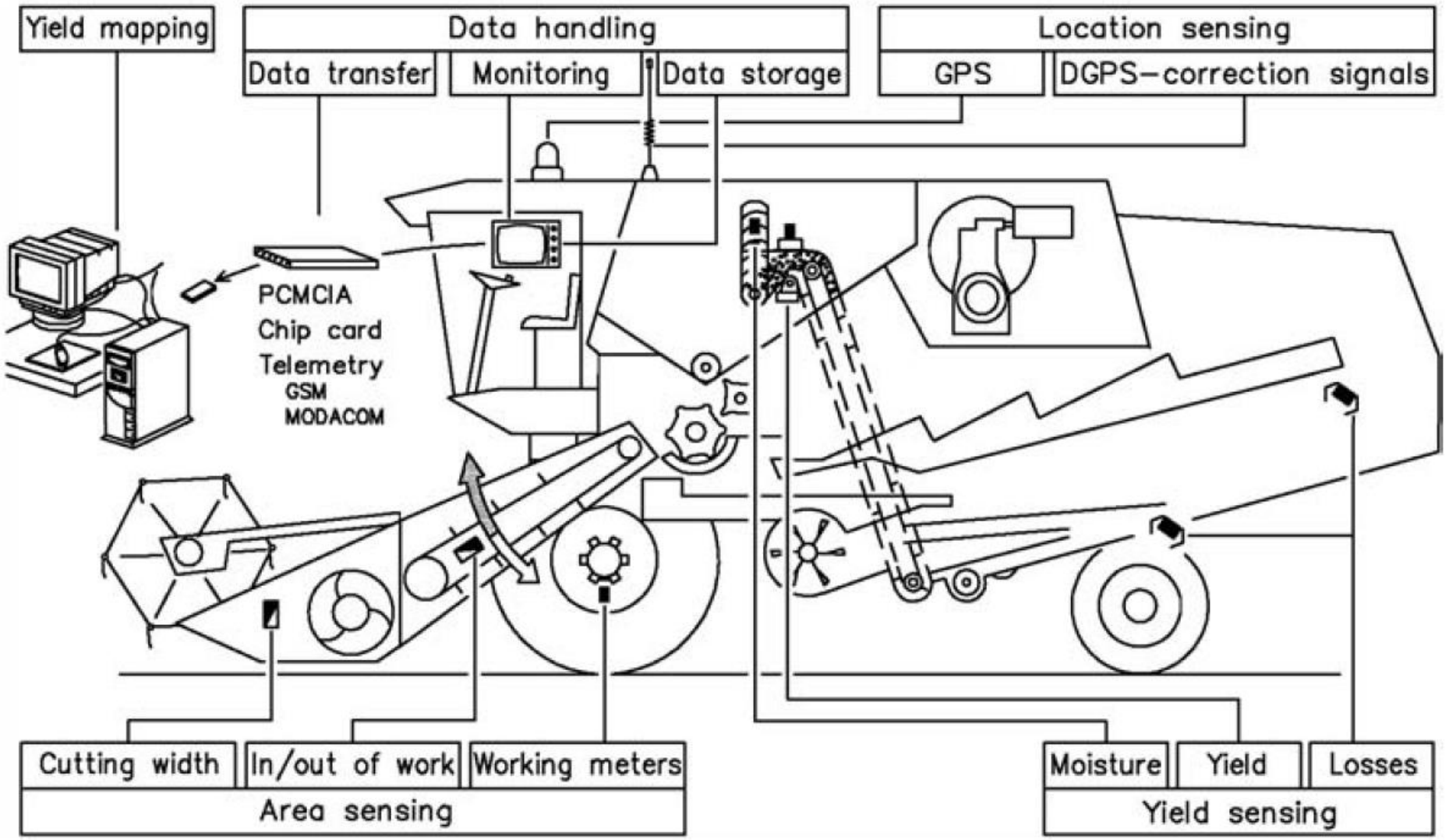
Nevertheless, measuring material moisture content is still a challenge.

Grain moisture content is usually measured by sensors working on capacitance principle. Moisture has a significant effect on the permittivity of the grain and its changes can be measured by changing the capacitance of the capacitor.

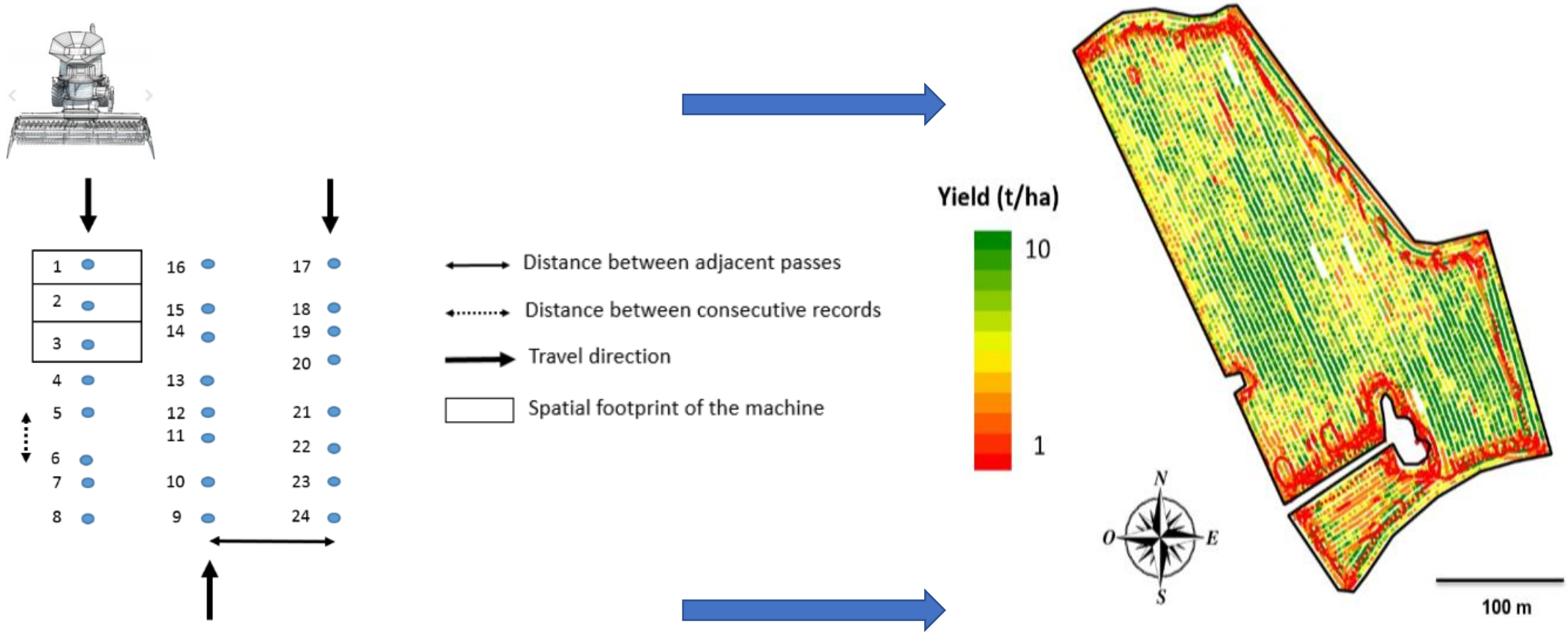
- Previously used grain moisture sensors were based on a relatively simple device inserted into the grain stream into a grain tank.
- This solution is no longer used today because it was not accurate enough. To ensure a more accurate measurement of grain moisture content, it is necessary to measure moisture at a defined compression of the grain layer.
- For this purpose, a grain flow splitter is made from the conveyor to the grain moisture content measuring device.



Practical solution of grain moisture sensor. Left New Holland, right John Deere.



Equipment for yield mapping in combine harvester

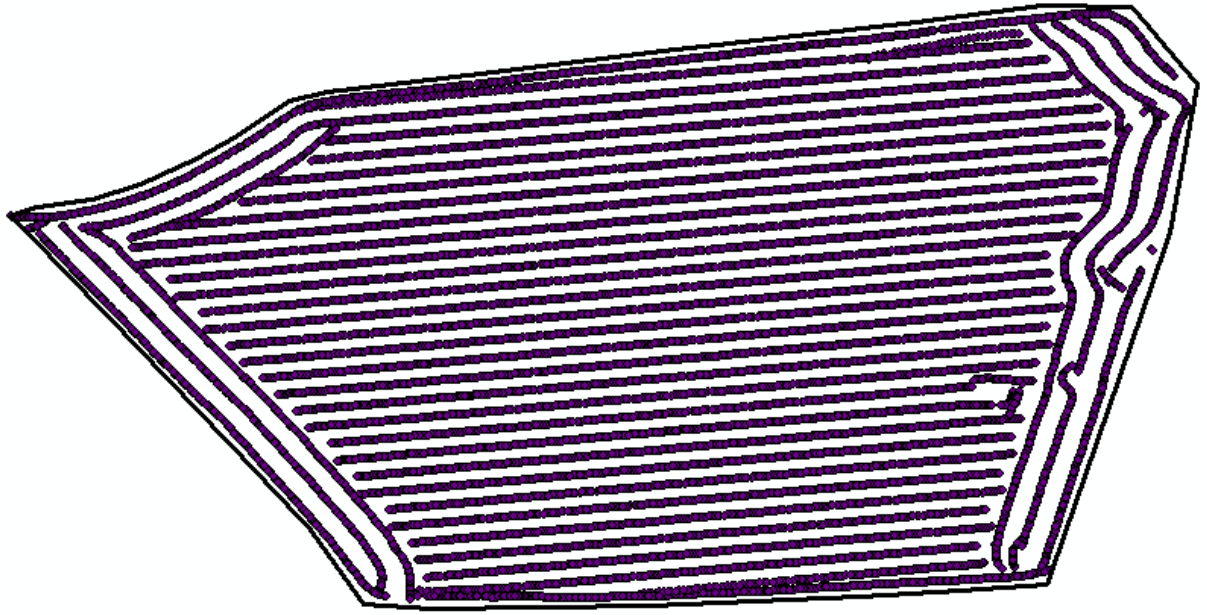


Acquiring within-field yield data (blue dots) with a combine harvester (Leroux et al., 2018)

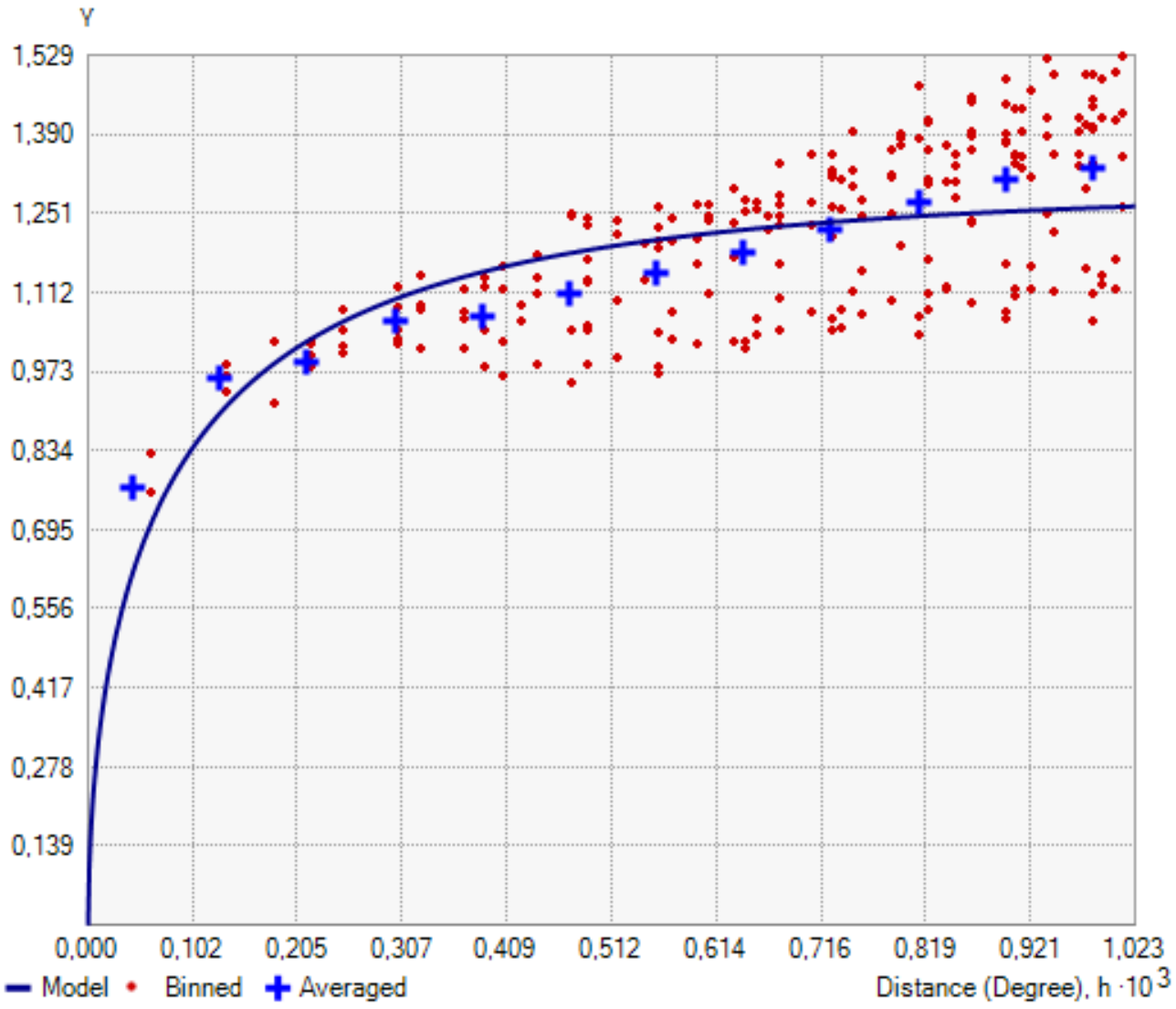
Yield map showing the within-field yield spatial variability

How to create a yield map from "raw" data

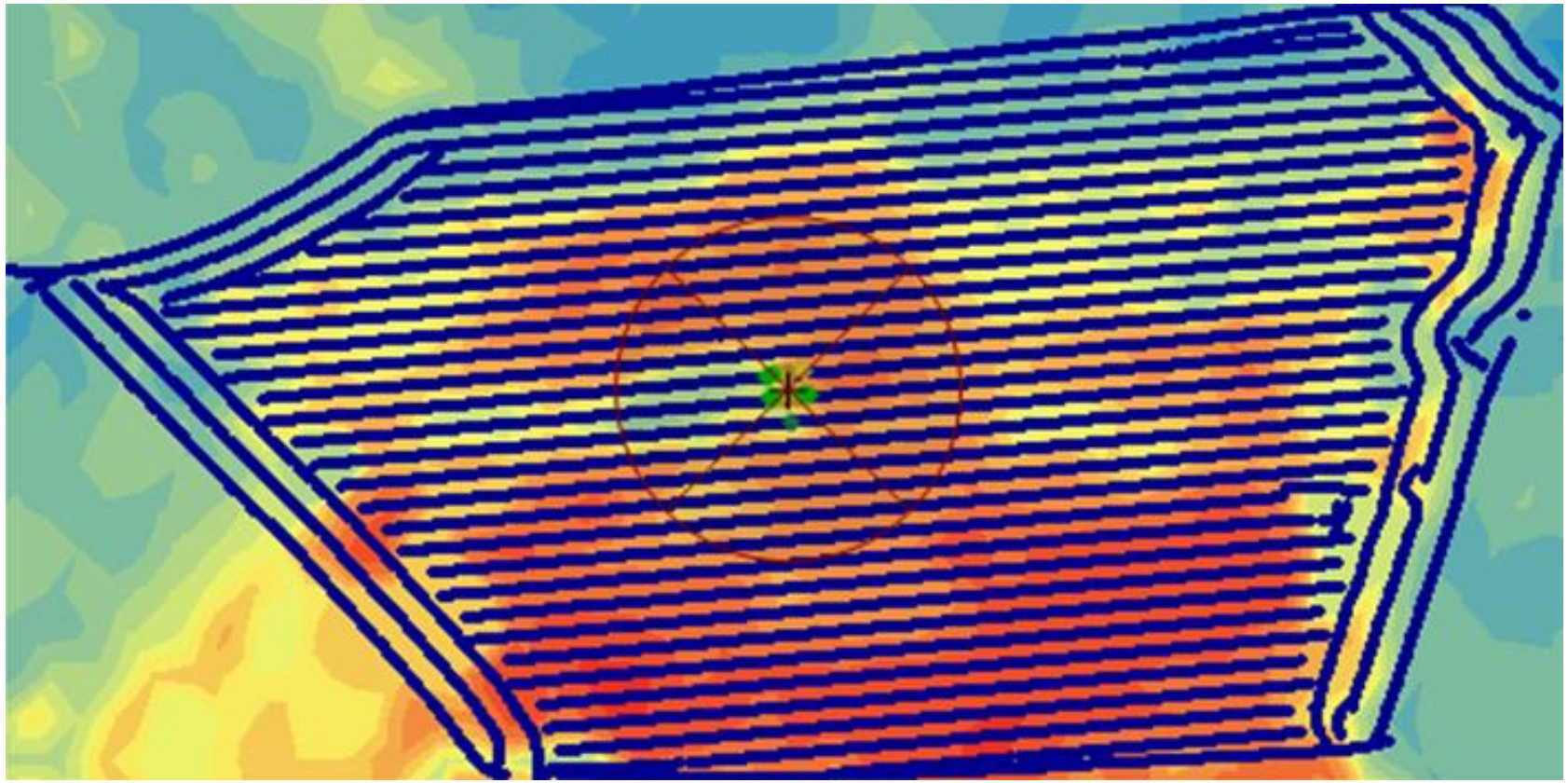
- Data range optimizing – remove extremes
- Usually average value ± 3 standard deviation
- Choose appropriate coordinate system and make point shapefile



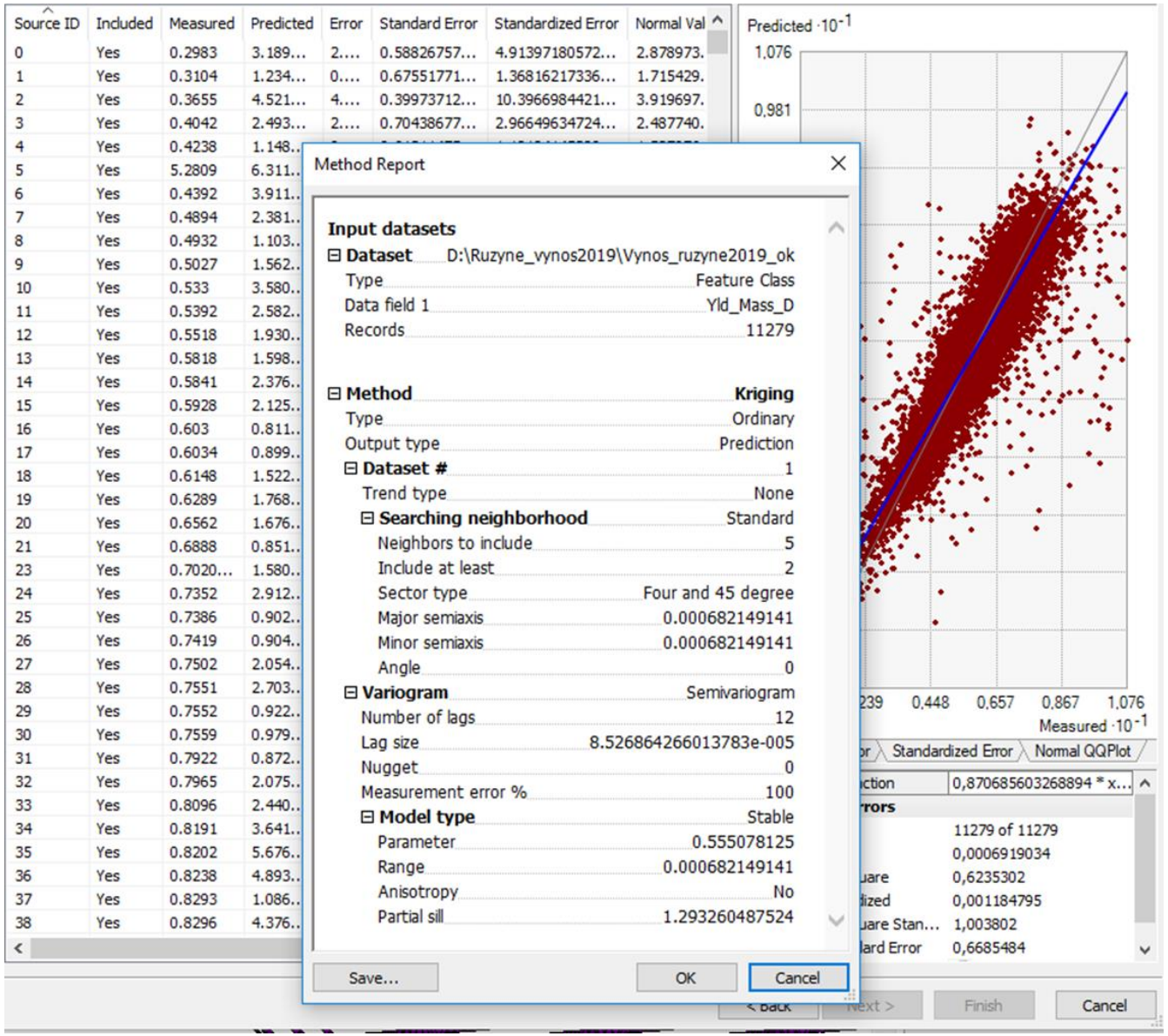
Point shapefile. Number of data – 11290 points. Than choose appropriate geostatistical method – usually kriging (alternatively IDW, Spline, etc.) .



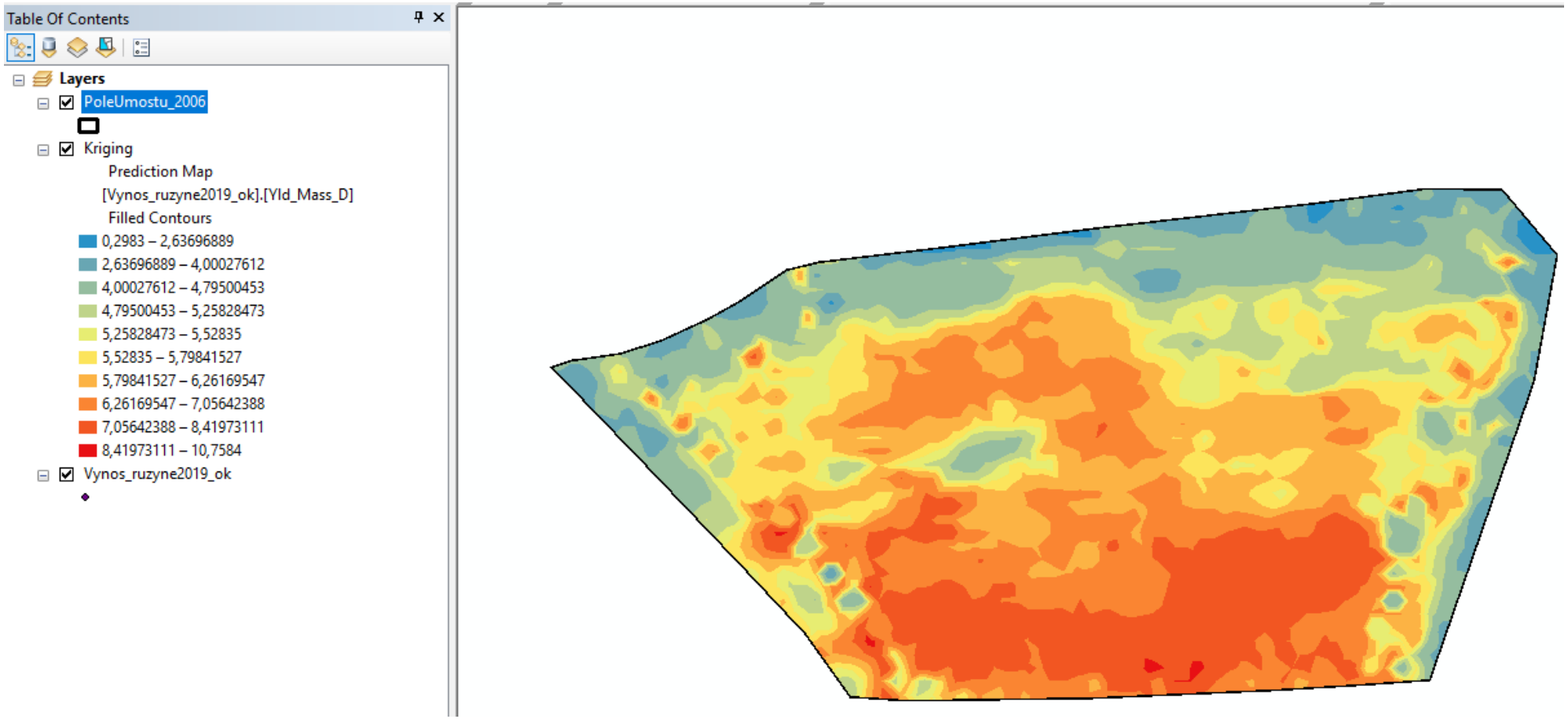
Semivariogram covariance modelling



Searching neighborhoods



Cross validation



Map of kriged estimates

Thank you very much for your attention!

František Kumhála

<u>Important note:</u> List of used literature is available in separate file.