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DEGLI STUDI  
FIRENZE



Regione Toscana



Coltivare con il biogas per ridurre l'impronta di carbonio ed aumentare sostenibilità e resilienza ai cambiamenti climatici

## CONVEGNO DI APERTURA

Venerdì 5 luglio 2019

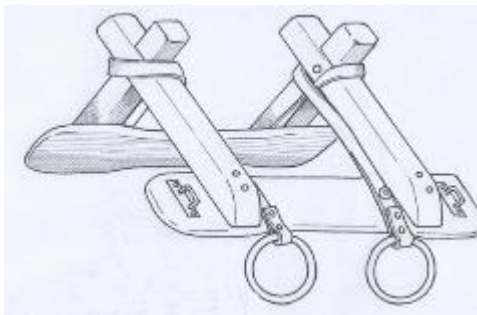
Centro "E. Avanzi" - Aula "A. Benvenuti"

San Piero a Grado, Pisa

# Tecniche e tecnologie per l'Agricoltura di Precisione a servizio della Agricoltura Conservativa

Marco Vieri, Daniele Sarri

# The new paradigm: from drawbar an manual labour to motorization and **digitalization - connectivity**



AGRICULTURE 4.0



TUSCANY REGION SYSTEMIC APPROACH

Technological evolution will be profitable with a balanced inclusive and deep rooted social evolution  
... from 90% to 5% of agricultural employers.  
... *motorization was effective with the rinsing of services and infrastructures*

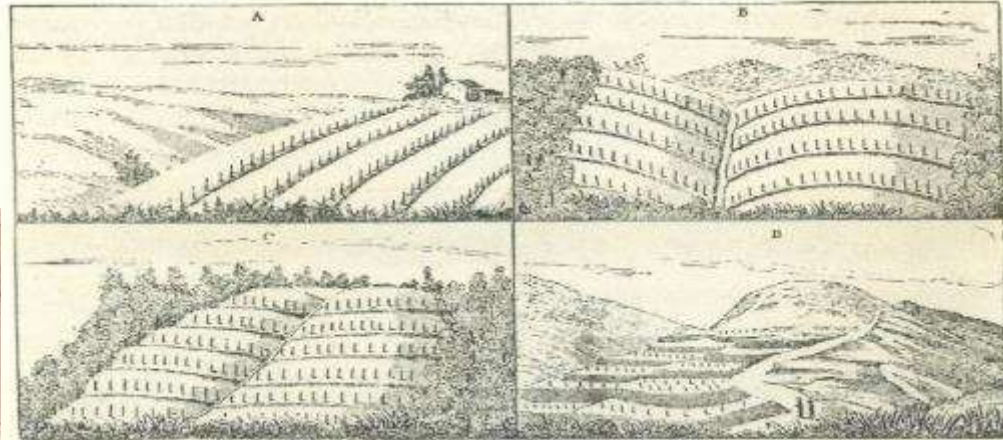
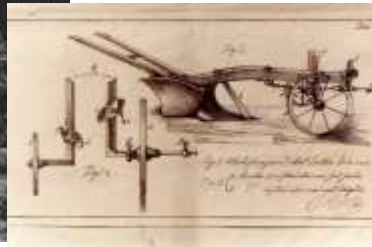


## PREVIOUS AGRICULTURAL REVOLUTIONS IN ITALY

At the end of 1700 were born agricultural schools, new machines were invented and new best rational practices were disseminated in rural areas.



AGRICULTURE 1.0



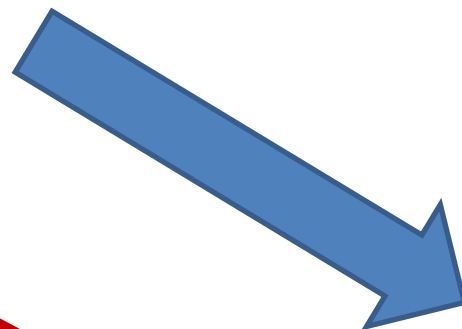
# AFTER WORLD WAR II – WITH A DEEP INTRODUCTION OF INDUSTRY IN AGRICULTURE



## GREEN REVOLUTION of the '50

It produces in 50 years a simplification of agronomic management with the use of:

1. Chemistry
2. Mechanics
3. Irrigation
4. Genetics



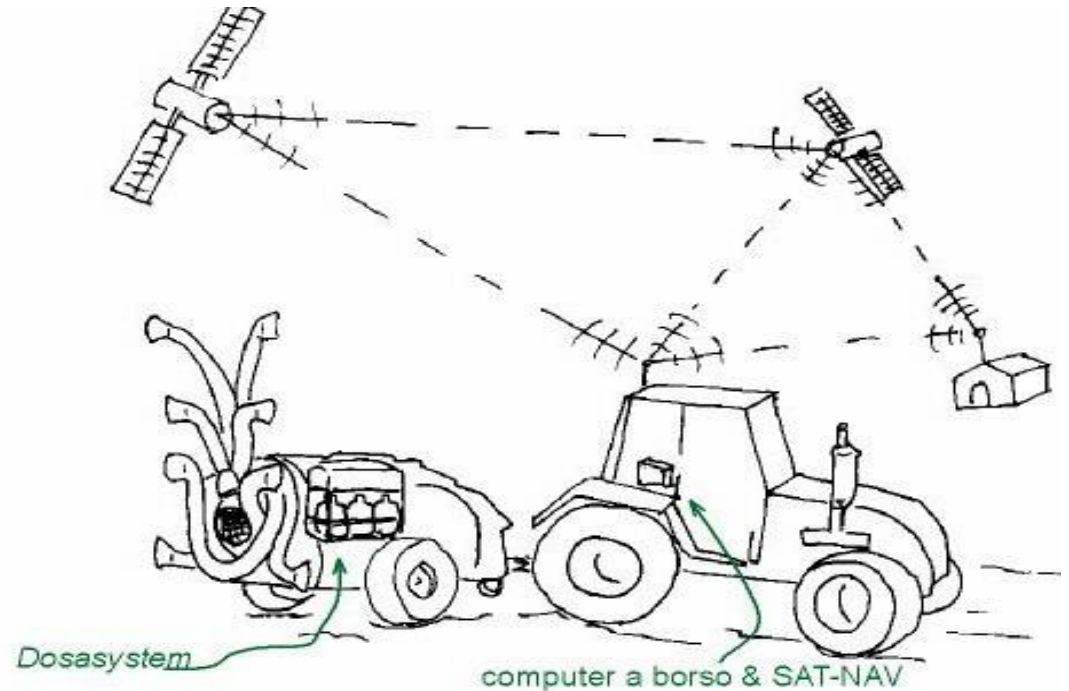
AGRICULTURE 2.0





*From hoe to satellite: two centuries of young age of humans in their mother earth*

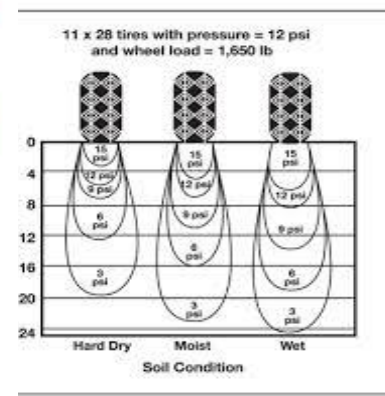
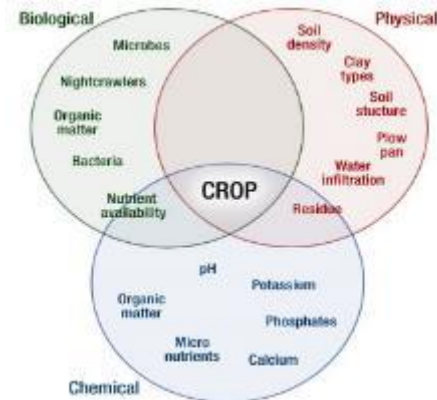
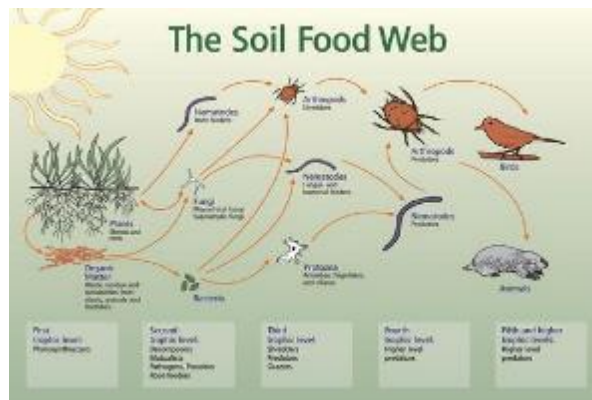
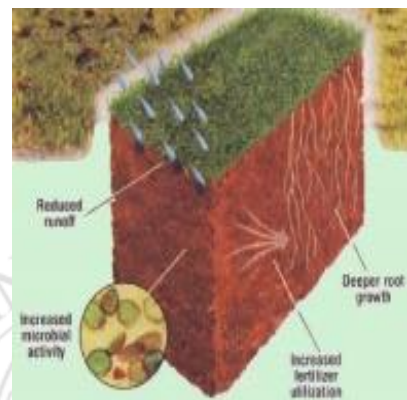
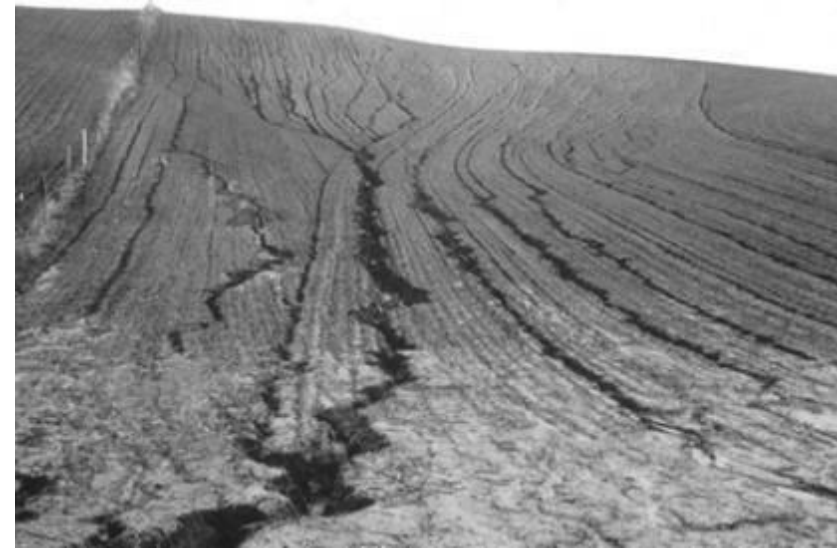
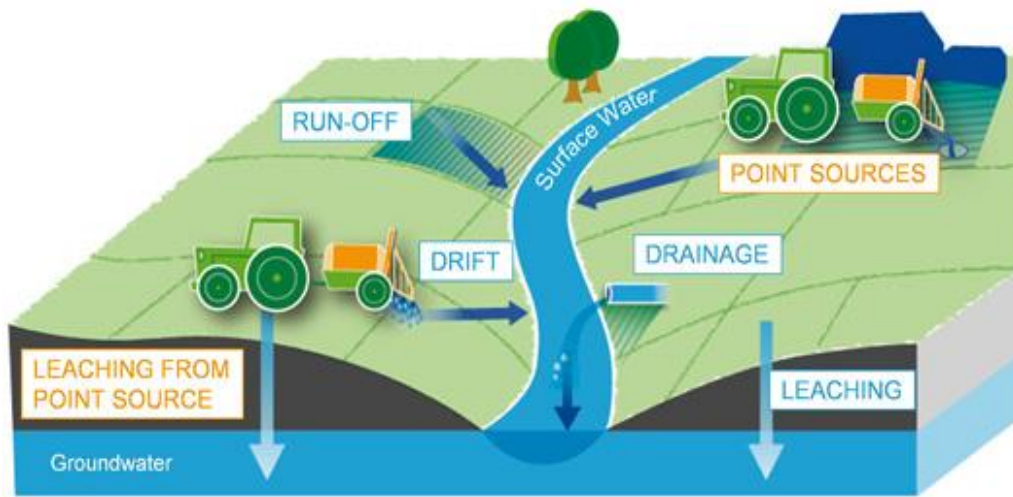
- × 800 times more productivity on ploughing
- × 400 times more productivity on growing and harverting







in the 90s the damages due to the loss of fertility of the soil, to their physical and biological erosion appear evident




# 1990

it is an innovative paradigm of punctual management of spatial variability

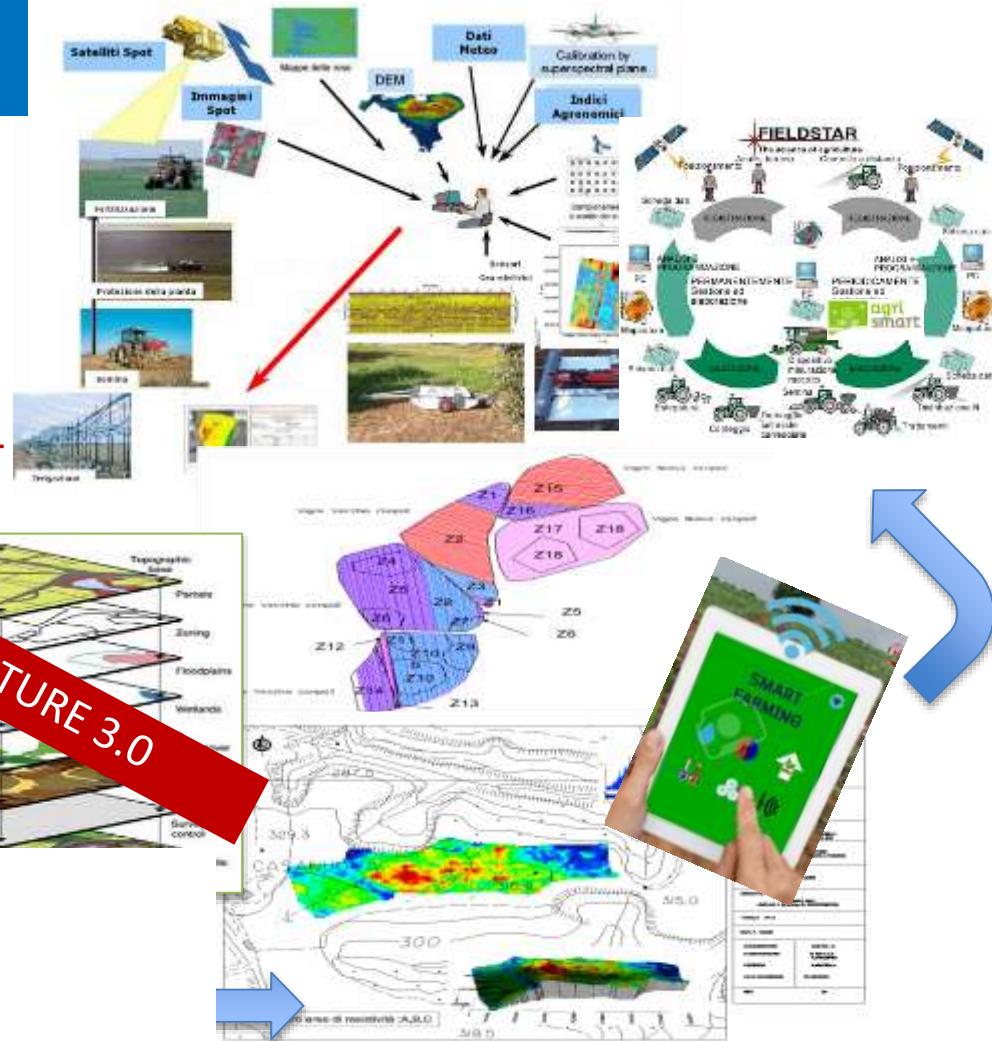
Technology makes it possible to apply it on large quantities (*surfaces, individuals, frequencies, number of parameters, ..*)

## Actions:

- ✓ Determines Punctual Variability
  - ✓ Evaluate the Causes
  - ✓ Indicates the improvement actions
  - ✓ It evaluates the economic and environmental effects
  - ✓ Implement specific operations
  - ✓ It tracks the flow
- 

## What innovations

- Digitalization
- Connectivity
- Automation
- Traceability...





The scientific technical reference framework - the STOA document  
with a milestone in the state of the art on Precision Agriculture



# Precision Agriculture and the Future of Farming in Europe

September 2016

## Technical Horizon Scan

<http://www.ep.europa.eu/stoa/>

[http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS\\_STU\(2016\)581892\\_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS_STU(2016)581892_EN.pdf)



## environmental and economic effects

No.	Process	Technique	Expected environmental gains
5	Avoid overlap of pesticide or fertilizer application	- Section control of sprayers and fertilizer distribution	Reduce/avoid excessive chemical input in soil and risk of water pollution
6	Variable rate manure application	On the go manure composition sensing Depth of injection adjustment	Reduced ground water pollution Reduced ammonia emissions into the air
7	Precision irrigation	Soil texture map	Avoidance of excessive water use or water logging. Reduction of fresh water use
8	Patch herbicide spraying in field crops	Weed detection (on line/weed maps)	Reduction of herbicide use with map-based approach (in winter cereals by 6–81% for herbicides against broad leaved weeds and 20–79% for grass weed herbicides*). Reduction of 15.2–17.5% in the area applied to each field was achieved with map-based automatic boom section control versus no boom section control**. 24.6% average herbicide savings was achieved in tramline spraying field trials
9	Early and localized pest or disease treatment	Disease detection - Multisensor optical detection - Airborne spores detection - Volatile sensors	Reduction of pesticide use with correct detection and good decision model (84.5% savings in pesticides possible. (Moshou et al., 2011)
10	Orchard and vineyard precision spraying	- Tree size and architecture detection - Precision IPM	Reduction in pesticide use up to 20–30 % Reduction of sprayed area of 50–80%
11	Variable rate nitrogen fertilizer application according to crop requirements and weather conditions	Crop vegetation index based on optical sensors Soil nutrient maps	Improvement of nitrogen use efficiency. Reduction of residual nitrogen in soils by 30 to 50 %
12	Variable rate phosphorus fertilizer application according to crop requirements and weather conditions	Crop vegetation index Soil nutrient maps	Improvement of phosphorus recovery of 25 %
13	Crop biomass estimation	Crop vegetation index	Adjust the fungicide dose according to crop biomass (Jensen and Jørgensen 2016)
14	Mycotoxin reduction	Crop vegetation index and fungal disease risk	Optimisation of fertilizer dose and fungicide use on the basis of higher disease risk in areas with high crop density

\*Gerhardt and Gebel 2006

\*\*Luck et al 2010

\*\*\*Dammer and Wartenberg 2007

Up to 15 % less time, fuel consumption, GHGs emissions with AUTOMATIC GUIDANCE  
Up to 70 % saving in crop protection chemicals use with DSS and Automation in VRT  
15 times reduction in soil losses and nutrients waste

Table 1. Expected environmental gains from main PA processes and techniques

No.	Process	Technique	Expected environmental gains
1	Timeliness of working under favourable weather conditions	Automatic machine guidance with GPS	Reduction in soil compaction Reduce carbon footprint (10 % reduced fuel consumption in field operations)
2	Leave permanent vegetation on key location and at field borders	Automatic guidance and contour cultivation on hilly terrain	Reduction of erosion (from 17 to 1 tonnes/ha/year and perhaps lower) Reduction of runoff of surface water and reduced runoff fertilizers Reduced flood risk
3	Reduce or slow down water flow between potato/vegetable ridges to slow water	- micro-dams or micro-reservoirs made between ridges ("tied ridges") - ridges along field contours	Reduced sediment runoff Reduced fertilizer runoff
4	Keep fertilizer or pesticide at recommended distances from water ways	- Automatic guidance based on geographic information - Section control of sprayers and fertilizer distribution	Avoidance/elimination of direct contamination of river water



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# Precision agriculture in Europe

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## Legal, social and ethical considerations

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EPRS | European Parliamentary Research Service

Author: Mihalis Kritikos

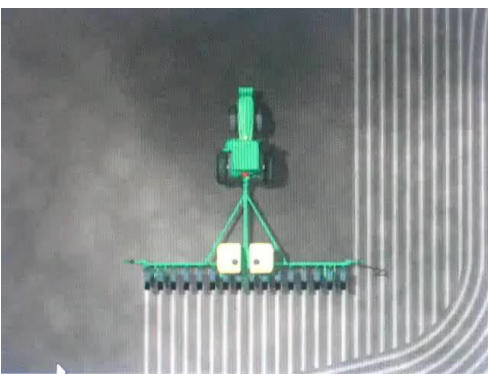
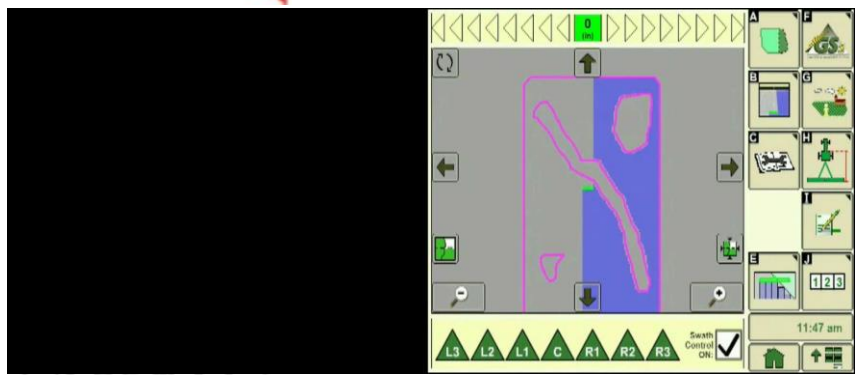
Scientific Foresight Unit (STOA)

November 2017 – PE 603.207

[http://www.europarl.europa.eu/regdata/etudes/stud/2017/603207/eprs\\_stu\(2017\)603207\\_en.pdf](http://www.europarl.europa.eu/regdata/etudes/stud/2017/603207/eprs_stu(2017)603207_en.pdf)

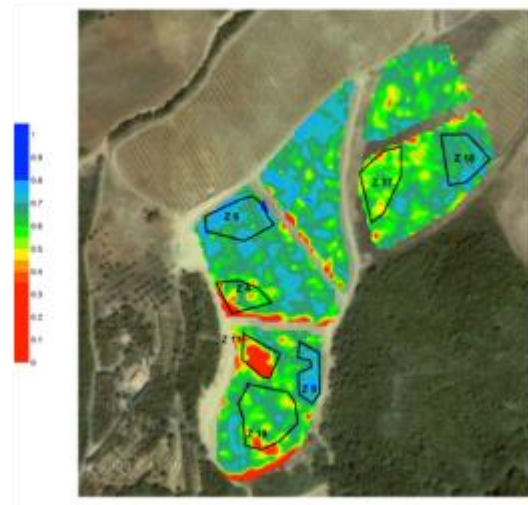


- ✓ ISOBUS
- ✓ AUTOMATIC  
DRIVEN
- ✓ PRESCRIPTION  
MAPs
- ✓ AUTOMATION



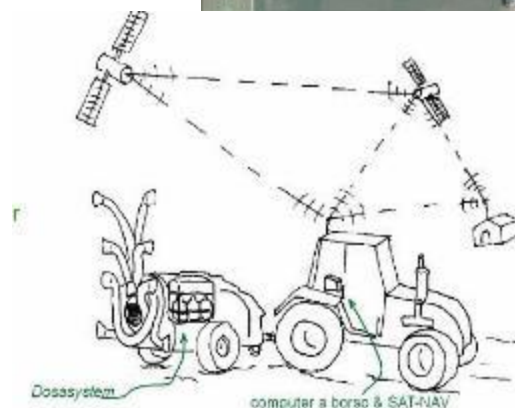
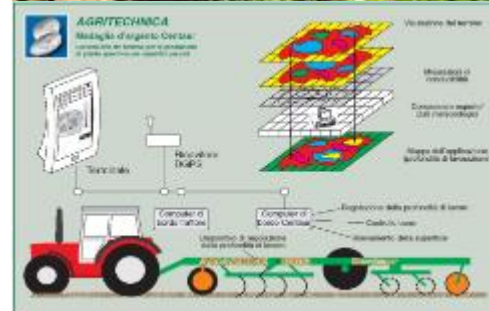


# VRA technologies available

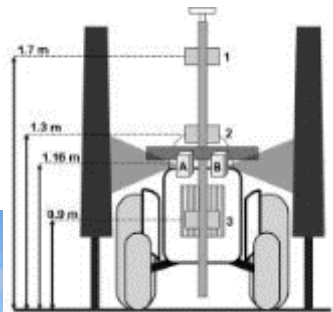


## ....nella pratica operativa??

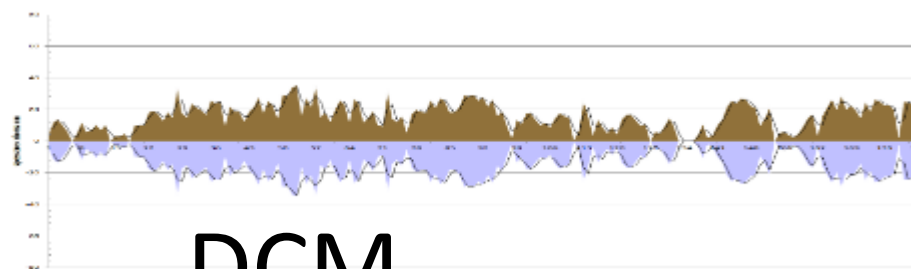
- Progettazione e realizzazione nuovi impianti
- Gestione agronomica differenziata VRT
  - Fertilizzazioni
  - Defogliatura
  - Vendemmia
  - Trattamenti antiparassitari
  - Irrigazione
  - Tracciabilità
  - Controllo flotte
  - Web-Gis gestionali aziendali





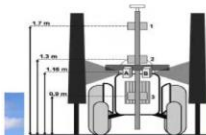


VRA – CAS  
canopy management and  
adaptation of treatment

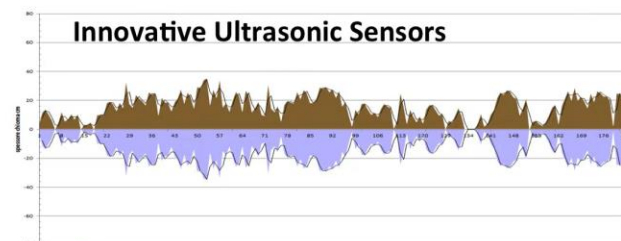


DCM

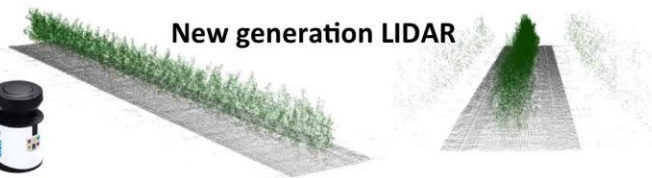
Innovative proximal perception systems



Innovative Ultrasonic Sensors

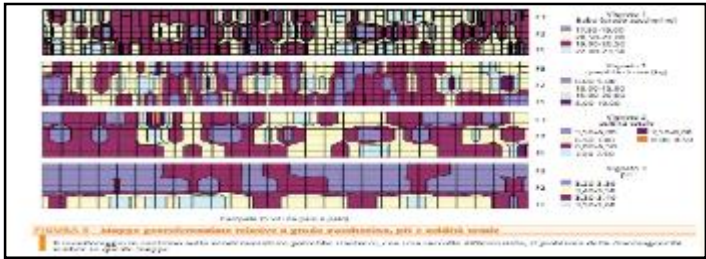
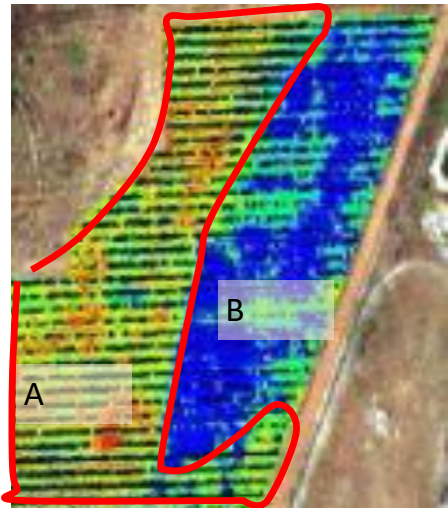


New generation LIDAR

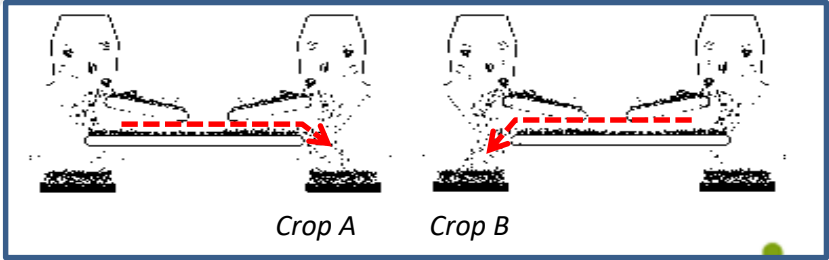




Differential Harvesting



Transversal conveyor

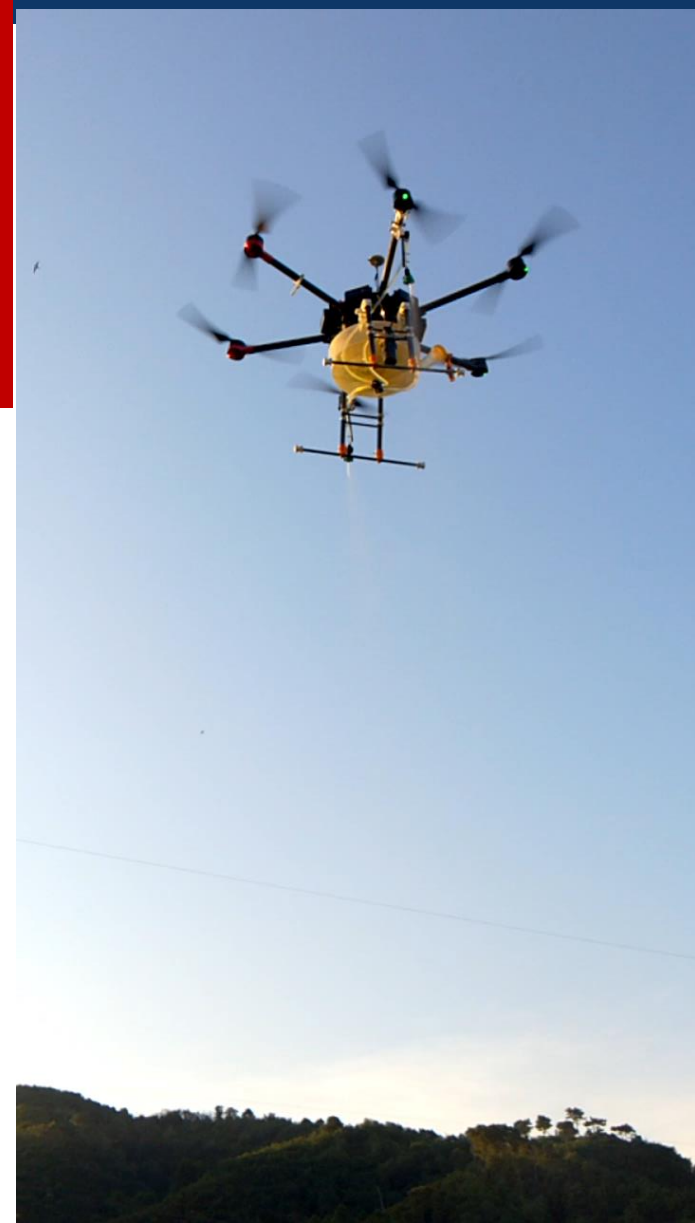


The map is loaded on USB flash drive for use in the HQS machine. Equipped with the GPS technology, the grape harvester knows its position and reads the map to determine A and B quality grape areas. Automatically, the harvester moves its conveyor to the right or to the left according to the map information.

# INTELLIGENT ARMS

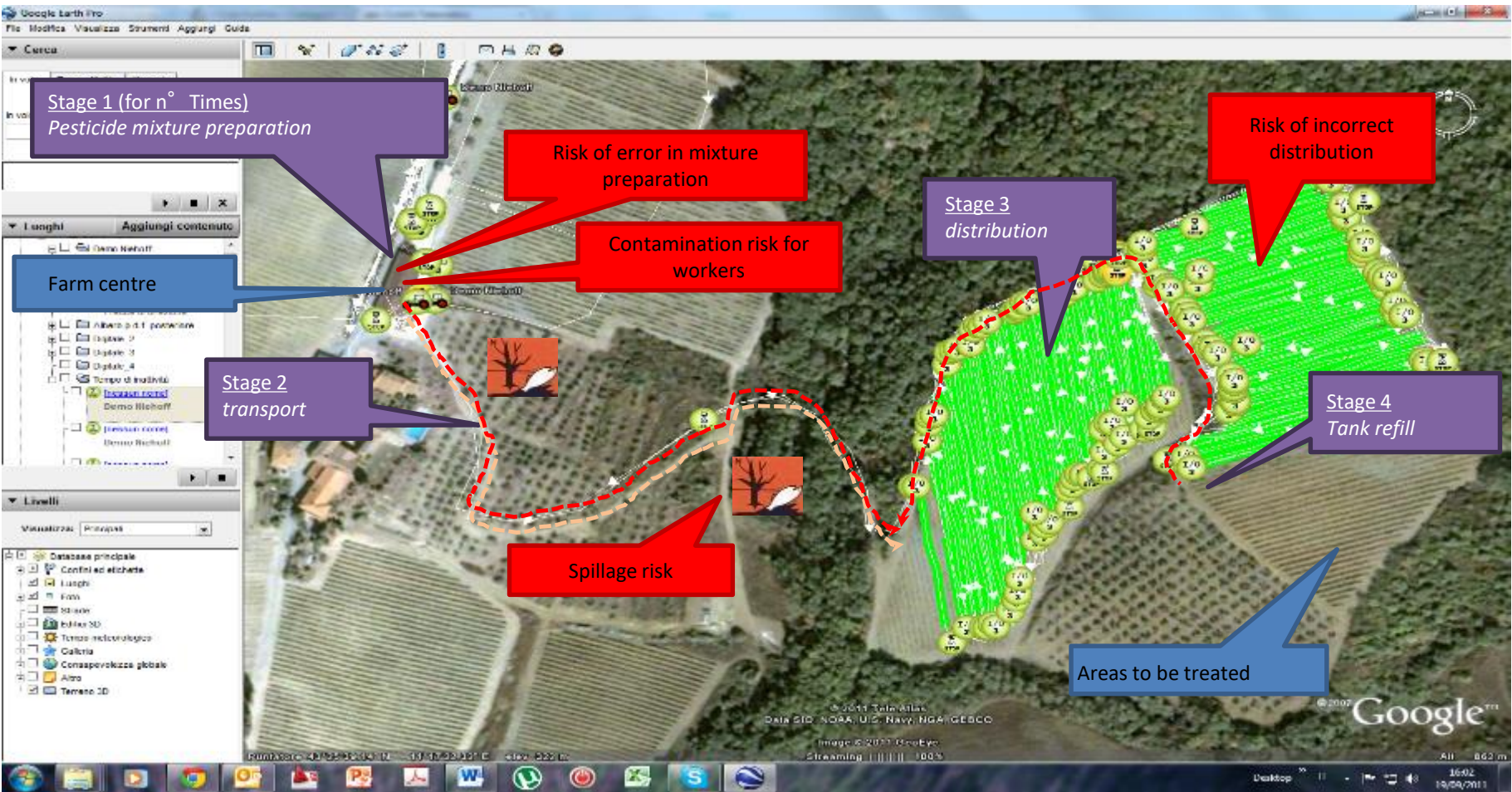
Experiences in Tuscany - VRT by drone

- Spraying nutrinets anche chemicals
- Pollinating
- launch of predators

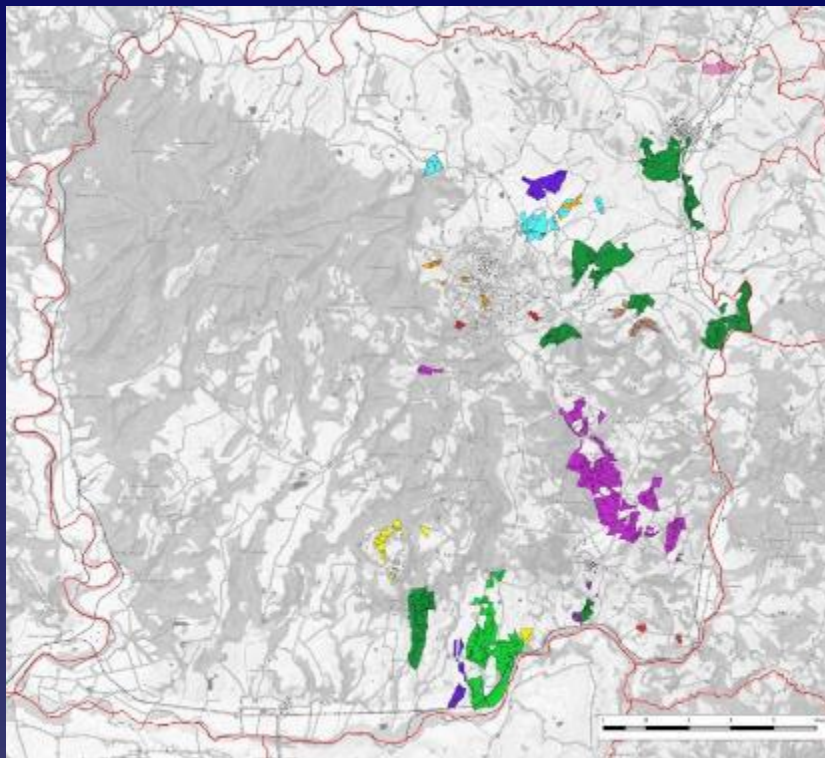




Telemetry , Fleet control, DDS, Traceability in management



# TERRITORIAL DIGITAL PLATFORM AND DIRECT PARTICIPATING COMPANIES



Farmers	Vineyards [ha]	Olive growing [ha]
<i>Az. Agr. Casanova di Neri di Giacomo Neri</i>	72,3	7,1
<i>Az. Agr. Martoccia di Brunelli Luca</i>	8,3	1,4
<i>Az. Agr. Podere La Vigna di Rubegni Adriano</i>	6,4	1,1
<i>Az. Agr. San Filippo di R. Giannelli</i>	9,4	0,7
<i>Siro Pacenti di Pacenti Giancarlo</i>	23,1	3,6
<i>Soc. Agr. Canalicchio di Sopra di Ripaccioli Marco &amp; F.lli s.s.</i>	19,1	2,3
<i>Talenti Riccardo</i>	14,9	3,6
<i>Tassi di Franci Franca</i>	5,2	0,3
<i>Tenuta di Sesta di Ciacci Giovanni</i>	36,5	22,9
<i>Tenuta Fanti di Fanti Baldassarre Filippo</i>	51,4	36,4



# System Architecture



## Monitoring

- **Aerial surveys:**
  - RGB Camera
  - Multispectral camera
  - Hyperspectral Camera
  - Gamma rays
- **Data collections on crops:**
  - Physiological measurements
  - Vigour indexes NDVI - NDRE
- **Data collection on soil :**
  - Conductivity measurements with electromagnetic induction
  - Profiles and drills
  - Laboratory analysis
- **Data collection from weather stations:**
  - Atmospheric pressure
  - Temperature
  - Rainfall
  - Humidity of the area
  - Wind intensity
  - Solar radiation
  - Dew point
  - Leaf wetness

## Data processing



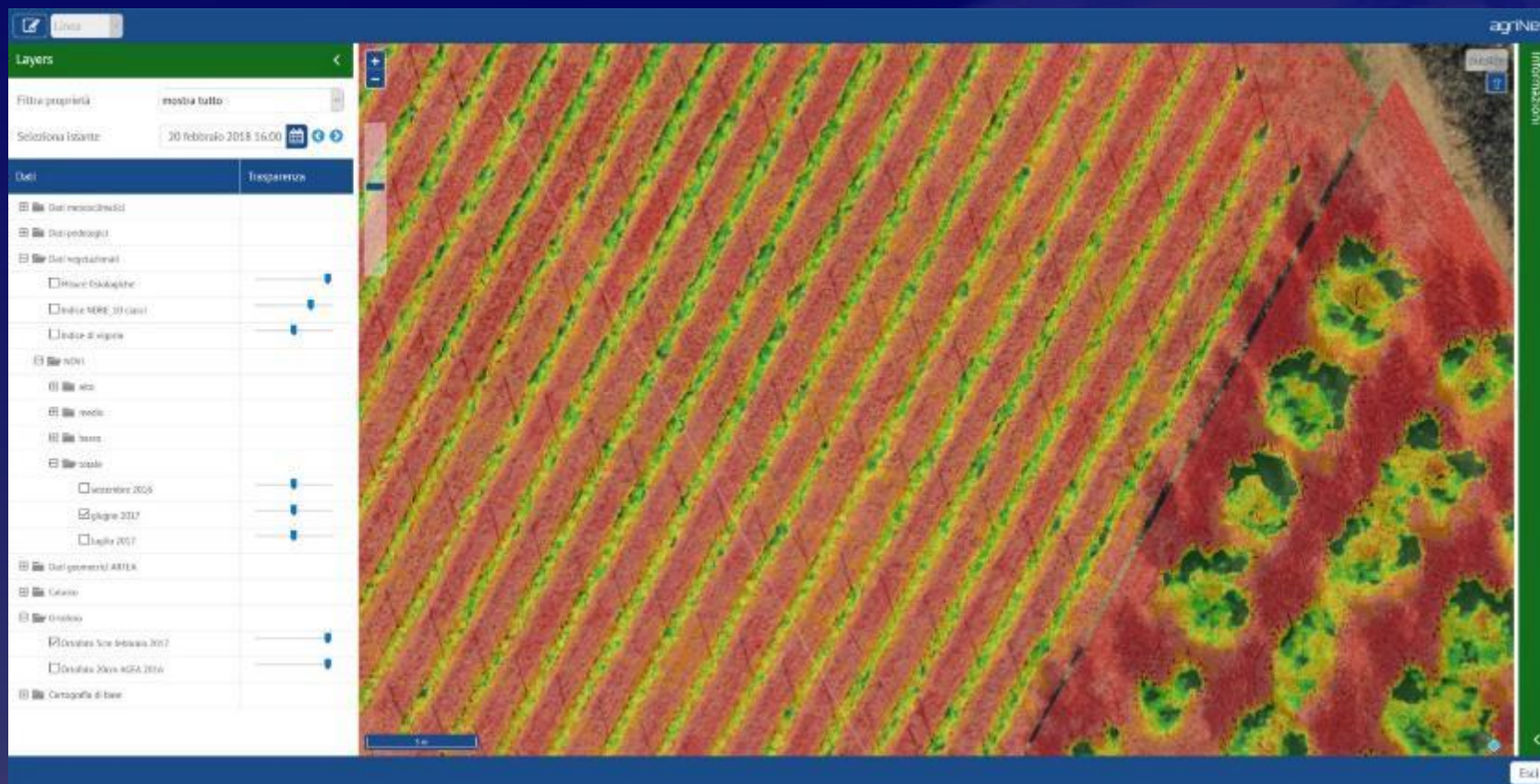
Piattaforma territoriale  
multi-servizi per la  
DIGITAL AGRICULTURE

## Field activities

## Services to companies and stakeholders

- **Digital maps for the management of parcels with 1 sqm mesh:**
  - Orthophoto (4 cm / pixel)
  - Vegetational maps and NDVI
  - Pedological maps
  - Hydrological modeling:
    - Water at field capacity (FC)
    - Water at the point of withering (WP)
    - Water available for plants (AWC)
    - Saturated hydraulic permeability (Ksat)
  - Weather-weather maps
  - Prescription maps
- **Telemetry control of operations**
- **Field books**
- **DSS Services - Decision Support System for:**
  - Crop protection alarms
  - Logistic decisions support for the collection of products
- **Analytical accounting of georeferenced parcel**
- **Traceability**
- **Typicality**
- **Identification of biodiversity footprints**

# CROP VIGOUR INDEXING NDVI-NDRE

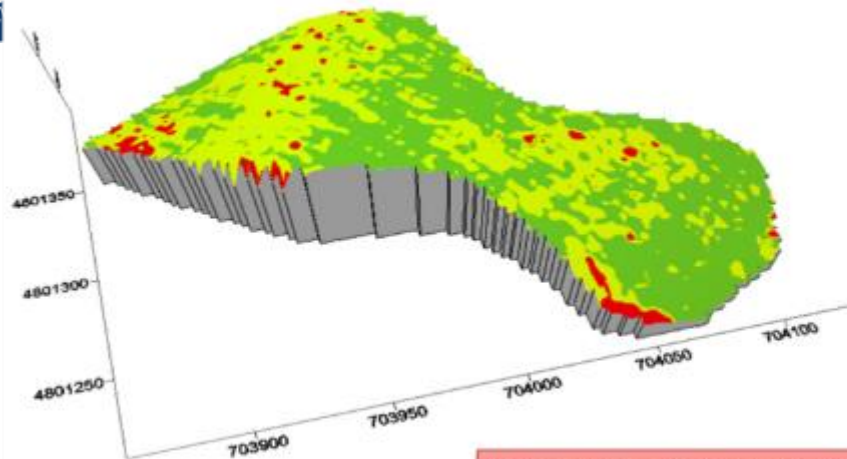




# ARTEA DATA – PIANO CULTURALE



Overlay Dem + Countour map

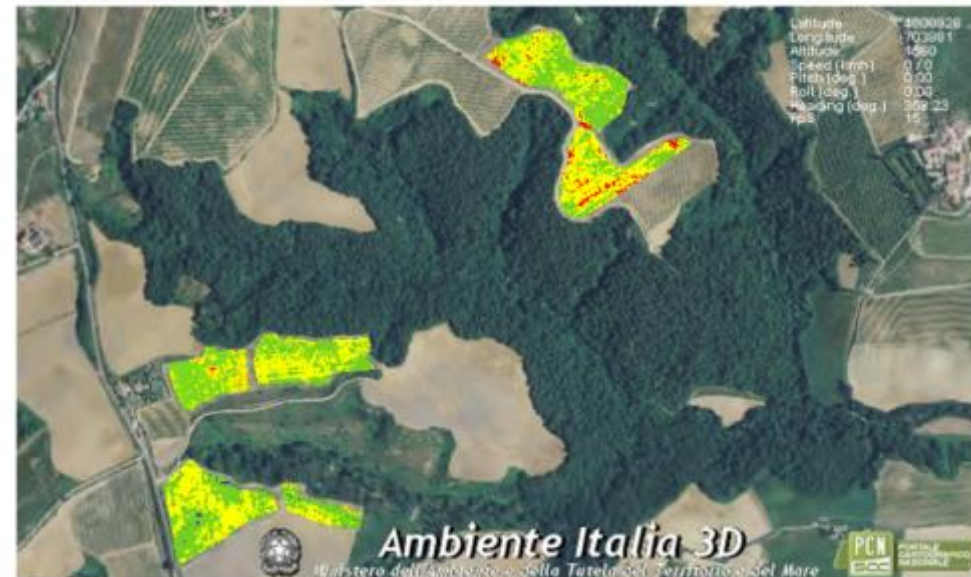
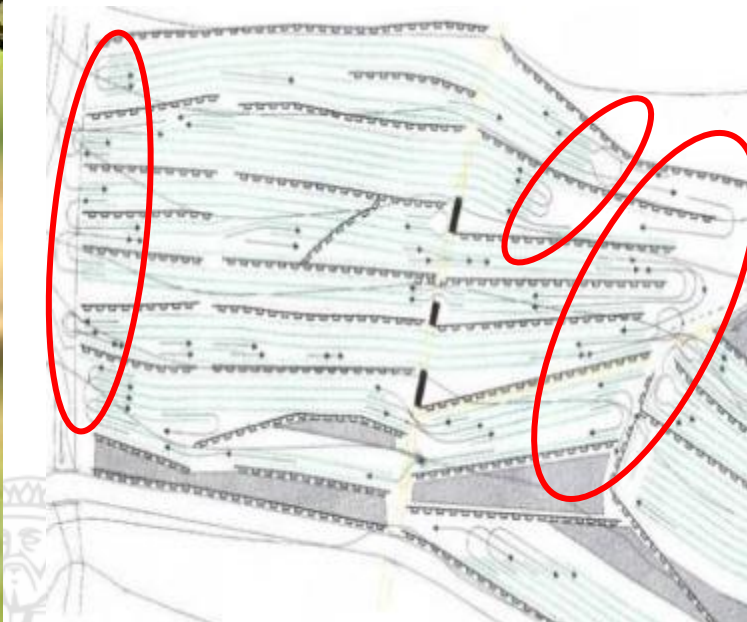


*if the maps are not organized into an overall project are unnecessary*

# The CAD DTM



Overlay general air photos

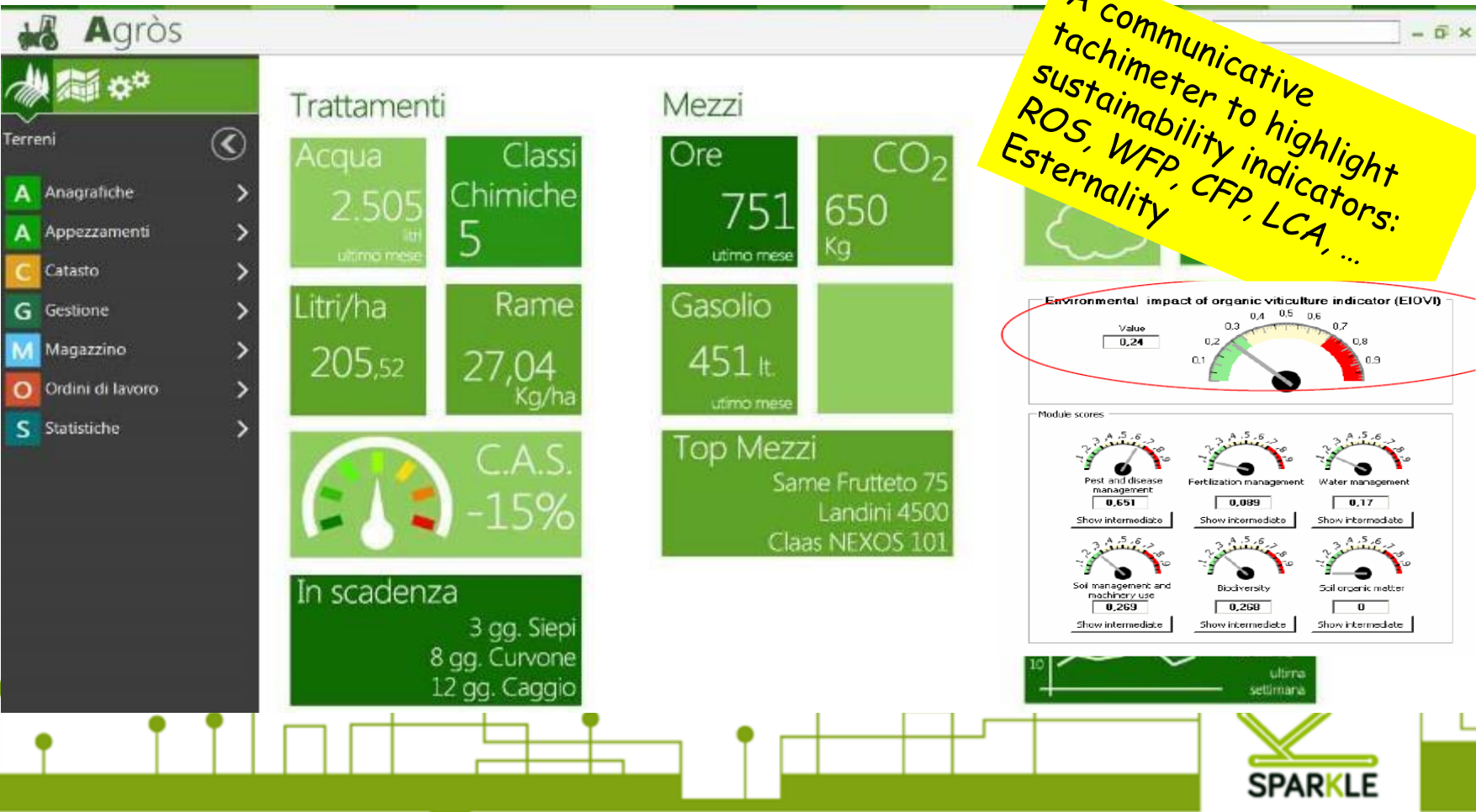


**TO ADD INFORMATIONS INTO A FARM SYSTEM MANAGEMENT**



# Farm dashboard with on time emission and consumption indexes compared with conventional practices

on time emission and consumption indexes compared with conventional practices

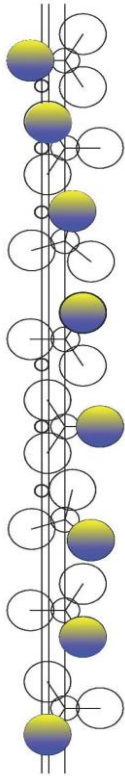
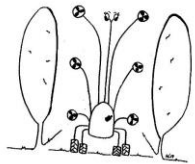




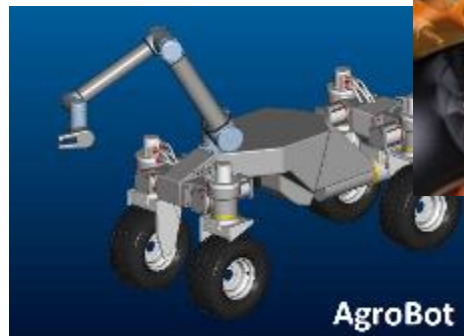


# SMASH for VITICULTURE

SMASH  
Smart Machine  
for Agricultural  
Solutions  
Hightech

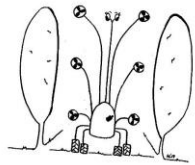


- Punctual detection and SPRAY
- Precise mechanical weed control on the row



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# SMASH for HORTICULTURE

- Soil control by PLANTOID
- Precise mechanical weed control on the row

SMASH  
Smart Machine  
for Agricultural  
Solutions  
Hightech



Regione Toscana



REPUBBLICA ITALIANA



EUROPEAN UNION





## MISURARE, ANALIZZARE, CONOSCERE AGIRE APPROPRIATAMENTE



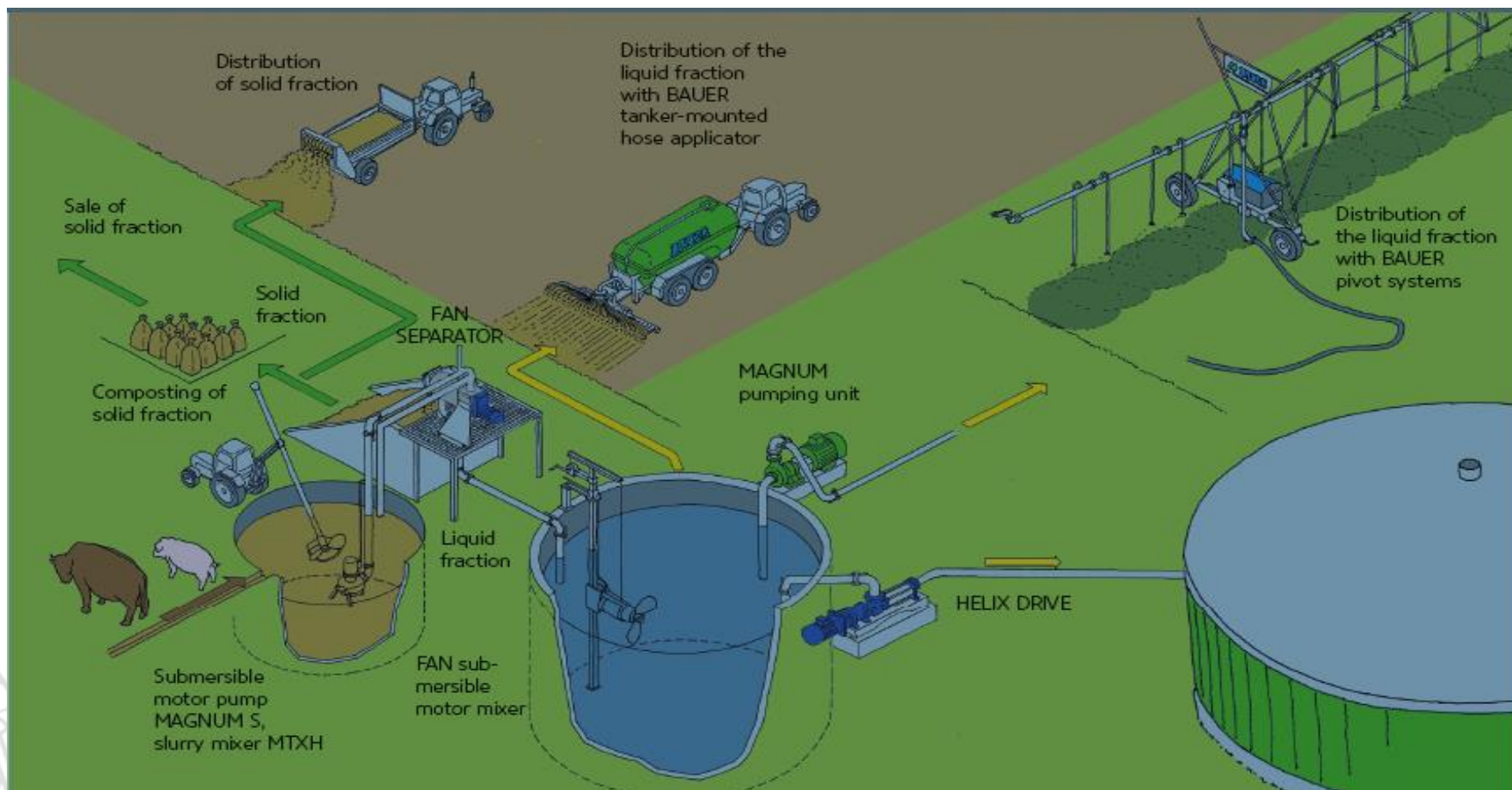






## PRECISION FARMING DI SECONDO LIVELLO

**RIEQUILIBRIO DELLA SOSTANZA ORGANICA, VARIABILIZZATA IN BASE ALLE ESIGENZE PEDOLOGICHE DEI TERRENI E NUTRIZIONALI DELLE COLTURE, RILEVATE DA SENSORI OTTICI SU MACCHINE, DRONI E/O SATELLITE**



## GESTIONE APPORTI SOSTANZA ORGANICA A BASSO COMPATTAMENTO

- Trattatrice a basso compattamento e con tecnologie DSS
- Aratro per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Erpice rotante per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Carro spanditore per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Carro botte per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS









UNIVERSITÀ  
CATTOLICA  
del Sacro Cuore

## Compattamento: cosa, chi, dove, quando, perché



Morris et al., 2010

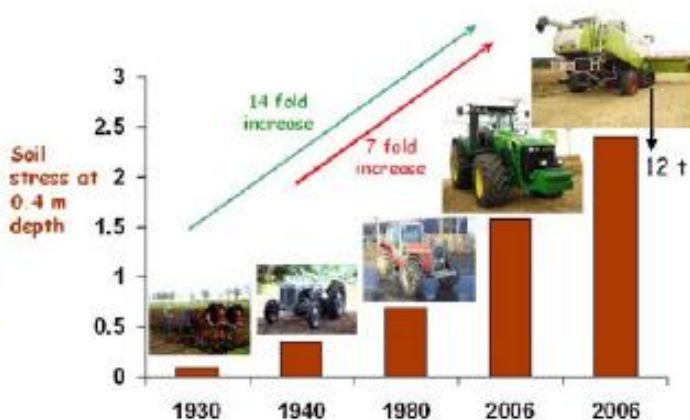
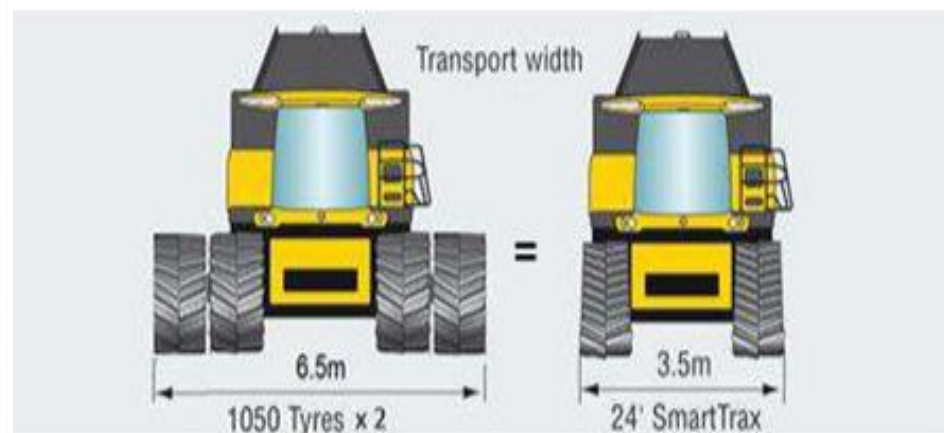
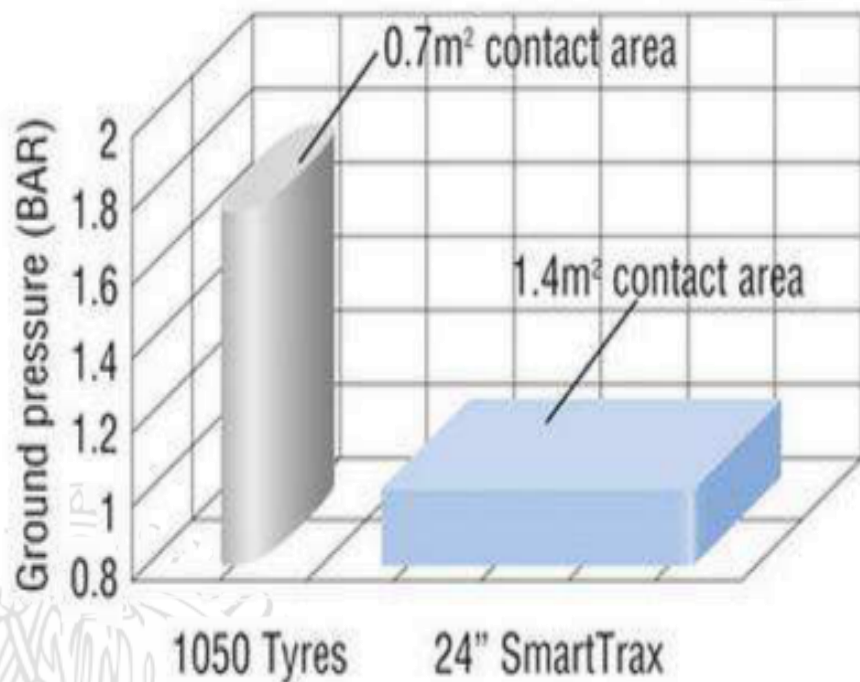


Fig. 9. Estimated changes in soil stress at 0.4 m soil depth resulting from increasingly heavy machinery running on the soil surface (figure courtesy of Chamen (2009) adapted from Koolen et al. (1992)).







- Superficie di appoggio di livello superiore
  - Rispetto ai MegaXbib 1050/50R32 (gli pneumatici di dimensioni maggiori), la superficie di contatto al suolo è pari al doppio con i cingoli SmartTrax da 24" (i più stretti della gamma).



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## IL RACCOLTO Società Cooperativa Agricola Rete Imprese Terre del Reno

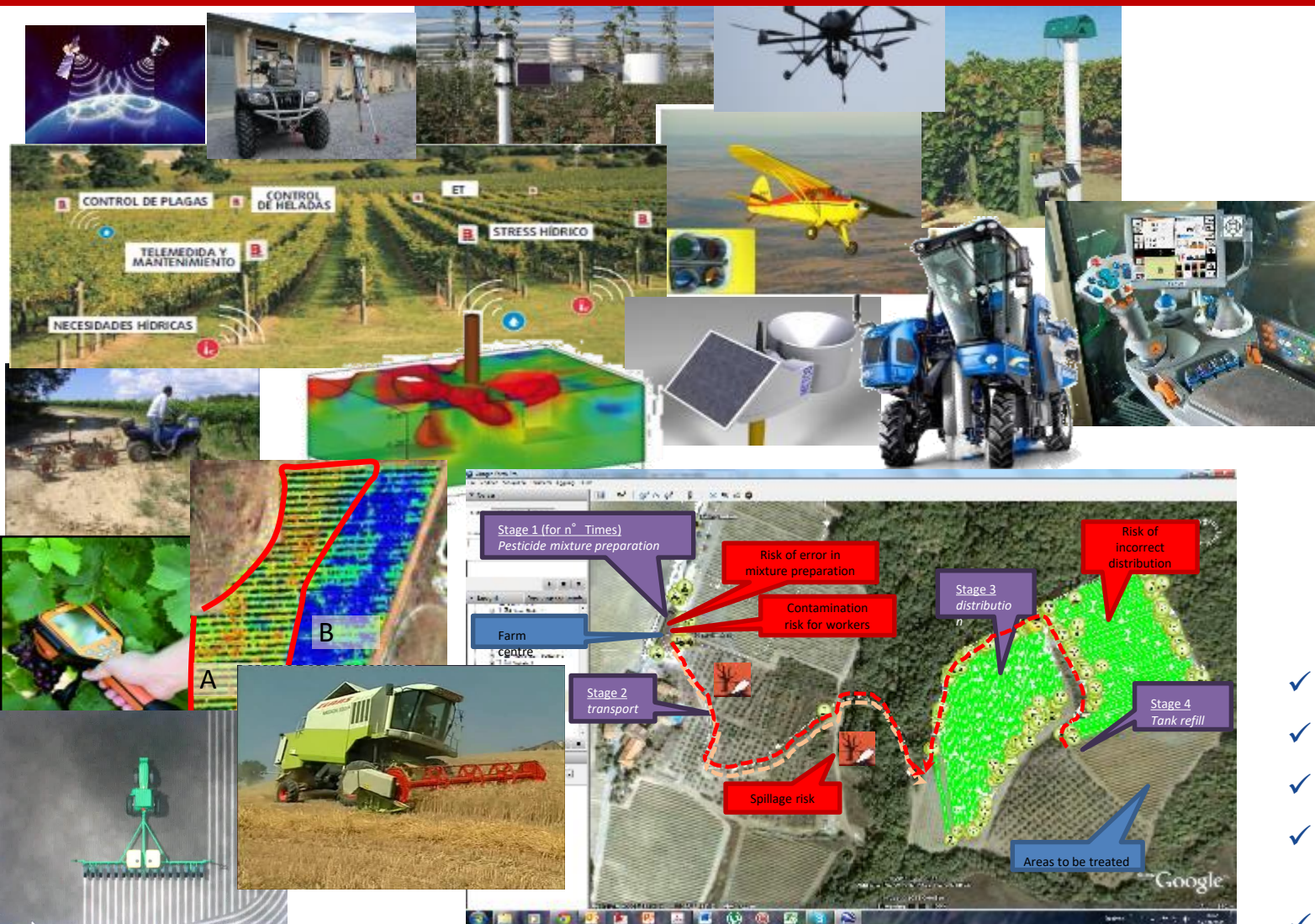




# MAKING ORDER IN A CHAOTIC UNIVERSE OF TECHNOLOGICAL PROPOSALS



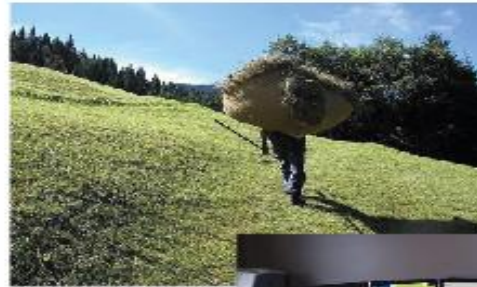
- ✓ ISOBUS
- ✓ AUTOMATIC GUIDE
- ✓ PRODUCTION MAPS
- ✓ PRESCRIPTION MAPS
- ✓ AUTOMATION
- ✓ TELEMETRY



**CLEARLY DEFINE THE  
AREAS IN WHICH THE  
TECHNOLOGIES  
BECOME "ENABLING"  
AND PROFITABLE**

Precision  
sustainable Farming  
is  
Spatial Intelligence  
and Precise  
Management  
High Technology  
Farming is a way  
that makes it  
possible

**EYES**  
monitoring wide areas  
(sensors and digital maps)



**TOUCH**  
understanding the answer  
on the treated elements  
( proximity sensors)

**ARMS**  
intelligent  
to develop accurate assignments  
(automation, robot)

**MIND**  
to knowingly choose thing,  
where and whether to intervene  
on the single elements  
(models e Decision Support  
System)

**MEMORY**  
to keep trace of things  
done  
(telemetry, traceability)

**EXPERIENCE**  
multi-annual data handling

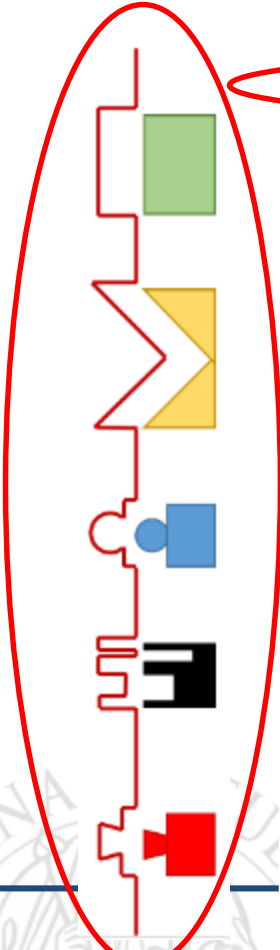
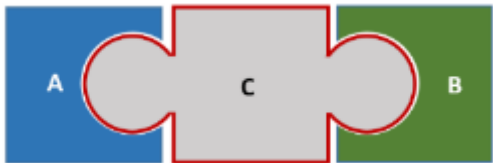
**IDENTITY**  
local and regional in the sustainable  
use of the resources





# Integrated multicompetencies multiactor approach in effective and profitable innovation development – COLLABORATIVE ECOSYSTEM

- Automatic guidance in tractors operating on open field: a mature integrated innovation system
- High technologies for farming: caotic scenario to be proper developed in actuating steps and appropriate competencies and actors.



Chain of technology development in High Tech Farming			
Element	Product type	Problems and needs	Who does what
Satellite, aerplane, drone, terrain station, onboard system	vector	Resolution, frequency	Engineering comp
FOTONICS	Sensors	Direct or Indirect measure or index	Phisics researchers
Digital Data	Raw Data	interconnettivity	Informatics competencies
Data Communication	Telecomunicazioni	Broad Band	Engineers researchers
Data mining	dati normalizzati	App	Informatics competencies
Informative digital systems	GIS + Digital Hubs territoriali	Hubs and Services	Agro-informatic & Informatics systems
Data analysis	Biological and environmental models	Agronomic, Biological and Environmental Science Knowledges	Agronomous researchers
Decision support systems	Manager interface	Development of effective Decision Support System	Agronomous Agroinformatic
Mission Plan for Variable Rate Treatment automatism	Data meaning and managing	Agro-electronics and agroinformatics training	Agricultural machinery engineers Agroinformatics & agroelettronics
AVT machinery set up	Automation	Agro-electronics and agroinformatics training	Agricultural machinery engineers , Agroinformatics

TRL - Tech Readiness	
9	Com
8	Pre
7	Field
6	Prot
5	Ben
4	Det
3	Prel
2	Con
1	Bas

please do not act as an one man band



The evolution of agricultural mechanics has become profitable when:

- ✓ the machines have become appropriate and reliable (*historic failures of the Borello tractor and Bonmartini tire tracks*);
- ✓ retailer, motorist, mechanic and gum services have become present in the territory (*within 100 km*);
- ✓ training centers have been established *Famous in Tuscany was the Agricultural Mechanization Training Center of Borgo a Mozzano (Lucca) financed by the Government and by the ESSO.*

Tuscany first highlighted these needs and identified them as essential

- The territorial approach of the **PRODUCTION ECOSYSTEM**. This had already been defined in the regional ROADMAP for RIS3, defining the INNOVATION support PLATFORMS
- The **BUSINESS CASE** in agriculture, which is a non-relocatable external rural activity, is the **CASE OF TERRITORIAL USE** and not the single product, service or activity.



1970 - PICCOLA ENCICLOPEDIA DI MECCANICA AGRARIA ESSO.it  
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Fig. 1802  
Disegno tecnico Bonmartini relativo ai trattori agricoli.







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# Grazie for Your precious attention

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