Ninsar

New ItiNerarieS for Agroecology using cooperative Robots

https://project.inria.fr/ninsar/

De l'avènement de nouvelles pratiques agro-écologiques par la création de systèmes robotiques collaboratifs

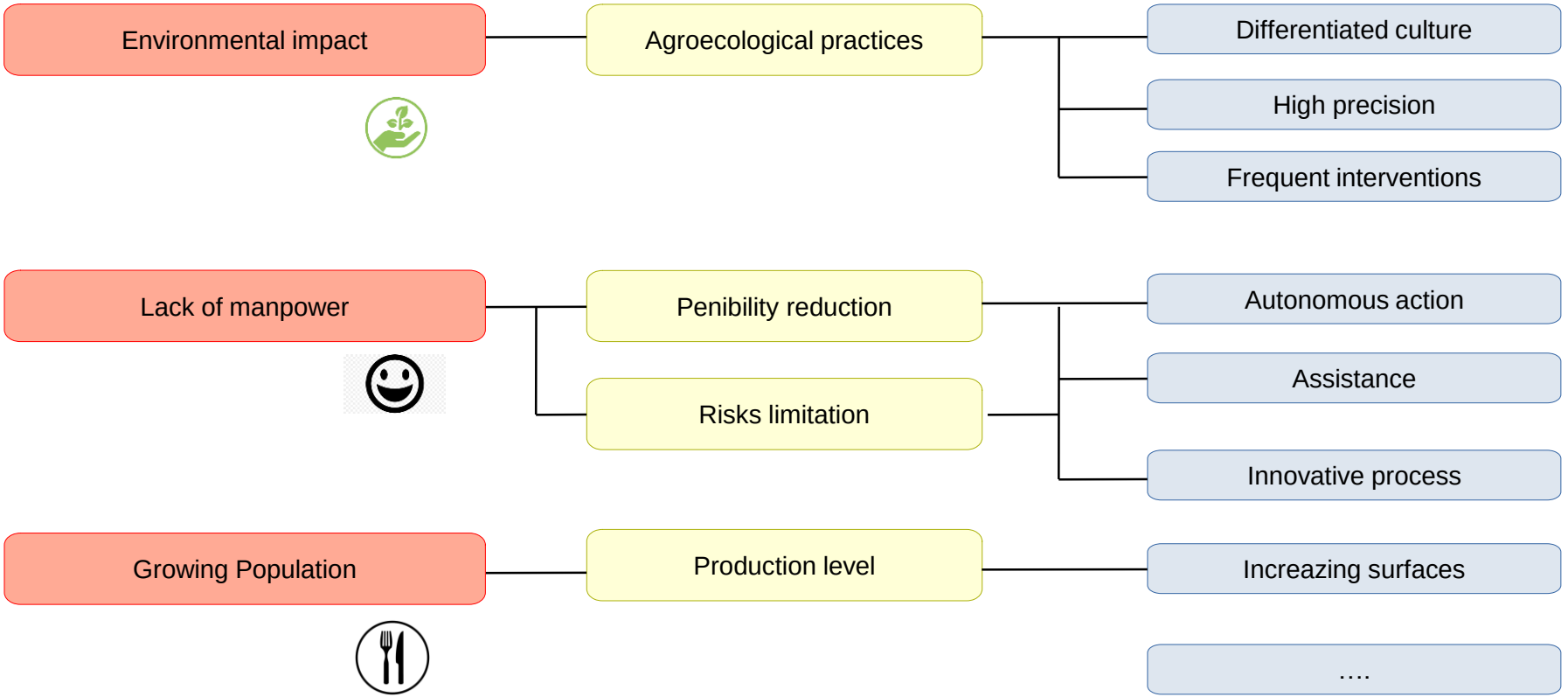
NINSAR Flagship project
PEPR Agroecology and ICT

Wednesday 5th july 2023, Champenoux

General Presentation

National task force

A societal motivation



How to use robots good for agroecology?

Advanced Driving Assistance Systems

Automated driving

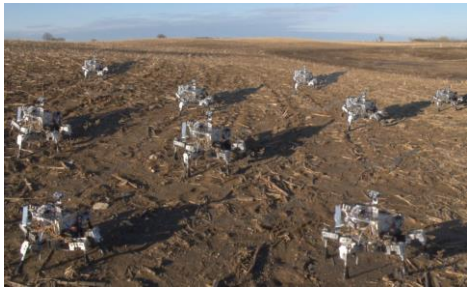
Tools Adaptation

Farmer Assistance

Toward concept of autonomous tractor

Autonomous tractors

The opportunity of defining new concepts ?



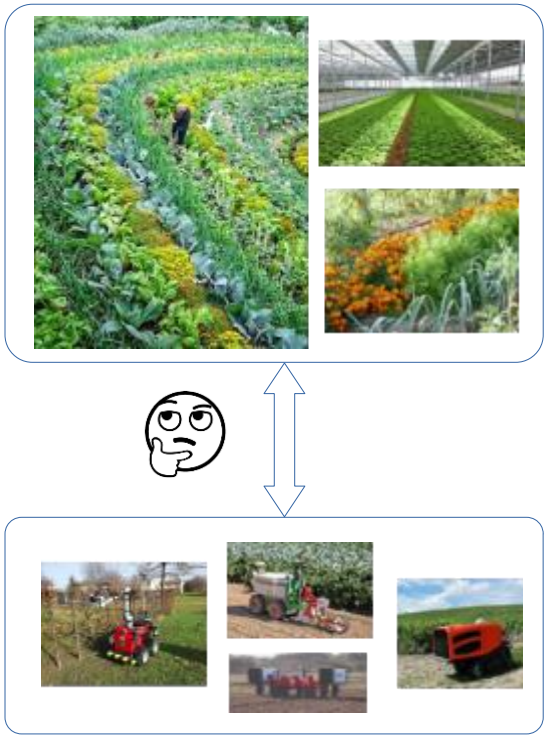
New architectures

Different Properties

Adaptable Robotic System

Multidisciplinary issues

Which **practices** evolution ?



How to **adapt** robots behaviors ?

People tracking

Association

Row following

Footprints tracking

How to ensure **safety**?

Detection and avoidance

Accuracy and integrity

Maintaining stability

Cobotic

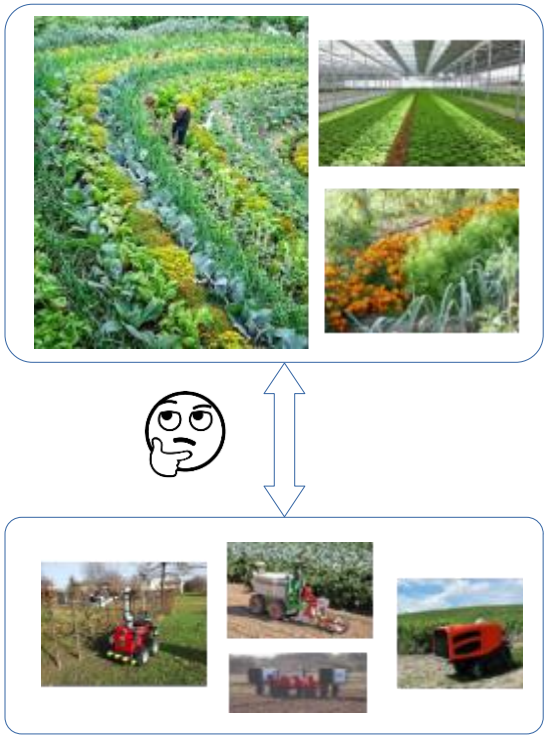
Supervision tools

Monitoring system

Adoption of new technologies ?

Multidisciplinary issues

Which **practices** evolution ?



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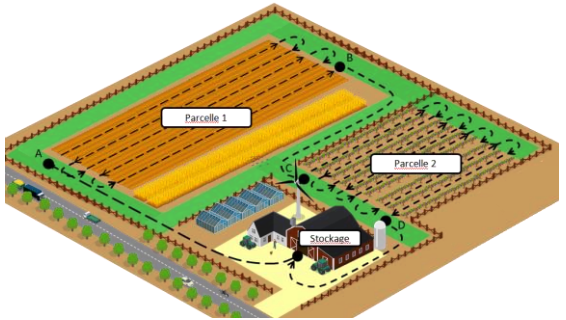
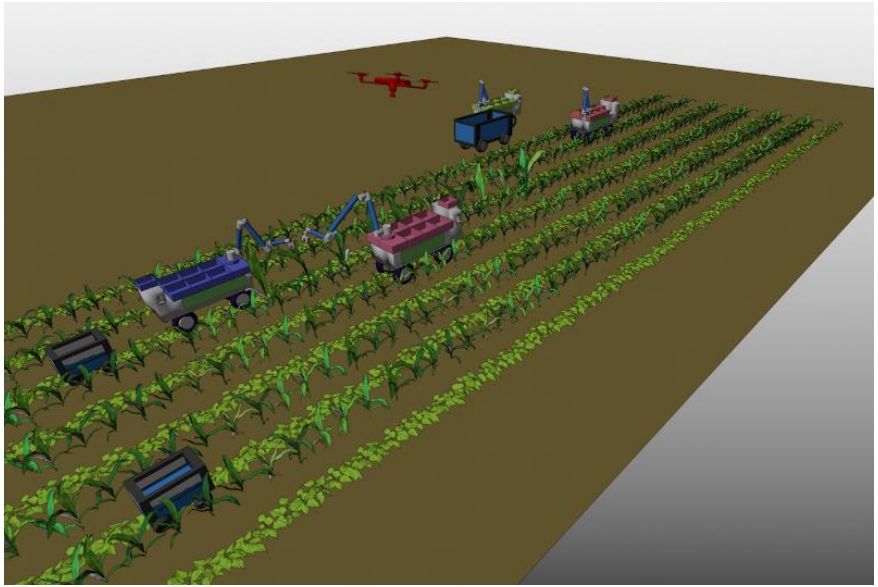
Adoption of new technologies ?

Toward a reconfigurable fleet of elementary robots

- Able to act at plant scale … up to multi-robot
- Discriminating vegetation type
- Acting on the crops/soil/weeds
- Optimizing ressources regarding the task





Achieving differents agricultural operation

- Soil preparation
- Sowing seeds
- Field monitoring
- Targeted plot maintenance
- Differentiated Harvest

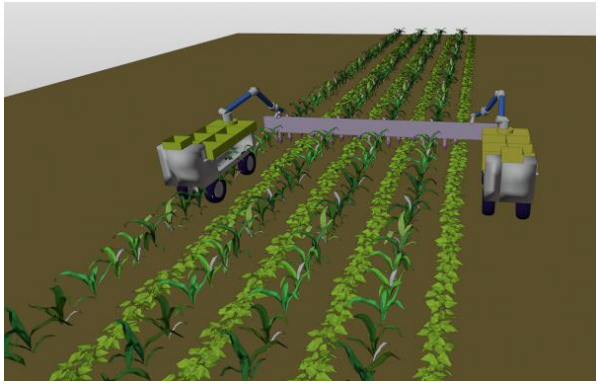
Allowing the rise of agroecological routes

- At large scale
- Without requiring harsh manpower
- Allowing local and discriminated treatment
- Reducing ressources consumption

Defining robotic agroecological routes

- Scouting mission

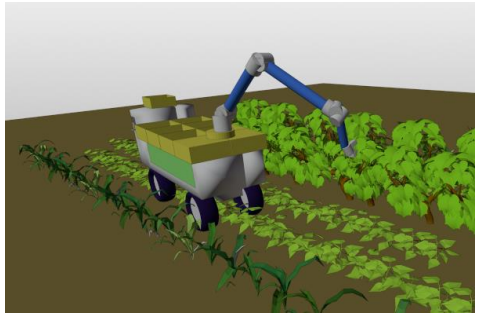
- Large field weeding



- Confined biocontrol spraying/lighting

Defining robotic agroecological routes

Remove rotten fruit



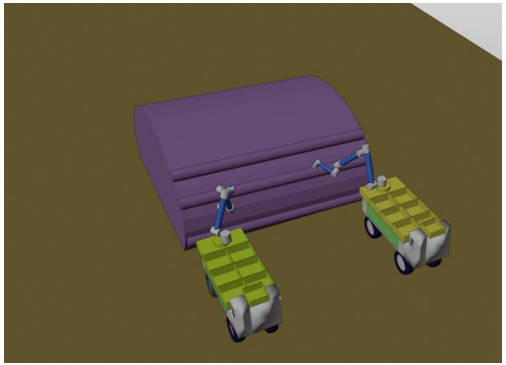
Local treatment

Selected picking

Orchard - Vineyard

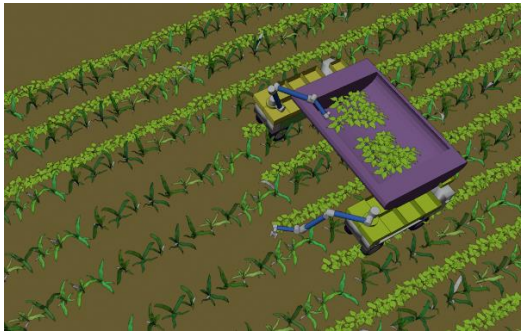
Level of complexity

Preliminary sowing



Sowing under cover

Cooperative harvesting



Market gardening

Main scientific issues to be addressed

A link between agronomy-ecology and robotics

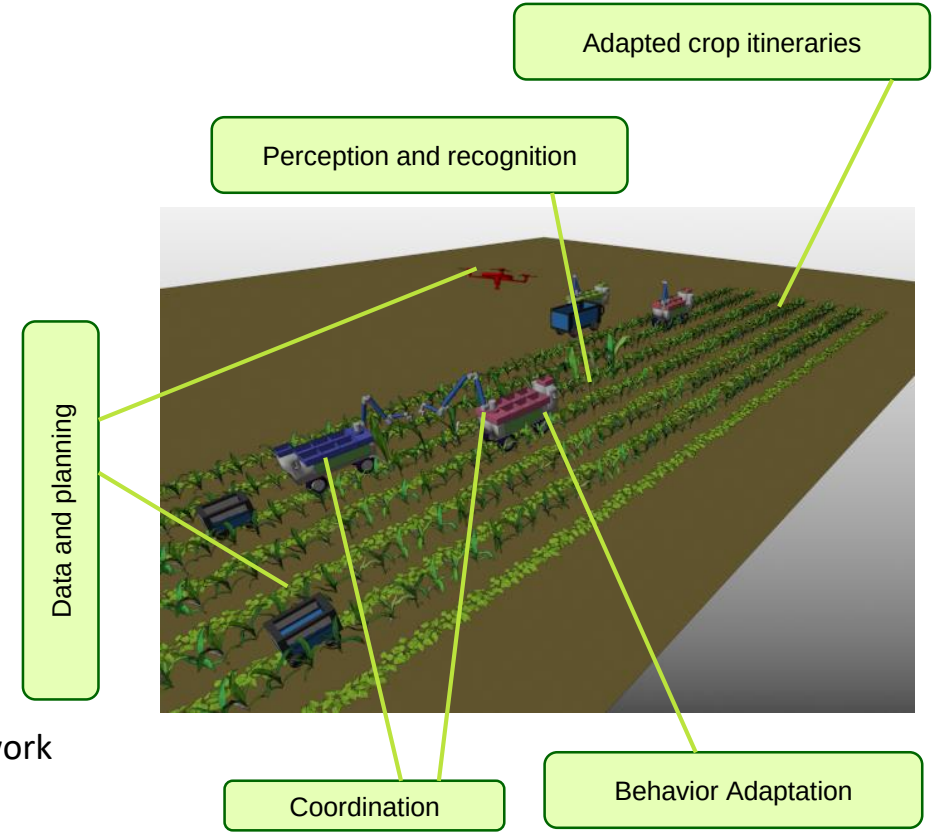
- How to take part of robotics in agroecological process
- Define key robotics behaviors to be improved
- Assess and improve environmental impacts

Robotics challenges

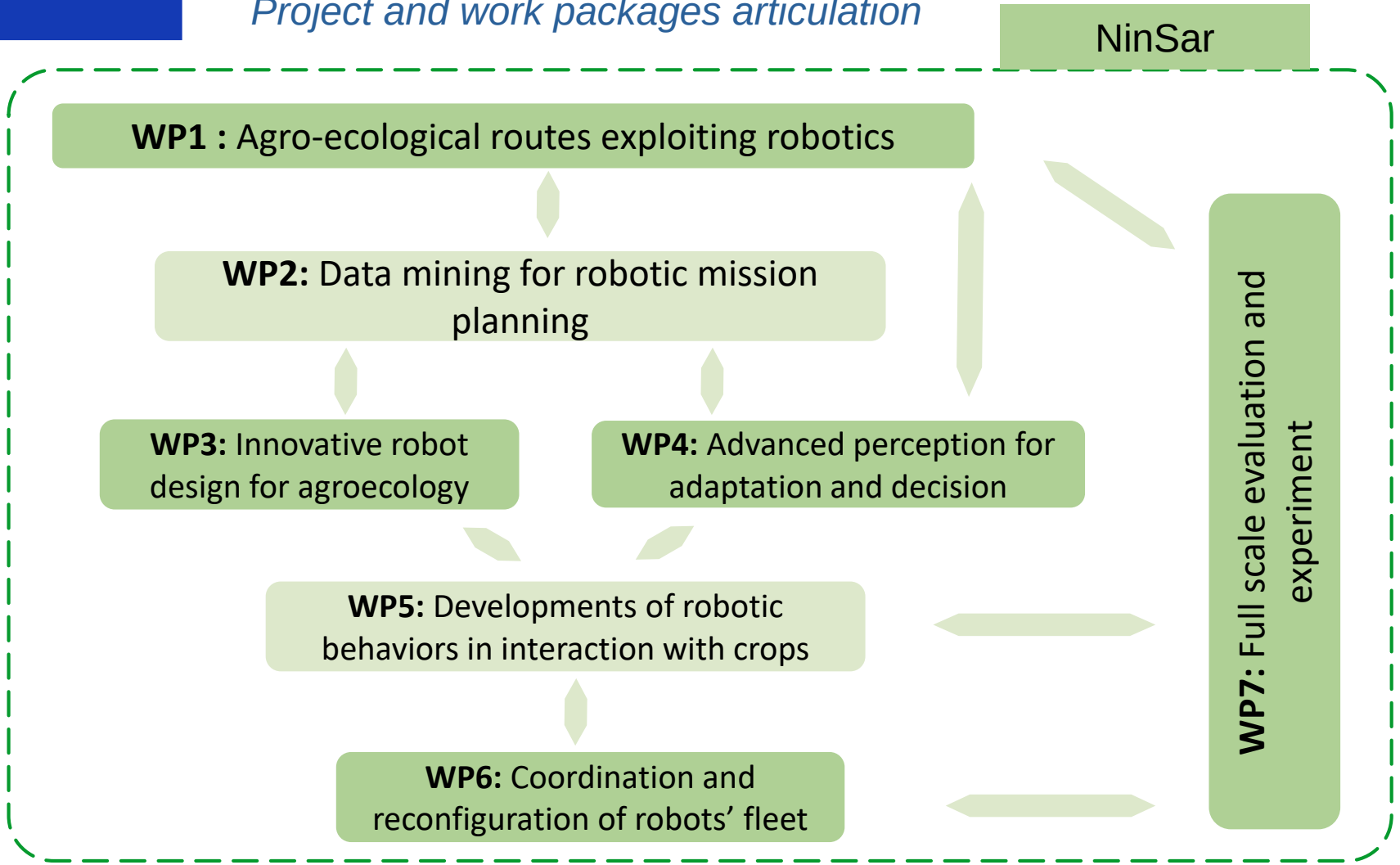
- Multi-robots and tasks planning
- Mobile manipulation
- Real time decision making and task allocation
- Multi-robots on-line reconfiguration
- Data processing
- Robots collaboration and association

Experimental and shared issues

- Shared material and algorithm through common framework
- Full scale and in field experiments
- Allowing to improve actual agroecological processes



Project and work packages articulation



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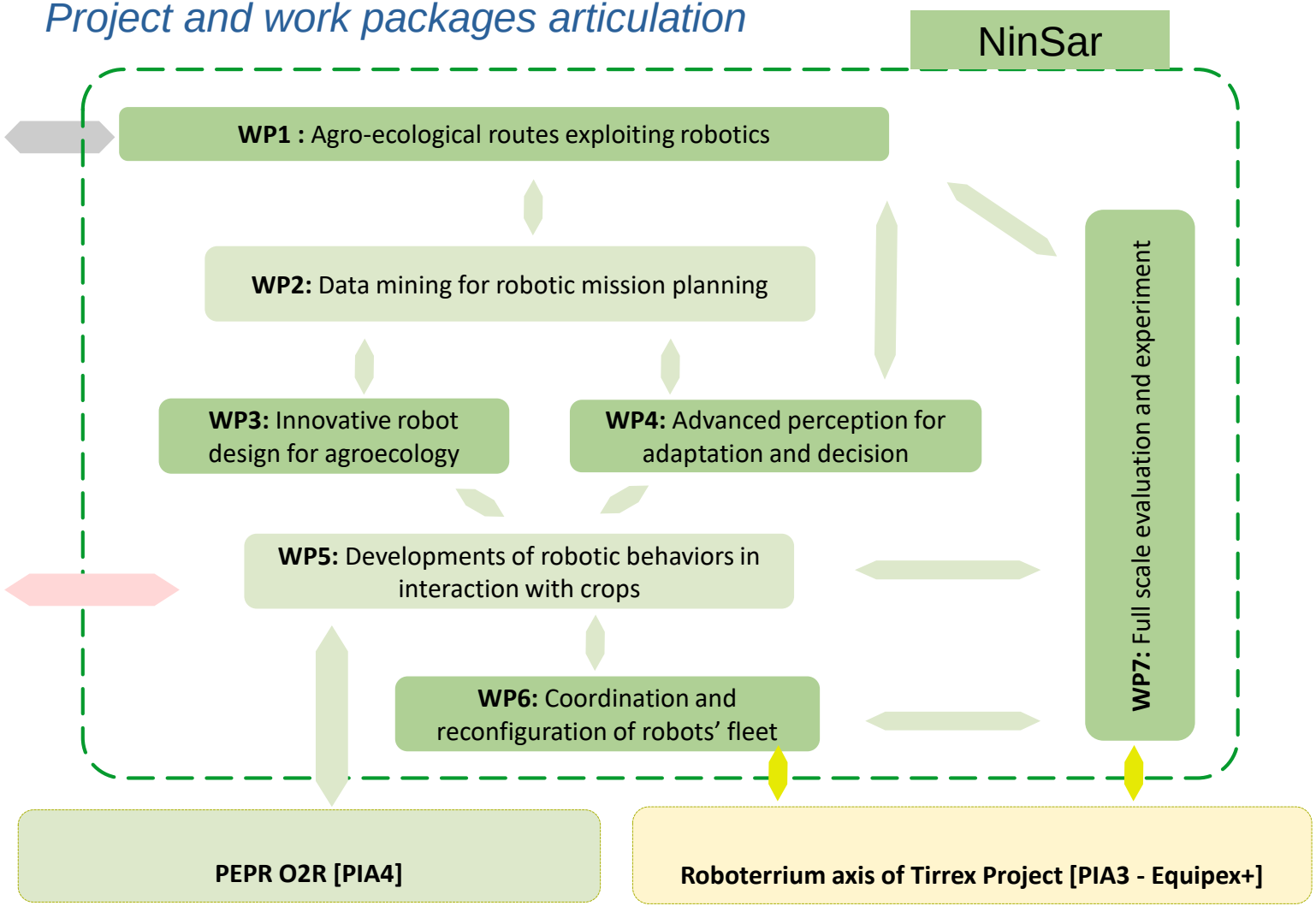


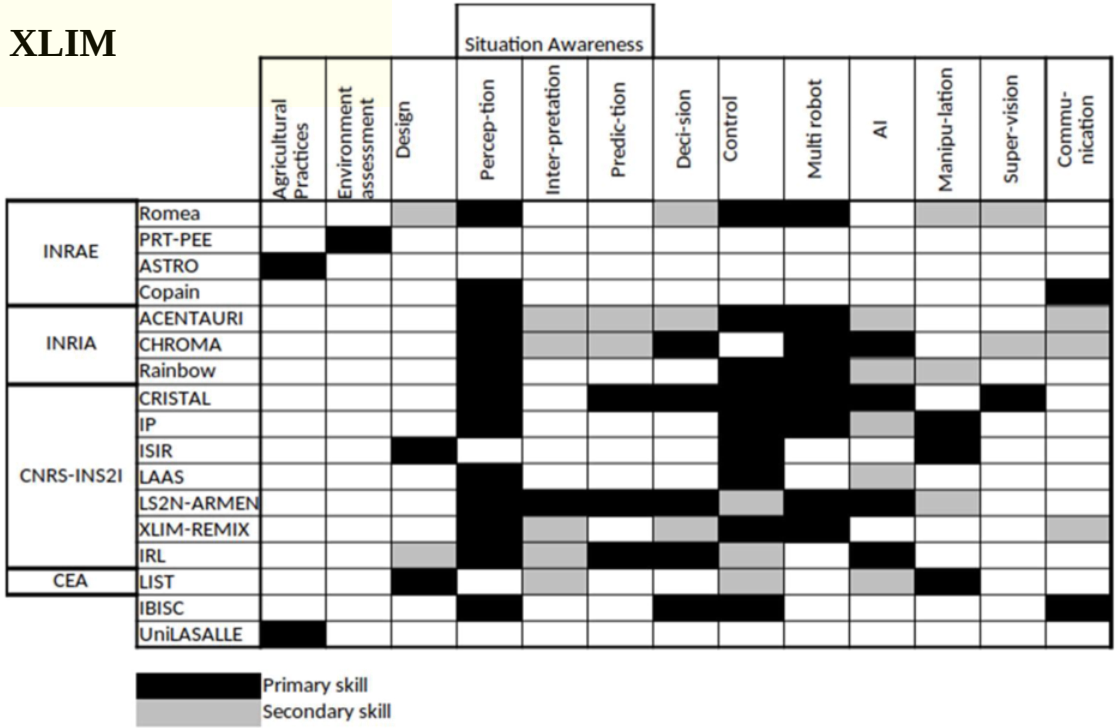
PEPR: Programmes et équipements prioritaires de recherche

Consortium

Inria	ACENTAURI	CHROMA	RAINBOW	
INRAE	ASTRO	COPAIN	PRE-RTT	ROMEA
cnrs	IRL	LAAS	XLIM	

CLERMONT AUVERGNE INP UCA	IP
Université de Lille	CRISTAL
SCIENCES SORBONNE UNIVERSITÉ	ISIR
CENTRALE NANTES	LS2N

université évry PARIS-SACLAY	IBISC
cea	LIST
UniLaSalle Institut Polytechnique	InTerACT UniLaSalle

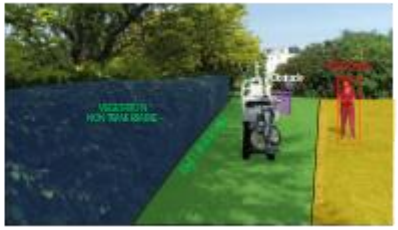


Partners expertise and achievement

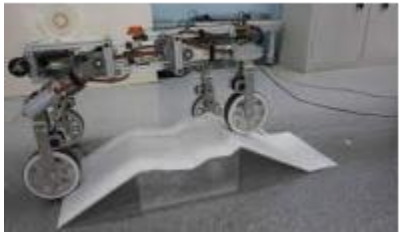
Agroequipment and environment assessment



Localization and environment recognition


Advanced autonomous navigation

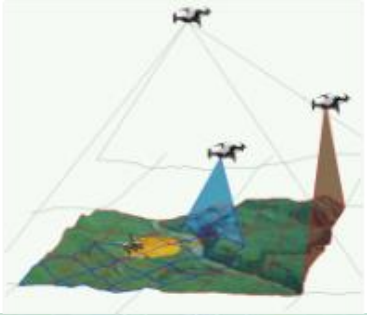



Mobile robots cooperation



Mobile manipulation and treatment


On-line adaptation and decision making

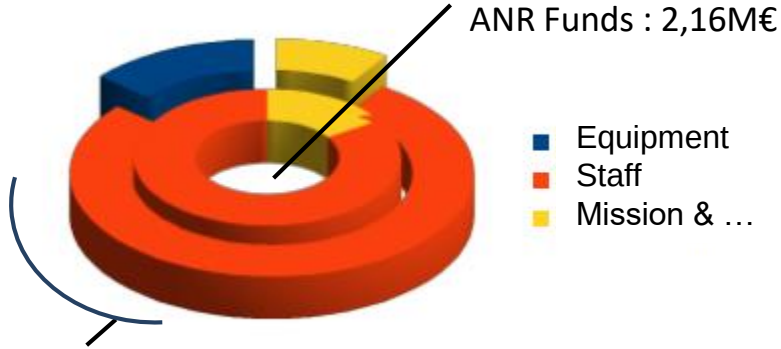




Project ressources

A project centered on human ressources sharing

- 6 PhD grants
- 5 Post doctoral Fellow
- 7 engineer contract
- > 50 permanent researcher involved

➡ Equipment aspects managed by roboterrium



Total labs contribution : 5,1M€

An unbalanced distribution of funds

- Pending on administrative aspects
- Representative of some aspects removal
- Showing labs interest in formal participation
- Agregation of expertise and knowledge

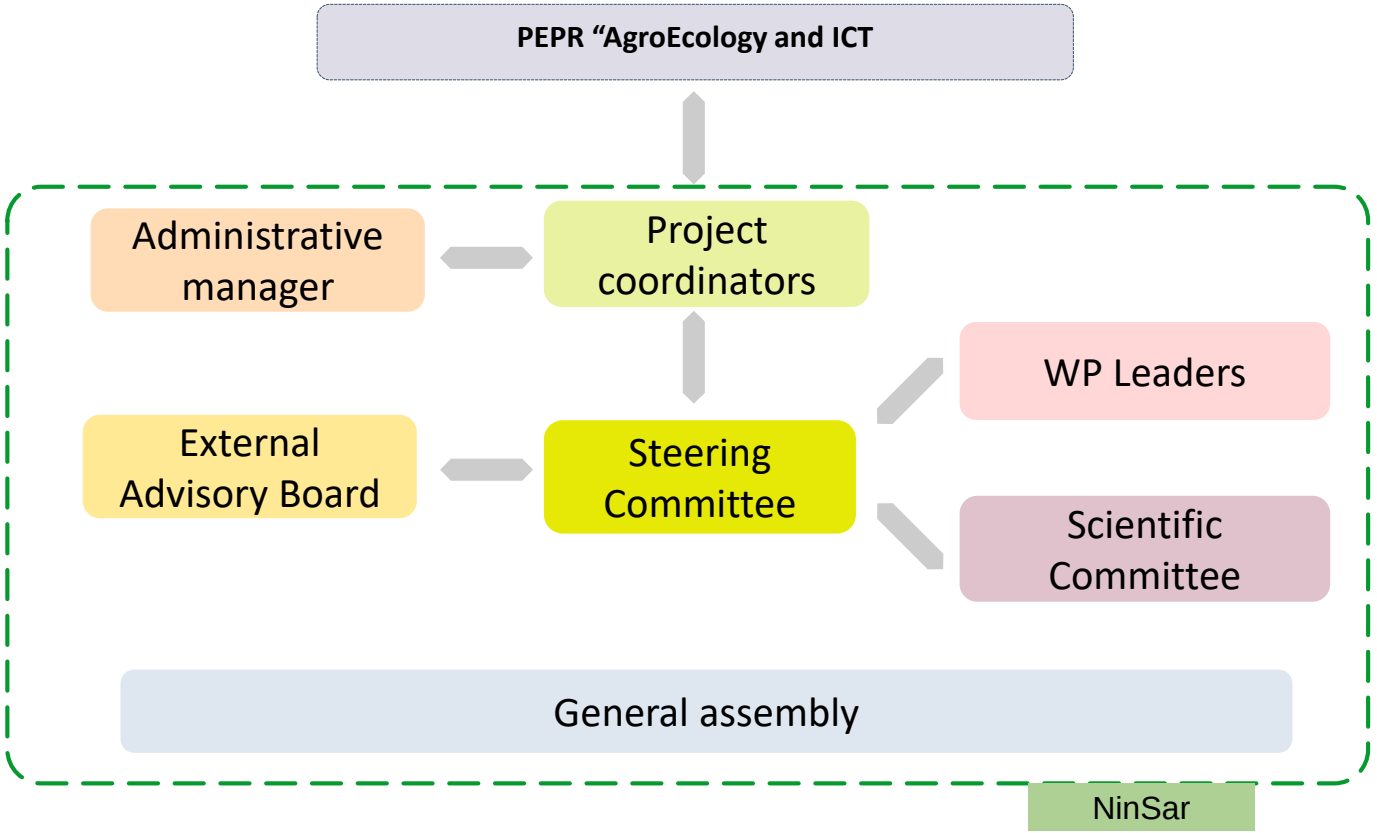
➡ A real collaborative dynamic

Fund sharing – 2,160k€

Project repartition regarding Workpackage

Type	Id	Dur.	Subject	WP	Funded Partner	Involved partners
IE	IE-A	12	Definition of metrics and evaluation metrics evaluation of robot works	1	INRAE-P	LaSalle, Astro
IR	IR-A	18	Iterative design of expected scenarios	1	Astro	LaSalle, INRAE-P
PhD	PhD-A	36	Contribution to achievement of agroecological routes using robotics	1(+2)	UniLaSalle	INRAE-C, Ideas
PostD	PD-A	12	Development and management of connected devices for field perception	2	INRAE-C	LaSalle + LPC
PostD	PD-B	12	Big Data Management	2	INRAE-C	INRIA-C
PhD	PhD-B	36	Muti-robots mission planning based on agronomic criteria	2	INRIA-C	IRL, XLim
IE	IE-B	12	Specification and design management of elementary robots	3	INRAE-R	All,
IE	IE-C	12	Specification and design management and connection review	3	ISIR	INRAE-R
PhD	PhD-C	36	Robust and shared localization in fields	4	LAAS	IP, XLim
PD-F	PD-C	18	Toward a semantic 3D mapping	4	IRL	LS2N, INRIA-A
PD-G	PD-D	18	Off-road environment recognition	4	LS2N	IRL, INRIA-A
IR	IR-B	18	Collection and standardization of autonomous and safe navigation approaches	5	INRAE-R	All
PhD	PhD-D	36	Mobile manipulation of soft object	5	IP	CEA, INRAE-R, ISIR
PostD	PD-E	12	Adaptation of autonomous navigation behavior parameters	12	CEA	INRIA-A, INRAE-R
IE	IE-D	12	Communication interface design and implementation	6	INRAE-C	Xlim, INRIA-CA
PhD	PhD-E	36	Autonomous selection of robotics behavior for mission achievement	6	INRIA-A	INRAE-R, CEA
PhD	PhD-F	36	Task allocation for multi-robots coordination	6	Xlim	INRIA-R, INRIA-C
IE	IE-E	48	Test and experimental validation and evaluation	8	INRAE-R	All

Project organization

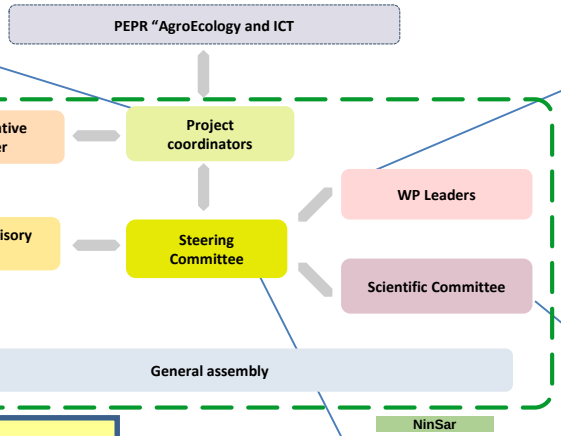


Project organization

Coordinators

P. Martinet
R. Lenain
Y. Perrot

J. Sainte-Marie
Claire Rogel-Gaillard



P. Martinet

WP Leaders
- WP1: Marco Medici [Marilys Pradel]
- WP2: François Pinet [Olivier Simonin]
- WP3: Roland Lenain [Faiz Ben Amar]
- WP4: Patrick Danès [Vincent Fremont]
- WP5 : Youcef Mezouar [Eric Lucet]
- WP6: Philippe Martinet [Ouiddad Labbani Igbida]
- WP7: Jean Laneurit [Marco Medici]

R. Lenain

Coordinators
Local coordinators
Scientific leaders
WP Leaders

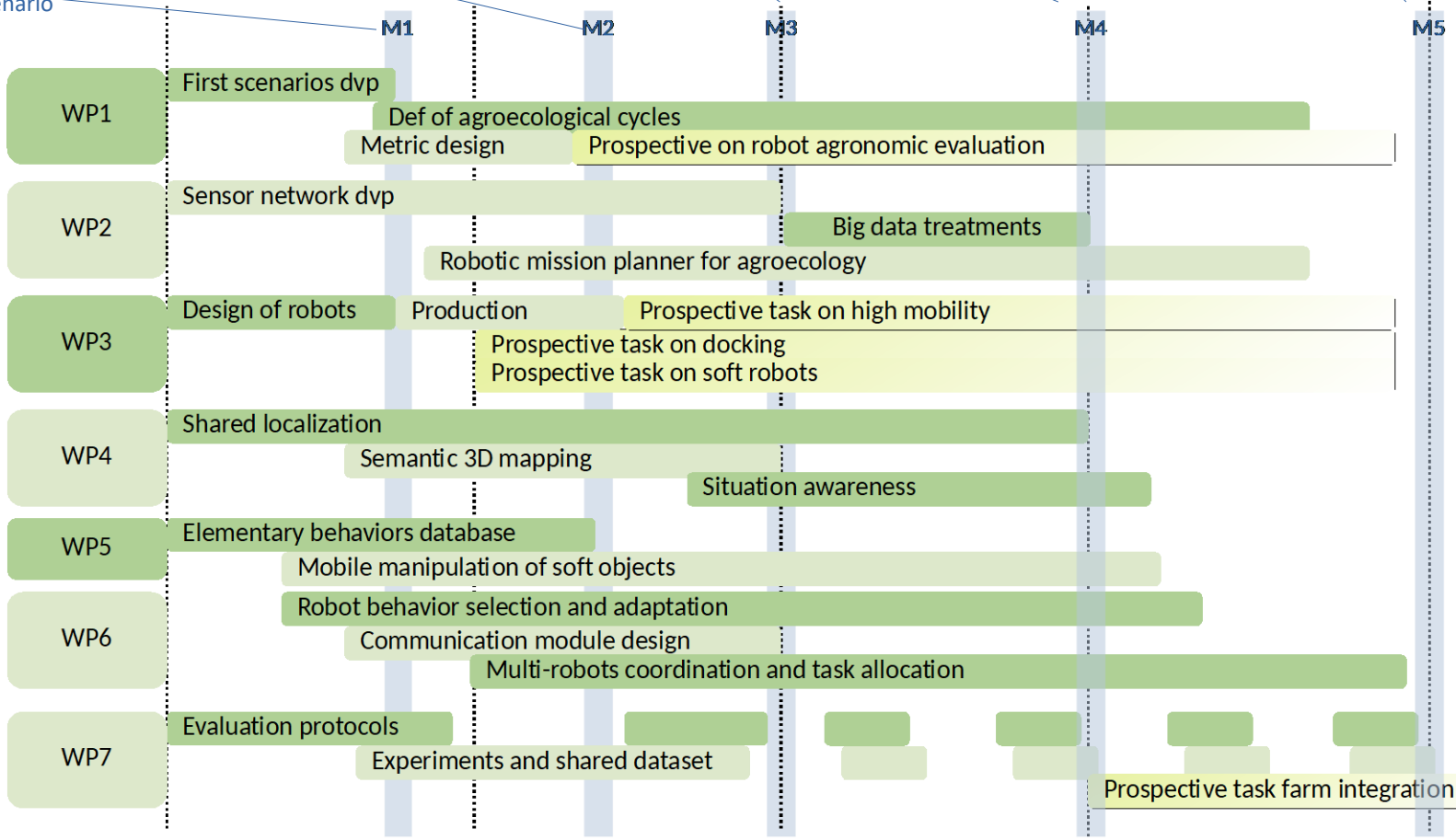
Y. Perrot

Coordinators
Local coordinators
WP Leaders

Christophe Aubé – AgreenCulture
Agronomy experts
- Marie-Hélène Jeuffroy
- Nicolas Munier-Jolain

Farmers representatives
- FN-CUMA – Stéphane Chapuis

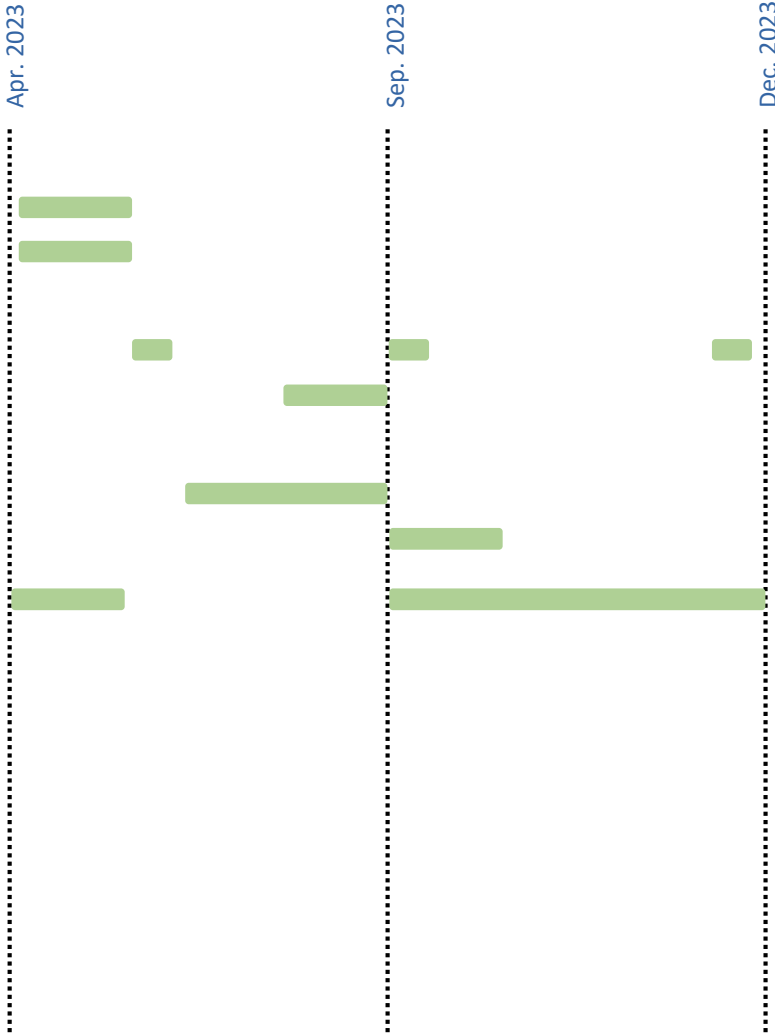
Project organization



Proposal of ST project organization

Short term actions

- Workpackages refined planning
  - PhD, PD, Engineer description
  - Short term planning of actions
- Definition of growing complexity of agroecological itineraries
  - Seminars on RobTech and Agroecology
  - Definition of evaluation metrics
- Material setup
  - Elementary robots Spec
  - Launching tender
  - Shared tool for development
- Communication aspects
  - Documents sharing
  - Logo projet
  - FIRA2024
  - ERF 2024
  - WS and Hackaton organization (link with GC)



Expected contributions and outcomes

Challenges centered on robotics

- Multi robots association
- Accurate and discriminate implement control
- Situation awareness and recognition
- Mobile manipulation of soft objects

➡ Generic contibutions for robots autonomy

Challenges centered on agroecology

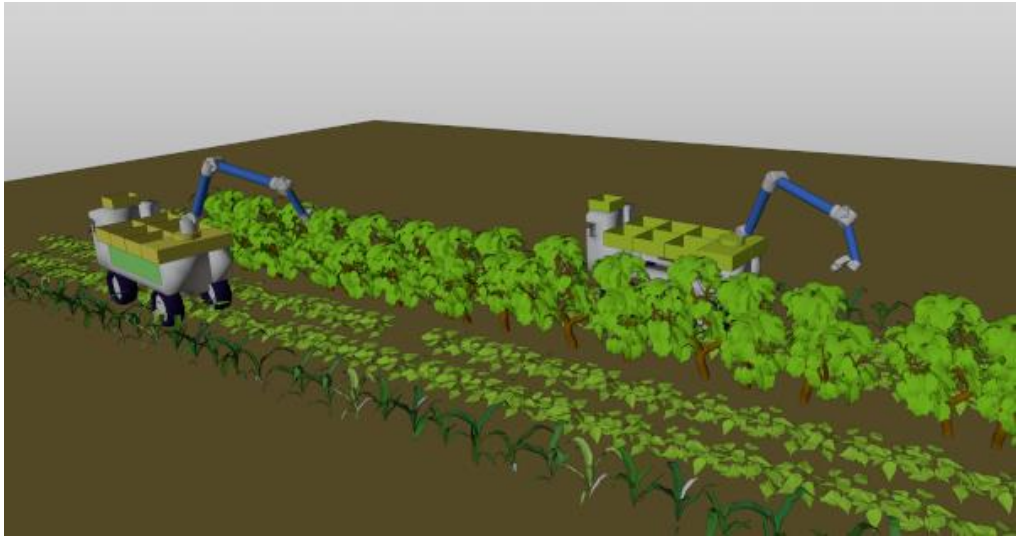
- Define new processes
- New robotics concept for agroequipment
- Short to long term outcomes
- Elementary validation of feasible itinaries

➡ Demonstrate full scale agricultural robots capabilities

Societal and common challenges

- Interdisciplinary projects
- Allowing to share forces and advances
- Shared works for a common application
- Agregation of expertise and knowledge

➡ A real collaborative dynamic for society



General Presentation

National task force

Sadea

PEPR – 60M€
Digital - Robotics - Genetic

AAP – BPI - 90M€

Grand challenge – 22M€
Maturation – Transfer - Structuration

Challenge – ??M€

AAP specific

Flagship projects

AAP Transfer

Devp. tools

PEPR "AgroEcology and ICT [Sadea]

NinSar

Grand Challenge "Robotics for AgroEcology" [Sadea]

Algo Dvp.

Robotics for ecological transition

Interactive mobile manipulation

PEPR O2R – Organic Robotics [PIA4]

Roboterrium

Tirrex Project [PIA3 - Equipex+]

AgroTechnoPôle

SADEA

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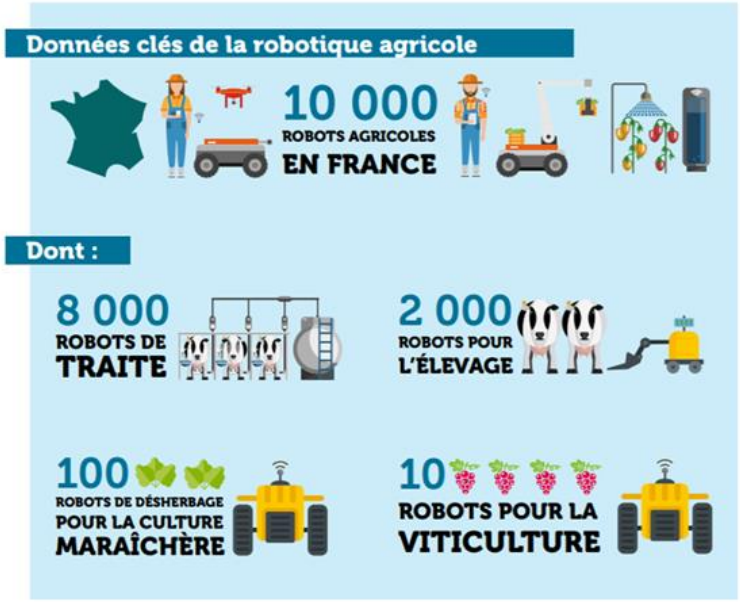
AgroTechnoPôle

Toward a national task force for developing actual robotics tools

- A societal need for new practices and tools

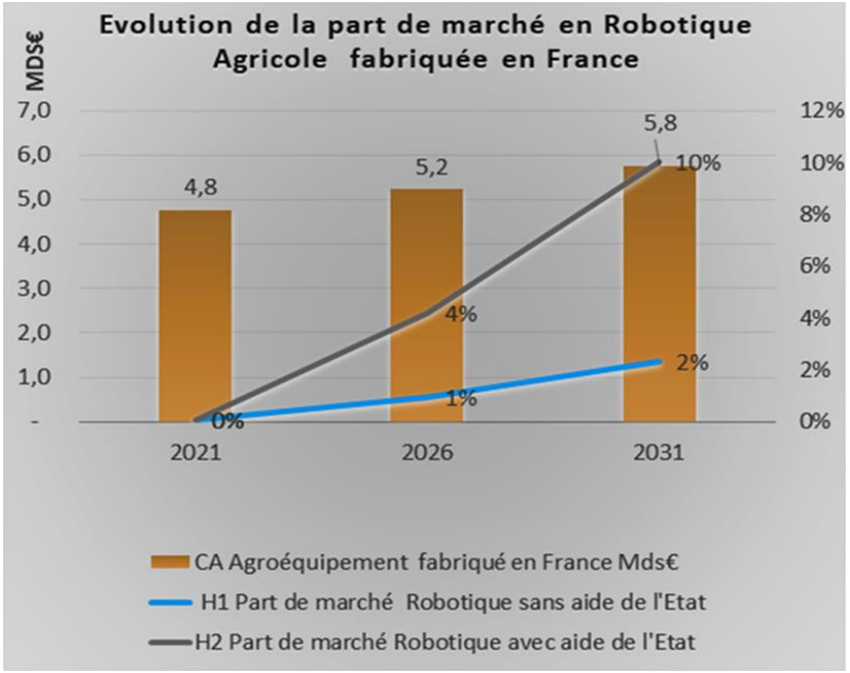


@Axema

Milking

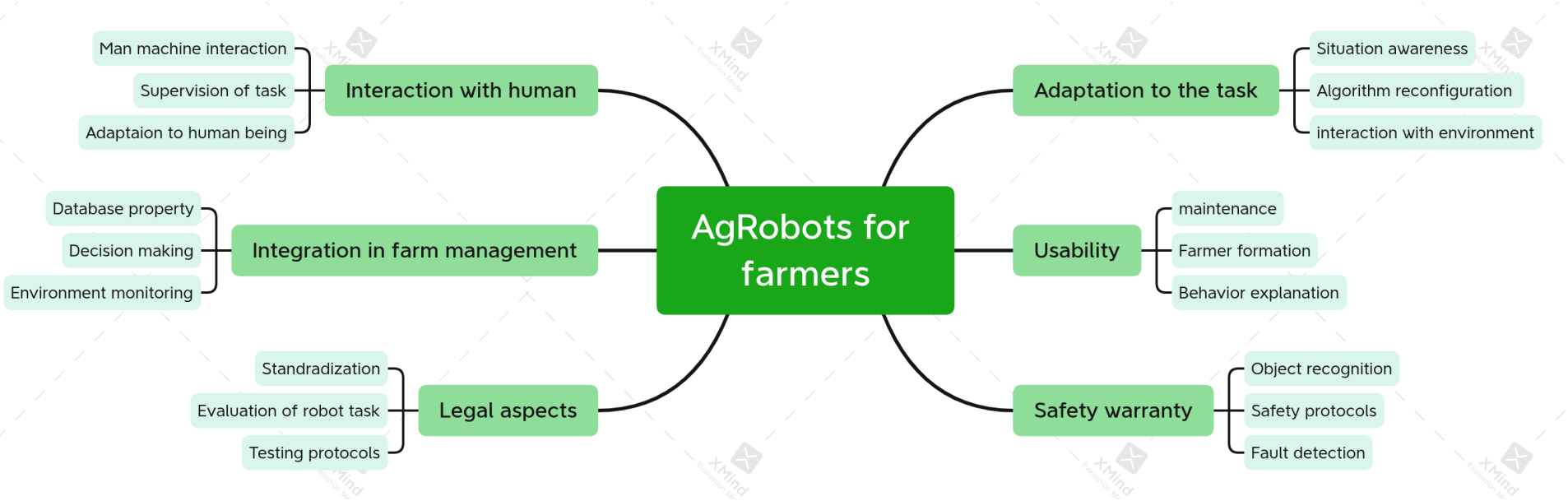
market gardening

breeding



Toward a national task force for developing actual robotics tools

- Several issues : scientific, legal aspects, actual access to market...



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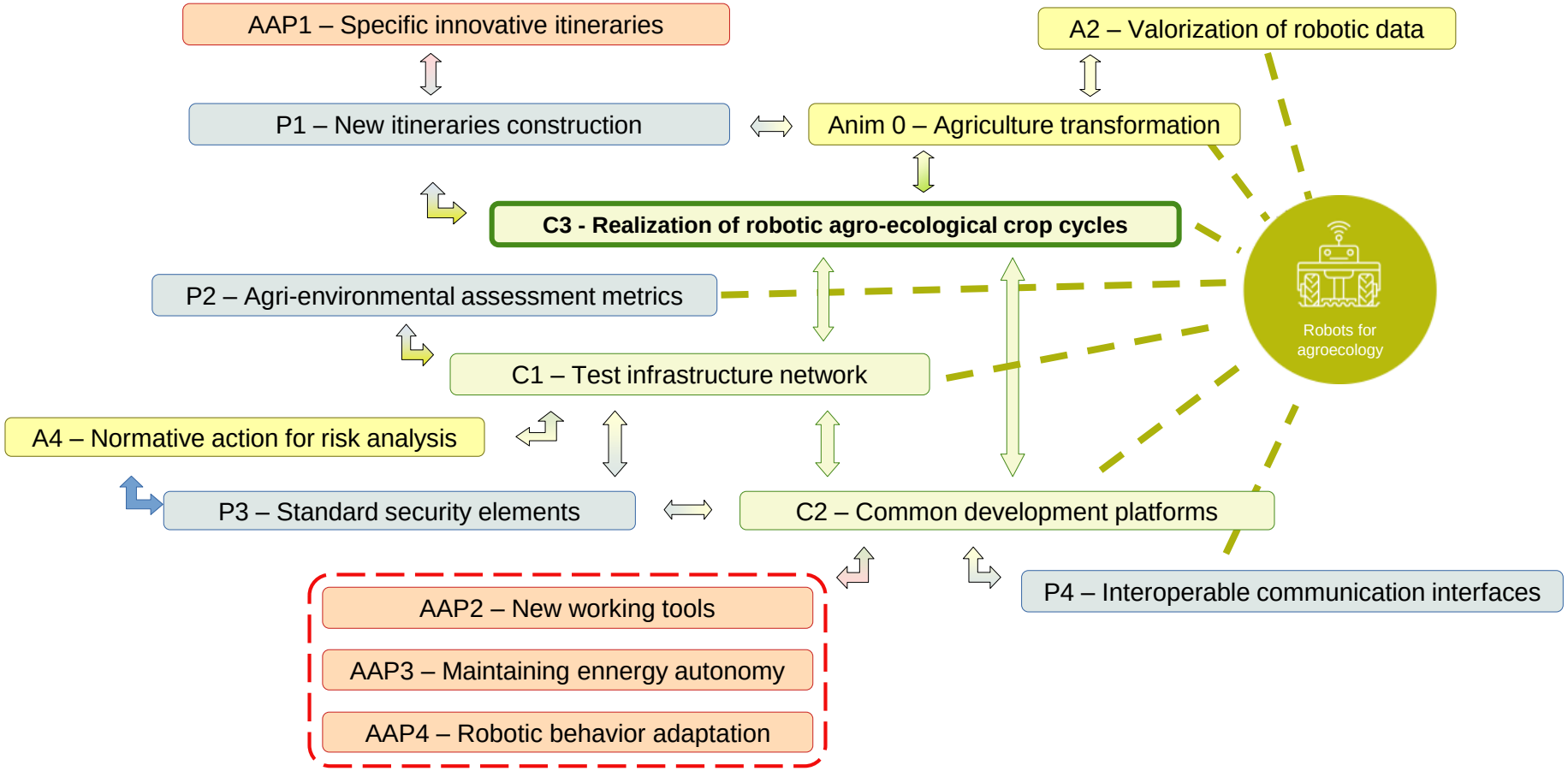


Example of a collective action

Safety Functions

Human detection

Integrity

...

Working group

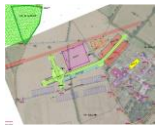
Datasets

Development

- Robust perception
- Sensor fusion
- ...
- learning
- Adaptive control
- Predicitive actions
- ...
- Control limitations

Robotic algorithms

Evaluation on infrastructure network



Shared forge

SADEA

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AgroTechnoPôle

A national initiative lead by CNRS/GdR Robotique – dedicated for robotics research

- XXL robotics
- Humanoid robots
- Aerial robotics
- Autonomous Land robotics
- Medical robotics
- Micro/nano robotics

Prototyping and design

Navigation - Manipulation – Interaction

Open infrastructure

A national initiative lead by CNRS/GdR Robotique – dedicated for robotics research

- XXL robotics
- Humanoid robots
- Aerial robotics
- **Autonomous Land robotics**
- Medical robotics
- Micro/nano robotics

Intelligent Autonomous vehicles


Virtuoz : a common modular and generic platform





Roboterrium : a set of generic off-road robots

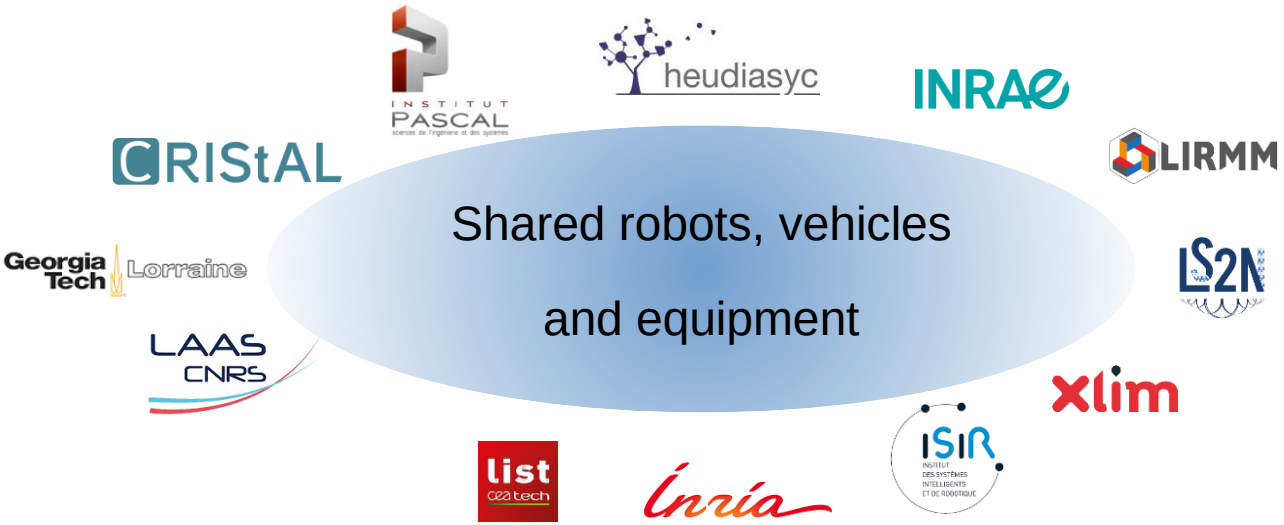
Agricultural robots

Prototyping and design

Navigation - Manipulation – Interaction

Open infrastructure

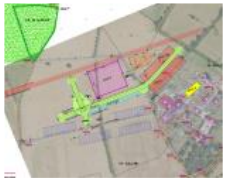
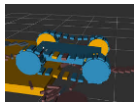
Partners involved in Rob@t action



Roboterrium : a robot vivarium to serve research and development

Shared robots, vehicles and equipment

A common site for agricultural robots




groTechnoPôle

Needs for research

- Off-road mobile manipulation
- Several locomotion modes
- Repetable environment
- Testing infrastructure
- Robots transportation capability

Equipment for safe testing and data acquisition

- Common simulation testbed, remotely accessible
- An algorithm database for perception and control
- Robots monitoring devices
- Prototyping tool




- Virtual twin
- Remote supervision for testing
- Datasets for replay

Available Equipment – ready to be shared

RE1. Robotized electric tractor – Alpo, SabiAgri - INRAE

Locomotion mode	2WS, 4WD
Weigth	800 kg (+500kg)
Size	2,5mx1mx 2,5m
Max Speed	2,5 m/s
Autonomy	4 H
Manipulation type	Not yet equipped?
On-boarded sensors pkg	RTK-GPS [Drotek], IMU [Xsens], Odometry, Lidar sick 1 layer

→ *Autonomy, Ag work, implement (Greenhouse, row navigation)*

RE2. Electric robot – Adap2E– INRAE

Locomotion mode	4WS-D
Weigth	550 kg (+100)
Size	2,5mx1,5mx1,5m
Max Speed	5m/s tested (th: 8m/s)
Autonomy	6 H
Manipulation type	UR10
On-boarded sensors pkg	RTK-GPS [Drotek], IMU [Xsens], Odometry, Lidar sick 1 layer

→ *Mobile manipulation, autonomous navigation*

RE3. Skid steer mobile manipulator – Campero platform - IP

Locomotion mode	differential
Weigth	400kg (20kg)
Size	1mx1mx1m
Max Speed	2m/s
Autonomy	1H30
Manipulation type	UR10
On-boarded sensors pkg	RTK-GPS [Drotek], IMU [Xsens], Odometry, 2 Lidar of 1 layer

→ *Mobile manipulation, autonomous navigation*

RE4. 2WS Robot – RobuFAST platform - INRAE

Locomotion mode	4WS-D
Weigth	550kg (10kg)
Size	1,2m
Max Speed	7m/s
Autonomy	2H
Manipulation type	none
On-boarded sensors pkg	RTK-GPS [Drotek], IMU [Xsens], Odometry, 2 Lidar of 1 layer

→ *High speed test, stability, regular ground*

RE5. 2WS mobile robot – Agilex Platform – LAAS

Locomotion mode	2WS
Weigth	150kg
Size	1,2*1*0,8m
Max Speed	2m/s
Autonomy	4H
Manipulation type	none
On-boarded sensors pkg	4 realsense, 1lidar

RE6. 2WS mobile robot – Cinteo –Xlim

Locomotion mode	Ackerman RWD
Weigth	190kg
Size	2,1*1,24*0,9
Max Speed	3,5m/s
Autonomy	12H
Manipulation type	none
On-boarded sensors	2 GPS RTK, IMU Xsens, 4 caméra (2RGB, 2NIR), 1 lidar3D

First equipment to be acquire

Acq 1 : legged mobile manipulator

Public consultation 29/03

Locomotion mode	Dog robot
Weigth	<50kg
Size	1*0,8*1m
Max Speed	>20km/H
Autonomy	>2H
Manipulation type	integrated
On-boarded sensors pkg	3D
Price idea	150k€

Acq 2 : tracked robot

Public consultation 29/03

Locomotion mode	Caterpillar
Weigth	<500kg
Size	<2x1,5x1,5m
Max Speed	>10km/H
Autonomy	>3H
Manipulation type	Cartesain 6Dof
On-boarded sensors pkg	Common pkg
Price idea	50k€

Acq 3 : Straddle – Unicycle, 4WD

Public consultation 29/03

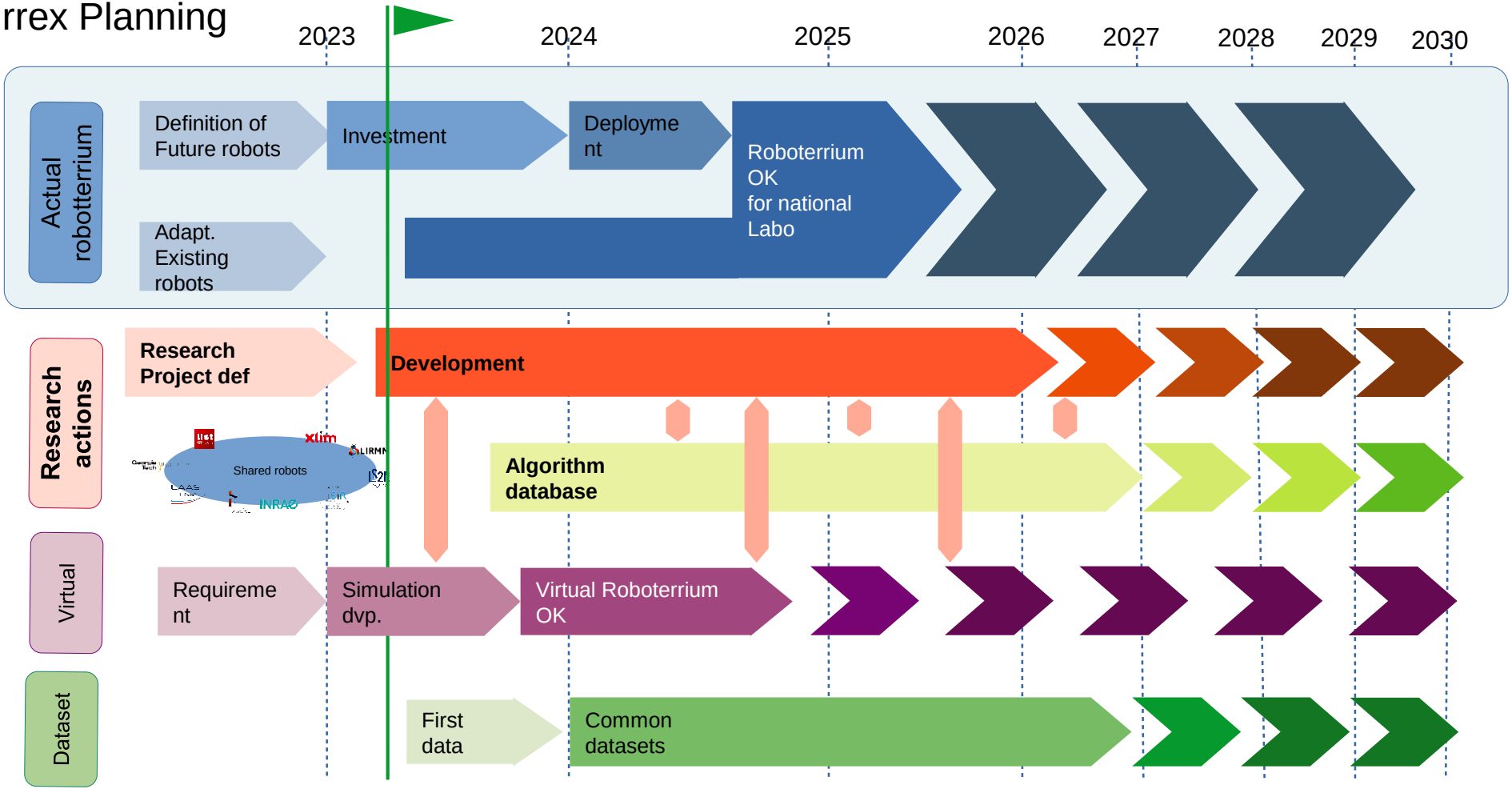
Locomotion mode	Unicycle -> 4WD
Weigth	<2,5t
Size	2,5*2*2m
Max Speed	>15km/H
Autonomy	>6H
Manipulation type	Cartesain 6Dof
On-boarded sensors pkg	Common pkg
Price idea	150k€

Acq 4. Fleet of elementary light mobile (manipulators)

TBD by Ninsar

Locomotion mode	?
Weigth	<100kg
Size	<1mx1mx1m
Max Speed	?
Autonomy	?
Manipulation type	?
On-boarded sensors pkg	?
Price Idea	?

Tirrex Planning



Robots and infrastructures access

Circle 1 : ANR contractors

Buy and own equipment

Circle 2 : Contributors
human resources or equipment

Referee and access equipment

Circle 3 : Potential users
Roadmap partners

Periodical access (challenges)

- Organisation of periodic joint challenge
- Related to the research roadmap

→ Show the complementarity between laboratories and scientific advances

- Common development tools
  - Numeric twins of equipment
  - Shared Libraries for robot control and algorithms
  - Sharing dataset

SADEA

Sadea

PEPR – 60M€
Digital - Robotics - Genetic

AAP – BPI - 90M€

Grand challenge – 22M€
Maturation – Transfer - Structuration

Challenge – ??M€

AAP specific

Flagship projects

AAP Transfer

Devp. tools

PEPR "AgroEcology and ICT [Sadea]

NinSar

Grand Challenge "Robotics for AgroEcology" [Sadea]

Algo Dvp.

Robotics for ecological transition

Interactive mobile manipulation

PEPR O2R – Organic Robotics [PIA4]

Roboterrium

Tirrex Project [PIA3 - Equipex+]

AgroTechnoPôle

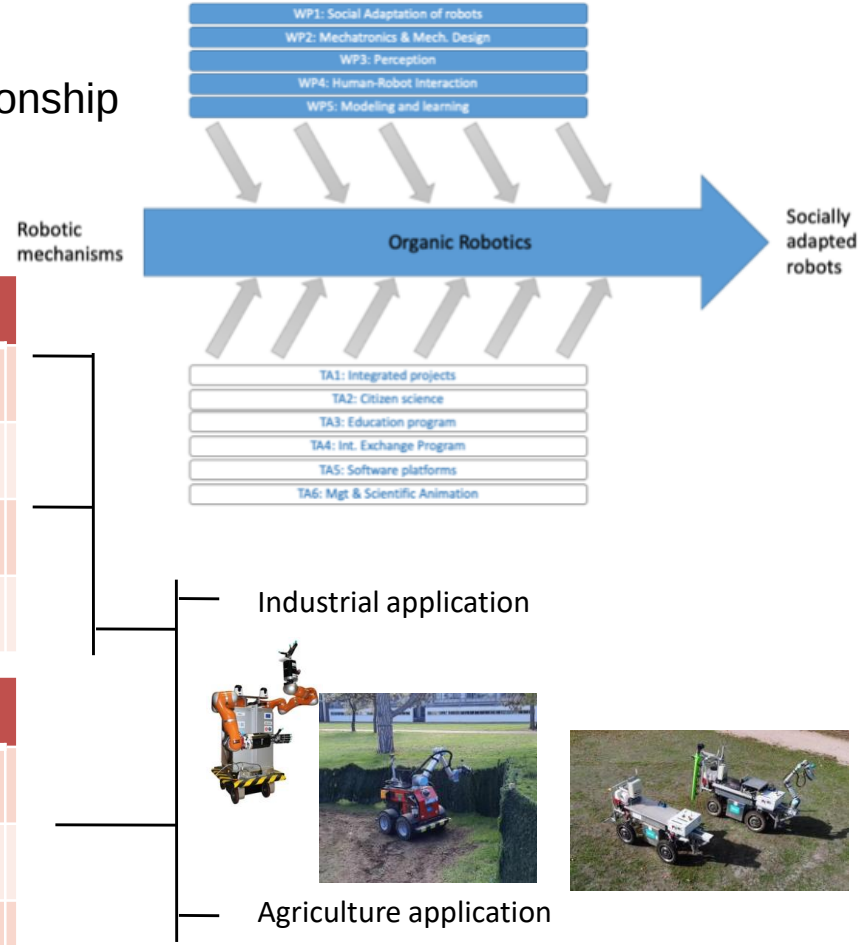
Global framework and objectives

Toward the design of robotics adapted to social relationship

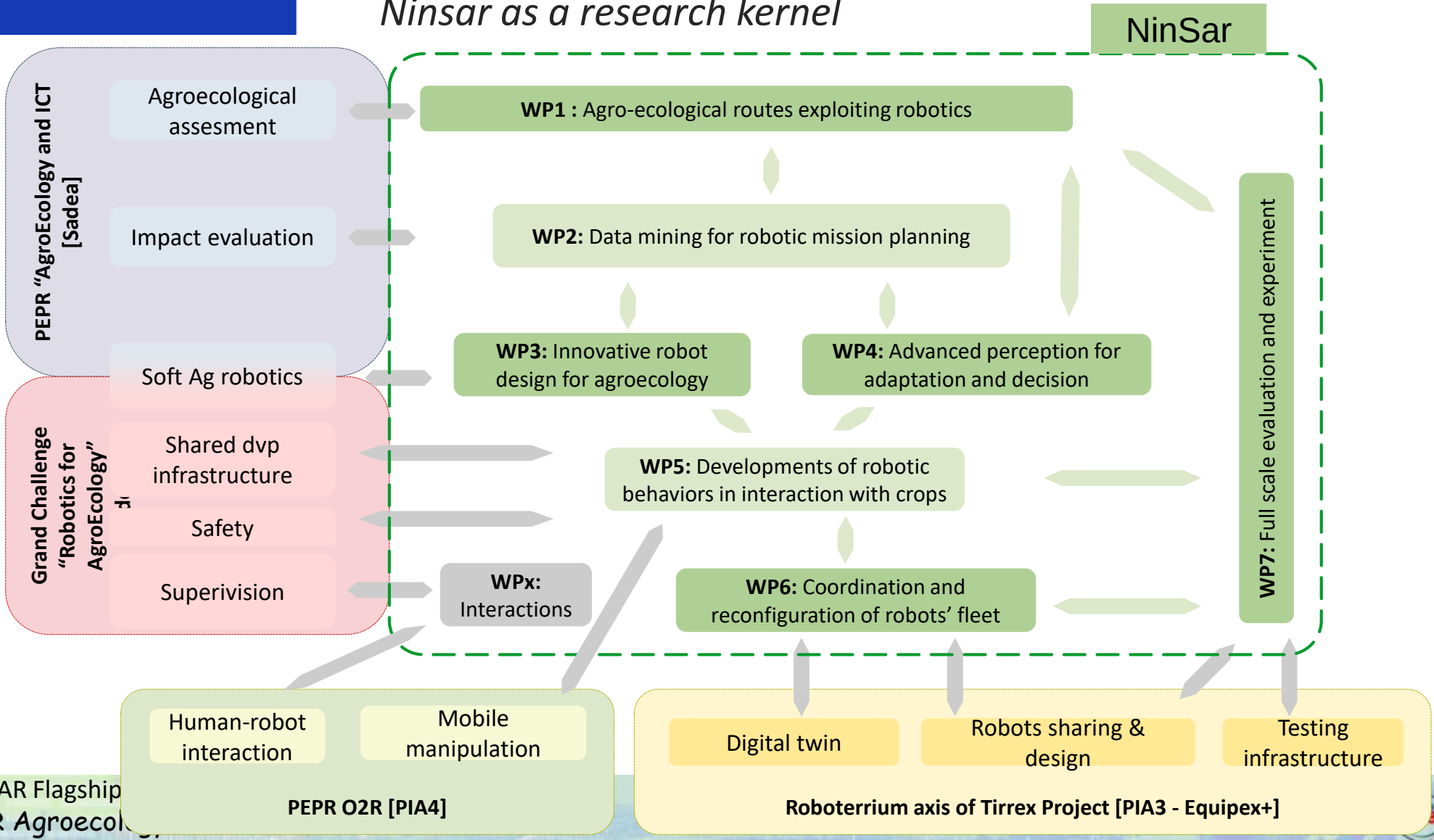
Desgining flagship project

4 Actions structurantes
Material, architecture and embodied intelligence
Robot motion with physical interactions and social adaptation
Decision, learning and social interactions
Multi-physics, multi-scale, simulation, biomechanics

3 projets intégrés
Sensori-motor extensions
Interactive mobile manipulation
Robotic assistance to human movements



Ninsar as a research kernel



A National Task Force

New tools for new practices

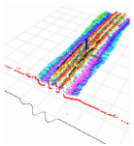
Farmers | Technical Institutes | Manufacturers | Solutions providers | Researchers

Societal challenges

- ✓ Ecological Transition
- ✓ Acceptability and usability
- ✓ Integration and exploitation
- ✓ New practices setup

Technical challenges

- ✓ Perception of the environment
- ✓ Operational safety
- ✓ Cost and robustness



Scientific challenges

- ✓ Robots behaviours adaptation
- ✓ Interactions with vegetation
- ✓ Autonomous systems safety

New robotic technologies available for Agroecological transition

prototypes | Maturation | Challenges | Grand Challenge | PEPR

Sadea : Innovate to succeed agroecological and food transitions