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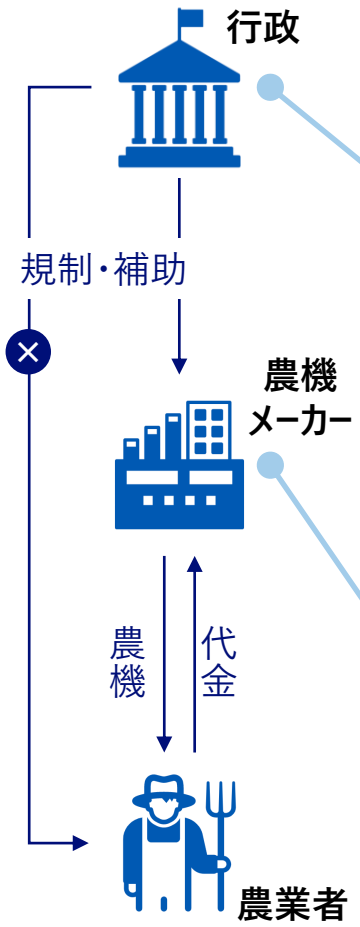
世界的にスマート農機の開発は活発化してきており、諸外国の政府は主として研究開発を資金面で支援することにより流れを加速化させている

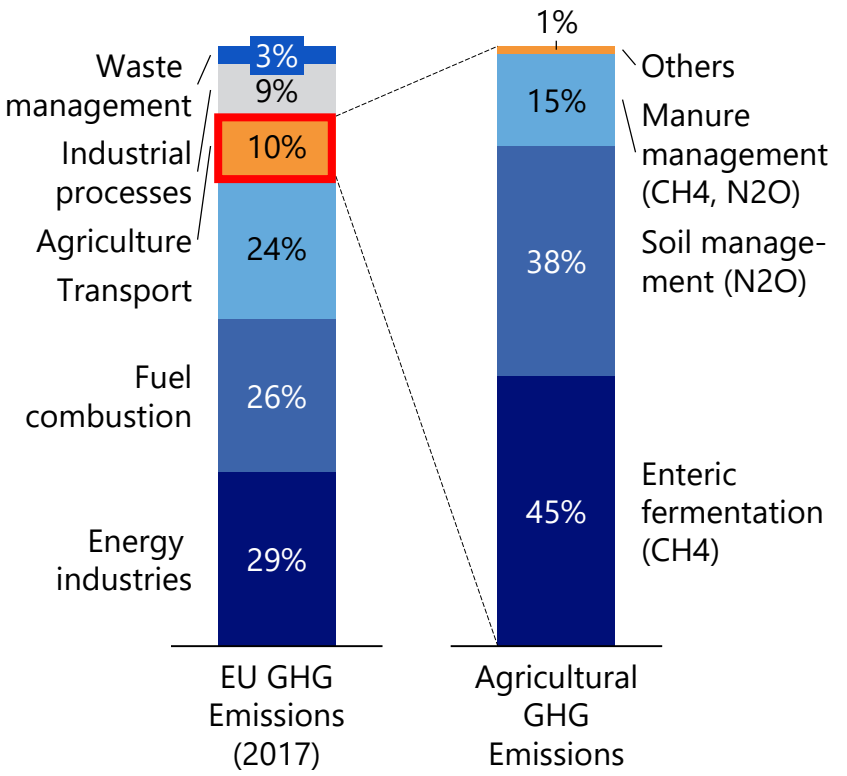


	現状	今後のトレンド（想定）
行政	● 諸外国におけるスマート農機の普及促進に資する政策は、農機メーカーの研究開発に対する資金支援が中心 イタリア (EU) ：農業向けの研究開発支援プログラムが機能 イスラエル　　：先端技術開発向けの基金より補助金を拠出 ● 農業者に対してスマート農機の導入を促すような直接的な施策（自動車で言うエコカー減税/補助金や排出ガス規制等）は実施されていない	● 普及促進のための施策の中心は、今後も当面は農機の研究開発への支援 ● 一部海外で進む自動車の販売・利用に係る規制強化の動きが、農業分野に波及する可能性はある
農機メーカー	● 諸外国において研究開発の盛んなスマート農機は、収穫作業の支援ロボット等であり、特にセンサー、アルゴリズム、マニュピレータ関連への注力が目立つ ● 果樹分野での研究開発主体は、多くが中小事業者 ● 海外における農機関連のビジネスモデルは、売り切り型（製品自体を売る）のではなく、サービス型（製品が生み出す付加価値を売る）が主流になりつつある	● 主要な研究開発分野は、今後も収穫作業の支援に主眼を置いた支援ロボット ● ビジネスモデルについては、サービス型を前提としつつ、各種スマート農機の特性に合わせて、さらに多様化する可能性がある

スマート農機に関する政策

EUにおける農業からのメタンやN2O等のGHG排出量は全体の10%を占める 削減のための戦略方向性も提示されているが、全体に占める石化燃料由来のCO2のシェアは少ないため、化学肥料の削減やその他領域によりフォーカスがあてられている

EU Agricultural GHG Emissions



Note: Fuel combustion excludes energy industries and transport. Transport includes road, rail, water (domestic) and air (domestic and international).

Source: European Commission

Agricultural Sector GHG Reduction Strategies

Efficient production	Reduce direct emissions (CH4, N2O)	Reduce emissions from livestock and fertilisers via appropriate farming practices
	Reduce fossil fuel intensity	Reduce energy and agrochemical inputs in agricultural production
	Reduce agricultural production losses and waste	Efficient production will reduce GHG emissions
Carbon sinks	Provide carbon sinks	“Capture” carbon organically in soil
	Sustainable production of biomass	Production of biomass for replacing fossil carbon (e.g. fuels, plastics, etc.)

「Green Deal」では、電力・輸送・建物業界からのCO2削減貢献が大きいと予想されている農業関連では、Clean Energy 領域として、農業廃棄物の再利用が主要トピック

■ 欧州の「Green Deal」は、「2050年気候中立目標（温室効果ガスの実質排出ゼロ）」を達成しつつ経済成長も実現する。

Green Deal Overview (1/3)

戦略	概要	対応する産業	リサイクル・環境汚染との関連

Clean Energy	• Prioritise energy efficiency and develop a power sector based largely on renewable sources
	• Secure and affordable EU energy supply
	• Fully integrated, interconnected and digitalised EU energy market
		• Power
		• Industry
		• Agriculture
			• Create a more circular energy system by
			  • Encouraging the reuse of waste heat from industrial sites and data centres
			  • Incentivising the use of agriculture residues to produce sustainable biogas and biofuels
			• Enable carbon capture, storage and use

Sustainable Mobility	• 90% reduction in greenhouse gas emissions in transport* by 2050	• Transport	• Ending subsidies for fossil-fuels • Extending emissions trading to the maritime sector • Boost supply of sustainable alternative transport fuels • Stricter standards on car pollution • Reduce pollution in EU ports • Improve air quality near airports
Building and Renovating	• Better energy performance of buildings	• Construction	• Design of buildings should be in line with the circular economy

*Transport in Europe refers to road, rail, water and air. There is no CO2 policy that specifically targets agricultural machinery.

Source: European Commission

持続可能な産業構築の中で、３Rの方針が掲げられている
それらの大方針にもとづき、EVバッテリーは重量ベースでの5割をリサイクルを目指すとしている

Green Deal Overview (2/3)

戦略	概要	対応する産業	リサイクル・環境汚染との関連

Sustainable Industry	• New industrial policy based on the circular economy
	  • Industries must be helped to modernise and exploit opportunities domestically and globally.
	  • Stimulate the development of new markets for climate neutral and circular products.
		• Energy-intensive industries such as steel and cement
		• Resource intense sectors such as textiles, construction, electronics, plastics
			• The decarbonisation and modernisation of energy-intensive industries such as steel and cement.
			• ‘Sustainable products’ policy that prioritises reducing and reusing materials before recycling them.
			• All packaging in the EU is reusable or recyclable by 2030
			• ‘Take-back’ schemes which will incentivise people to bring back their electronic devices for recycling.
			• Digital sector for monitoring of air and water pollution as well as how energy and natural resources are consumed

Battery Recycling in the EU

Batteries Directive

- EV batteries should not be disposed in landfill sites or by incineration.
- EV batteries should achieve a minimum recycling efficiency of 50% by mass.
- Extended Producer Responsibility: OEMs are responsible for ensuring that battery is recycled (actual process can be outsourced to third parties).

Strategic Action Plan on Batteries

- Secure access to secondary raw materials through recycling batteries
- Promote sustainable battery value chain in a circular economy context.
- Conduct further R&D on battery recycling
- Analyse how to promote the second use of advanced batteries

Source: European Commission

その他農業に関連する戦略方針では、環境汚染を最小化に焦点があてられている

Green Deal Overview (3/3)

戦略	概要	対応する産業	リサイクル・環境汚染との関連
Farm to Fork	• Access to healthy, affordable and sustainable food • Tackle climate change • Protect the environment and preserve biodiversity • Fair economic return in the food chain • Increase organic farming	• Agriculture	• Circular bio-based economy (e.g. biogas from agriculture waste and residues) • Reduce the use and risk of chemical pesticides by 50% by 2030 • Reduce fertiliser use by at least 20% by 2030
Biodiversity	• Establish protected areas for at least 30% of land and sea in Europe • Restore degraded ecosystems at land and sea across Europe	• Agriculture • Forestry	• Increasing organic farming and biodiversity-rich landscape features on agricultural land • Reducing the use and risk of pesticides by 50% by 2030
Eliminating Pollution	• Zero-pollution action plan to prevent pollution of air, water and soil	• Agriculture • Manufacturing • Heavy industry • Chemicals	• Prevent pollution of air, water and soil • Reduce pollution from excess nutrients • Reduce particularly harmful pollution from micro-plastics and pharmaceuticals • Reduce pollution from large industrial installation • Improve prevention of industrial accidents • Develop more sustainable alternatives to dangerous chemicals

Source: European Commission

イタリアの農業研究戦略では、スマート農機の研究開発は主に労働力や農薬等の農業投入の最小化を目指している

Strategic Plan for Innovation and Research in the Agricultural, Food and Forestry Sector (2014-2020)

Strategic Areas for Research and Innovation	スマート農機開発事項
1. Sustainable increase in productivity, profitability and resource efficiency in agro-ecosystems	Precision spraying of agropharmaceuticals
2. Climate change, biodiversity, soil functionality and other ecological and social services of agriculture	ICT systems that can optimise machine operations and reduce energy inputs
3. Coordination and integration of supply chain processes and strengthening of the role of agriculture	Mechanisation/automation of pruning, thinning, harvesting
4. Quality, typicality and safety of food and healthy lifestyles	Organic farming machines (e.g. for sowing, mechanical weeding, harvesting, monitoring, etc.)
5. Sustainable use of biological resources for energy and industrial purposes	Precision irrigation – crop water sensors and irrigation robots
6. Development and reorganisation of the knowledge system for the agricultural, food and forestry sectors	Engines and agricultural machines that can use innovative biofuels of various kinds

Source: MiPAAF

イタリアでは、「Rural Development Programme」の中に、「Operational Groups」が存在しており、農業関連の研究開発支援の補助金を拠出している

- 国（例：National Research Programme）と地域（例：各大学の研究補助金）レベルの研究補助金が存在する。
- 「Rural Development Programme」は国と地域レベルでスマート農機を含めて多数のの農業研究開発プロジェクトを支援する。

Operational Groups概要

Name	Operational Groups (funded by the Rural Development Programme)
Budget	EUR 112 million across 352 projects, as of 2020
Project size	Average ~EUR 300,000
Focus	Innovation projects tackling specific issues and opportunities according to the needs of the agricultural and forestry sector. Innovations must be more ago resource efficient, productive, low emission, climate-friendly, and resilient and operate in harmony with the essential natural resources on which farming depends.
Target	Minimum of 2 entities, such as farmers, research institutions, businesses, consultants, etc.

Source: EIP AGRI

（参考）「Operational Group」にて選定、支援が行われたプロジェクト

■ イタリアのスマート農機開発は主に収量・品質の向上を目指している。対象作物は値段が高いオリーブとブドウである。

スマート農機 Operational Groups

Topic	Description	Target crop	Time-frame	Budget	Objective
Operating group for the diffusion of autonomous robots connected to DSS for the sustainable and efficient management of the vineyard (ROVITIS 4.0)	Rovitis 4.0 aims to demonstrate the feasibility of **robotic vineyard management** through a system of robots, sensors and software in order to minimise human labour. The project will field test 2 robot prototypes that will carry out treatments, processing, mowing and data collection.	Vineyards	2018-2020	EUR 587 thousand	Labour reduction, pesticide reduction, yield improvement
Increased olive productivity through artificial pollination (OLIMPOLLI MONTAGNANI)	The project will compare 2 **pollination** methods – manual pollination by farmers and via programmed **drones** with flight routes calibrated for each plant. If drone dispersion is effective, it can be provided as a paid service to farmers in the future.	Olives	2019-2021	EUR 363 thousand	Yield improvement
Digital Viticulture in Tuscany (DigiViT)	This project will develop a **drone** prototype to collect ultra-high resolution images, which will be analysed by an operational tool that can **forecast yields and quality**.	Vineyards	2019-2022	EUR 220 thousand	Yield improvement
Precision agriculture: reduction of the environmental impacts of production systems	This project will develop a **drone spraying system** to combat plant diseases. The drone will also be used to **check the state of the plant** and perform **precision fertilisation** operations. The field test will be carried out on olive trees.	Olives	2019-2021	EUR 385 thousand	Yield improvement, pesticide/ fertiliser reduction

Source: EIP AGRI

（参考）「Operational Group」にて選定、支援が行われたプロジェクト

Name	Rovitis 4.0
Developer	Giorgio Pantano Farm, Terre Grosse, Confagricoltura Veneto, Energreen, CREA, University of Maribor, CIRVE, CET Electronics
Country	Italy
Target crop	Vineyards
Function	Plant monitoring, spraying
Power source	NA
Status	Prototype
Description	• ROVITIS is an autonomous driving robot that can collect data from vineyards and carry out treatments based on the data. Precise treatment can be carried out, thus optimizing resources, minimizing environmental impact and reducing labour. • ROVITIS is intended to be a cost-effective solution that can work for estates smaller than 20 hectares. 

Name	OLIMPOLLI MONTAGNANI
Developer	CAICT SRL, CNR IBE, University of Siena, Tenuta Montagnani, Mascagni Organic Farm, Olearia Santella, Green Company Siena/Grosseto, University of Florence, Aermatica 3D, Biotac
Country	Italy
Target crop	Olives
Function	Pollination
Power source	Battery
Status	Prototype
Description	• A drone outfitted with special equipment is used to distribute pollen to plants at the time when flowers are most receptive to pollination. • Assisted pollination is expected to increase yields by up to 20-25%. • This solution can be easily implemented by farmers without changing their business structure. 

Source: EIP AGRI

（参考）「Operational Group」にて選定、支援が行われたプロジェクト

Name	DigiViT
Developer	CNR IBE, Ama Castle, Marchesi Mazzei SpA Agricultural, Cennino Agricola, Sigma Ingegneria srl
Country	Italy
Target crop	Vineyards
Function	Plant monitoring
Power source	Battery
Status	Prototype
Description	• This project will develop a prototype drone that can take very high-resolution images of vineyards with its high-performance sensors. • The images will be analysed by an operational tool that will forecast yields and quality. 

Name	Precision agriculture: reduction of the environmental impact of production systems
Developer	Adriatic Agricultural Consortium Cooperative Society, ASSAM, Filippetti spa, Pegaso Management srl, Green Company Marche, Marche Polytechnic University
Country	Italy
Target crop	Olives
Function	Spraying, plant monitoring
Power source	NA
Status	Prototype
Description	• This project will develop an aerial spraying system (drone) to fight against plant diseases. • The drone will also be able to monitor the status of the fruit and carry out fertiliser interventions.

Source: EIP AGRI

限られた資源や国土の中で食料需給率を高める必要があることから、イスラエルでは、農業効率向上、汚染の削減、農地保全を目的にスマート農機の活用を進めている

持続可能農業戦略目標	スマート農機の位置づけ
Efficient use of resources and materials in agricultural activity	Efficient agricultural machines can reduce the amount of input required for (energy, fertilisers, pesticides, labour, water)
Reduction of agriculture related hazards and damage to the environment.	Precise and targeted spraying reduces the use of pesticides and fertilisers that damage the environment.
Preservation of agricultural land and soil conservation	Light agricultural robots can reduce soil compaction and prolong field lifespan.

Source: United Nations

スマート農機への特定の資金スキームはなく、一般的な技術支援の枠組み内で個別プロジェクト毎に承認・支援が行われる

- Israel Innovation Authorityは、研究から商業化までのプロジェクトに資金を提供する独立した公的機関である。
- ヨーロッパとは異なり、イスラエルにはスマート農機の研究開発に特化した特別な資金はないが、R&D FUNDやMAGNETプログラムなどの有望な技術革新に対するR&D基金を利用することができる。
- さらに、イスラエルは自動的にHorizon 2020からの資金提供の対象となり、EU加盟国と同じ条件でプロジェクトに参加できる。

Israel Innovation Authority Funding Programmes

Division	Description	Programmes (non-exhaustive)
Startup	The Startup Division offers unique tools to support the early developmental stages of technological initiatives at the pre-seed or initial R&D stages, thus helping transform their ideas into reality while reaching significant funding milestones.	• Incubators Incentive Programme • Innovation Labs Program - Incentive Programme • Tnufa (Ideation) Incentive Programme • Early Stage Companies Incentive Programme
Growth	The Growth Division operates incentive programmes that assist hi-tech companies in the sales growth stage as well as mature hi-tech companies that utilise growth channels based on technological innovation and/or seek assistance in funding innovative research and development.	• Incentive Programmes for Innovation with Government Entities • Generic R&D Incentive Programme for Large Companies • R&D Fund
Techno-logical Infra-structure	The Technological Infrastructure Division focuses on funding applied R&D infrastructure, promoting applied research in academia, technology transfer, Leveraging R&D for Dual Use Technologies, exchange of knowledge and experience and developing of ground-breaking innovation by an integrated group of researchers from academia and industry.	• TELEM (The National Infrastructure Forum for Research and Development) • Applied Support of Research Institutes • Promoting Applied Research in Academia - NOFAR, KAMIN • Technology Transfer - MAGNETON • Generic Technologies R&D Consortiums - MAGNET • Users' Association R&D Infrastructure

Source: Israel Innovation Authority

欧州等の海外諸国ではスマート農機はまだ商業化の初期段階にあり、主に研究開発活動への補助が主要な支援施策として行われている。一方で、スマート農機に特定したプログラム等は存在せず、幅広く農業や一般技術支援の枠組みを活用した支援となっている。

	Key strategy (Agriculture /Technology)	Financial Support		Non-Financial Support
		Agriculture-specific R&D Support	General R&D Support	
EU	• "Farm to Fork"	• Horizon2020 research themes for agricultural digitalisation/robotics	• Eurostars • COSME	• Development of broadband infrastructure in rural areas • Knowledge exchange platforms such as AKIS at EU/national level • Data sharing via Farm Sustainability Data Network etc.
Italy	• "Strategic Plan for Innovation and Research in the Agricultural, Food and Forestry Sector"	• Rural Development Programme	• National Research Programme • Individual university research grants	
Israel	• *NA*	• Incentive Programmes for Innovation with Government Entities • Horizon2020 participation	• Israel Innovation Authority Funding Programmes such as R&D Fund, etc.	• *NA*

スマート農機の開発状況

ヨーロッパとイスラエルにおいて、果樹園芸のスマート農機は労働集約的な事業プロセスの代替を目指されており、特に収穫関連の開発がさかんに行われている

形態／事業プロセス		圃場・果樹整備	作物育成	防除	収穫
移動型ロボット＋車両	汎用性高い		BYELAB UniBZ Mamut Cambridge Vitirover Vitirover Solutions S55 HGM SWEEPER Wageningen UR FFRobot FF Robotics VINBOT Robotnik TED Naio Octinion Rubion BACCHUS AUTH		
	汎用性低い	MYCE_Vigne WALL-YE			
ドローン	大型		Spraying drone Drone4Agri	AGRO AirBoard	Tevel Tevel Aerobotics Tech
	小型	eBee SQ senseFly	Skyx Skyx		

Source: company websites, news articles

スマート農機は依然として人間のように適切は判断を行うことができないため、センサー、アルゴリズム、エンドエフェクターの速度と感度の向上に研究の焦点が当てられている

- スマート農機は人の労働に匹敵する競争力を確保するために、より良い意思決定を行い、より速くより正確に動くことができる必要がある。
- スマート農機の人件費に対する費用対効果も改善する必要がある。

Field operation	Future research direction	Example H2020 project for technology
Field preparation (Seeding, pruning, etc.)	• Increase planting accuracy (in position/depth/number of planted seeds) • Improve speed of planting operation • Develop algorithms that can decide on the best way to manage the plant • Improve dexterity of machines to carry out pruning quickly and accurately without plant damage	• A gardening robot for rose, hedge and topiary trimming (TrimBot2020) • Rapid tree-planting through the use of remote sensing and unmanned vehicle planting technologies for large scale reforestation (BioCarbon)
Field scouting and data collection (disease detection and plant monitoring)	• Develop image databases for each disease to train the robots • Develop sensors that can work better in non-uniform lighting conditions • Develop better algorithms that can interpret large amounts of image data and inconsistent lighting/intrusive backgrounds • Develop systems that can detect insects hidden in leaves	• Precision Farming of Hazelnut Orchards (PANTEHON) • Intelligent decision from vineyard robots (VineScout)
Weeding and spraying	• Increase speed and accuracy of weed detection • Increase performance by increasing working area and speed • Increase spraying speed and detection accuracy of plants that need spraying	• Weeding robot for precision farming reducing herbicide usage by 95% (Asterix) • RObotics for Microfarms (ROMI)
Harvesting	• Improve speed of picking • Improve detection rate of ripe fruit • Reducing damage to plant and/or picked fruit	• Sweet Pepper Harvesting Robot (SWEEPER) • The first high-performance robotic system for automated harvesting of vegetables greenhouses (GRoW)

Source: Agricultural Robotics for Field Operations, news articles

スマート農機におけるコスト削減の取組みは、複数のタスクを実行できる多目的ロボットの開発による実現が目指されている

- 作物生産サイクル内では、ほとんどのフィールド作業は短期間に実行され、年に1～2回しか実行されない。また、これらの期間は通常すべての栽培者で同じである。従って、ロボットを購入して共有することは現実的な選択肢ではない可能性がある。
- ロボットシステムは、複数のフィールド操作用に設計することにより、生産者にとってより手頃な価格にすることができる。フィールドで様々なタスクを実行するために異なった器具を装備できるロボットプラットフォームが開発された。

Robotic platformの事例

Bosch Deepfield Robotics（DEU）

- Bosch develops BoniRob as farming robot that can perform various tasks with one unit.
- It can not only monitor crops as measurement and health analysis, but also fertilise, water and weed by exchanging modules.
- Price: N.A.

Saga Robotics（NOR）

- Thorvald is an autonomous modular robot that can be configured for most agricultural environments. It can perform tasks such as picking fruits and vegetables, phenotyping, spraying, and data collection.
- Price: N.A.

Clearpath Robotics（CAN）

- Clearpath Robotics develops unmanned robotic platforms that can be equipped with different sensors, cameras and actuators to carry out different tasks.
- The Warthog robot is the base for FF Robotics' apple harvesting robot.
- Price: US$12-20k (Jackal robot; 20kg payload)

Autonomous Systems, Inc（USA）

- The Forge Robotic Platform is designed for use with over 100 attachments such as mowers, blades and sprays.
- ASI works together with CNH Industrial (major European tractor company) to bring autonomous control to farm equipment.
- Price: N.A.

Source: company websites news articles

スマート農機の研究と促進には、官民様々な機関が参画している
主要なプレーヤーは汎用性の高いロボットに注力する傾向がある

■ スマート農機の研究と促進には、民間と公共の両方が参加している。主要なプレーヤーは、ロボットプラットフォームや幅広いアプリケーションを備えたスマート農機に注力する傾向がある。一方で、果樹園のロボットはよりタスク固有で、汎用性が低い傾向がある。

主要な研究開発機関（民間／公共）

Category	Name	Description
Machinery manufacturers	CNH Industrial	CNH is a Dutch MNC that designs. Produces and sells agricultural equipment. Together with ASI, they are developing autonomous tractors with the ability to seed, plant and till broad acre and row crops. CNH is also exploring connected vehicles with Microsoft's Azure cloud.
	Bosch Deepfield Robotics	Bosch is a leading German engineering and technology company that has developed BoniRob, a robotic platform that can be adapted for many agricultural applications, such as weeding and spraying.
	John Deere	John Deere is a leading agricultural machinery manufacturer. The MyJohnDeere platform is a centralised, online platform that allows third parties to consolidate and manage farming data.
Research institutes	Wageningen University and Research (UR)	Wageningen UR has more than 60 engineers and researchers working together with industrial partners on new robotic systems for agri and food, specialising in artificial intelligence and sensing, learning and vision.
	Fraunhofer Institute of Manufacturing Engineering and Automation IPA	Fraunhofer IPA develops and offers agricultural robotics solutions for undefined and dynamic environments, ranging from navigation software for field swarm cooperation to machine vision and new small-scale robot concepts.
	Agricultural Research Organisation	The Agricultural Research Organisation is the largest institute in Israel involved in agricultural research. Its main functions are to assist the Israeli farmer in solving problems, to conduct research and development in promising new agricultural fields and food sciences, and to plan, organise and implement agricultural research in Israel.
Non profit organisations	CEMA (European Agricultural Machinery Association)	CEMA's goal is to advance agricultural machinery and solutions for sustainable farming. The CEMA network represents both large MNCS and European SMEs active in the sector.
	EurAgEng (European Society for Agricultural Engineers)	EurAgEng supports scientists and engineers working in the field of Agricultural and Biosystems Engineering in Europe. They promote collaboration between academic and industry research.
	euRobotics aisbl	euRobotics aisbl is a non-profit association for all stakeholders in European robotics that aims to boost robotics research, development and innovation and to foster a positive perception of robotics. euRobotics is currently engaged in the preparation of the Horizon Europe programme (2021-2027).

Source: company websites news articles

果樹園芸のスマート農機の開発目的は重要度順で労働力の削減、収量・品質の向上と農薬最小化による環境汚染の回避となっている。以下は、主要な機器の例。（1/2）

■ 果樹園芸専用のスマート農機は非常にコストがかかるため、ブドウ畑やイチゴなどの価値の高い作物や、非常に労働集約的な収穫に焦点を当てた開発が行われている。

Name	Developer	Country	Field operation				Target crop	Status*	Power source	Main objective		
			Field prep	Field scouting	Weeding/ spraying	Harvest				Yield	Labour	Environ-ment**
BAKUS	VitiBot	FR	x		x		Vineyards	C	Battery		x	x
MYCE_Vigne	WALL-YE	FR	x	x	x		Vineyards	C	Battery; solar charged		x	x
Xf-Rovim	Polytechnic University of Valencia	ES		x			Olive trees	P	Gel battery	x		
BYELAB	University of Bolzano	IT		x			Orchards	P	Battery	x		
PANTHEON	Roma Tre University	IT		x			Hazelnuts	P	Battery	x		
Mamut	Cambridge Consultants	UK		x			Orchards	P	NA	x		
VINBOT	Robotnik Automation SLL	ES		x			Vineyards	P	Lithium battery	x		
OUVA	Polariks	NL		x			Vineyards	P	NA	x		
VineScout	Polytechnic University of Valencia	ES		x			Vineyards	P	Battery; solar charged	x		
eBee SQ	senseFly	CH		x			All crops	C	Battery	x		
UX11Ag	Delair	FR		x			All crops	C	Battery	x		
mdLiDAR	Microdrones GmbH	DE		x			All crops	C	Battery	x		
Skyx	Skyx	IL		x	x			C	Battery	x	x	x
TED	Naio technologies	FR			x		Vineyards	C	Lithium battery		x	x

*P: Prototype; C: Commercial, PC: Pre-commercial　　**Environment: Agrochemical reduction, not CO2 reduction

Source: company websites, news articles

果樹園芸のスマート農機の開発目的は重要度順で労働力の削減、収量・品質の向上と農薬最小化による環境汚染の回避となっている。以下は、主要な機器の例。（2/2）

Name	Developer	Country	Field operation				Target crop	Status*	Power source	Main objective		
			Field prep	Field scouting	Weeding/ spraying	Harvest				Yield	Labour	Environ-ment**
Vitirover	Vitirover Solutions	FR			x		Vineyards	C	Battery; solar charged		x	x
AgriRobot	Innovate Integra Ltd	UK			x		Orchards	P	NA		x	x
S55	Holland Green Machine	NL			x		Greenhouses	C	NA		x	x
Agribot	Agribot sp	PL			x		Orchards	C	NA		x	
Spraying drone	Drone4Agro	NL			x		All crops	C	Lithium battery		x	
AGRO	AirBoard	LV			x		All crops	C	Lithium battery		x	
BACCHUS	Aristotle University of Thessaloniki	GR		x		x	Vineyards	P	Lithium battery	x	x	
E-Series	Agrobot SL	ES				x	Strawberries	PC	Battery		x	
Strawberry harvesting robot	Dogtooth Technologies	UK				x	Strawberries	P	NA		x	
Rubion	Octinion	BE				x	Strawberries	C	NA		x	
Raspberry harvesting robot	Fieldwork Robotics	UK				x	Raspberries	P	Battery		x	
Cucumber harvesting robot	Wageningen UR	NL				x	Cucumbers	P	NA		x	
SWEEPER	Wageningen UR	NL				x	Sweet peppers	P	Battery		x	
FFRobot	FF Robotics	IL				x	Apples	PC	Battery		x	
GRoW	MetoMotion	IL				x	Greenhouses	P	NA		x	
Tevel	Tevel Aerobotics Technologies	IL				x	Apples, oranges	P	Battery		x	

*P: Prototype; C: Commercial, PC: Pre-commercial

**Environment: Agrochemical reduction, not CO2 reduction

Source: company websites, news articles

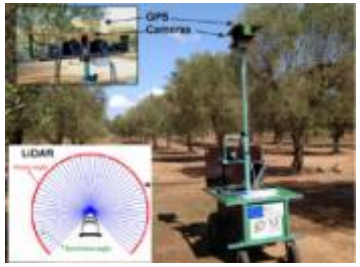
（参考） 果樹園芸のスマート農機事例

Name	BAKUS
Developer	VitiBot
Country	France
Target crop	Vineyards
Function	Soil management, spraying
Power source	Battery
Status	Commercial; price unavailable
Description	• BAKUS is an autonomous electric robot that can be fitted with interchangeable tools. • Currently, the robot is able to loosen soil and spray. Other tools are being developed. • BAKUS can work up to 10 hours on a single 2 hour quick charge. 

Name	MYCE_Vigne
Developer	WALL-YE
Country	France
Target crop	Vineyards
Function	Pruning, weeding, soil management
Power source	Battery (solar charged)
Status	Commercial; from EUR 15,000
Description	• MYCE_Vigne is a solar-charged robot that can prune, hoe and mow grapevines. • The robot can prune 50-150 vines an hour (depending on type) for 24 hours. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	Xf-Rovim
Developer	Polytechnic University of Valencia, Institut Valencià d'Investigacions Agràries (IVIA)
Country	Spain
Target crop	Olive trees
Function	Disease detection
Power source	Gel battery
Status	Prototype (funded by Horizon 2020)
Description	• Xf-Rovim is a small field robot for early detection of *Xylella fastidiosa* disease in olive trees. • The robot is remotely driven and fitted with different sensing equipment to capture thermal, spectral and structural information. • It can inspect a field of 4 hectares without interruptions in less than 6 hours. • Although the robot is efficient in gathering data, the data are yet to be analysed in an efficient way to give accurate results on infection levels. 

Name	BYELAB
Developer	University of Bolzano
Country	Italy
Target crop	Orchards (e.g. apples), vineyards
Function	Plant monitoring
Power source	Battery
Status	Prototype
Description	• BYELAB is an autonomous robot that can travel within orchards with uneven terrain. • It is a crop-monitoring mobile laboratory that can monitor different crop health indicators such as vegetation thickness and flower density. • Future work on the BYELAB will include improving its abilities to measure plant health, detect plant diseases, navigate uneven terrain and avoid obstacles. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	PANTHEON
Developer	Roma Tre University, University Trier, Tuscia University, Université libre de Bruxelles, Sigma Consulting, Ferrero Trading
Country	Italy
Target crop	Hazelnuts
Function	Plant monitoring
Power source	Battery
Status	Prototype (funded by Horizon 2020)
Description	• PANTHEON is an integrated system whereby a limited number of unmanned aerial and ground robots move within the orchard to collect data and perform typical farming operations. • The information is collected on a plant-by-plant basis. This will allow to dramatically increase the detection of limiting factors for each individual plant, such as lack of water or pests and diseases affecting the plant health, and to react accordingly. 

Name	Mamut
Developer	Cambridge Consultants
Country	UK
Target crop	Orchards
Function	Plant monitoring
Power source	NA
Status	Prototype
Description	• Mamut is an autonomous robot that explores crop fields, capturing data on health and yield at the level of individual plants and on a massive scale. • By automating data capture, Mamut gives growers regular, precise and actionable information on their crops, enabling them to predict and optimise yields. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	VINBOT
Developer	Robotnik Automation SLL, Cooperativa Agricola de Granja CRL, Orgovanyi Gazdaszovetkzet Szovetket, Bodegas Familiares de Rioja Provir etc.
Country	Spain
Target crop	Vineyards
Function	Plant monitoring
Power source	Lithium battery
Status	Prototype (funded by 7th European Framework Programme)
Description	• VINBOT is an all-terrain autonomous mobile robot with a set of sensors capable of capturing and analysing vineyard images and 3D data. • VINBOT is able to estimate the yield of vineyards in kg/m2 based on the amount of leaves, grapes and other phyto-data throughout the vineyard. • Wineries and wine growers will be able to make accurate yield predictions to plan their wine production and marketing. 

Name	OUVA
Developer	Polariks
Country	Netherlands
Target crop	Vineyards
Function	Plant monitoring
Power source	NA
Status	Prototype
Description	• OUVA is an autonomous rover equipped with a hyperspectral camera. • OUVA can autonomously traverse vineyards to collect data on canopy health and grape maturity. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	VineScout
Developer	Polytechnic University of Valencia, WALL-YE Sarl, Sundance Multiprocessor Technology Ltd, University of Rioja, Symington Family Estates
Country	Spain
Target crop	Vineyards
Function	Plant monitoring
Power source	Battery (solar charged)
Status	Prototype (funded by Horizon 2020)
Description	• VineScout is an autonomous robot that takes high resolution images of the vines. • The images are analysed to assess the needs and status of the vineyard so that the grower can make decisions on irrigation, treatment and harvest. • This research project has a strong focus on commercialisation from the start. However, there have been issues with durability and cost of the robot. 

Name	eBee SQ
Developer	senseFly
Country	Switzerland
Target crop	All crops
Function	Plant monitoring
Power source	Battery
Status	Commercial; ~EUR 10,000, including 1 year subscription to Pix4Dfields software
Description	• senseFly provides drones that monitor crops from the sky. Images are analysed to gain more efficient crop insights and to more accurately plan and manage farm operations. • Insights are provided from plant emergence to pre-harvest yield prediction and drainage planning for the next season. • eBee SQ's flights can be automated. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	TED
Developer	Naio Technologies
Country	France
Target crop	Vineyards
Function	Weeding
Power source	Lithium battery
Status	Commercial
Description	• TED is a fully electric autonomous mechanical weeding robot for vineyards, reducing herbicide use. • The TED robot can cover up to 40 hectares and has a speed of up to 4km/h. • There are prototype tools in development for trimming, spraying, etc. • Naio Technologies also has the OZ and DINO robots that can be used for vegetable crops. 

Name	Vitirover
Developer	Vitirover Solutions
Country	France
Target crop	Vineyards
Function	Mowing
Power source	Battery (solar charged)
Status	Commercial; Robot-as-a-service model, price unknown
Description	• Vitirover is a small economical and ecological robot that mows grass without the need for chemicals. Each robot is electric and runs on solar energy. • The Vitirover is deployed in fleets controlled by a single operator. It is used to mow the grass in between plants in vineyards and orchards. • Going forward, Vitirover could be upgraded to include plant monitoring capability. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

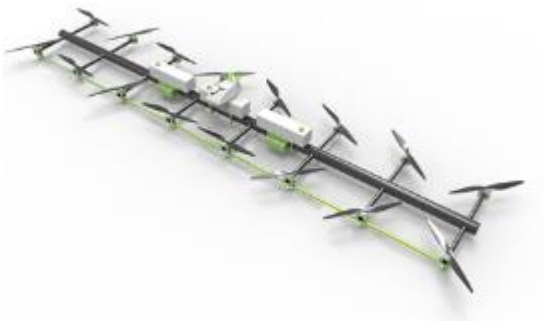
Name	AgriRobot
Developer	Innovate Integra Ltd, Loughborough University, Jiangsu University, Nantong Guangyi Mechanical & Electrical Co Ltd
Country	UK
Target crop	Orchards
Function	Spraying
Power source	NA
Status	Prototype (funded by Innovate UK and Jiangsu Province Science and Technology Department)
Description	• The AgriRobot is a semi-autonomous agricultural robot capable of intelligently spraying orchard crops using automatic navigation in a field by following lanes rows between plants and trees. • The AgriRobot can analyse the presence, size, shape and density of the target trees to precisely apply the necessary amount of pesticide when needed, leading to more efficient spraying. 

Name	S55
Developer	Holland Green Machine
Country	Netherlands
Target crop	Greenhouse crops such as tomatoes, cucumbers, peppers, eggplants and flowers.
Function	Spraying
Power source	NA
Status	Commercial; price unknown
Description	• The S55 spray robot is a robot with batteries that can spray automatically. It uses a pipe rail system to move through the greenhouse. • The S55 can be adapted into the AIRMIXer, Dosatron, foam disinfector and gutter cleaner versions to achieve different functions. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	Agribot
Developer	Agripot sp
Country	Poland
Target crop	Orchards
Function	Spraying
Power source	NA
Status	Commercial; price unknown
Description	• The Agribot is a small robot that autonomously sprays orchards (water, fertiliser, herbicide or pesticide). • The Agribot can be used for orchards, vineyards ,plantations, olive groves and vegetables. • The Agribot travels at a maximum speed of 10km/h. 

Name	Spraying drone
Developer	Drone4Agro
Country	Netherlands
Target crop	All crops
Function	Spraying
Power source	Lithium battery
Status	Commercial; price unknown
Description	• The Drone4Agro drone can be used for different applications such as spraying and fertilizing. • The drone models can operate with a 5 – 100 litre payload. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	AGRO
Developer	AirBoard
Country	Latvia
Target crop	All crops
Function	Spraying
Power source	Lithium battery
Status	Commercial; price unknown
Description	• AirBoard AGRO is a Air Board fully autonomous spraying designed for organic ingredients and chemical liquid substances. • It offers customisable spray nozzles for pesticide and fertiliser overlay for vineyards, avocado, wheat, corn, etc.

Name	BACCHUS
Developer	Aristotle University of Thessaloniki
Country	Greece
Target crop	Vineyards
Function	Harvesting
Power source	Lithium battery
Status	Prototype (funded by H2020)
Description	• BACCHUS is an autonomous robotic ecosystem utilizing mobile platforms and manipulators for intelligent and selective harvesting of grapes. • In the future, the robot is expected to be able to predict grape yield, thin out small wine grapes and detect and remove grapes infected with fungi.

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	E-Series
Developer	Agrobot SL
Country	Spain
Target crop	Strawberries
Function	Harvesting
Power source	Battery
Status	Pre-commercial; ~EUR 210,000 expected
Description	• The E-Series is a pre-commercial electric robotic harvester for gently harvesting strawberries. • It uses colour and infrared depth sensors to assess fruit ripeness for picking. The robot is equipped with 24 independent robotic arms to pick fruit, • The robot picks the strawberry from the stem and does not damage the fruit 

Name	Strawberry harvesting robot
Developer	Dogtooth Technologies
Country	United Kingdom
Target crop	Strawberries
Function	Harvesting
Power source	NA
Status	Prototype
Description	• Dogtooth's autonomous strawberry harvesting robot uses computer vision to identify ripe fruit and machine learning to evolve efficient picking strategies. • After picking, the robot grades the fruit to determine their size and quality and places them directly into punnets. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	Rubion
Developer	Octinion
Country	Belgium
Target crop	Strawberries
Function	Harvesting
Power source	NA
Status	Commercial; price unknown
Description	• Rubion is an autonomous strawberry picking robot that can pick strawberries gently like a human picker. • Rubion can pick a strawberry every 4 seconds and is able to pick 70-100% of ripe fruit, depending on the variety. • Octinion claims that its robot is the first commercial strawberry picking robot available. 

Name	Raspberry harvesting robot
Developer	Fieldwork Robotics (University of Plymouth spin-out), Bosch UK
Country	United Kingdom
Target crop	Raspberries
Function	Harvesting
Power source	Battery
Status	Prototype
Description	• The raspberry harvesting robot uses sensors, 3D cameras and machine learning to identify ripe fruit. • Currently, it takes the robot about a minute to harvest a fruit, with the eventual goal being 25,000 berries a day. • The final version is expected to have 4 arms working simultaneously. • Separate field trials for this robot in China for tomatoes and cauliflower are underway. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	Cucumber Harvesting Robot
Developer	Wageningen University & Research
Country	Netherlands
Target crop	Cucumbers
Function	Harvesting
Power source	Battery
Status	Prototype
Description	• In 2001, Wageningen UR developed an autonomous harvest machine for cucumbers. • The robot was able to successfully harvest 75% of the ripe cucumbers but took about a minute to harvest each cucumber. 

Name	SWEEPER
Developer	Wageningen University & Research, Umea Universitet, Proefstation Voor de Groenteleelt, Ben Gurion University of the Negev, etc.
Country	Netherlands
Target crop	Sweet peppers
Function	Harvesting
Power source	NA
Status	Prototype (funded by Horizon 2020)
Description	• SWEEPER is an automatic sweet pepper harvesting robot that works in greenhouses. • During trials, the robot was able to pick 18% of ripe fruit and took 24 seconds to pick each fruit. • A fully automatic robotic sweet pepper harvester is expected to be commercially viable in 5-10 years. • SWEEPER's technology and results are applicable to other fruit crops such as cucumbers, tomatoes, grapes, apples, cardamom, banana and coconuts. 

Source: company websites news articles

（参考） 果樹園芸のスマート農機事例

Name	FFRobot
Developer	FF Robotics
Country	Israel
Target crop	Apples
Function	Harvesting
Power source	Battery
Status	Pre-commercial; EUR 250-300k price expected
Description	• The FFRobot is an apple picker equipped with 12 robotic arms and picks fruit based on size and colour. It can be adjusted based on the width of the orchard row. • The robot requires one human supervisor. • The machine has been shown to do only 3-5% damage to the fruit, compared to 10-15% with human pickers. • The machine is expected to cost US$300-500 thousand and could provide a return within 2 to 3 years. 

Name	GRoW
Developer	MetoMotion
Country	Israel
Target crop	Greenhouse crops such as tomatoes, eggplants, cucumbers, peppers, etc.
Function	Harvesting
Power source	NA
Status	Prototype (funded by Horizon 2020)
Description	• GRoW uses advanced 3D vision system and machine vision algorithms to identify and locate ripe fruit. • GRoW's error rate for tomatoes is less than 5% and can harvest more than 720kg per hour. Its ROI is expected to be about 3 years. • In the future, GRoW will be able to do other greenhouse tasks such as pruning, pollinating and monitoring. 

Source: company websites news articles

大手の農機メーカーが汎用性の高いロボットに集中するため、果樹園芸のスマート農機を開発する企業はほとんど中小企業である。

主要な果樹園芸スマート農機の研究開発機関（民間／公共）

Name	Established	Country	Category	Projects/Products
Wageningen University and Research (UR)	1876	Netherlands	Research Institution	• Cucumber picking robot • SWEEPER
Robotnik	2002	Spain	Manufacturer	• BACCHUS • VINBOT
WALL-YE	2008	France	Manufacturer	• MC_Vigne • VineScout
NaioTechnologies	2011	France	Manufacturer	• TED • DINO
senseFly	2009	Switzerland	Manufacturer	• eBeeSQ
Delair	2011	France	Manufacturer	• UX11Ag
Saga Robotics	2016	Norway	Manufacturer	• Thorvald • BACCHUS
Robert Bosch GmbH	1886	Germany	Manufacturer	• BoniRob • Raspberry picking robot

Source: company websites, news articles

（参考）企業概要　－　Wageningen University & Research（蘭）

企業概要

Name	Wageningen University & Research
Founded	1876
Headquarters	Wageningen, Netherlands
Geographic Coverage	NA
Revenue	NA
Employees	12,819 students (2019-20) 5,928 undergraduates (2019-2020) 6,409 postgraduates (2019-2020)
Shareholders/ Investors	NA
Website	https://www.wur.nl/
Description	Wageningen UR has more than 60 engineers and researchers working together with industrial partners on new robotic systems for agri and food, specialising in artificial intelligence and sensing, learning and vision.

具体プロジェクト・製品事例

Cucumber picking robot

- In 2001, Wageningen UR developed an autonomous harvest machine for cucumbers.
- The robot was able to successfully harvest 75% of the ripe cucumbers but took about a minute to harvest each cucumber.

SWEEPER

- SWEEPER is an automatic sweet pepper harvesting robot that works in greenhouses. A fully automatic robotic sweet pepper harvester is expected to be commercially viable in 5-10 years.
- SWEEPER's technology and results are applicable to other fruit crops such as cucumbers, tomatoes, grapes, apples, cardamom, banana and coconuts.

Source: company websites, news articles

（参考）企業概要　－　Robotnik（西）

企業概要

Name	Robotnik
Founded	2002
Headquarters	Barcelona, Spain
Geographic Coverage	Offices in China, Singapore Distributors present globally
Revenue	NA
Employees	11-50
Shareholders/ Investors	NA
Website	https://robotnik.eu/
Description	Robotnik designs, manufactures and markets mobile robots and mobile manipulators. Robotnik participates actively in European research projects to develop robotic solutions together with research institutions.

具体プロジェクト・製品事例

BACCHUS

- BACCHUS is an autonomous robotic ecosystem utilizing mobile platforms and manipulators for intelligent and selective harvesting of grapes.
- In the future, the robot is expected to be able to predict grape yield, thin out small wine grapes and detect and remove grapes infected with fungi.

VINBOT

- VINBOT is an all-terrain autonomous mobile robot with a set of sensors capable of capturing and analysing vineyard images and 3D data.
- VINBOT is able to estimate the yield of vineyards in kg/m2 based on the amount of leaves, grapes and other phyto-data throughout the vineyard.

Source: company websites, news articles

（参考）企業概要　－　WALL-YE（仏）

企業概要

Name	WALL-YE
Founded	2008
Headquarters	France
Geographic Coverage	NA
Revenue	NA
Employees	NA
Shareholders/ Investors	NA
Website	http://wall-ye.com/
Description	WALL-YE creates software and robots for agriculture. Currently, in addition to participating in research, they have two commercial robots, one for vineyards and the other for row crops.

具体プロジェクト・製品事例

MYCE_VIGNE

- MYCE_Vigne is a solar-charged robot that can prune, hoe and mow grapevines.
- The robot can prune 50-150 vines an hour (depending on type) for 24 hours.

VineScout

- VineScout is an autonomous robot that takes high resolution images of vineyard vines.
- The images are analysed to assess the needs and status of the vineyard so that the grower can make decisions on irrigation, treatment and harvest.

Source: company websites, news articles

（参考）企業概要　－　Naio Technologies（仏）

企業概要

Name	Naio Technologies
Founded	2011
Headquarters	Midi-Pyrenees, France
Geographic Coverage	NA
Revenue	EUR 2 million (2017)
Employees	1-10
Shareholders/ Investors	JCS Consulting Group, Bpifrance, Capagro, etc.
Website	http://www.naio-technologies.com/
Description	Naio Technologies develops and markets machines for agriculture and viticulture. It features electric tools for weeding, hoeing, and harvesting that help farmers collect and harvest their products.

具体プロジェクト・製品事例

TED

- TED is a fully electric autonomous mechanical weeding robot for vineyards, reducing herbicide use.
- The TED robot can cover up to 40 hectares and has a speed of up to 4km/h.
- There are prototype tools in development for trimming, spraying, etc.

DINO

- Dino is a fully electric autonomous mechanical weeding robot for raised vegetable beds and rows.
- Dino can work for up to 8 hours at a time and cover 5 hectares in a day.

Source: company websites, news articles

（参考）企業概要　－　senseFly（スイス）

企業概要

Name	senseFly
Founded	2009
Headquarters	Lausanne, Switzerland
Geographic Coverage	USA, distribution available globally
Revenue	NA
Employees	101-250
Shareholders/ Investors	Parrot SA
Website	https://www.sensefly.com/
Description	SenseFly develops and produces aerial imagine drones for professional applications. In 2012, Parrot SA invested EUR 5 million in the company for a 57% stake.

具体プロジェクト・製品事例

eBee SQ

- The TED robot can cover up to 40 hectares and has a speed of up to 4kmsenseFly provides drones that monitor crops from the sky. Images are analysed to gain more efficient crop insights and to more accurately plan and manage farm operations.
- Insights are provided from plant emergence to pre-harvest yield prediction and drainage planning for the next season.
- eBee SQ's flights can be automated.
- There are prototype tools in development for trimming, spraying, etc.
- In 2017, a leading Basque winemaker employed senseFly drone data to optimise its yield, resulting in a 17% increase in bottles.

Source: company websites, news articles

（参考）企業概要　－　Delair SAS（仏）

企業概要

Name	Delair SAS
Founded	2011
Headquarters	Toulouse, France
Geographic Coverage	France, USA, Singapore Distribution available globally
Revenue	EUR 8.5 million (2018)
Employees	101-250
Shareholders/ Investors	Andromede, Intel capital, etc.
Website	http://delair.aero/
Description	Delair is a leading provider of end-to-end, visual intelligence solutions. The company's offerings combine high performance UAV hardware with delair.ai, the industry's most robust platform.

具体プロジェクト・製品事例

UX11Ag

- Delair manufactures and sells professional drones for visual intelligence for multiple industries, including agriculture.
- The UX11Ag is equipped with a high-end multispectral camera for plant level measures.
- The Delair.ai platform helps to analyse the image data to provide insights to the farmer. The insights can be loaded onto the MyJohnDeere platform to inform tractor decisions.

Source: company websites, news articles

（参考）企業概要　－　Saga Robotics（ノルウェー）

企業概要

Name	Saga Robotics
Founded	2016
Headquarters	As, Norway
Geographic Coverage	NA
Revenue	NA
Employees	11-50
Shareholders/ Investors	Rabobank Food & Agri Fund, Nysno, Cibus Fund
Website	https://sagarobotics.com/
Description	Saga Robotics revolutionises the agricultural sector by developing autonomous robots capable of performing a wide variety of agricultural operations at a lower price and with higher quality than conventional systems.

具体プロジェクト・製品事例

Thorvald

- Thorvald is an autonomous modular robot that can be configured for most agricultural environments. It can perform tasks such as picking fruits and vegetables, phenotyping, spraying, and data collection.

BACCHUS

- BACCHUS is an autonomous robotic ecosystem utilizing mobile platforms (Thorvald) and manipulators for intelligent and selective harvesting of grapes.
- In the future, the robot is expected to be able to predict grape yield, thin out small wine grapes and detect and remove grapes infected with fungi.

Source: company websites, news articles

（参考）企業概要　－　Robert Bosch GmbH（独）

企業概要

Name	Robert Bosch GmbH
Founded	1886
Headquarters	Gerlingen, Germany
Geographic Coverage	Global
Revenue	EUR 78.5 billion (2018)
Employees	400,000 (2019)
Shareholders/ Investors	Robert Bosch Stiftung
Website	https://www.bosch.com/
Description	Bosch is a German multinational engineering and technology company engaged in the manufacture of electrical and electronic products, automotive technology, power tools, thermo technology, household appliances, security systems and broadband networks, as well as automation technology and packaging technology.

具体プロジェクト・製品事例

BoniRob

- Bosch develops BoniRob as farming robot can perform various tasks with one unit.
- It can not only monitor crops as measurement and health analysis, but also fertilise, water and weed by exchanging modules.

Raspberry picking robot

- The raspberry harvesting robot uses sensors, 3D cameras and machine learning to identify ripe fruit.
- Currently, it takes the robot about a minute to harvest a fruit, with the eventual goal being 25,000 berries per day.
- Bosch UK is collaborating with Fieldwork Robotics to optimise the robotic arms and develop software in preparation for full-scale production.

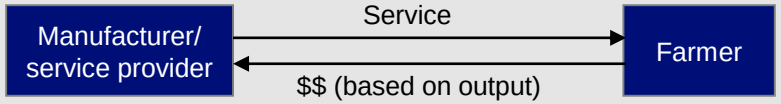
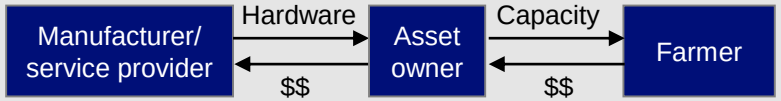
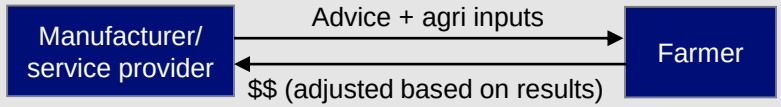
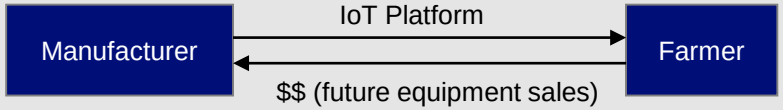
Source: company websites, news articles

スマート農機関連のビジネスモデル

機器販売ではなく、成果やサービスで対価を得るようなビジネスモデルが実施されている

- 農業機械がよりスマートになるにつれて、無人の農業機械の所有と維持のコストが複雑さを増している。投資収益率が不明な高価なスマート農機に投資するよう農業者に説得するのは難しいと思われる。
- 従って、単に農業者に機器を販売する代わりに、ビジネスモデルは結果ベースになることが期待される。この場合、製造業者とサービスプロバイダーの収益は、農業者のために創出できる価値に直結される。

Business Models

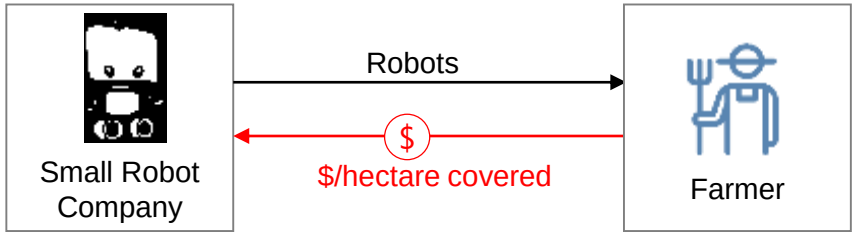
モデル	ビジネススキーム	概要	スマート農機	実用段
Farming-as-a-Service		利用者は、製品の代わりに提供される実際の成果・便益に対して対価を支払う。 例えば、農業者は機械を用いた土地の広さに基づいて代金を支払う形態	適用可能	商業ベース
Asset-sharing		高額な機器の場合、シェアリングを通じて余った稼働キャパシティを売り戻し、危機の稼働率を最大化する方法も採りうる。（機器の市場浸透を高める効果も期待される）	適用可能（現在は一般的な農機のみ）	パイロット
Outcome-based pricing		製品・サービス提供者が、利用者にアドバイスや農業情報を提供し、収穫量等のパフォーマンスを保証する形式（したがって最終的な収益は、パフォーマンスに基づき確定する）	適用可能（現在は種子・化学業界のみ）	パイロット
Ecosystem		製品提供者が、利用者に追加費用なしでIoTプラットフォームを提供することにより、利用者を自社のエコシステムに囲い込み、将来的な製品販売を促進する。	適用可能	商業ベース

Source: NRI

Farming-as-a-Serviceモデルでは、顧客は製品そのものではなく、製品により提供されたサービスに対して支払いを行う

■ Small Robot Company（英国）は、畑作物を自律的に植え付け、監視し、処理できる小さなロボットを扱う。ロボットを購入する代わりに、農業者はロボットが農場をデジタル化して作業するための料金を1ヘクタールごとに支払う。これにより、農業者にとって、新しいテクノロジーを採用するコストとリスクが軽減される。

Farming-as-a-Service business model



- The Small Robot Company has 2 autonomous robots – Tom and Dick, as well as Wilma, the AI behind the robots.
- Instead of selling the robots directly to farmers, the farmers pays a per-hectare fee for the robots to take care of their crop.

TOM: Crop monitoring and mapping

DICK: Mechanical weeding

Pros and cons of business model

Pros

- **Low risk** for farmers as they do not have to commit to expensive equipment with unknown benefit and obsolescence. Farmers can easily opt out if the robot is not right for their operations.
- Start-up companies can **bring their product to market early** without having to perfect the design until it can be reliability operated without expert intervention.
- Farmers are already **used to paying for output** – fruit pickers are paid for the amount they harvest, not by the number of hours worked.

Cons

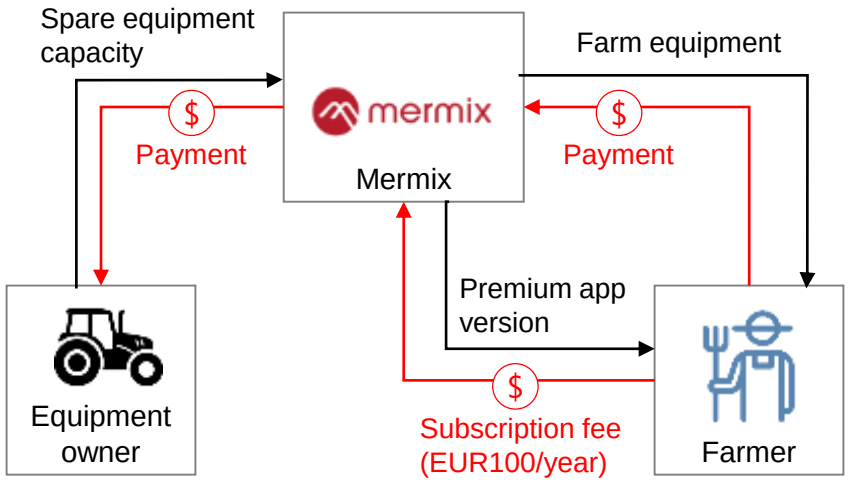
- This business model is **not as effective for highly specific robots** that do tasks that only need to be done once a year for a short period of time and by all farmers at the same time.
- Unlike software, robots are physical machines, so their **range and deployment are limited** by geographical location. There has to be sufficient farm density and enough operators in the area.

Source: Small Robot Company

Asset sharingモデルでは、農機の"遊び"時間にシェアリングサービスを提供し、農機の稼働率の最大化を目指している

■ Mermix（ギリシャ）は、機器の所有者がマシンの余剰容量を収益化するための「Uber for 農業機械」プラットフォームを運営している。パイロットは2016年に実施され、EUの第7次フレームワークプログラムから資金提供を受けた。

Asset sharing business model



- Mermix is a platform that allows farmer to monetise the spare capacity of their machinery, or an "Uber for farm machinery". The owners set the price for use of their machinery, from which Mermix will take a cut.
- In addition, the Mermix app has a premium version, which provides additional service beyond equipment matching, such as cost and crop reports. This subscription service costs EUR 100 annually.
- The pilot for Mermix ran in 2016 and was funded by the EU 7th Framework Programme. There have been no updates since 2017.

Pros and cons of business model

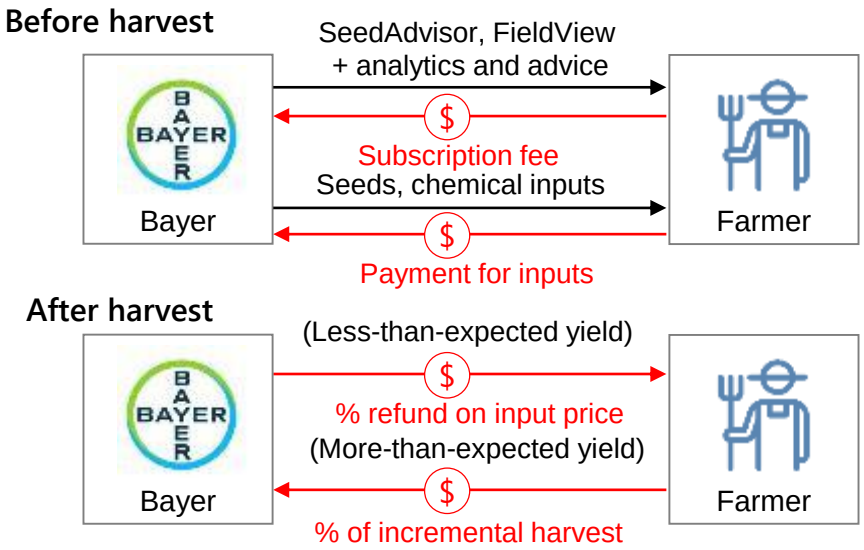
Pros	• Equipment owners are able to **monetise their excess capacity**. • Farmer are **able to use expensive machinery** that they may otherwise not have access to.
Cons	• The model works best if there is **sufficient equipment and farm density within a small area**, as it is neither efficient not feasible to transport heavy equipment over long distances. • Since many farming activities in the same area are dependent on climate and are carried out at the same time, **equipment may not be available at the right time** as the owner is using it.

Source: Mermix

Outcome-based pricing モデルでは、製造業者とサービスプロバイダーは、顧客にアドバイスおよび農業資材を提供し、収穫実績に基づいて対価を得る

■ バイエル（ドイツ）は、米国で成果ベースの価格モデルを試行している。このモデルでは、増分歩留まりのシェアと引き換えに、作物の歩留まりパフォーマンスを保証します。保証された結果に満たない場合、バイエルは農業投入物のコストの一部を払い戻す。このビジネスモデルは現在パイロットにすぎないが、今後5年以内に商用化される可能性がある。

Outcome-based pricing business model



- In 2019, Bayer ran a pilot in the USA for outcome-based pricing. Bayer provides farming advice through its digital apps, based on the farmers data, and guarantees a certain yield if their advice is followed.
- If the farmer takes Bayer's advice and produces a better-than-predicted yield, the upside is shared with Bayer. If not, Bayer will refund a portion of the input price.
- The pilot is currently only for seeds, but will be extended to chemical products in the future. This model may be implemented within the next 5 years.

Pros and cons of business model

Pros

- This business model **reduces the production risk** for farmers as the downside is shared with Bayer.
- It also encourages farmers to **try new products** as the Bayer covers some of the risk.
- For Bayer, the advice they gives is a **direct sales channel** through which they can push their products.

Cons

- Bayer has to have **high confidence that its data analysis and advice will lead to positive outcomes**, as it is sharing the risk with the farmer.
- There are many factors in farming beyond seeds and chemical inputs (e.g. weather, irrigation). It is **hard to determine the farmer's baseline and the extent to which Bayer's advice is responsible** for the increase or decrease in yield.
- Performance metrics and fair pricing are hard to determine, especially since there is **no transparency** into Bayer's data algorithms and pricing models.

Source: Bayer, news articles

（参考）バイエルは種子と農薬の主要生産者である

■ バイエルはドイツの多国籍企業であり、製薬、消費者の健康、作物科学をカバーする世界最大の製薬会社の1つである。彼らの作物科学部門は、殺菌剤、除草剤、殺虫剤、種子を製造、販売しています。

企業概要	
Name	Bayer AG
Founded	1863
CEO	Werner Baumann
HQ	Leverkusen, Germany
Geographic coverage	Global
# of Employees	104,000 (2019)
Latest Revenue	Total: EUR 43.5 billion (2019) Crop science: EUR 19.8 billion (2019)
Owners / Investors	• Norges Bank Investment Management (3.0% shareholding) • The Vanguard Group (3.0% shareholding)
Description	Bayer is a Germany MNC and one of the largest pharmaceutical companies in the world, covering pharmaceutical, consumer health and crop science.

Crop Science Products	
Herbicides	Roundup™, Adengo™, Alion™, Corvus™
Fungicides	Fox™, Luna™, Nativo™, Serenade™, Xpro™
Insecticides	BioAct™, Confidor™, Movento™, Sivanto™
Seeds	Dekalb™, Asgrow™, Seminis™, DeRuiters™
Environmental Science	Ficam™, Maxforce™, Esplanade™, K-Othrine™, Fludora™ Fusion
Digital Agriculture	Climate FieldView™

Climate FieldView

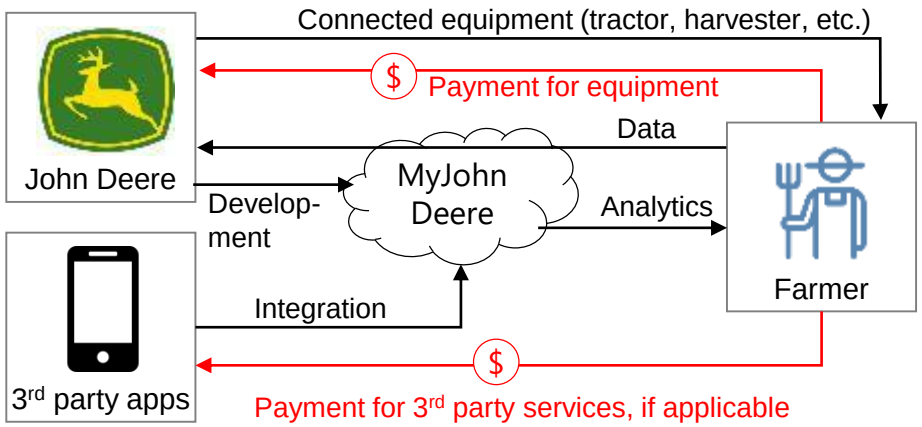
Climate FieldView is a platform that allows farmers to collect, store and view their field data in one digital platform that they can access from anywhere. Farmers can visualises and analyse crop performance with field data maps so they can build customised plans for each field and optimise their inputs.

Source: Bayer, Climate FieldView

Ecosystem business モデルでは、IoTプラットフォームを顧客に無償提供しつつ、農業資材やサービス提供、オペレーションへのレコメンデーションを提供している

■ John Deere（米国）は、機器の購入者がMyJohnDeereプラットフォームを無料で使用できるようにする。このプラットフォームは、機器、天気、作物などのデータを所有者、オペレーター、ディーラー、コンサルタントなどと結び付ける。このプラットフォームを通じて、サードパーティの開発者はアプリケーションを提供することができる。John Deereはプラットフォームの使用料を請求しないことで、将来のハードウェア販売を促進するために顧客をエコシステムに閉じ込める戦略を取っている。

Ecosystem business model



- John Deere launched their MyJohnDeere platform in 2012, which connects data from equipment, weather, crops etc. with owners, operators, dealers, consultants etc. The platform helps farmers to manage their fleet more effectively.
- The platform allows 3rd party developers to connect and provide applications. John Deere does not appear to be charging for this.
- MyJohnDeere is free for consumers who purchase John Deere equipment. The strategy is to lock customers into their ecosystem to drive future hardware sales.

Pros and cons of business model

Pros

- By providing the platform at no additional cost to its customers, John Deere hopes to lock its customers into its ecosystem to **drive future hardware sales**.
- The data from farmers that John Deere gathers can be **monetised in the future** (with the right privacy protections).
- **Smaller players are unable to offer a similar platform** for free as they will not be able to recover development costs.
- John Deere is able to build **direct relationships with end-customers** and understand how they interact with John Deere's products.
- John Deere is able to leverage the data to **provide additional services** such as predictive maintenance.

Cons

- Customers have not been as easily sold into the data features as expected, and John Deere has had to **improve customer service and education efforts in order to encourage platform adoption**.
- John Deere's **software licensing terms have prevented farmers from making DIY repairs** to their own equipment, which is costly for the farmer in both repairs and time, resulting in **illegal software hacking**.

Source: John Deere, news articles

（参考）John Deereは農業機械の企業概要と提供機器

■ John Deereは、農業、建設、林業機械を製造するアメリカの多国籍企業であるDeere & Companyのブランド名である。

企業概要	
Name	Deere & Company
Founded	1837
CEO	John C. May
HQ	Moline, Illinois, USA
Geographic coverage	Global
# of Employees	73.500 (2019)
Latest Revenue	Total: US$39.26 billion (2019) Agri: US$23.67 billion (2019)
Owners / Investors	• Cascade Investment LLC (10.1% shareholding) • The Vanguard Group (7.1% shareholding)
Description	John Deere is the brand name of Deere & Company, an American MNC that manufactures agricultural, construction and forestry machinery.

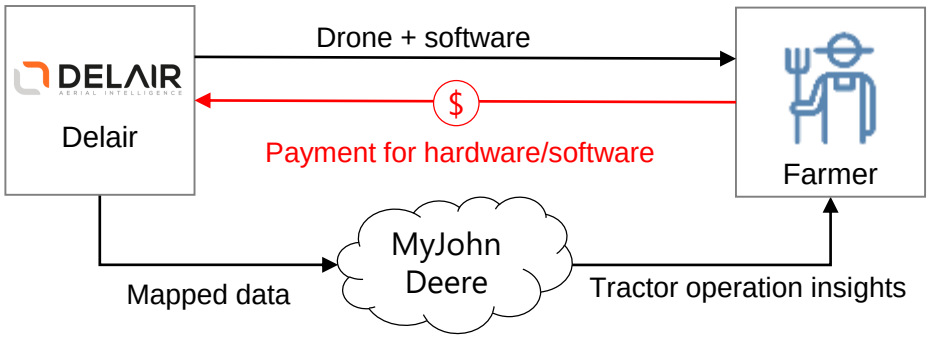
Agricultural Machinery		
Crop Harvesting	• Combines • Front-end equipment • Sugar cane • Cotton	
Turf & Utility	• Utility vehicles • Riding lawn equipment • Commercial mowing • Walk-behind mowers	
Hay and Forage	• Self-propelled forage harvesters • Heads • Balers • Mowing	
Crop Care	• Seeding • Tillage • Application equipment	
Tractors	• Large • Medium • Utility • Loaders	

Source: John Deere

エコシステムが作れる企業は大手に限られているが、中小企業はそのエコシステムを活用して自社の製品を販売することができる

■ Delair（フランス）は空中マッピングのドローンとソフトウェアを提供する会社である。空中地図は直接に「MyJohnDeere] に転送し、種苗や農薬散布等を自動化することができるので、「MyJohnDeere」のエコシステムユーザは他社より、Delairの製品を利用することが想定されている。

Delair business model

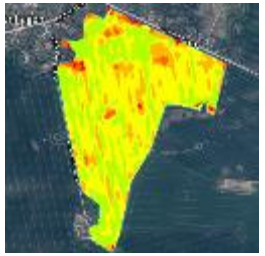


- Delair is a French company that provides high performance drones and accompanying software. Images taken by Delair's drones can be managed and analysed via Delair's software.
- Also, the aerial maps from the software can be seamlessly transferred to the MyJohnDeere ecosystem and used to automate field tasks such as planting and herbicide/fertiliser application according to field variability.
- Existing MyJohnDeere users are likely to prefer Delair's drones and software ahead of other non-integrated competitors as it works with an ecosystem that they are already familiar with.

Pros and cons of business model

Pros	• The product has **access to the large customer base** of the existing digital ecosystem. • The product gains **credibility** if access to the ecosystem requires prior approval from the ecosystem operator. • **Synergies** between the product and other services in the ecosystem can **unlock additional value** for users.
Cons	• The product may be seen as **exclusionary** to users who are not part of the ecosystem. • **Over-reliance** on any single ecosystem exposes the company to the **risks** of the ecosystem's owner.

Delair UX11Ag drone



Aerial map example on MyJohnDeere for variable application of farm input (e.g. more fertiliser on the red areas, etc.)

Source: Delair, news articles

スマート農機は自国での普及率はまだ低いため、海外に展開した企業がない。ドローンの海外展開のみが進んでいる。畑のマッピングに使われている。(1/2)

Agricultural Drone Mapping Case (South Africa)

Peanut Field Mapping in South Africa

- The farmer used senseFly's eBee Ag drone to map the healthy and unhealthy peanut plants in his field.
- It only took 8 minutes to capture the images and 20 minutes to process the data.
- From further investigation, it was found that parts of the field were waterlogged, while other parts were being eaten by hungry animals.
- The farmer was able to take immediate action on these problems.

Agricultural Drone Mapping Case (Asia/Africa)

Rubber and Oil Palm Plantation Mapping in Asia and Africa

- The SIAT group uses Delair's DT18 AG drones to survey 75,000 hectares of rubber and oil palm plantations in Asia and Africa.
- The images are used to map the health of the crop in order to improve yield quality and quantity.
- Using Delair's drone, the company managed to reduce its aerial data acquisition costs by 50%.

Source: senseFly, news articles

スマート農機は自国での普及率はまだ低いため、海外に展開した企業がない。ドローンの海外展開のみが進んでいる。畑のマッピングに使われている。(2/2)

Agricultural Drone Mapping Case (Asia/Africa)

DELAIR
AERIAL INTELLIGENCE

Rubber and Oil Palm Plantation Mapping in Asia and Africa

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- Using Delair's drone, the company managed to reduce its aerial data acquisition costs by 50%.

Source: Delair, news articles

（参考）MyJohnDeereのプラットフォーム概要

MyJohnDeereの概要

5秒ごとにクラウドへ送信

センサーから得られる情報
- 機械の稼動情報
- 土壌の含水率、栄養分の組成など

プラットフォーム
“My John Deere”

農業者

My John Deereが提供する情報
- **農地の成熟度**
- **機械の使用状況**
- **業務状況**

GPSと土壌情報から農地に関する情報提供

アイドル、移動、収穫中等の
機械の使用状況

ジョブスケジューリングや
機械の稼動実績

Source: John Deere

技術レベルの更なる向上、業界標準の欠如、曖昧な法律、自律機械の信頼性向上、などがスマート農機とその関連ビジネスモデルの普及における阻害要因とされている

1 技術水準	• スマート農業ロボットのセンサー、アクチュエーター、パターン認識、意思決定技術は、現段階において人間の労働力と同等レベルとは言えず、同じコストで利用することもできない
2 産業標準化	• 資機材の分野では統一された基準・規格がないため、メーカーが満たさなければならない各国の要件は多数にわたる。将来的にはロボットの性能・技術の進歩を比較するためのターム、システムの性能測定方法等の標準化が必要となる。 • 車両と管理ソフトウェア間の通信には、オープンデータ標準が必要であり、全てではないにせよ、ほとんどのメーカーが標準規格に加入すると予想されている。
3 規制	• 自動走行を採用する前に、おもに自動走行する機械とその製造事業者の責任に関する法律や規制を定義する必要がある。すでに制定されている責任法に加え、保険会社にとっては適切な保険パッケージを開発・提供する必要がある。 • 自律システムによって生成されるデータについては、そのデータが誰の所有物となるかが問題となっており、現時点で未解決の状態である。
4 信頼性・受容性	• 農機の利用者（オペレーター）は、信頼できるシステムを求めている。ある調査によれば無人トラクター、農作物収穫ロボット、UAVを現時点で導入しない理由として、①信頼できない、②（背景となる）農業知識が不足している、③社会的認知の低下、などが挙げられており、第一に信頼性が着目されている。 • 例えば、小規模な農業地域では、自動化技術が必要であることを農業者が納得することは難しいと考えられる。多くの場合、農業者は自動化技術を望んでおらず（贅沢で派手なものであるとみなされている）、さらには伝統的な農業への挑戦・脅威として捉えられている。

Source: Scouting the Autonomous Agricultural Machinery Market