

User Experience for Agricultural Drones at CLAAS

Design an agricultural drone with new applications to explore the use and system-integration of drones in a agricultural context by the company CLAAS.

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Abstract

Carion | CLAAS Drone

This work explores the integration of drone systems within an agricultural context, focusing on their potential to enhance logistics, efficiency, and connectivity between farmers, companies, and service providers such as CLAAS. While there is a clear technological push toward automation across the agricultural workforce, the application of drones as complementary products beyond traditional machinery remains underdeveloped. This research investigates the role of drones from a user-centered perspective, assessing their desirability, feasibility, and viability while acknowledging the broader challenges facing automation in agriculture.

Several barriers currently hinder the adoption of new agricultural technologies. Among the most significant are limited knowledge, technical skills, and awareness among users, along with inconsistent information across communication channels. Social factors—such as low engagement, skepticism toward innovation, and resistance to change—also play a key role. On the economic side, weak incentives, high production costs, and limited willingness among consumers to pay premium prices further reduce the appeal of adopting advanced technologies. Practical challenges, including complex implementation processes, insufficient technical support, and high investment requirements, contribute to hesitation. Finally, regulatory uncertainties, unclear industry standards, and limited public funding reinforce risk aversion and a short-term decision-making mindset among farmers.

During interviews with farmers, After Sales representatives, and contractors, it became evident that the overall attitude toward automated delivery systems is cautiously positive. Stakeholders are open to the idea but express concerns regarding safety, operational procedures, and organizational responsibilities. These uncertainties led to the proposal of a structured user briefing to ensure trust and safe adoption. Although the actual time savings achieved through drone use were lower than expected, the qualitative value of improved connectivity, reduced waiting times, and potential task automation remains promising. Observing multiple drones per operator could further enhance efficiency and compensate for limited immediate time savings.

In terms of feasibility, drones currently appear to have limited short-term viability for CLAAS. However, by positioning itself as a service provider, CLAAS could leverage this technology to expand its automation portfolio. Integrating drones with existing tractor systems—either physically or digitally—could enable a more connected ecosystem. The drone may serve as a low-threshold entry point for farmers into data-driven operations, collecting valuable insights on machine use and maintenance. Prototyping demonstrated that the developed mechanism fulfills its function, though further refinement is required regarding surface friction, angles, and material behavior. By referencing the DJI M400 for electronic and structural components, the concept maintains a feasible foundation while visually aligning with CLAAS's product identity.

Future development could focus on refining the cargo mechanism, introducing motorized grabbers, and enabling modular attachments to connect with various CLAAS machines. Multiple drones could work collaboratively to transport heavier payloads, extending operational flexibility. The integration of smart systems and data connectivity through CLAAS Connect would significantly enhance functionality and value.

Ultimately, this drone concept serves as a catalyst for discussion and experimentation—illustrating how automation can extend beyond tractors and combines to reshape agricultural logistics. While full autonomy remains restricted by regulation and public perception, the study concludes that drones offer desirable and feasible potential for CLAAS, positioning them as an early step toward a more connected and intelligent farming ecosystem.

1.6 Renewable Energy Goods

Agricultural holdings with intercropping

Subject of the notification	2022/2023		2019/2020		2015/2016		2009/2010	
	Holdings	Area under cultivation	Holdings	Area under cultivation	Holdings	Area under cultivation	Holdings	Area under cultivation
Intercropping	305,280	2,154,500	102,192	1,873,512	100,509	1,238,452	88,905	1,188,529
Summer intercropping	26,190	392,700	34,230	447,825	40,662	307,408	43,565	420,572
Crops for green manure	22,730	345,800	27,801	370,548	25,961	208,270	35,200	350,987
Crops for fodder extraction	4,190	32,500	6,780	44,704	5,860	29,111	10,400	49,114
Crops of biomass production for energy	670	12,400	810	12,573	761	10,800	1,300	22,492
Winter intercropping	105,900	1,755,800	85,813	1,575,806	80,305	1,431,844	54,714	767,057
Crops for green manure	93,610	1,593,200	76,731	1,330,861	83,351	1,303,233	44,955	656,083
Crops for fodder extraction	10,510	138,700	12,574	150,806	9,351	91,803	8,480	73,038
Crops of biomass production for energy	1,920	19,900	1,642	12,859	1,849	26,748	2,999	38,835

Fig.9 Agriculture culcers with intercropping

1.5.6 Biomass

In 2022, biomass—including biogenic waste—was the largest source of renewable energy in Germany, accounting for 57.6% of the renewable primary energy consumption across electricity, heat, and transport sectors. Within the electricity sector, bioenergy contributed around 20%, ranking third behind wind power and photovoltaics. In 2021, bioenergy dominated the heating and transport sectors, with shares of over 86% and 88% respectively.

Germany dedicated around 2.3 million hectares, or 14% of its agricultural land, to energy crop cultivation in 2022 (excluding forest wood). However, the country remains highly dependent on imports, especially for biofuels, where 85% of feedstocks are imported. Typical energy crops include maize, cereals, and rapeseed, which are generally not used for direct food consumption.

1.5.7 Biogas

Biogas is seen as a promising option for stabilizing the future energy system, thanks to its storability and ability to supply energy during demand peaks, such as when there is no sun or wind. Nevertheless, due to limited sustainable biomass resources, its contribution must be critically assessed and supplemented where possible with other renewables. A future focus lies in generating biogas from residual and waste materials, which could yield up to 17.5 terawatt hours (TWh) more if these materials are not diverted to other uses. In 2022, biogas plants produced around 33.2 TWh of electricity, 20.9 TWh of heat, and 1 TWh of fuel.

The Renewable Energy Act (EEG) amendments of 2021 and 2023 changed the framework for biomass. Auction volumes were increased from 150/200 MW to 600 MW in 2023 and are scheduled to be reduced to 300 MW by 2026. A new auction category for highly flexible biomethane plants was introduced, along with improved support measures for existing installations and small-scale manure-based biogas plants.

1.5.8 Solar energy

In parallel, Germany is expanding solar energy on agricultural land, aiming for 80 gigawatts (GW) by 2030 and 177.5 GW by 2040, while requiring at least 50% of new PV installations to be placed on buildings or infrastructure like noise barriers.

Beyond energy, the industrial use of renewable raw materials is gaining momentum. In 2021, 21.3% of new homes were built using wood, and in 2019, 9% of insulation materials came from plant-based sources.

Biobased polymers made up 8% of the global polymer market, and 13% of all organic raw materials used by Germany's chemical industry were derived from renewables—corresponding to a cultivated area of 293,000 hectares. Compared to energy use, industrial biomass use relies more heavily on imports, with around 60% of renewable raw materials used in the chemical sector coming from abroad in 2019.

1.4 Animal products

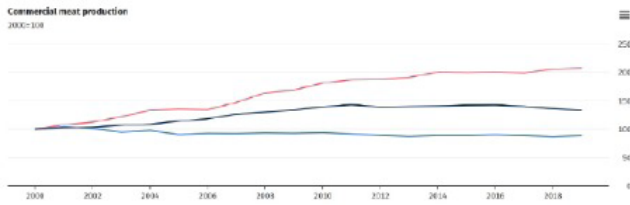


Fig.7 Commercial meat production over the years

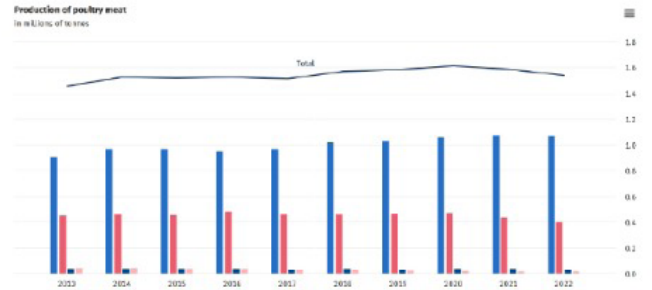


Fig.6 Production Trends for poultry meat

Looking into the different fields of agriculture and their worldwide distribution will give a better understanding of how the current agricultural landscape is standing.

1.3.3 Beef

Global beef production is growing slowly and unevenly, with increases in Brazil and China, and declines in the U.S., Argentina, and Europe. Brazil has the world's largest cattle herd, while Germany ranks 31st. The EU's beef production has declined since 2019. Despite decreasing slaughter numbers, Germany remains the second-largest beef producer in the EU. Beef consumption in the EU and Germany has decreased steadily. In 2021, Germany reached a self-sufficiency rate of 98.1% and reduced beef imports. Beef exports fluctuated, and producer prices rose significantly due to COVID-19 and geopolitical tensions.

1.3.4 Pork

The EU produces about 24 million tons of pork annually, about 20% of global production. While global production is increasing—the EU's output has remained stable. Pork remains the dominant meat in Germany, though per capita consumption has fallen from 55 kg in 1999 to 43 kg in 2021. Despite outbreaks of African Swine Fever (ASF), Germany remains a net exporter. However, many countries-imposed import bans following ASF detection. Some market access has been restored, but negotiations with key markets like China remain difficult.

1.3.5 Poultry

In 2020, global poultry production reached 134 million tons, with China, the U.S., and the EU leading. Poultry meat, especially chicken, is the most consumed meat worldwide. EU production slightly declined after 2020, with Germany ranking fourth among EU producers. Germany's poultry slaughter volume grew modestly, but production of turkeys, geese, and ducks declined. The self-sufficiency rate was 98% in 2021.

1.3.6 Eggs

Global egg production rose to 86.7 million tons in 2020, with China producing 35%. EU production reached 7.14 million tons in 2021, with France as the leading producer. Germany's per capita egg consumption steadily increased. The self-sufficiency rate reached 73.1% in 2021. However, Germany remains reliant on imports, mainly from the Netherlands, Poland, and Belgium. Recent egg price increases are driven by avian influenza, high feed costs, and the 2022 ban on chick culling in Germany, which affected domestic chick supply.

1.3.7 Milk

Global cow milk production continues to rise, reaching 736 million tons in 2021. The EU, especially Germany, produces more milk than it consumes, with Germany contributing 32.5 million tons. COVID-19 initially disrupted the market in 2020, but consumer demand remained stable. Milk delivery volumes recovered, and the average yield per cow increased slightly. Producer prices for milk rose significantly in 2021 and 2022, with conventional milk reaching a record 52.08 cents/kg. The price gap between organic and conventional milk narrowed. Butter and cheese production also reached record levels, though energy and feed costs heavily impacted sector sentiment in 2022.

1.3.8 Fishery

Germany's marine fisheries sector has faced significant challenges in recent years, including a sharp decline in the number of coastal fishing operations, fleet size, and catch volumes. Economic pressures stem from quota reductions, stock collapses, climate change impacts, rising fuel prices, and competition for marine space. While some fishers have shifted to new species or diversified into tourism and direct sales, many small-scale operations are nearing succession crises. Government support programs and a future strategy commission for the Baltic Sea fishery have been initiated to address the sector's structural and ecological problems.

■ Statistisches Bundesamt, Commercial slaughtering
 ■ Statistisches Bundesamt, Agricultural holdings
 ■ Bundesministerium für Ernährung und Landwirtschaft, 2024

3.4 Agriculture Parameters

3.4.1 Agricultural functions

Digital functions



Physical functions



Fig.49 Overview Agricultural drones

While there are different ways to abstract the functions of drones within an agricultural context. The two groups of digital and physical are always apparent.

3.4.2 Intelligence within Agriculture

By combining sensor data from drones, machines, and satellites, farms can monitor crop health, soil conditions, and environmental factors in real time. This allows predictive decisions such as adjusting fertilizer use, scheduling harvests, or identifying anomalies based on continuously

updated information. Agricultural intelligence transforms raw data into actionable insights, improving efficiency, reducing resource waste, and supporting a more sustainable and autonomous farming future.

Soil Parameters	Crop & Plant Health	Environmental & Weather Conditions	Field Operations & Machinery	Remote Sensing & Aerial Data	Livestock & Grazing
Soil moisture content Soil temperature Soil electrical conductivity (salinity) Soil pH Soil nutrient levels (N, P, K) Soil organic matter Soil compaction Soil texture and structure Soil respiration (CO ₂ flux)	Chlorophyll content Leaf temperature Plant height Canopy cover / density Biomass estimation Leaf area index (LAI) Water stress indicators Plant disease presence Nutrient deficiency symptoms Photosynthetic activity (NDVI, PRI) Turgor pressure Transpiration rate / sap flow	Air temperature Relative humidity Solar radiation / PAR Rainfall Wind speed and direction Barometric pressure CO ₂ concentration UV index	GPS location of equipment Machine speed / engine parameters Fuel consumption Spray rate or application volume Payload weight Implement position and pressure Obstacle detection	Multispectral reflectance Hyperspectral signatures Thermal imaging (canopy temp, soil heat loss) Vegetation indices (NDVI, SAVI, EVI, etc.) 3D topography (LIDAR or photogrammetry) Crop row spacing and alignment Canopy shadow mapping Flooded or drought-affected areas	Multispectral reflectance Hyperspectral signatures Thermal imaging (canopy temp, soil heat loss) Vegetation indices (NDVI, SAVI, EVI, etc.) 3D topography (LIDAR or photogrammetry) Crop row spacing and alignment Canopy shadow mapping Flooded or drought-affected areas

Fig.48 Mesurable parameters agriculture

■ Soussi, Smart sensors and smart data for precision agriculture
 ■ Steenekerk, Sensors in agriculture
 ■ Steckel, Technology Management

UAV | unmanned aircraft vehicle

refers to a drone.

UAS | unmanned aircraft system

refer to a drone, its system, and all the other equipment used to control and operate it, such as the command unit, the possible catapult to launch it, and others.

VLOS | visual line of sight

refers to the operation of a drone whereby the pilot maintains direct visual contact with the aircraft, without the help of cameras, goggles, or other visual aids (except corrective lenses).

BVLOS | beyond visual line of sight

refers to the operation of a drone where the pilot flies the aircraft without maintaining direct visual contact, typically requiring additional technologies such as cameras, sensors, or radar to ensure safe operation.

BEP | Break Even Point

The break-even point represents the stage at which total revenue equals total costs—meaning the business is neither incurring a loss nor generating a profit. It marks the moment when an investment begins to recover its costs and transitions from loss to potential profitability.

ROI | Return of Investment

The Return on Investment measures the efficiency of an investment by comparing the net profit to the initial cost. It indicates how much value or return is generated for every unit of currency invested.

EBIT | Earnings Before Interest and Taxes

EBIT reflects a company's operating profit, showing its ability to generate earnings from core operations before financing costs and taxes are considered.

EBITDA | Earnings Before Interest, Taxes, Depreciation, and Amortization

EBITDA provides a clearer view of operational performance by excluding non-cash expenses like depreciation and amortization, as well as financing and tax effects. It highlights the cash-generating potential of the business's core activities.

Design an agricultural drone with new applications to explore the use and system-integration of drones in a agricultural context by the company CLAAS.





Project Setup ■

Research

- Agriculture ■
- Drones ■
- CLAAS ■
- User ■

Future

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

Concept

- Desirability ■
- Feasibility ■
- Viability ■
- Finish ■

Appendix ■

1.1 Project approach



Hardware portfolio



software portfolio



Desirability

RQ2 What are the barriers to adopting drones as an agricultural company?

Feasibility

RQ2 What are the technologies inside the CLAAS system that can be used for drones?

Viability

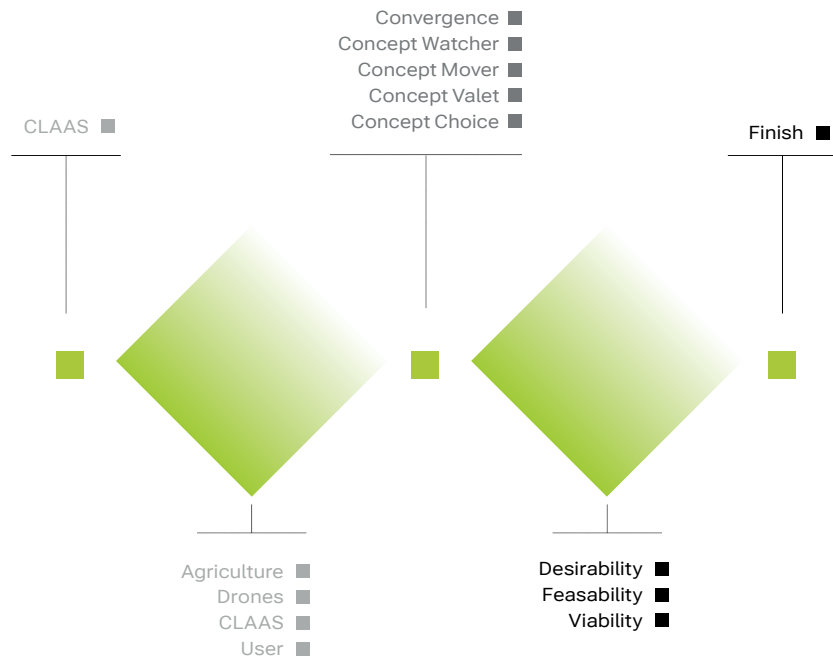
RQ3 What are the primary barriers to adopting drones systems in the Claas company?

The goal is to build a bridge between the company CLAAS its values and portfolio and the technology drone.

As guiding research question, the three pillars of desirability, feasibility and viability will be used to create a holistic drone concept.



1.2 Method base



The design process followed the Double Diamond model, guiding the project through four phases: exploration, definition, development, and delivery.

During the initial internship, the research began with a broad exploration of agriculture, drone technology, the company CLAAS, and the end user. This phase helped establish an understanding of agriculture as a user-centered, agronomic system rather than a purely technical field. Insights from both user and expert interviews deepened this perspective and provided the foundation for defining design opportunities.

The drone research focused on understanding core working principles and identifying relevant applications. The resulting functionalities were categorized by their sensor and technical requirements, leading to the development of three concept directions.

The most promising concept was then evaluated using the IDE framework of desirability, feasibility, and viability. Desirability was assessed through customer surveys and concept interviews, supported by a break-even analysis. Feasibility was validated through iterative prototyping and evaluation of the mechanism and assembly. Viability was examined through ROI calculations and internal interviews with CLAAS employees.

The final phase focused on creating communication materials to present the concept within CLAAS, enabling internal discussion and reflection on the drone's strategic and practical potential for the company's future.

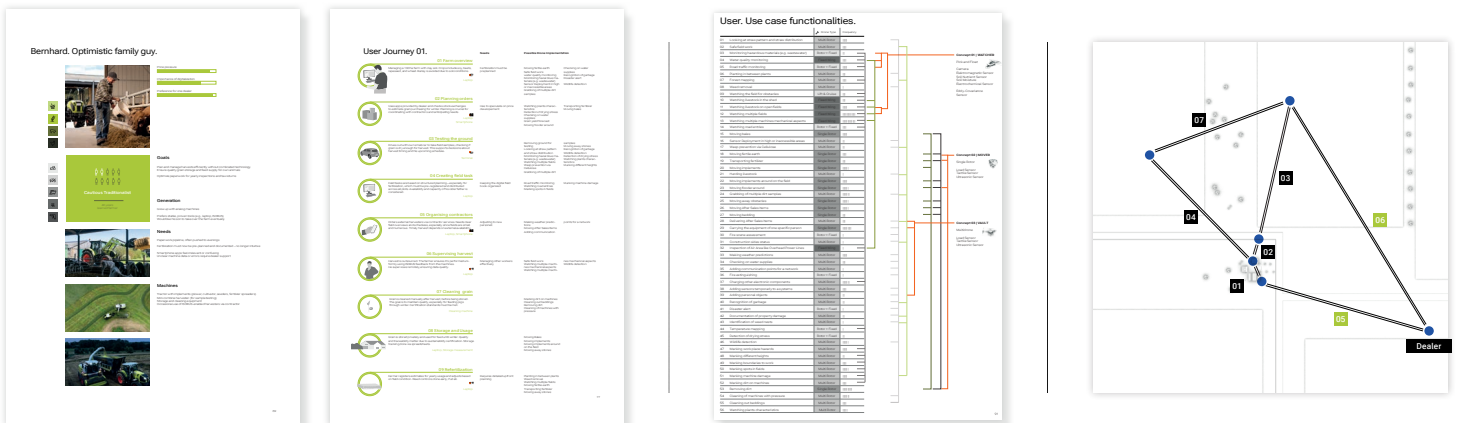


Fig.1 Persona, User Journey, Functionality convergence and use case modeling

Research

In this chapter the current state of agriculture, of drones and of the company CLAAS is explored, each of which relate directly to the research questions based on with the thriad of desirability, feasibility and viability.

- Agriculture ■
- Drones ■
- CLAAS ■
- User ■



1. Agriculture

As there are various forms of agriculture dependend on region and knowlegde base, this chapter gives a brief overview of the most important concepts and gives a focus for the upcoming concepts. Special farming methods may be shortly adressed.

1.1 Importance of agriculture

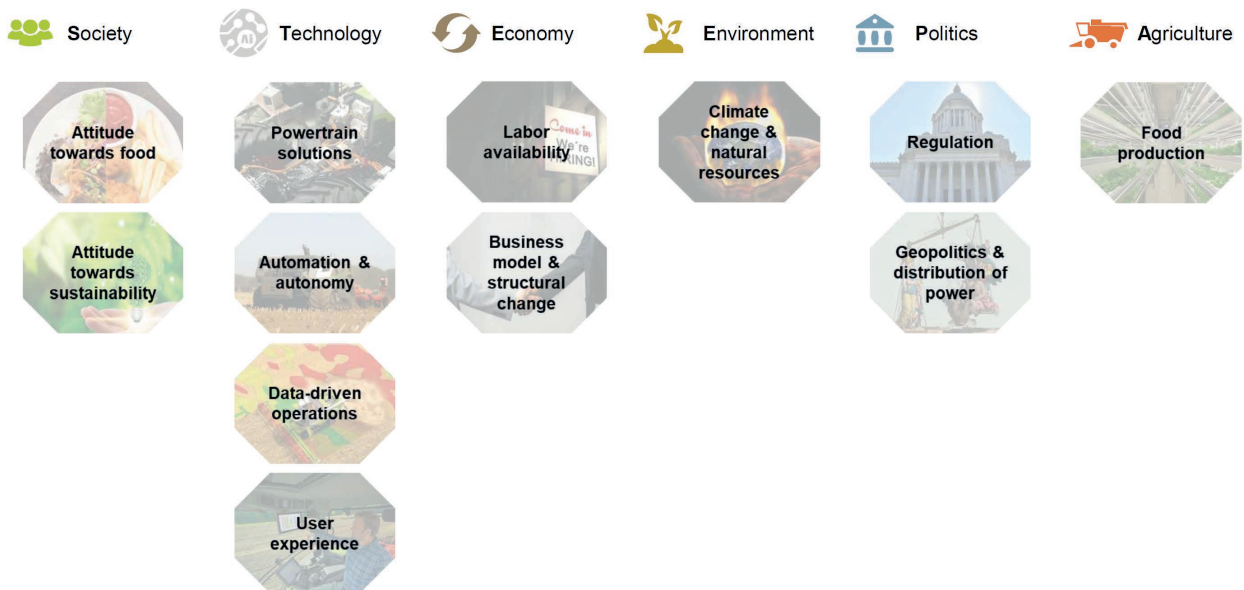
1.1.1 Growing Necessity for Agriculture



Global demand is expected to rise significantly across several key sectors by 2050. Population growth alone will add around 1.7 billion people worldwide, an increase of 21 %, driving a higher need for food. Over the next five to six decades, the global population is projected to keep increasing, rising from 8.2 billion in 2024 to a peak of about 10.3 billion in the mid-2080s.

In parallel, the energy sector is undergoing a major transformation, with the demand for emission-free fuels steadily increasing. In line with this, the European Union and North America have set the target of achieving net-zero emissions by 2050.

At the same time, global livestock numbers are projected to expand by 9 billion animals, equivalent to a 28 percent rise, which will further accelerate the demand for feed.



Societal attitudes toward food, sustainability, and animal product consumption are evolving alongside a growing focus on environmental integrity and economic governance. Technological advances, such as automation, data-driven operations, and improved powertrain solutions, aim to enhance efficiency and reduce reliance on human labor in consideration of shifting labor availability.

Climate change, resource scarcity, and regulatory frameworks increasingly influence production and energy systems, while new business models emerge to adapt to structural and economic change. Meanwhile, geopolitics, population growth, and innovation in food production are changing how societies meet rising global demand under limited natural resources.

1.2.5 Farmers perspective

Farming remains a highly challenging business, shaped by a complex mix of environmental, economic, and political pressures. The most pressing concern for farmers worldwide is extreme weather events, cited by 37 % as one of their top three challenges.

Close behind are price and income volatility (36 %) and fertilizer costs (30 %), followed by political or regulatory decisions affecting operations (29 %). Other notable concerns include labor shortages (27 %), pest and disease threats (22 %), and crop protection costs (20 %).

Many farmers see digital technologies as a vital tool to tackle key challenges, optimize performance, and improve efficiency—although barriers such as cost, connectivity, and technical know-how still slow adoption.

At the same time, a growing number are embracing regenerative agricultural practices—like crop rotation, soil conservation, and reduced tillage—to strengthen soil health, increase yields, and make their farms more resilient to climate stress.

Farmers also express a desire for greater societal recognition. The majority believe their work is essential for food security and environmental stewardship, yet feel underappreciated or misunderstood by the public.

1.2.6 Digitalisation

Farmers must consider customer, meaning end consumer and dealer expectations regarding sustainability, catered food patterns and the need for digitalization.

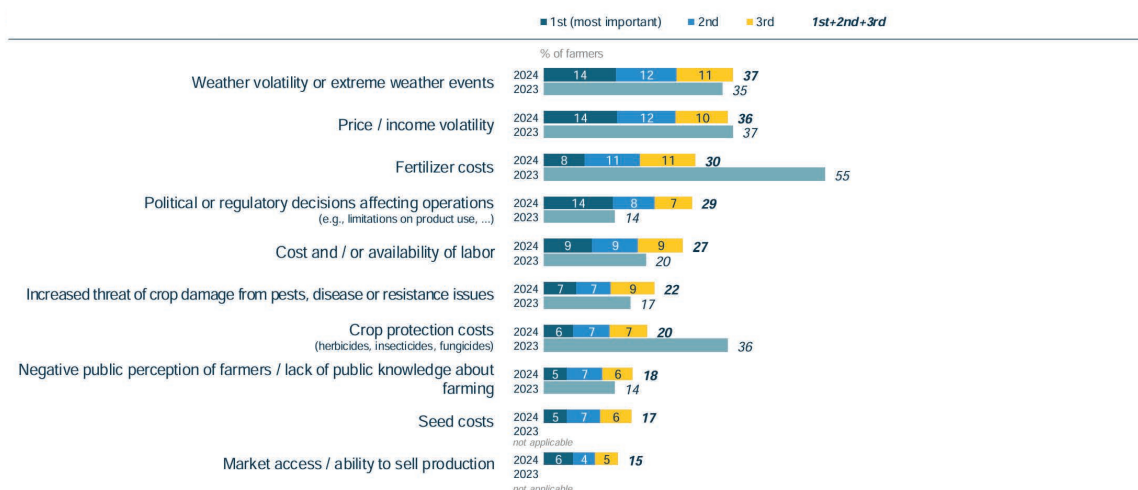
To promote sustainable agriculture, several ambitious targets have been set. These include reducing the overall use and risk of chemical pesticides by 50%, with an emphasis on cutting the use of more hazardous pesticides by over 50%. Additionally, nutrient losses must decrease by at least 50% without compromising soil fertility, which is anticipated to lead to a 20% reduction in fertilizer usage. The sale of antimicrobials for farmed animals is also targeted for a 50% reduction.

The goal is to achieve a 25% share of organic farming in relation to total agricultural land in the EU while significantly increasing the capacity of organic aquaculture. These initiatives aim to enhance agricultural sustainability and environmental protection.

1.2.7 Autonomy

Autonomy provides numerous advantages, including precise and reliable operations, uninterrupted functionality regardless of weather conditions, and long-term solutions for heavy and complex tasks, such as harvesting and plowing. As these innovations reshape the agricultural landscape, they are positioned to enhance productivity and sustainability in farming practices.

Fig.3 Challenges for farmers



© CLAAS Group, 2025
 © Appun, 2021
 Fact, 2024
 Kynetec & Kekst CNC, 2024
 Apun, EU's Farm to Fork strategy

1.3 Agriculture in europe










		Operating size							
		0-29 ha	30-49ha	50-99 ha	100-199 ha	200-499 ha	500-999 ha	1000-1999 ha	2000+ ha
Business type	Specialist field crops	<ul style="list-style-type: none"> Cash crop production (cereals, oilseeds, protein crops, rice and general field cropping) provides at least two-thirds of the business size 							
	Specialist grazing livestock	<ul style="list-style-type: none"> Dairying, rearing and fattening of cattle and grazing of sheep, goats and other livestock provides at least two-thirds of the business size 							
	Specialist granivores	<ul style="list-style-type: none"> Pigs rearing, pigs fattening, laying hens, poultry meat provides at least two-thirds of the business size 							
	Mixed farming	<ul style="list-style-type: none"> No clear business focus (e.g. cash crop, dairying, rearing or fattening of cattles, pigs, sheeps, goats and other grazing livestock) 							
	Others Horticulture / permanent crops Non classifiable	<ul style="list-style-type: none"> Two-thirds of business is permanent crops (vineyards, fruits, citrus fruits; olives) or horticulture (indoor and outdoor) 							
	Ag contractors								

Fig.4 Average farm sizes, CLAAS KGaA mbH, 2025

1.2.8 Business Strategies

Classical farming strategies reflect various ways farmers have historically adapted to economic, technical, and environmental pressures. These include labour-driven intensification, where higher yields are achieved through greater technical efficiency using existing resources.

Another approach is low-cost farming, which reduces dependence on external inputs by optimizing internal resource use. Scale enlargement—characterized by standardization, mechanization, and automation—enhances labour productivity by increasing farm size and externalizing certain operations.

High-tech farming builds on this by combining technological intensification with scale growth, increasing both resource input and productivity per labour unit. Pluriactivity involves farm households engaging in non-agricultural economic activities, with their significance often measured by the share of non-farm income. Farmers may also pursue changes in productive specialization or even exit agriculture altogether as part of strategic restructuring.

In response to evolving social, ecological, and economic contexts, new farming strategies have emerged, like establish new micro-enterprises that combine food production, processing, and direct distribution, retaining value within the farm enterprise.

Multi-functionality—engaging in activities like tourism, education, or ecosystem services—has become a viable way to diversify income and strengthen farm resilience. A growing number of farms are also turning to agroecology, which seeks to base farming practices more strongly on natural processes and cycles, promoting sustainability and ecological balance.

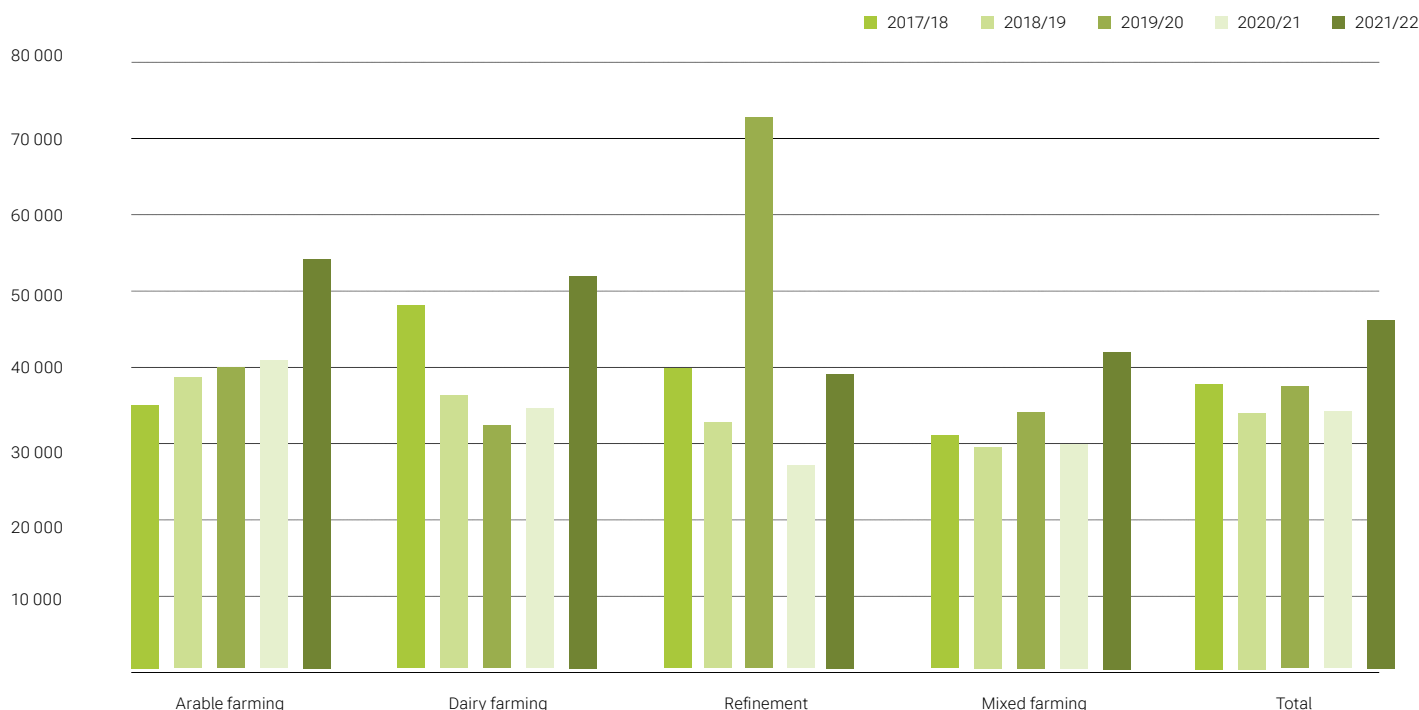


Fig.5 Farming incomes

1.3.1 Farming Styles

Between 2017 and 2022, farm incomes in Germany rose sharply across nearly all types of agricultural businesses. Arable farms saw increases of around 34 %, while dairy farms achieved the strongest growth at over 50 %.

Livestock production and mixed farms also recorded substantial gains of roughly 43 % and 41 %, respectively. Overall, the average income across all farm types grew by more than a third.

These developments reflect a period of relatively favorable market conditions, supported by high product prices and productivity gains in several sectors. The strong fluctuations between years also underline the continuing volatility of agricultural earnings, which remain closely tied to global market movements, weather extremes, and rising input costs.

1.3.2 Farming distributions

In general terms a style of farming can be defined as a particular unity and coherence of the following elements:

- (a) a set of strategic notions, values and insights shared by a particular group of farmers concerning the way farming ought to be organised;
- (b) a specific structuring of the practice of farming that corresponds to the strategic notions, or 'cultural repertoire' used by these farmers;
- (c) a specific set of interlinkages between the farm enterprise on the one hand and the surrounding markets, market agencies, government policy and technological developments on the other.

These interrelations are structured in such a way that the specific farming practice can be reproduced overtime.

Organic farming is politically promoted, with initiatives like the European Green Deal aiming for 25% of agricultural land to be farmed organically by 2030. It offers potential health and environmental benefits, such as reducing pesticide-related deaths and preserving biodiversity. Due to significantly lower yields, organic farming requires more land, posing a challenge to its large-scale implementation.

No-tillage farming has seen a significant global rise, expanding from 45 million hectares in 1999 to over 507 million hectares by 2021. This method can offer long-term economic benefits for farmers, but its adoption is hindered by several factors. Key barriers include limited knowledge and experience, traditional mindsets, policy constraints like commodity-based subsidies, lack of suitable machinery and limited access to effective herbicides in many developing countries.

Carbon farming offers significant co-benefits like increase soil carbon storage can enhance farmers' productivity and climate resilience, while also contributing to biodiversity conservation and improved water quality. A central challenge remains the accurate and cost-effective measurement of mitigation impacts. Without reliable and permanent carbon removal, the climate benefits of carbon farming remain limited.

1.5 Non-Animal products



Fig.8 Bundesministerium für Ernährung und Landwirtschaft, 2024

1.5.1 Rice

Rice is one of the most important staple foods worldwide, providing a vital nutritional foundation for billions of people across diverse cultures. Its many regional varieties reflect the adaptability of rice to different climates and cultivation practices.

1.5.2 Maize

Maize, in contrast, plays a key role not only in human diets but also as a primary component of animal feed. It is additionally processed into products such as cooking oil, food starch, and biofuel. While mature maize plants are harvested using combine harvesters for their grain, maize silage is produced from whole, green plants and used extensively in livestock nutrition.

1.5.3 Rapeseed

Rapeseed is another valuable crop, known for its versatile use. It is primarily cultivated for rapeseed oil, which serves both culinary and industrial purposes, including the production of engine fuel.

1.5.4 Cereal Crops

Cereal crops such as wheat or barley are predominantly grown for human consumption, but they also yield straw as a byproduct. This straw can be collected in bales and used on the farm—commonly as animal bedding or for energetic purposes like biomass fuel.

1.5.5 Forrestry

The German forestry and wood sector manages approximately 10.2 million hectares of forest, with 43% privately owned. Extreme weather events and pest infestations have caused substantial damage, resulting in over 250 million cubic meters of damaged timber between 2018 and 2022. Biotic and abiotic damages have led to large reforestation needs and fluctuating timber harvest volumes.

In 2022, about 73 million cubic meters of roundwood were used, with 30% burned for energy and 70% used for materials, mostly by the sawmill industry. The economic performance of forestry declined sharply in 2019 and 2020, with historic losses due to falling timber prices, especially for coniferous wood. Recovery began in 2021, supported by rising prices, increased harvests, and government aid programs. Nonetheless, the sector remains challenged by forest degradation, high reforestation demand, and volatile market conditions.

1.7 Agricultural segmentation

1.7.2 Farm Sizing

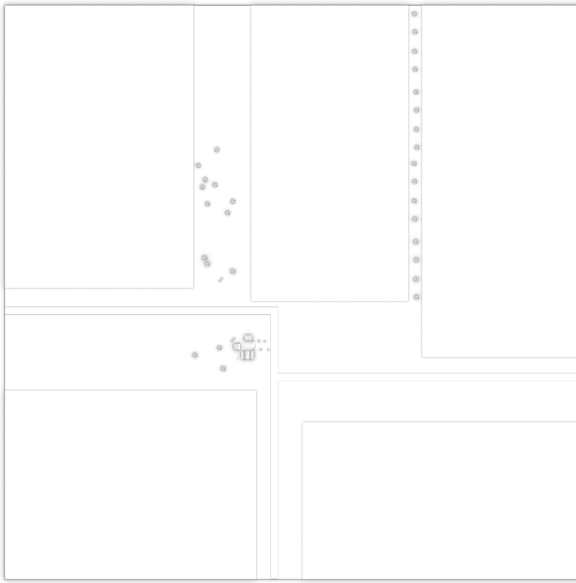


Fig.12 Average field proportions

The average farm size in Germany is approximately 60 to 65 hectares, with the 2020 national average recorded at 63 hectares. Farms are predominantly engaged in either arable cropping or forage production, supporting dairy and livestock operations. Roughly 85% of these farms operate as family-run, single-owner businesses. Over half of all farms are managed on a part-time basis, typically being smaller in scale, while full-time farms tend to be larger, averaging around 73 hectares.

The agricultural sector shows a high degree of land concentration: just 14% of farms manage 62% of the total agricultural land. Many farms are economically diversified, with more than half generating additional income through renewable energy, direct marketing, or agricultural contracting. Approximately 10% of farms are certified organic.

Overall, farm-to-field distances in Germany are typically short—around 2–2.5 km, especially for conventional arable and grassland parcels.

Higher average distances are applied in biomass logistics contexts, where delivery areas extend beyond immediate neighboring land.

1.7.1 Farm Logistics

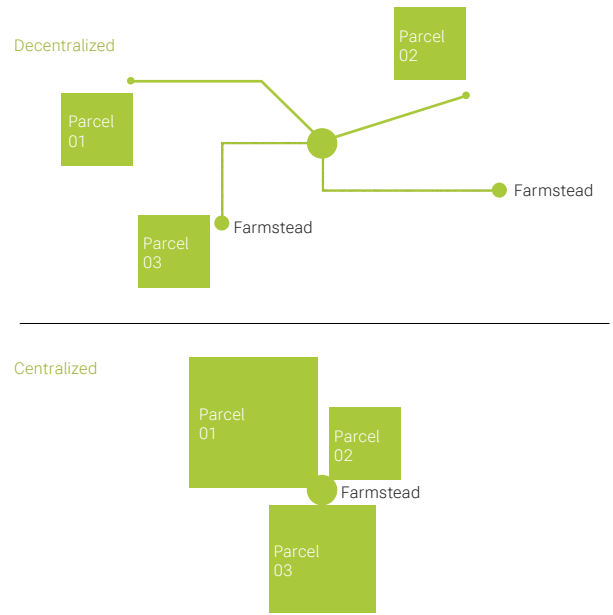


Fig.11 Farmstructure centralized and decentralized

Larger farms benefit from economies of scale: as size increases, fixed costs are spread over more output, making larger operations more cost-competitive. Technological change plays a key role, since high-investment machinery and automation are easier to justify on larger units.

Structural factors also push consolidation: fewer farmers are entering the sector and many small-scale operations exit, which results in land and operations being absorbed by larger farms.

Policy and market forces contribute too: agricultural subsidies, market access, global competition and technological demands all favour farms that can operate at a larger scale and adopt innovations quickly.

Finally, natural and regional conditions matter: land quality, climate, and local infrastructure make some regions more suited to larger farms, which reinforces structural change through an uneven geography of viability. Drones could address more scattered and smaller farming landscapes in Europe. The use cases also become relevant for bigger farms.

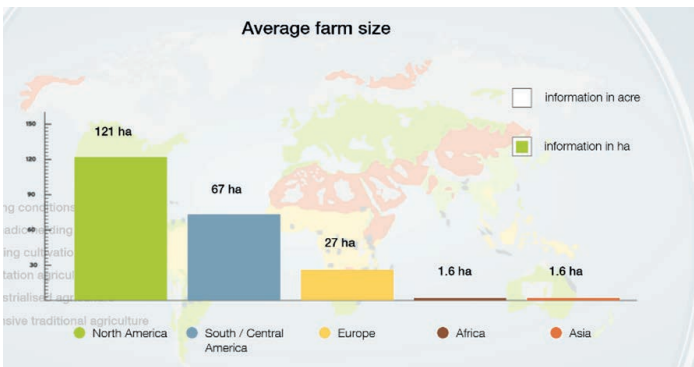


Fig.10 Average farm sizes, CLAAS KGaA mbH, 2025

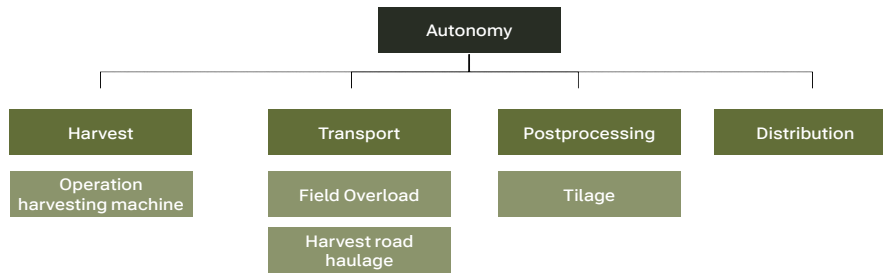
19 Machl, T. (2017). Analyse landwirtschaftlicher Transportbeziehungen [Vortrag]. Technische Universität München

20 Bundesministerium für Ernährung und Landwirtschaft, 2024

21 Sebastian Neufeld, Explaining farm structural change in the European agriculture

1.8 Robotization in Agriculture

1.7.5 Touchpoints for Autonomy



Support usually is more common for less complex tasks. Touchpoints for autonomy appear throughout the interaction between human operators, control systems, and the autonomous field units. The process begins with mission setup and coordination, where operators define tasks and locations through digital interfaces or virtual simulations.

During deployment, remote control and alignment systems—similar to those used in aviation or space docking—ensure precision in coupling, field entry, and navigation. Once in operation, autonomous behavior takes over, supported by continuous communication between the robot, service stations, and control units. Visual signals and light communication act as intuitive feedback channels to confirm system status and movement.

After fieldwork, data transfer, maintenance, and calibration connect the machine back to the operator through intelligent management systems that learn from performance. Across all these moments, the key touch-

points blend physical presence and digital oversight—maintaining human trust while allowing the system to operate with increasing independence.

Drones demonstrate strong potential in surveillance applications across logistics, forestry, and resource monitoring, particularly when used independently of specific machine types. In Germany, regulatory requirements such as mandatory human supervision limit the feasibility of continuous or fully autonomous drone operations.

From a viability standpoint, achieving cost efficiency depends on balancing deployment scale, energy consumption, and integration into existing infrastructure like parking systems or radar networks. The overall business case hinges on reaching a break-even point where operational savings and data value outweigh implementation and maintenance costs.

© CLAAS, MMI2030
 © Hardes, Autonomous Networks

1.7.3 Autonomy at CLAAS

Farmers business-model preferences for autonomous tractors are largely independent of general acceptance but linked to technological openness and risk attitude. Economic context like minimum wage and hardware costs strongly shapes willingness to pay, while operational factors like ROI time, use-cases, support play a lesser statistical role.

1.7.4 Working principles

Autonomy develops along a continuum, from complete human control to full robot independence. At the lowest levels, machines act only when commanded and rely entirely on human input for sensing, decision-making, and execution. As autonomy increases, systems begin to handle specific subtasks such as navigation or path planning while still following general human guidance.

Mid-level autonomy describes shared control, where the robot can propose actions, make local adjustments, or carry out operations within predefined limits, while humans remain responsible for overall goals. High-level autonomy allows the robot to sense, interpret, and act independently, adapting its behavior to changes in the environment or its own condition.

The highest levels describe machines capable of evaluating complex situations, prioritizing goals, and deciding when to request or reject human assistance, achieving self-directed operation within broad objectives.

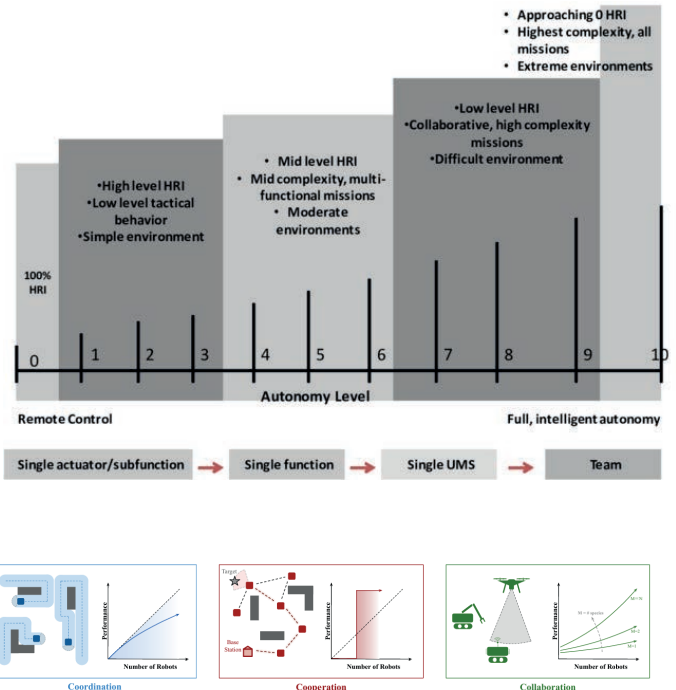


Fig.13 Functionalities of swarm robotics

© Hardes, Software Innovation Campus Paderborn
 © Li, B et al. Human or robot?

1.8.1 Advantages

Efficiency Advantage

Robots can operate continuously, day and night, increasing efficiency compared to human labor.

+

Biodiversity and Nutrients Challenge

Increasing biodiversity introduces more complex and labor-intensive systems that require innovative solutions.

=

Goal – Sustainable Affordability

Use robotics to reduce labor costs, making sustainable farming methods more financially viable.

Robotic automation in agriculture offers a clear efficiency advantage, as robots can operate continuously, day and night, without the physical limitations of human labor. The biodiversity and nutrients challenge makes more diverse and sustainable farming systems less accessible as they often require intricate, labor-intensive processes that traditional mechanization struggles to handle.

The key goal is to achieve sustainable affordability—using robotics not just to cut labor costs, but to make complex, environmentally conscious farming methods economically viable in the long term.

1.8.2 Current Limitations

Advanced onboard processing demands significant computational power and energy, making systems costly and less efficient for extended use.

Although machines can technically operate in dynamic environments, their response times remain too slow for truly agile behavior, limiting performance in unpredictable settings.

There is a lack of interoperability between digital platforms—data cannot flow seamlessly across brands, machines, or software systems, reducing overall efficiency and integration potential.

These technical and infrastructural challenges are compounded by high implementation costs, which increase the divide between large, industrial farms and smaller family-run operations that struggle to afford new technologies. Unresolved issues surrounding data ownership, security, and privacy continue to erode trust, discouraging full adoption of connected and automated systems in the agricultural sector.



Fig.14 Nexat



Fig.16 SAM Dimensions



Fig.15 AgBot 5.115T2, Agxeed



Fig.17 GROTHAUS

²⁶ Prorok, A et al. Beyond robustness: A taxonomy of approaches towards resilient multi-robot systems
²⁷ CLAAS. Correlation analysis of autonomous & semi-autonomous tractor
²⁸ Amazone. Field Day Plant growth Innovation
²⁹ Araujo. Characterising the Agriculture 4.0 landscape

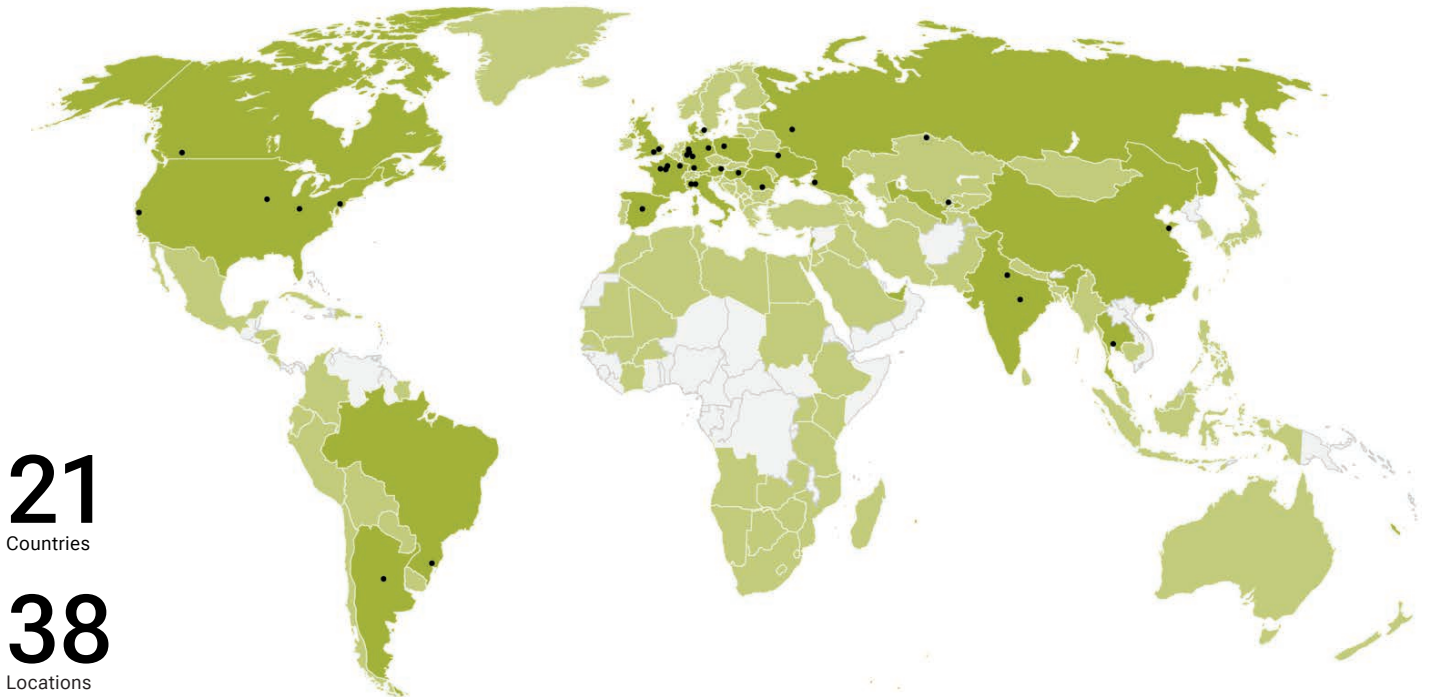


2. CLAAS

CLAAS is a German agricultural machinery manufacturer founded in 1913, with the guiding principle 'Enable farmers to be the best in their field'. Originating with the development of the combine harvester, the company has built a strong portfolio of machines with a particular emphasis on harvesting technologies, which remain central to its contribution to agricultural processes.

2.1 Company Facts

Agriculture ■
CLAAS ■
Drones ■
User ■



2.8.1 History

CLAAS, founded around 1900 by Franz Claas Senior in Heerde, Germany, began with the development of a milk centrifugal and haybinder. A significant milestone was achieved in 1913 with the introduction of the knot binder, designed by Franz Claas and his brothers, featuring limited lip movement and variable band sizing to improve hay binding efficiency.

Post-World War II, specifically around 1945, CLAAS advanced with the creation of the combined harvester, leveraging automation spirit and American agricultural ideologies. Key contributors like Prof. Karl Vormfeld and engineer Dr. Walter Gustav Brenner were instrumental during this transformative phase.

In 1965, CLAAS experienced a breakthrough with the launch of self-driving combined harvesters, including models such as the SUPER, EUROPA, MATADOR, and SF, which enhanced productivity and competitiveness in the market. By around 1975, the company diversified its product portfolio, introducing innovations like the JAGUAR forage harvester and the DOMINATOR combined harvester, establishing itself as a specialist in harvesting technology.

2.8.2 Company structure

As a family-owned company with around 10,000 employees, CLAAS has a considerable organizational structure, recently reshaped through matrix restructuring. Several boundary conditions influence the company's design approach — most notably, the scale of production, which directly affects the level of detail and customization possible in each product.

CLAAS

© CLAAS KGaA mbH, (2024), CLAAS annual report 2024.

2.2 Company Philosophy

CLAAS builds its strategy on growth, innovation, and sustainability to strengthen its position as a global leader in agricultural technology.

The company's objective are to achieve top customer loyalty, a sales growth rate (CAGR) of 6 %, and a 7 % profitability return on sales. Its vision—"We enable farmers to be the best in their field"—captures commitment to empowering agricultural professionals through reliable and intelligent solutions.

The brand's core belief—Growing Together—reflects its mission to evolve alongside farmers, ensuring progress, efficiency, and sustainable success in modern agriculture.

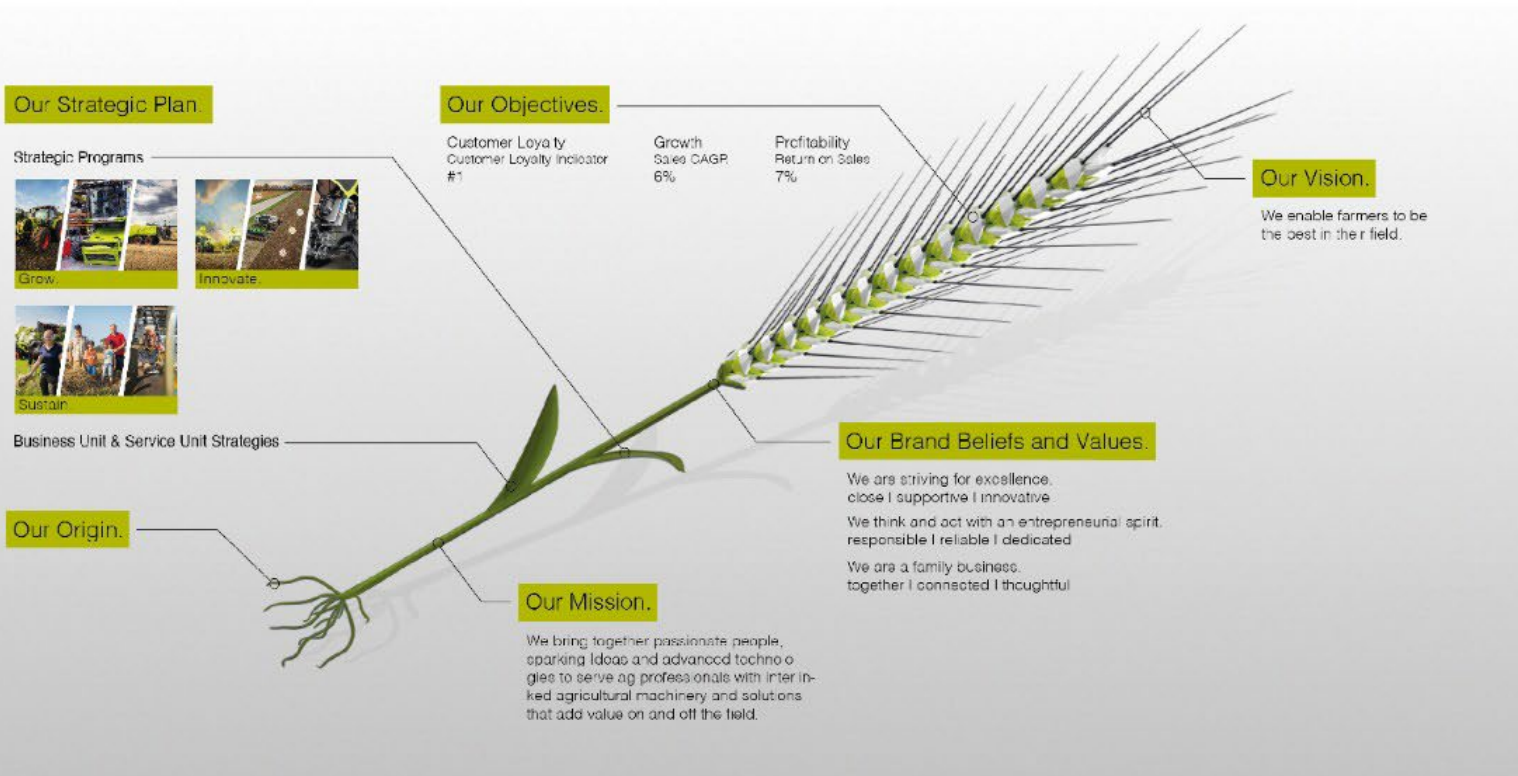


Fig.18 CLAAS company philosophy

2.3 Core business



Fig.19 Combine Harvester | Lexion, Tiron, Evion



Fig.23 Tractors | Xerion, Axion, Arion, Axos, Elios, Nexos



Fig.24 CLAAS Connect



Fig.20 Forage Harvester | Jaguar



Fig.21 Wheel loaders & Telehandler | Scorpion, Torion



Fig.22 Implements | Mowers, Tedders, Swathers, Balers

CLAAS is the world leader in another large product group, self-propelled forage harvesters. CLAAS is successfully represented around the world with tractors, agricultural balers, and green crop harvesting machines.

2.2.1 Tractors

Support in very versatile areas since 2003. Tractors are used on the farm, the field and on the street for: extraction of food, crop protection, ploughing, swathing, seeding, baling, application of slurry, transport works, fertilizer application and municipal labour. Heavy loads can be moved flexibly by pulling, pushing, lifting and loading. Daily work during the whole year is supported. There are different tractor models that vary in size, versatility and also region of distribution.

2.2.2 Combined harvester

The main aim of the combined harvester is to extract the seeds. It is the Flagship product of CLAAS.

The grain harvesting process is a precise sequence designed to extract clean, high-quality grain efficiently. It starts with collecting, where the crop is gathered from the field. Threshing follows, separating the grain from the plant by beating or rubbing. The next step, separating, ensures that the loosened grain is fully detached from the remaining crop material. After that, cleaning removes any remaining impurities such as chaff, dust, or small debris. Finally, grain handling involves transporting, storing, or loading the clean grain for further use or distribution. Each stage plays a vital role in protecting yield and maintaining grain quality. SEMAS AUTOMATIC can adjust the environment.

Different attachments cater to different harvesting lengths and grain shapes.

2.2.3 Foliage harvester

Used in the vegetation period to develop grass. There are different machines which are used for handling grass in different stages.

2.2.4 Forage harvester

Crop variety can be harvested but need logistical coordination. The harvesting process involves a series of coordinated mechanical steps to ensure efficient crop collection and preparation. It begins with picking up the crop, where the material is gathered from the field. Next comes re-compressing, which compacts the crop slightly to optimize the following

steps. During cutting, the material is chopped into smaller, manageable pieces, which are then cracked to break open plant structures—improving digestibility for feed purposes. The crop is then accelerated, gaining speed to be transported effectively through the system, before finally being loaded into a trailer or container for storage or transport. Each step is critical for preserving quality and maximizing processing efficiency.

2.2.5 Loader

Telehandler and wheel loaders are used for handling material. Stacking and space saving are the main functions hereby. Combined with different attachments, bulk material, earth, sand, gravel, big bags, silage, manure and bales can be handled. Besides this service functions like sweeping can be carried out. Wheel loaders are used to extract from silos, load bales, clean the stable, filling the mix wagon, loading of trailers, collecting bales, compacting of silo.

2.2.6 Balers

Gathering and shaping of material. Different bale sizes can be produced, and bales can be simultaneously wrapped.

Efficient forage harvesting relies on three key factors to ensure quality and performance. First, proper picking-up of harvested material is essential to minimize losses and collect all usable crop from the field. Once gathered, achieving a high bale density is crucial, as it improves storage efficiency, reduces transport costs, and preserves nutritional value by limiting oxygen exposure. The cutting of harvested material into uniform lengths enhances bale compaction and feed intake for livestock. Together, these steps optimize both the handling and nutritional quality of the forage.

2.4 Machine Touchpoints

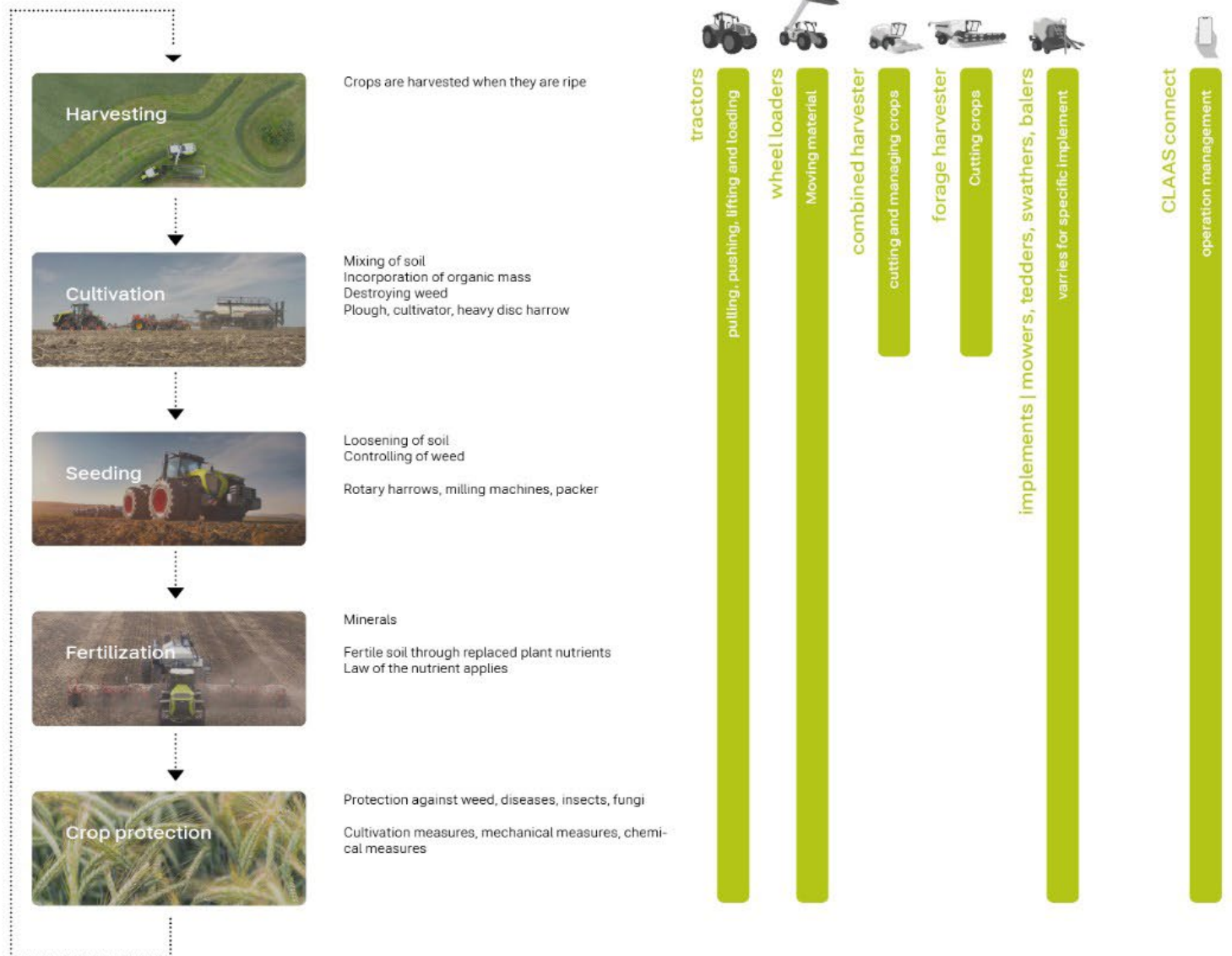


Fig.25 Harvesting and Machine correlation

Most CLAAS machines are used around the harvesting season.

The agricultural process is structured in several key stages that require different types of machinery to ensure efficiency and productivity. It begins with cultivation, where the soil is mixed and organic mass is incorporated to prepare the ground for planting. Implements like ploughs, cultivators, and heavy disc harrows are used, typically pulled or operated by tractors.

Next is seeding, which involves loosening the soil and controlling weeds. Machines such as rotary harrows, milling machines, and packers—again supported by tractors—ensure uniform seed placement. Fertilization follows, replenishing the soil with nutrients essential for plant growth, using spreaders and sprayers.

The crop protection stage safeguards plants from weeds, diseases, and pests through a combination of cultivation, mechanical, and chemical measures. Implements such as mowers, tedders, and swathers play a role here, attached to tractors for specific tasks.

Once the crops reach maturity, harvesting begins. Depending on the crop type, different CLAAS machines are deployed: combine harvesters for grain crops, forage harvesters for silage and feed, and wheel loaders for moving harvested material. Throughout all stages, CLAAS CONNECT serves as the digital backbone, enabling operational management and monitoring across the entire process.

This system demonstrates how CLAAS machinery integrates across the agricultural cycle from soil preparation to digital farm management.

2.5 Digital competence

Digital service mainly empowers the dealer to deliver a better customer experience.

2.4.1 Digital System Integration

Modern agricultural operations are becoming increasingly demanding, placing higher requirements on drivers to operate complex machinery efficiently. As machines grow more advanced, adapting them to work with new crop varieties and cultivation methods presents significant challenges. This leads to difficulties in understanding the relationship between threshing, cutting, and cleaning, which are crucial for optimizing performance.

The industry is facing a growing number of less experienced drivers, making it harder to maintain consistent machine output and crop quality. These factors highlight the urgent need for an operator assistance system, better training, and smart automation to support operators in the field.

2.4.2 Machine steering system

The digital system CEMOS as well as assisted Steering help with this process. Accurate machine configurations are important for maximizing the performance of modern agricultural equipment. Well-adjusted settings enable efficient operation and consistent results under varying field conditions. Automated or pre-set configurations further support the process by reducing the need for manual adjustments and limiting operator fatigue. This contributes to steady productivity and maintains operational comfort during extended or demanding work periods.

2.4.3 Sensor System

The steering system is supported by tactile sensors as well as satellite data. Precision guidance systems in modern agricultural machinery offer significant advantages by ensuring that every track is exactly the same as the previous one. This consistency reduces overlapping, preventing wasted fuel, time, and input materials. By maintaining precise alignment, the system makes full use of the working width, maximizing efficiency in every pass. As a result, it saves operational time, allowing farmers to cover more ground with fewer resources.

The enhanced accuracy provides the possibility to extend work into the night, as operators can rely on the system even in low-visibility conditions.

2.4.4 Data management

Data management is handled through TELEMATICS. The collected data presents a detailed overview of multiple machines used in agricultural operations, focusing on key performance indicators across different tasks. Metrics include process time, working speed, fuel consumption, and engine rpm, providing insight into each machine's operational efficiency. Additional parameters such as moisture content, bale pressure, and yield per hectare give further context on output quality and productivity. These values are essential for evaluating resource use, planning maintenance intervals like inspection times, and identifying optimization potential in field operations.

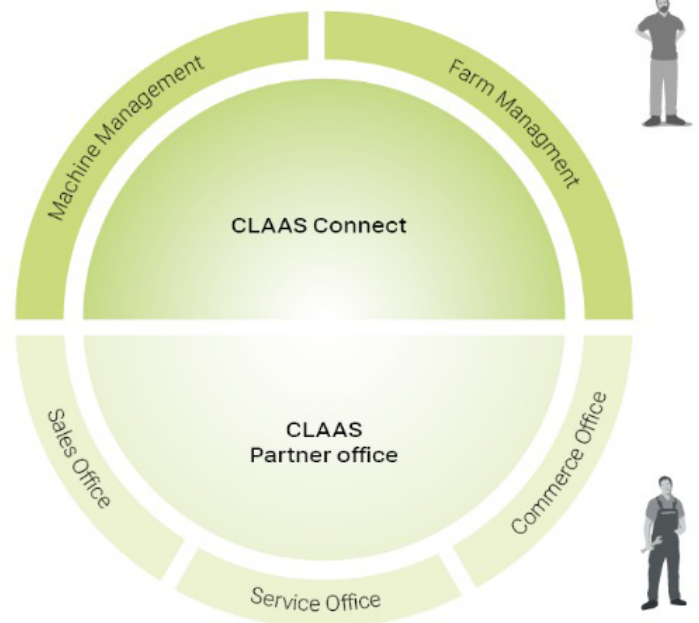


Fig.26 Service Ecosystem CLAAS

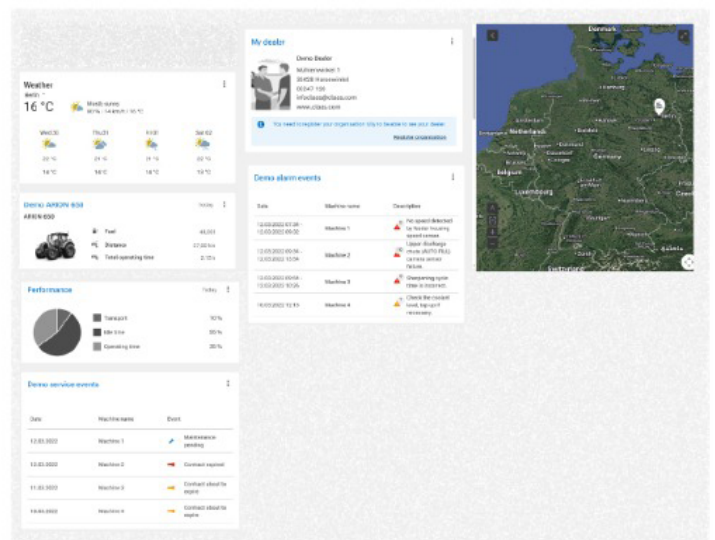


Fig.27 Overview CLAAS Connect functions

2.6 Service and parts

2.5.1 Technical Support

The MAXI CARE package provides extended protection for harvesting machines, tractors, balers and telescopic loaders to minimize downtimes at calculable costs.

A service offered by CLAAS and CLAAS sales partners that enables the delivery of data-based and personalized services. The sales partner gets access to CLAAS machines, and the data generated by them. On this basis he can provide support in the event of maintenance and, if necessary, rectify faults directly.

2.5.2 Field Support

The Corporate Technical Support Center supports the national markets (CLAAS sales companies, regional centres and importers). They face technical challenges and provide short-term solutions.

About 30 specialized CLAAS International Field Service Inspectors and International Field Service Engineers are supporting the markets worldwide. The Service Inspectors help to set up adequate After Sales structures in new markets and also provide training. The Field Service Engineers support importers and sales partners in the event of complex on-site repairs, such as special engine repairs and first use of pre-series machines.

2.5.3 After Sales

After Sales business ensures longer lifetime of products, both proactive and reactive. More than 200,000 part numbers are stored at the site, and the trend is increasing due to new machines and increasingly complex parts. For the most important parts availability is even higher. Both CLAAS ORIGINAL parts and CLAAS FARM PARTS are offered. ORIGINAL parts, accessories and consumables are dedicated for the use in and with CLAAS machinery.

Apart from spare parts, consumables and accessories such as lubricants, batteries or crop packaging materials (net, twine, film) are on offer. For all other needs on a farm, such as tools, fencing material or spare parts for other machines, CLAAS FARM PARTS offers solutions.

2.5.4 CLAAS Academy training program

The CLAAS Academy training program is designed to provide comprehensive education and skill development for customers, dealers, and employees related to CLAAS machinery and agricultural technology. The academy offers a mix of theoretical and practical training sessions covering topics such as machine operation, maintenance, troubleshooting, and the latest innovations in agricultural equipment.

The CLAAS training program builds employee competence step by step. After meeting entry requirements at Level 0, trainees advance from basic understanding to full independence.

At Level 1, technicians learn to service and hand over products, while sales staff grasp the sales process and customer relations. Level 2 develops professional skills—technicians perform diagnostics by set procedures, and salespeople match products to customer needs through consultative selling.

At Level 3, both act autonomously: technicians diagnose without defined procedures, and sales staff sell confidently under pressure. This structure ensures technical excellence and strong customer engagement across all roles.

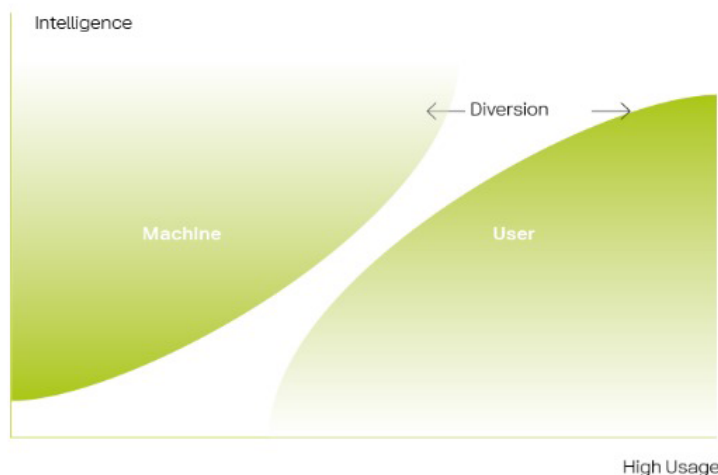


Fig.29 Technology User Diversion

	Objectives Technician	Objectives Salesman
Level 3	Employee can proceed diagnosis independently and effectively even if procedures are not defined and is able to report according to the requirements.	Employee is able to persuade in situations with strong competition and to sell under pressure ("Assertive Selling")
Level 2	Employee can carry out diagnosis according to defined procedures	Employee is able to qualify the customers' needs and to propose the ideal CLAAS product fitting to his demands ("Consultative Selling")
Level 1	Employee can explain, prepare, service and hand over the related product to the customer	Employee understands the sales process, his role in the organisation and is able to build up relationships with customers
Level 0	Trainee has to fulfil prerequisites to start with the CLAAS service or sales qualification process.	

Fig.28 CLAAS trainee program



Fig.30 CLAAS customer training

2.8 Strategy and Innovation

2.7.4 Innovation management

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3. Drones

Drone as a filming device have been established for long, and have emerged in different fields with different properties in different fields. The goal is to get an understanding of the current abilities of drones and their limitations.

3.1 Market

3.1.1 Market Overview

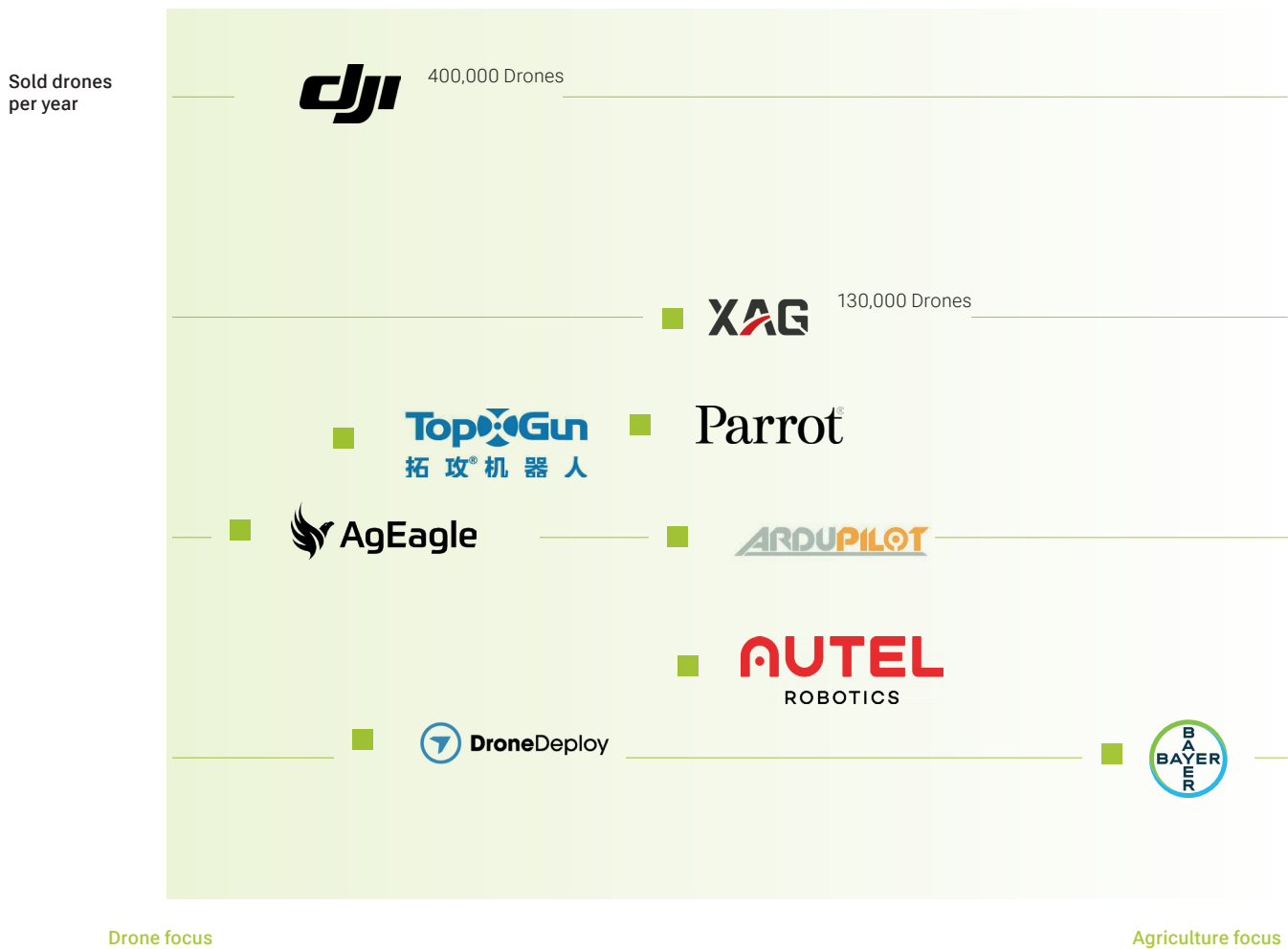


Fig.37 Competitor overview, Jonas Schöne

DJI is by far the market leader, selling around 400 000 units per year. The chart visualizes the annual drone sales and market focus of key industry players, showing the spectrum between general drone manufacturing and agricultural specialization. DJI dominates the global market with around 400,000 drones sold per year, far surpassing other competitors.

XAG follows with about 130,000 units annually, focusing strongly on agricultural applications such as crop spraying and precision farming. Companies like Parrot, Autel Robotics, and ArduPilot occupy the mid-range segment, offering both consumer and industrial solutions.

AgEagle, DroneDeploy, and Bayer position themselves closer to the agriculture-focused side, emphasizing drone software and services that enhance field analysis and agronomic decision-making. The graphic highlights DJI's clear market leadership while illustrating the growing overlap between drone technology and agricultural innovation.

3.1.2 Drone advantages

Drones and air mobility technologies offer substantial benefits across multiple sectors: they enable faster and more flexible delivery of goods, critical medical supplies and humanitarian aid, especially in remote or difficult-to-reach locations. They enhance public safety by supporting search and rescue, firefighting and policing operations, and they optimise infrastructure inspections, agriculture, and environmental monitoring.

In addition, by utilising efficient unmanned or vertical take-off aircraft, these technologies can reduce traffic congestion, lower emissions and open up new mobility services, contributing to more sustainable transport ecosystems

⁴² CLAAS KGaA mbH, (2024), Technology Management
⁴³ EASA (2025), Benefits of drones and air mobility

3.1.3 Drones on the Market





			
DJI Matrice 4TD	DJI FlyCart 30	DJI Mavic 3	DJI Neo
Thermal drone with AI tracking, long range, and autonomous Dock 3 support for industrial and emergency missions.	Heavy-lift delivery drone for rugged, long-range transport in extreme conditions.	Premium compact drone featuring a 4/3" Hasselblad camera with telephoto lens, 5.1K video support, and ~46-min flight time—ideal for prosumers and pros.	Entry-level AI-powered mini drone for effortless flying, tracking, and capturing 4K videos.
€7,000–8,000	€15,500–20,000	€1,300–2,800	€ 200-300
<p>Thermal + quad camera (zoom, wide, NIR, 640x512 thermal)</p> <p>Flight time up to ~50 min (no load), ~18 min under 10 km ops</p> <p>25 km range with O4 transmission</p> <p>Weatherproof (IP55, -20 °C to +50 °C, 12 m/s wind)</p> <p>Omnidirectional sensing, AI tracking</p> <p>Dock 3 ready for full autonomous use</p>	<p>Carries up to 30 kg (40 kg in emergency mode)</p> <p>Range: 16 km (dual battery), 9 km (single)</p> <p>Max speed: 20 m/s; altitude: 6,000 m</p> <p>Works in -20 °C to 45 °C, IP55 weatherproof</p> <p>O3 + 4G transmission, dual-operator mode</p> <p>Built-in parachute, obstacle detection, ADS-B</p> <p>Cargo box or winch mode</p> <p>Smart functions: RTK, cruise control, DJI Pilot 2</p>	<p>4/3" Hasselblad camera, 20 MP photos</p> <p>5.1K video, 28x hybrid zoom (Pro model)</p> <p>Flight time up to 46 min</p> <p>360° obstacle sensing</p> <p>15 km range, O3+ transmission</p> <p>Smart tracking & return functions</p>	<p>4K video, 12 MP photos</p> <p>AI-powered tracking and voice control</p> <p>Lightweight (135 g) – no registration needed</p> <p>~20 min flight time, 50 km/h top speed</p> <p>Gesture control and auto land/takeoff</p> <p>USB-C charging (no hub needed)</p>
<p>High cost: ~€7,000–8,000 drone only; ~€21,500 with Dock 3</p> <p>Heavy + non-foldable – bulkier for transport</p> <p>Shorter flight time under payload</p> <p>Requires BVLOS permits in most regions</p> <p>Sensitive thermal sensor – avoid heat/laser exposure</p>	<p>High price (~€15,000–35,000+)</p> <p>Short flight time with heavy loads (~8–18 min)</p> <p>Heavy & bulky (up to 95 kg loaded)</p> <p>Regulations restrict use in many regions</p> <p>Winch kit sold separately</p>	<p>High price (€1,300–2,800 depending on model)</p> <p>Zoom quality drops past 8x</p> <p>Large file sizes, high SD card demands</p> <p>Basic app for pros, minor stitching bugs</p> <p>Controller ergonomics could be better</p>	<p>No obstacle avoidance</p> <p>Limited wind resistance</p> <p>No GPS, less stable in outdoor use</p> <p>Short range (compared to larger drones)</p>
Level 4 - High autonomy – Fully automated mission execution, remote ops, intelligent decision-making	Level 3 - Conditional autonomy – Can follow complex flight paths, carry out missions under pilot supervision	Level 2 - Partial automation – Autopilot features like RTH, obstacle avoidance, basic tracking	Level 1 - Assisted flight – Basic stabilization and auto-hover; limited AI aids

Fig.38 DJI functional analysis

The Matrice 4TD offers full autonomy and long-range capabilities for industrial and emergency use, while the FlyCart 30 supports heavy-lift logistics under challenging conditions. The Mavic 3 provides a balanced solution for professional imaging and field analysis, combining strong camera performance with smart automation.

In contrast, the Neo focuses on simplicity and accessibility for casual users. DJI's portfolio demonstrates a clear trade-off between cost, autonomy, and capability, scaling from basic assistance to fully automated operations.

3.1.4 Docking stations on the market

Charging stations are usually drone specific purchases and require an energy source. Hybrid energy systems with solar energy are not yet common.

Charging stations that can be used autonomously require induction charging. Contact charging would require a very specific geometry.

Name	Company	Short Description
DJI Dock 2	DJI	Compact, weatherproof docking station for DJI Enterprise drones; automated charging, remote control, data transfer.
DJI Dock (Gen 1)	DJI	Rugged outdoor station for M30 drones; designed for remote inspections and surveillance.
Skydio Dock	Skydio	Autonomous 'drone-in-a-box' for industrial inspection and security; integrates with Skydio drones.
Skydio Dock Lite	Skydio	Smaller, portable version of Skydio Dock for flexible deployments.
Percepto Base with Air Max / Air Mobile	Percepto	Modular base station supporting AI-driven drone operations for industrial monitoring.
DroneBox	Azimutel	Industrial drone-in-a-box with automated charging and data offload, suitable for 24/7 use.
BOLO S1	Sky Charge	FAA-approved autonomous docking system; widely used in agriculture and oil & gas sectors.
Hextronics Atlas / Sentinel	Hextronics	Docking stations with battery-swapping tech to minimize downtime between flights.

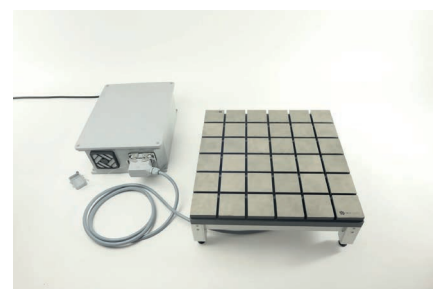
Fig.39 Charging station overview



DJI, DJI Dock2



DJI, DJI Dock



BOLO S1, Sky Charge



Skydio, Dock X10



Skydio, Dock Lite



Dronebox

Fig.40 Examples of Docking Stations

3.2 Differentiation

3.2.1 Drone Differentiation types

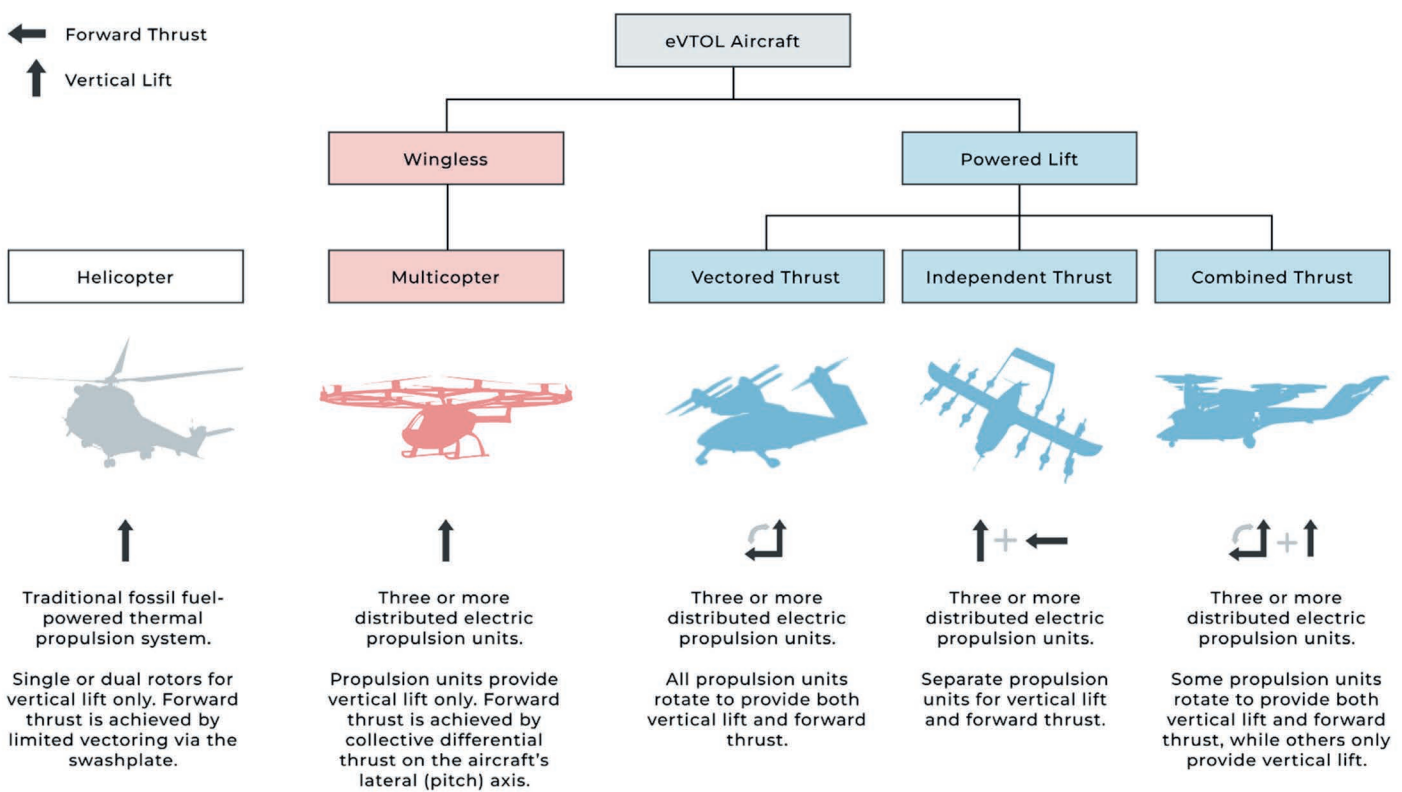


Fig.41 Different Wing Architectures

Multicopter and Helicopter have the easiest technical feasibility.

3.3 Agriculture Context

3.3.1 Overview drone functionalities

Healthcare & Emergency Services include medical supply delivery to remote or crisis-affected areas, drug delivery in wildlife medicine focusing on precise placement and safe transport assistance during health crises enabling movement or support for confined individuals, and firefighting and emergency response support with aerial views, situational awareness, and coordination.

Swarm drones can cover long distances and cooperate with external systems to generate high-level resource maps.

Imaging & Analysis covers aerial imaging for perspectives that are otherwise unreachable and 3D imagery for analyzing both static structures and complex scenes like accidents, especially in inaccessible areas.

Infrastructure & Industrial Monitoring involves the attachment of sensors in hard-to-reach areas, especially in energy networks, to enhance environmental monitoring and thermal safety assessments.

Finally, Urban & Passenger Mobility focuses on urban air mobility for goods and passenger transport being developed to reduce road congestion, while systems such as ALAADy – Automated Low Altitude Air Delivery provide rapid delivery in urban environments.



Fig.42 The Drone Interceptor is made from racing drone components. (Aleksey Zaitsevsky)

Fig.43 Wasp prevention through Cellulose. (Tree Copter)

Fig.46 A2Z Drone Delivery's new RDST octocopter. (A2Z)

Fig.47 The Helios hexacopter delivers the Helios robot to a photovoltaic panel (ART Robotics)

Fig.44 Sensor attachments on lines. (APG, 2024)

Fig.45 Weather predictions. (Meteomatics GmbH)



« Brüggmann (2024), Designing trust in human-robot interaction
« Shay (2023), Fire department usage of drones
« APG (2024), Sensor installation
« European Union Aviation Safety Agency (2024), Urban Air mobility

3.4 Agriculture Parameters

3.4.1 Agricultural functions

Digital functions

Warning Disaster alert Aerial reconnaissance & monitoring Documentation of weather Documenting wild animal damage Disaster alert Aerial reconnaissance & monitoring Documentation of weather Documenting wild animal damage	
Watching Documentation for public institutions Straw distribution Documentation for public institutions Safe field work Thermal imaging for hotspot detection Monitoring hazardous materials Water quality monitoring Biodiversity conservancy Forest mapping Road traffic monitoring Weed control Watching the field for obstacles Watching livestock in the shed Watching livestock on open fields Watching multiple fields Watching multiple machines at the same time Watching livestock on open fields Watching road entries	
Transparentize Fire scene assessment Grain yield forecast Construction sites Woods mapping Inspection of Overhead Power Lines Weather Predictions (Meteoromatics GmbH) Straw forecast Drying stress Making weather predictions Hovering over water supplies	
Single out Recognition of garbage Recognition of marine divers Recognition of garbage Ranking the fields	
Locating Bales logistics Identification of weed nests Temperature mapping Accident victim tracing Automated forest restoration Search and rescue operations Hovering around the machine	
Marking Wildlife detection Safe field work Marking different heights Marking boundaries to work at night Marking spots in fields Marking possible damages on machines Marking dirt on machines	

Physical functions

Moving Autonomous baling Sensor Attachments on Lines (APG, 2024) Wasap Prevention via Cellulose (Fres Cooper) Drone Delivery Drug Delivery for Wildlife Medicine (Brüggmann, 2024) Moving fertile earth Transporting fertilizer Moving implements in tight locations Moving items with drones Moving attachments around on the field Moving fodder around Moving of multiple dirt samples Moving away stones Moving After Sales Items Delivering After Sales Items	
Adding Swarm drones Adding communication points Sensor Deployment in High or Inaccessible Areas (APG, 2024) Fire extinguishers Multiple drones to cover bigger areas Completing otherwise incomplete networks Charging other electronic components Adding familiar sensors to one system Adding sensors to temporarily to a system Adding personal objects Adding charging opportunity	
Sorting Interpretation of yield maps Autonomous weed control Detection of drying stress Online determination of fertilizer Sorting plant characteristics	
Subtract Drone Interceptor Cleaning Removing ground for testing Cleaning of machine with compressor Cleaning with wipers Cleaning with sprayer Cleaning out beddings	
Changing Autonomous baling Carrying the equipment of one specific person	

Fig.49 Overview Agricultural drones

While there are different ways to abstract the functions of drones within an agricultural context. The two groups of digital and physical are always apparent.

3.4.2 Intelligence within Agriculture

By combining sensor data from drones, machines, and satellites, farms can monitor crop health, soil conditions, and environmental factors in real time. This allows predictive decisions such as adjusting fertilizer use, scheduling harvests, or identifying anomalies based on continuously

updated information. Agricultural intelligence transforms raw data into actionable insights, improving efficiency, reducing resource waste, and supporting a more sustainable and autonomous farming future.

Soil Parameters	Crop & Plant Health	Environmental & Weather Conditions	Field Operations & Machinery	Remote Sensing & Aerial Data	Livestock & Grazing
Soil moisture content Soil temperature Soil electrical conductivity (salinity) Soil pH Soil nutrient levels (N, P, K) Soil organic matter Soil compaction Soil texture and structure Soil respiration (CO ² flux)	Chlorophyll content Leaf temperature Plant height Canopy cover / density Biomass estimation Leaf area index (LAI) Water stress indicators Plant disease presence Nutrient deficiency symptoms Photosynthetic activity (NDVI, PRI) Turgor pressure Transpiration rate / sap flow	Air temperature Relative humidity Solar radiation / PAR Rainfall Wind speed and direction Barometric pressure CO ² concentration UV index	GPS location of equipment Machine speed / engine parameters Fuel consumption Spray rate or application volume Payload weight Implement position and pressure Obstacle detection	Multispectral reflectance Hyperspectral signatures Thermal imaging (canopy temp, soil heat loss) Vegetation indices (NDVI, SAVI, EVI, etc.) 3D topography (LiDAR or photogrammetry) Crop row spacing and alignment Canopy shadow mapping Flooded or drought-affected areas	Multispectral reflectance Hyperspectral signatures Thermal imaging (canopy temp, soil heat loss) Vegetation indices (NDVI, SAVI, EVI, etc.) 3D topography (LiDAR or photogrammetry) Crop row spacing and alignment Canopy shadow mapping Flooded or drought-affected areas

Fig.48 Mesurable parameters agriculture

© Soussi, Smart sensors and smart data for precision agriculture
 © Steeneken, Sensors in agriculture
 © Steckel, Technology Management

3.4.3 Deer rescue

As a service provider for actual farmers this is a common practice among hunters. While talking about drones and agriculture, this is the most mentioned use case besides crop analysis and it requires minimal technology intelligence.

There are logistical challenges when it comes to deer rescue itself, and while the sensors are sensitive to heat accumulations on fields, physical inspections are required to see if it is indeed an animal.

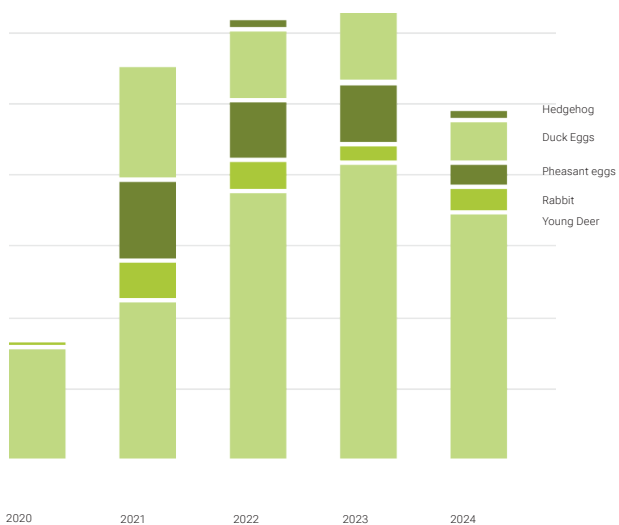
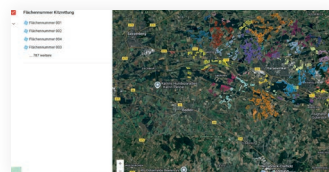
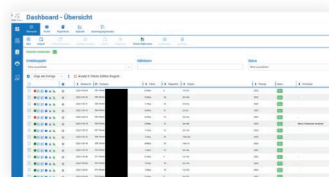


Fig.50 Process of Deer rescue and hunters yearly numbers



Area mapping



Task reception and team coordination



Charging batteries



Preparing drone car



Area mapping and team coordination



Starting the drone at corner of area



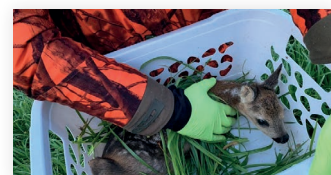
Sending people with handheld transceiver



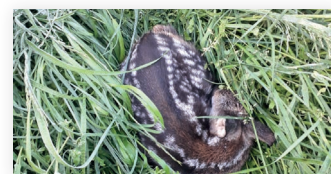
Starting the drone



Preventing livestock to escape



Handling with basket and gloves



Setting free in other area or after mowing

3.4.4 Drone Touchpoints at CLAAS

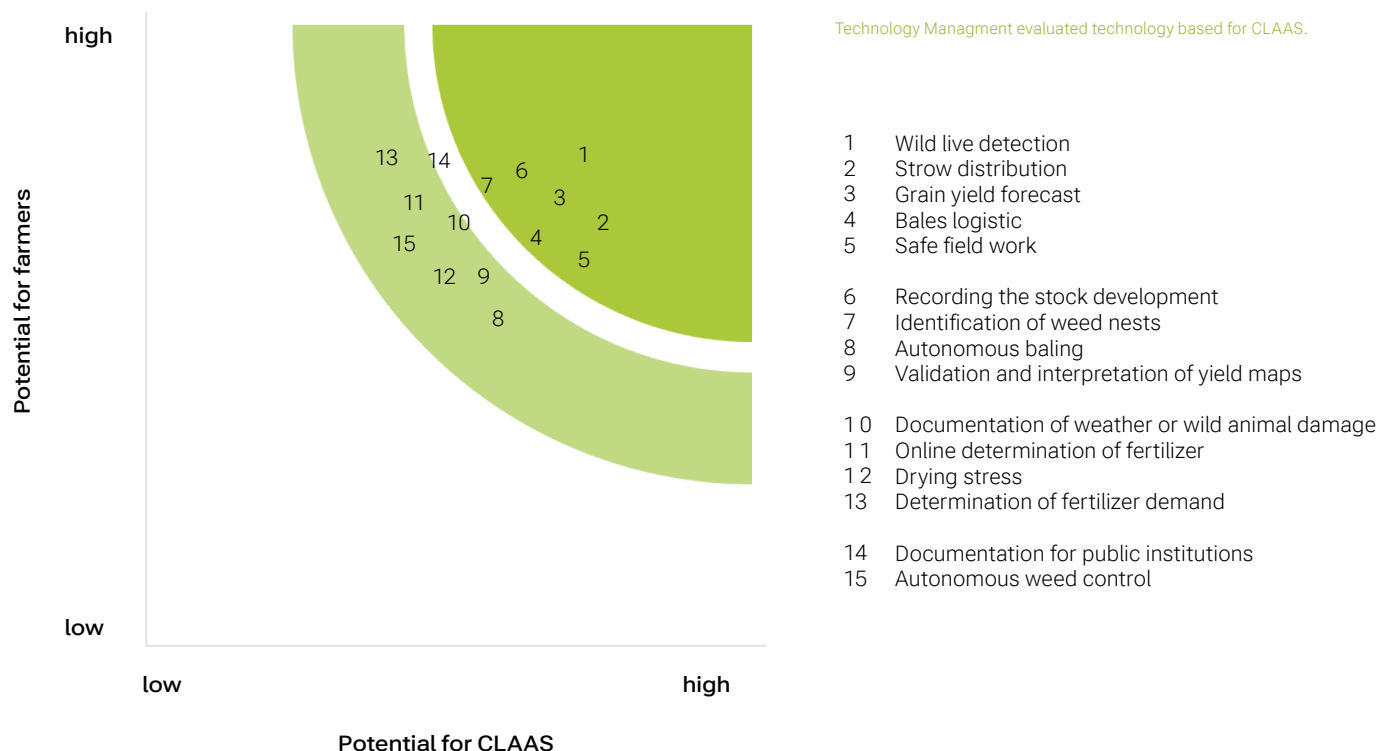


Fig.51 Technology Management on Drones

Analysis of the technical equipment requirements of selected customer groups and cost reduction potential of drone technology in grain harvesting for the case company CLAAS Selbstfahrende Erntemaschinen GmbH, Harsewinkel

Within CLAAS, drone technology is viewed through a technology-scouting lens, with the main focus on aligning emerging innovations with existing company knowledge and strategic priorities. Although drones have repeatedly surfaced in internal discussions, their long-term role remains undefined.

A threefold decision framework guides evaluation—considering the perspectives of CLAAS, its dealer network, and end users

(farmers)—to determine whether the company should act as a drone producer, a service provider, or leave drone implementation entirely to farmers.

Despite general openness toward drones, internal understanding of user needs is limited, as few direct farmer or dealer dialogues exist. Cost-cutting measures and a reactive, pull-driven innovation culture have slowed progress, with development occurring only when concrete internal needs arise.

Drone technology currently lacks a fixed position in CLAAS's strategic structure and is inconsistently classified, sometimes as a standalone topic and sometimes merely as a sensor platform.

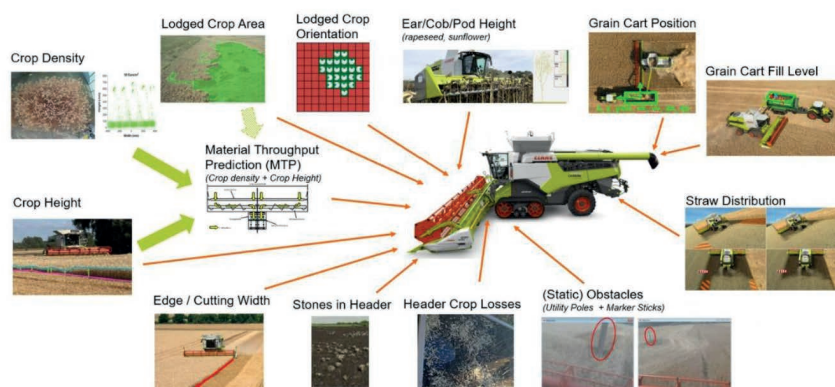


Fig.52 Intelligence on machine exterior

⁶⁵ CLAAS Group, (2024), Problem-Solution-Fit Analysis of possible Drone Use Cases.

⁶⁶ Foelsch, M. Drones and software

⁶⁷ Steckel, CLAAS Drones

⁶⁸ Giesker, Technology Scouting

3.5 Regulations

3.5.1 Drone Certification

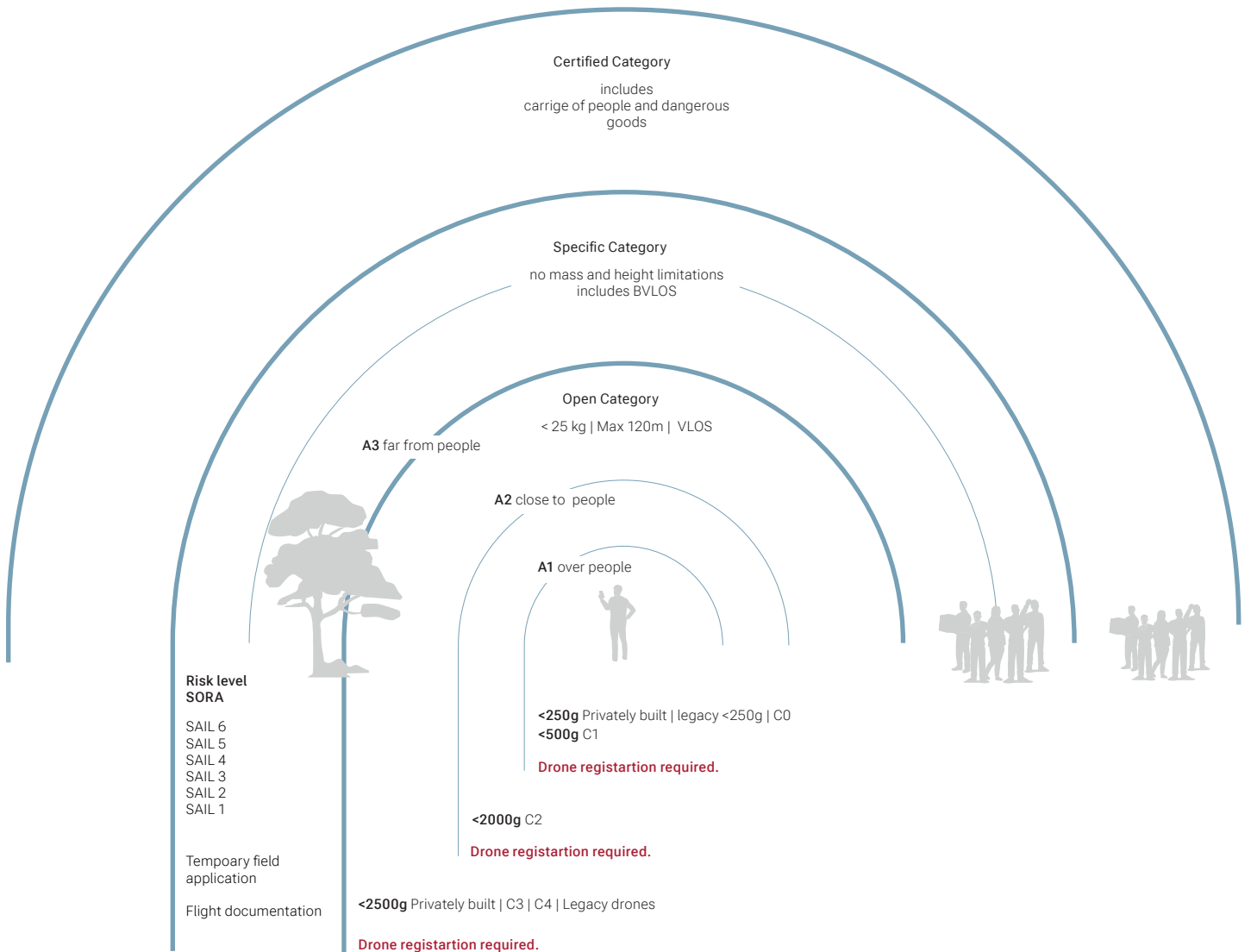


Fig.54 Regulation and registration classes for drones

There are three different categories of drone operation namely open, specific and certified.

Drones under 25 kg fall into the "Open" category, which allows flights up to 120 meters in altitude and requires visual line of sight (VLOS) operation. These drones must not transport dangerous goods or drop objects. The category is divided into three subcategories: A1 permits drones under 250 g but prohibits flying over crowds; A2 covers drones under 4 kg and requires a minimum distance of 30 meters from bystanders; A3 allows drones up to 25 kg but mandates a 150-meter distance from residential, commercial, industrial, and recreational areas.

Drones in the Specific category require either an operating license based on a risk assessment or a declaration aligned with a standard scenario (STS). The EU currently recognizes two STS, while Germany includes an additional one—DE.STS.FARM—for farming operations with drones under 50 kg. Operators holding a Light UAS Operator Certificate (LUC) are exempt from the license or declaration requirement.

The Certified category applies to drones with a dimension of at least 3 meters or operations that involve flying over crowds, transporting people,

or carrying dangerous goods. These high-risk use cases demand certified aircraft, operators, and remote pilots under strict regulatory oversight.

Drone operators in the "Open" and "Specific" categories must be at least 16 years old. Two types of pilot certificates exist: the EU A1/A3 certificate (basic competence) and the EU A2 certificate (for closer proximity to people). Both are valid for five years.

The EU classifies drones into seven risk classes (C0–C6) based on weight and speed, which determine the required certifications and operational limitations. Lower classes (C0–C4) are typically used in the "Open" category, while C5 and C6 are reserved for "Specific" operations. All drones must be registered and insured.

3.5.2 Drone Registration

1. Confirm your system's readiness

Ensure your DJI Dock 3 and Matrice 4D are updated with the latest firmware and have visible C2/C6 laser-etched labels
[facebook.com](https://www.facebook.com)

Activate and test safety features—GeoCaging, Flight Termination System (FTS), ADS-B—via FlightHub 2 following DJI's test guidelines



2. Obtain the EU STS Remote Pilot Certificate

In Germany, STS-02 operations (BVLOS in specific scenarios) require a remote pilot certificate for the special category (STS), issued by the LBA.

You can train and take the exam online through providers like Droniq (~€199 including VAT)
[flytbase.com](https://www.flytbase.com)

After passing, the result is sent to the LBA and you'll receive your official STS remote pilot certificate (~€30 fee).



3. Prepare your application documentation

You'll need:

-> ConOps / Operations Manual: Describing how and where you'll fly, your organizational setup, pilot training, equipment, etc.

-> SORA template: Evaluate your operation's risk via AirRisk & GroundRisk to determine its SAIL level. DJI + AirHub provide pre-filled SORA templates
[droniq.de](https://www.droniq.de)

-> Compliance checklist: Ensures FTS, geocaging, parachutes (if needed), ADS-B, and other OSOs are in place

-> SORA risk assessment report: Include hazard assessments, mitigation strategies (GeoCaging, FTS, ADS-B, parachutes), weather considerations, communication redundancy .



4. Submit to the Luftfahrt-Bundesamt (LBA)

Use the EU SORA transnational process (formerly SORA-GER), effective in Germany

Pay the fee (€200–€2000 depending on complexity)
[airclip.de](https://www.airclip.de)

Include all documentation: ConOps, SORA, Ops manual, checklists, pilot cert, proof of equipment features, and GeoCaging/FTS test logs.



5. Post-approval operations & compliance

Once authorized (typically up to 2 years)

Conduct flights within the defined Operation Volume.

Keep FTS and GeoCaging routinely tested.

Implement any OSO safeguards tied to your SAIL level (e.g., parachute, weather monitoring)

Use FlightHub 2 and AirHub tools to streamline fleet management, monitor changes in regulations, and handle renewals

„It's like opening a buisness.“





For flying a drone at the moment, it requires multiplesteps, like obtaining a flight certificate and a registration within the countries Federal Aviation Office.

If the drone will fly a fixed, pre-programmed path, with a remote pilot who remains able to intervene (monitoring, ready to take over), its possible to fly autonomously right now.

Fig.55 Registration process of a drone
© EASA (n.D). Open Category

3.6 Drone Architectures

3.6.1 Overview

	Lift and Cruise 	Multi Drone 	Single Rotor 	Fixed Wing 
Definition	Hybrid UAVs combining rotors and fixed wings for both vertical takeoff and efficient forward flight.	UAV with three or more rotors (e.g. quadcopters, hexacopters, octocopters).	UAV with one large main rotor, like a helicopter.	Fixed-wing drone = UAV with non-moving wings, like a traditional airplane.
Lift	Vertical lift via rotors; cruise supported by aerodynamic wings.	All rotors provide lift; flight is controlled by varying individual rotor speeds.	Main rotor provides lift and propulsion.	Uses aerodynamic wings for passive lift
Efficiency	More energy-efficient in cruise mode than multi-rotors; less than pure fixed-wing.	Less energy-efficient due to constant rotor thrust; limited flight time (typically 20–40 minutes).	Generally more efficient than multi-rotors, especially for longer flights.	More energy-efficient and longer flight time than rotary-wing drones.
Payload	Can carry moderate to heavy loads, depending on configuration.	Lower payload capacity and shorter flight time compared to fixed- or single-rotor types.	Capable of carrying heavier loads than typical multi-rotor drones.	Can carry heavier loads due to stable and efficient flight.
Control	Maneuvered via tilting rotors (vector-thrust) or separate lift and cruise systems.	Maneuvered via rotor speed adjustments to control yaw, pitch, and roll.	Maneuvered via main rotor pitch (cyclic/collective) and tail rotor thrust for yaw stability.	Maneuvered via control surfaces (rudders, elevators, ailerons).
Strength	Efficient forward flight, flexible take-off/landing, range	Precise hovering, easy to operate, agile	Shorter flight time, lower payload, wind-sensitive	Long range, high efficiency, wide coverage
Weakness	More complex, higher cost, more technical challenges	Shorter flight time, lower payload, wind-sensitive	More complex mechanics, higher cost	No hover capability, needs more space to operate

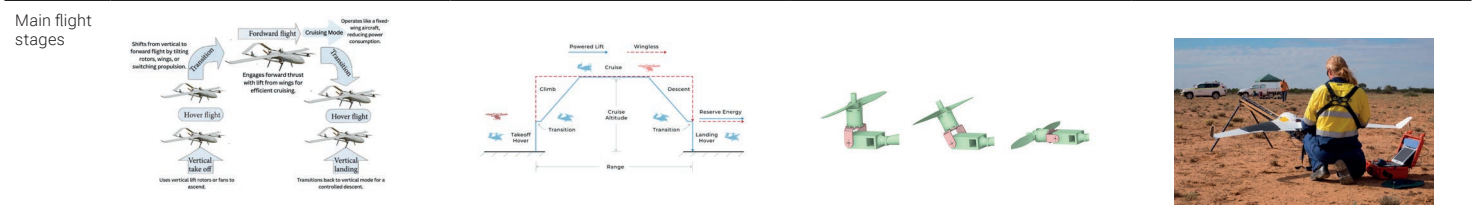
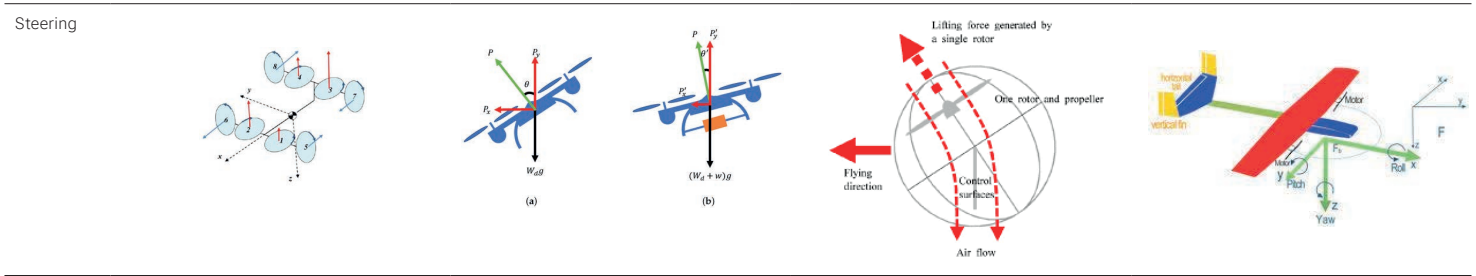
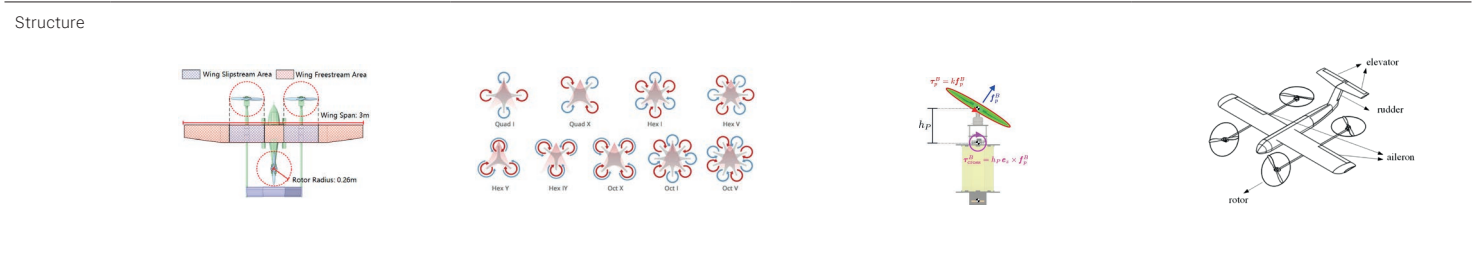


Fig.56 Mesurable parameters agriculture

Multidrones allow for the most precise steering with less intelligence than single rotor, while fixed wing and cruise drones offer more energy efficiency.

Hovering and steering behaviour is different and allows for different levels of precision.

⁶⁴ Wang, H., Sun, W., Zhao, C., Zhang, S., & Han, J. – Dynamic modelling and control for tilt-rotor UAV based on 3D flow field transient CFD
⁶⁵ Basset, P.-M., Dang Vu, B., Beaumier, P., Reboul, G., & Ortun, B. – Models and methods at ONERA for the sizing of eVTOL hybrid aircraft including analysis of failure scenarios
⁶⁷ Ito, S., Akaiwa, K., Funabashi, Y., Nishikawa, H., Kong, X., Taniguchi, I., & Tomiyama, H. – Load and wind aware routing of delivery drones
⁶⁸ Bernardes, E., Boyer, F., & Viollet, S. – Modelling, control and simulation of a single-rotor UAV with swashplateless torque modulation
⁶⁹ Author(s) – Design and control of an ultra-low-cost logistic delivery fixed-wing UAV

3.6.4 Sizing

The comparison highlights the key distinctions between Unmanned Aerial Vehicles (UAVs) and Micro Aerial Vehicles (MAVs). UAVs vary significantly in size—from small models under one kilogram to large systems weighing several tons—and are commonly used in military, industrial, agricultural, and delivery applications. They offer long endurance, capable of flying for several hours depending on their class, and can operate with varying levels of autonomy, from remote-controlled to fully autonomous systems.

In contrast, MAVs are extremely small, typically measuring 15–20 cm and weighing less than 100 g. They are designed for specialized indoor operations, such as surveillance, research, or bio-inspired flight. Due to their compact size, MAVs have short flight times limited by battery capacity but often exhibit high autonomy to cope with the challenges of cluttered, GPS-denied environments.



	UAV	MAV
Size	Varies widely (from <1 kg to several tons)	Very small (typically <15–20 cm, <100 g)
Typical Use	Military, industrial, agriculture, delivery	Indoor use, surveillance, research, bio-inspired flight
Endurance	Can fly for hours (depending on class)	Short flight time (minutes), battery-limited
Autonomy Level	Ranges from remote-controlled to fully autonomous	Often highly autonomous due to size constraints
Environment	Outdoor, long-range	Indoor or cluttered, GPS-denied environments

3.6.2 Thrust Weight Ratio

The thrust-to-weight (TW) ratio is a key performance metric indicating how much upward thrust a drone can generate relative to its weight. A TW ratio of 2 means the drone can produce twice as much thrust as its own weight. Higher ratios enable faster acceleration and more agile flight. FPV racing drones often target TW ratios of 4 or higher, while drones built for carrying payloads typically operate effectively around 2, with a minimum viable ratio around 1.5. A TW ratio of 1 means the drone can only hover at best, with no lift margin. Defining a target TW ratio is a critical first step in drone design.

Fig.57 Different Wing Architectures

3.6.3 Different lift generating behaviours

Drones can be classified by how they generate lift and propulsion. Multicopter are the most widespread type, typically featuring four or more electric rotors. They are easy to control, produce low noise, and are ideal for aerial photography, mapping, and measurement tasks. Their compact design and safety features, such as rotor cages, make them suitable for use in populated or sensitive areas, although they have limited speed and flight time.























Helicopter drones use one or two large rotors and offer greater hovering efficiency, longer range, and higher payload capacity. They are often powered by combustion engines, which provide higher energy density but also introduce more mechanical complexity, noise, and the need for sophisticated control systems.

Fixed-wing drones rely on forward motion to generate lift through their wings. They are highly efficient, capable of long flight times and high speeds, and well suited for applications like research and surveillance. Their need for runways or dedicated launch systems limits their flexibility in everyday use.

Hybrid drones combine the benefits of multicopters and fixed-wing aircraft by using fixed or swiveling propellers. This allows them to take off and hover like a multicopter and then transition to efficient forward flight. Although they offer high versatility and are ideal for time-sensitive missions such as medical deliveries or emergency response, they require complex control systems to manage the transition between flight modes.

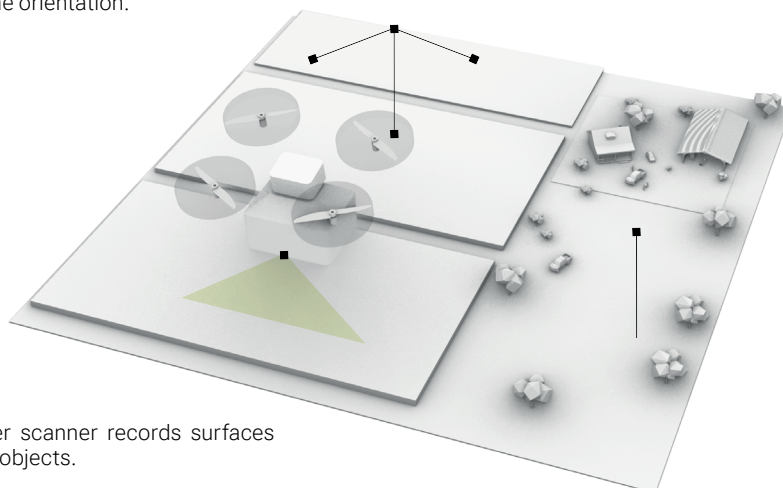
3.7 Hardware competence

3.7.1 Sensors

-  **Acoustic based sensors**
Detection and monitoring of pest population; harvesting of fruits.
-  **Electromagnetic sensors**
Record electromagnetic responses; measures residual nitrate level and organic matter concentrations in soil; real time measurement of transpiration rate.
-  **Light detection and ranging (LIDAR)**
Agricultural land-based utilities such as 3D modeling; soil erosion monitoring; agricultural land mapping; soil type detection.
-  **Optical sensors**
Employed to sense soil parameters like soil texture; mineral contents; clay content; moisture and color of soil. Fluorescence-mediated optical sensors are used to sense fruit maturation. Integral optical sensors along with microwave scattering is used to monitor orchard canopies.
-  **Mechanical sensors**
Measures soil mechanical resistance and soil particle compactness.
-  **Mass flow sensors**
Assist in assessing yield production by measuring the grain flow through a combined harvester.
-  **Electrochemical sensors**
Helps in measurement of nutrient status and pH of soil.
-  **Geo magnetic sensor**
Measures magnetic fields to determine orientation and detect changes in the Earth's magnetic field.
-  **Eddy covariance-based sensors**
Record changes in levels of various gases including green house gases such as CO₂, methane, water vapor etc in agricultural lands.
-  **Airflow sensors**
Assess soil-air content and permeability; moisture content and in mobile or static conditions.
-  **Ultrasonic sensors**
Helps in pest detection; crop canopy monitoring; weed recognition. Repulsion of pests in agricultural fields is also possible
-  **Soil Moisture**
Measure volumetric water content using techniques like capacitance, TDR (Time Domain Reflectometry), or tensiometers.
-  **Soil Nutrient Sensors (NPK)**
Use ion-selective electrodes or electrochemical methods to detect levels of nitrogen, phosphorus, and potassium.
-  **Gas Sensors**
Gas sensors detect harmful and odorous gases like VOCs, VSCs, carbon monoxide, and hydrogen. They support air quality monitoring and early warning in farming and industrial settings.
-  **Thermal imaging**
Measures temperature by detecting changes in thermal energy or resistance.
-  **Humidity sensor**
Measures humidity by detecting changes in moisture content in the air.
-  **Barometer sensor**
Measures altitude by detecting air pressure changes.
-  **Infrared sensor**
Measures infrared radiation to detect heat and identify objects based on thermal differences.
-  **Camera sensor**
Captures visual information by detecting light to create images or video of the environment.
-  **Radar sensor**
Measures distance and motion by emitting radio waves and analyzing their reflections from objects.
-  **GPS sensor**
Measures position by receiving signals from satellites to determine geographic location.
-  **Inertial Measurement Unit (IMU)**
Accelerometer and gyroscope

3.7.2 Positioning in environment

IMU (Inertial measurement unit) gives the drone orientation.



GPS gives location.

Laser scanner records surfaces and objects.

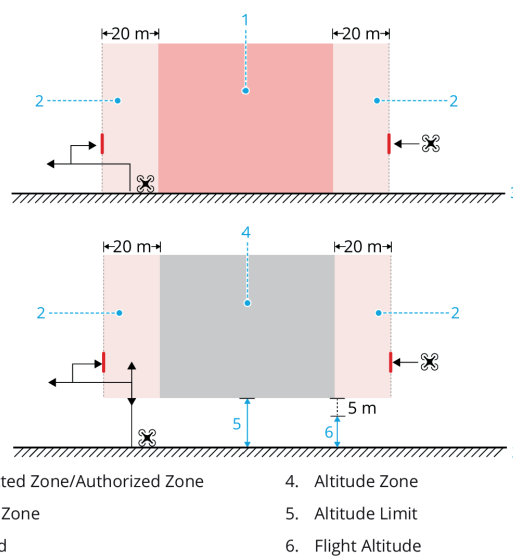
ation units drone

Avionics refers to the electronic systems that enable the remote control and automation of aircraft operations, effectively replacing or augmenting the skills of an onboard pilot. These systems contain various components, including navigation tools such as GPS for precise positioning, remote guidance and monitoring interfaces, and airspace integration capabilities IMU that transmit the vehicle's location.

For drone orientation there are different ways of defining exact position. ICM-42688-P for example measures linear acceleration and angular rotation. It is used to track motion and orientation changes in real time, making it essential for stabilization and navigation.

Magnetometer on the other hand measures magnetic fields and is primarily used as a digital compass. It helps determine the device's orientation relative to the Earth's magnetic field, supporting heading estimation and directional navigation. High-resolution barometric pressure sensor that measures atmospheric pressure to estimate altitude. It provides vertical positioning information, crucial for altitude control in UAVs and other aerial systems.

These orientation systems help to navigate restricted areas and altitude limits.



- | | |
|------------------------------------|--------------------|
| 1. Restricted Zone/Authorized Zone | 4. Altitude Zone |
| 2. Buffer Zone | 5. Altitude Limit |
| 3. Ground | 6. Flight Altitude |

Fig.58 Restriction zones of DJI M400

⁷¹ Aeronautics Research Centre Niedersachsen, n.D.
⁷² Bosch Sensortec GmbH, (n.d.) Sensing solutions for drones
⁷³ Drone Nerds, (n.d.) DJI payloads & sensors
⁷⁴ SPH Engineering, (n.D.), GPR (Ground Penetrating Radar) for drones

3.7.3 Differentiation of propulsion systems

Modern drone propulsion systems rely on various technologies, each with distinct advantages and limitations. Electrically driven propellers are the most common, used in multicopters and hybrid or fixed-wing configurations. These systems are powered mainly by lithium-based batteries and feature simple, low-noise designs with high controllability through electronic speed controllers. They have a limited range and payload capacity due to battery constraints—an issue that may be addressed by using hydrogen fuel cells, which allow quick refueling and longer operation times.

Piston engine-driven propellers enable significantly longer flight times but come with increased mechanical complexity, higher noise levels, and greater wear. Due to poor drive controllability, they are not suitable for multicopter designs.

For applications demanding maximum performance at minimal weight, such as in professional vertical take-off and landing (VTOL) aircraft, turbine propulsion is used. These systems deliver high power-to-weight ratios but are complex and require intensive maintenance.

Hybrid propulsion systems aim to combine the strengths of different technologies. A typical hybrid setup merges electric drives with combustion engines or fuel cells to extend flight time and improve efficiency. In some cases, solar cells are also integrated to enable continuous operation during both day and night by charging onboard batteries.

3.7.4 Motor Differentiation

According to Unmanned Systems Technology (2025), several key parameters determine the performance of drone motors. One critical factor is RPM (Revolutions Per Minute), which defines how fast a motor spins. High-RPM motors are typically used when speed is a priority, such as in racing drones, whereas high-torque motors are better suited for lifting heavier payloads due to their superior thrust capabilities.

Another essential specification is the KV rating, which indicates how many RPM the motor produces per volt of input. Higher KV motors (e.g., 2300 KV) generate greater speeds and are commonly used in light-weight, agile drones.

In contrast, lower KV motors (e.g., 900 KV) provide more torque, making them ideal for drones carrying heavy equipment or used in industrial applications. Finally, power output, measured in watts, represents the motor's ability to generate thrust. A higher power output directly correlates with the motor's efficiency and capability to perform demanding tasks in various drone operations.

Thrust = Mass * Acceleration

m = total mass (drone + battery + payload)
 and $g = 9.81 \text{ m/s}^2$.

■ A heavier drone burns through battery faster because motors draw more current to maintain lift.

Energy (Wh)=Battery Voltage (V) * Capacity (Ah)

■ To lift something heavy, motors draw more current, which means the battery drains quicker.

■ But if your drone is heavy or motors are inefficient, that energy burns faster, reducing both flight time and distance.

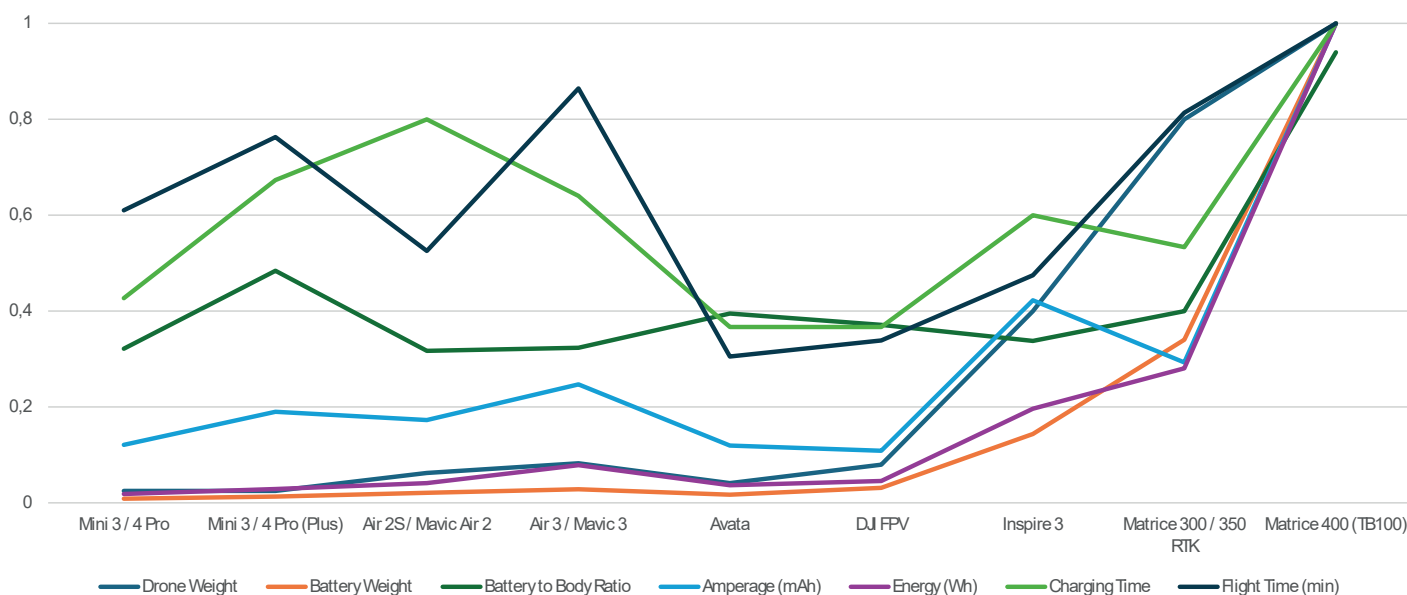
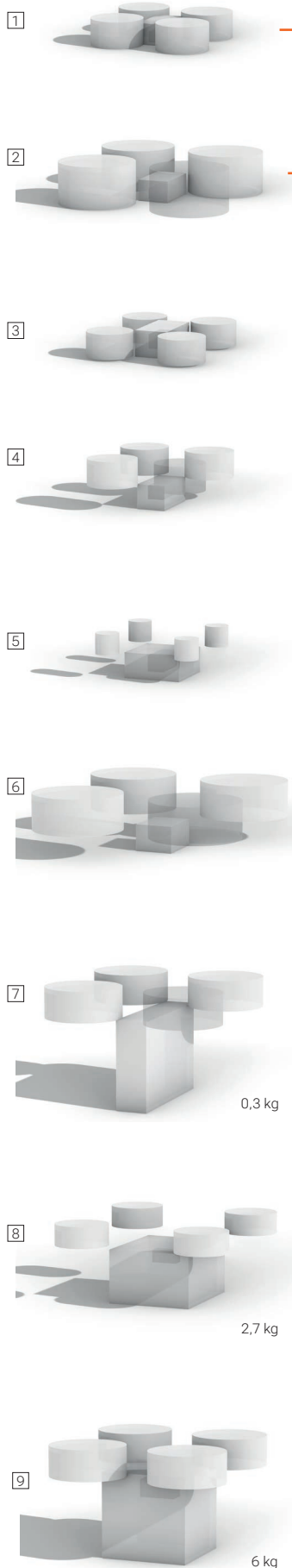


Fig.60 Physical parameters of drones in comparison

3.7.5 Propellor



Propellers are identified by a four-digit code, where the first two digits indicate the diameter in inches and the last two represent the pitch—the distance the prop would move forward in one rotation.

A higher pitch propeller pushes more air and is typically used with low KV motors for greater torque at lower speeds. In contrast, low pitch propellers pair with high KV motors, which spin faster and require less air displacement per rotation. Proper matching of pitch and motor type is essential for efficient drone performance.

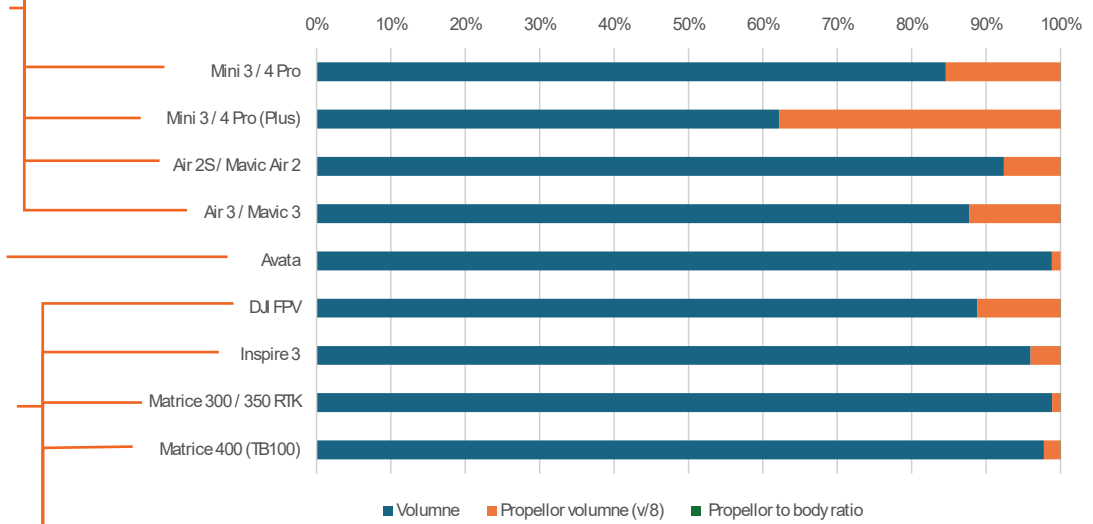


Fig.61 Drone volume to propellor relation

0,3 kg

2,7 kg

6 kg

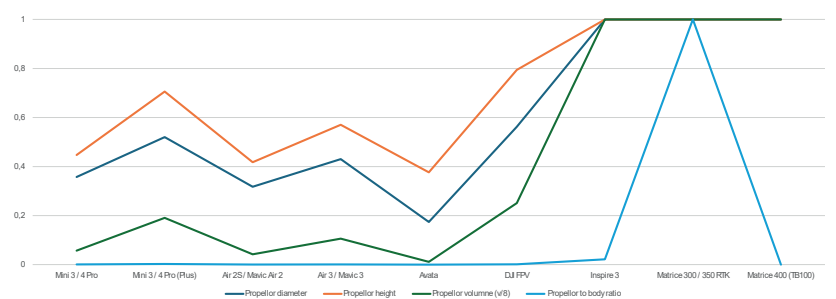


Fig.62 Propellor parameters in comparison

3.7.6 Assembly steps

1	Motor & ESC Connector Soldering	Solder 3.5 mm bullet connectors to each brushless motor and Electronic Speed Controller (ESC) to ensure secure and modular electrical connectivity.
2	Power Distribution Assembly	Integrate the ESC power leads and battery connector onto the Power Distribution Board (PDB), ensuring stable power flow throughout the drone's electrical system.
3	Mounting the Power System	Secure the PDB to the lower or central plate of the drone frame using non-conductive materials like zip ties, ensuring safe and accessible placement.
4	ESC Placement	Attach each ESC firmly to the corresponding frame arms using double-sided tape or zip ties to protect against vibration and shifting during flight.
5	Motor Installation	Mount motors to the ends of the drone arms, verifying correct orientation (CW or CCW) per motor position. Connect them to ESCs via bullet connectors.
6	Motor Rotation Verification	Connect a battery and run each motor through a basic test. If the direction is incorrect, reverse any two ESC-to-motor wires to change spin direction.
7	Receiver Integration	Mount the radio receiver centrally or away from power electronics, using adhesive tape to avoid signal interference and ensure stable communication with the RC transmitter.
8	Flight Controller Mounting	Affix the flight controller (e.g., Pixhawk) securely to the central top plate using vibration-dampening materials to enhance stability and sensor accuracy.
9	Telemetry Module Installation	Install telemetry modules to allow wireless data communication between the flight controller and Ground Control Station (GCS). Ensure secure cable management.
10	GPS & Compass Mounting	Position the GPS module (with built-in compass) above the frame, using an elevated mast or bracket to reduce magnetic interference and optimize satellite visibility.
11	System Integration	Connect all components—motors, ESCs, receiver, GPS, telemetry—to the flight controller, adhering to pin layouts and voltage tolerances as per manufacturer specs.
12	ESC Calibration	Calibrate ESCs via your Ground Control Software (e.g., Mission Planner) to synchronize throttle range for consistent motor response.
13	Propeller Attachment	Securely attach clockwise (CW) and counterclockwise (CCW) propellers to the correct motor shafts. Tighten appropriately and verify rotation match.
14	System Configuration & Sensor Calibration	Connect to a Ground Control Station to calibrate accelerometers, gyros, magnetometers, and set up flight modes. Verify telemetry, GPS lock, and failsafe settings.
15	Initial Flight Testing	Conduct a tethered or low-altitude test flight to validate system integrity, sensor data, and control responsiveness under safe conditions.

Fig.63 Building Process of an open source drone

Even though CLAAS is currently unable to produce drones themselves, a look at the assembly reveals how many different steps need to be outsourced and managed in order to create a drone with specific sensors, functions, and design features.

Depending on the level of involvement in actual production, the value chain can vary for CLAAS.

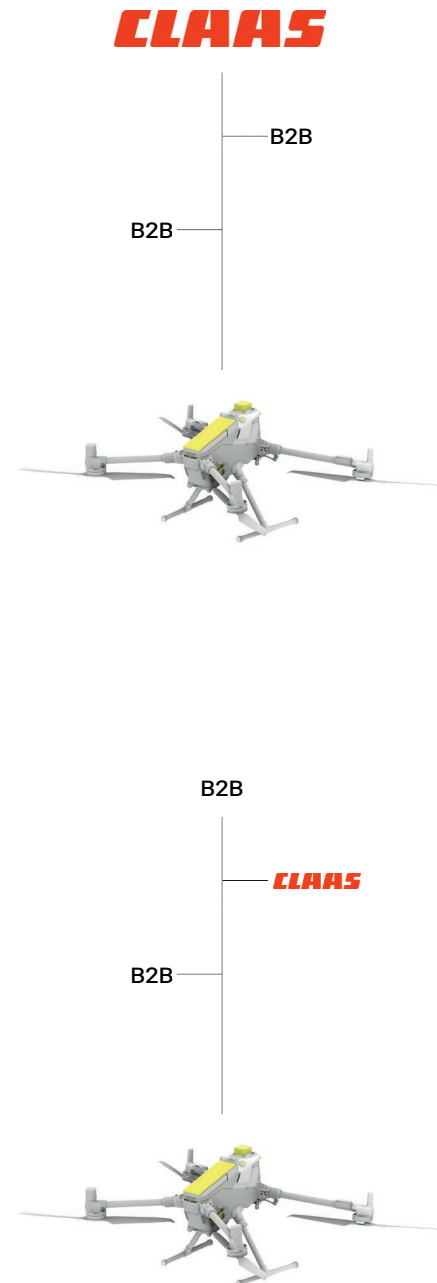
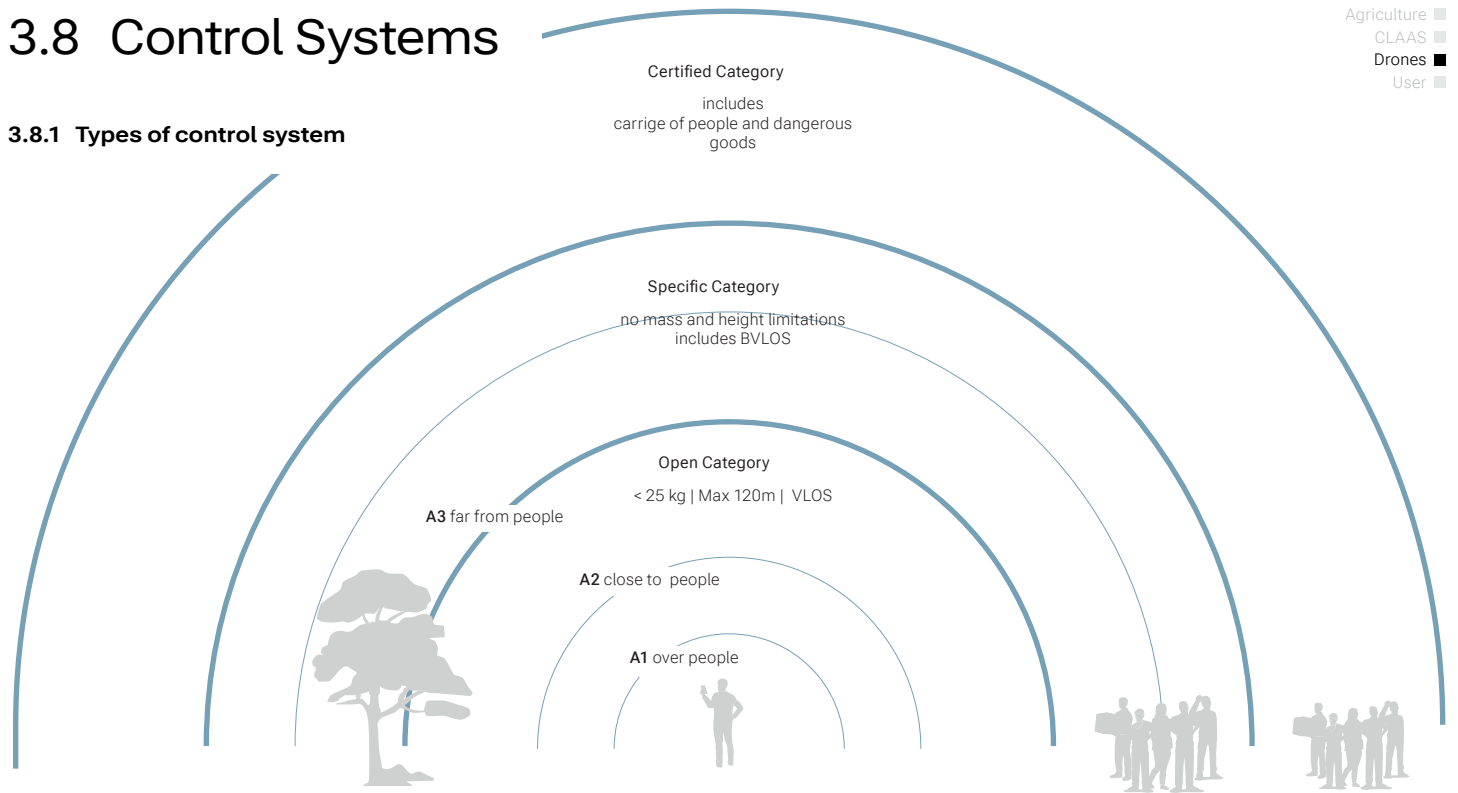


Fig.64 Possible value chains for CLAAS

71 Giesker, Technology Scouting
 78 Popovic, Software Considerations
 79 Shil, Cyber Zoo

3.8 Control Systems

3.8.1 Types of control system



Autonomous Swarm Control **BVLOS Semi Autonomous Way-Point Navigation** **VLOS Manually within View**

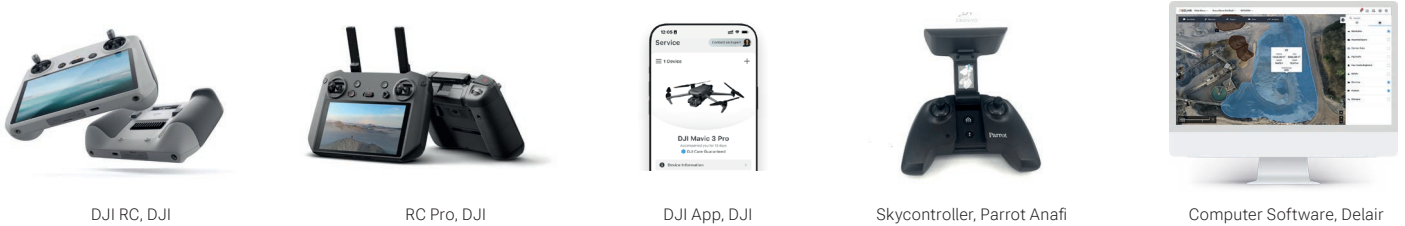
Control/Viewpoint Mode	Pilot Visibility	Control Type	Use Cases	Typical Features
FPV (First-Person View)	Camera feed (goggles/screen)	Manual/Semi-manual	Racing, freestyle, immersive filming	Low latency video, high agility
VLOS (Visual Line of Sight)	Direct eye contact with drone	Manual	Hobby flying, training	Basic controller, LOS-only
BVLOS (Beyond Visual Line of Sight)	No visual contact	Autonomous or telemetry-based	Agriculture, infrastructure, delivery	Telemetry, long-range control, GPS
Autonomous (Waypoint Navigation)	No visual contact needed	Fully autonomous	Mapping, surveying, agriculture	GPS waypoint systems, flight planning
Manual (No Stabilization)	Visual or FPV	Fully manual	Acrobatics, racing, training	No flight assistance, high skill
Semi-Autonomous / Assisted	Partial visual or telemetry	Manual + automated aids	Consumer drones, cinematography	Obstacle avoidance, return home
Swarm Control / Multi-UAV	No individual visibility	Centralized/distributed autonomous	Coverage, light shows, rescue	Coordinated flight, AI logic

Fig.65 Overview of control systems, regulations and level autonomy

Currently every control mode except swarm control requires human oversight in various levels of intensity. Direct eye contact is implicated for manual and VLOS.

Higher level of autonomy require more internal intelligence within the drone itself.

3.8.2 Types of control units



DJI RC, DJI

RC Pro, DJI

DJI App, DJI

Skycontroller, Parrot Anafi

Computer Software, Delair

Fig.66 Overview of control systems, regulations and level autonomy

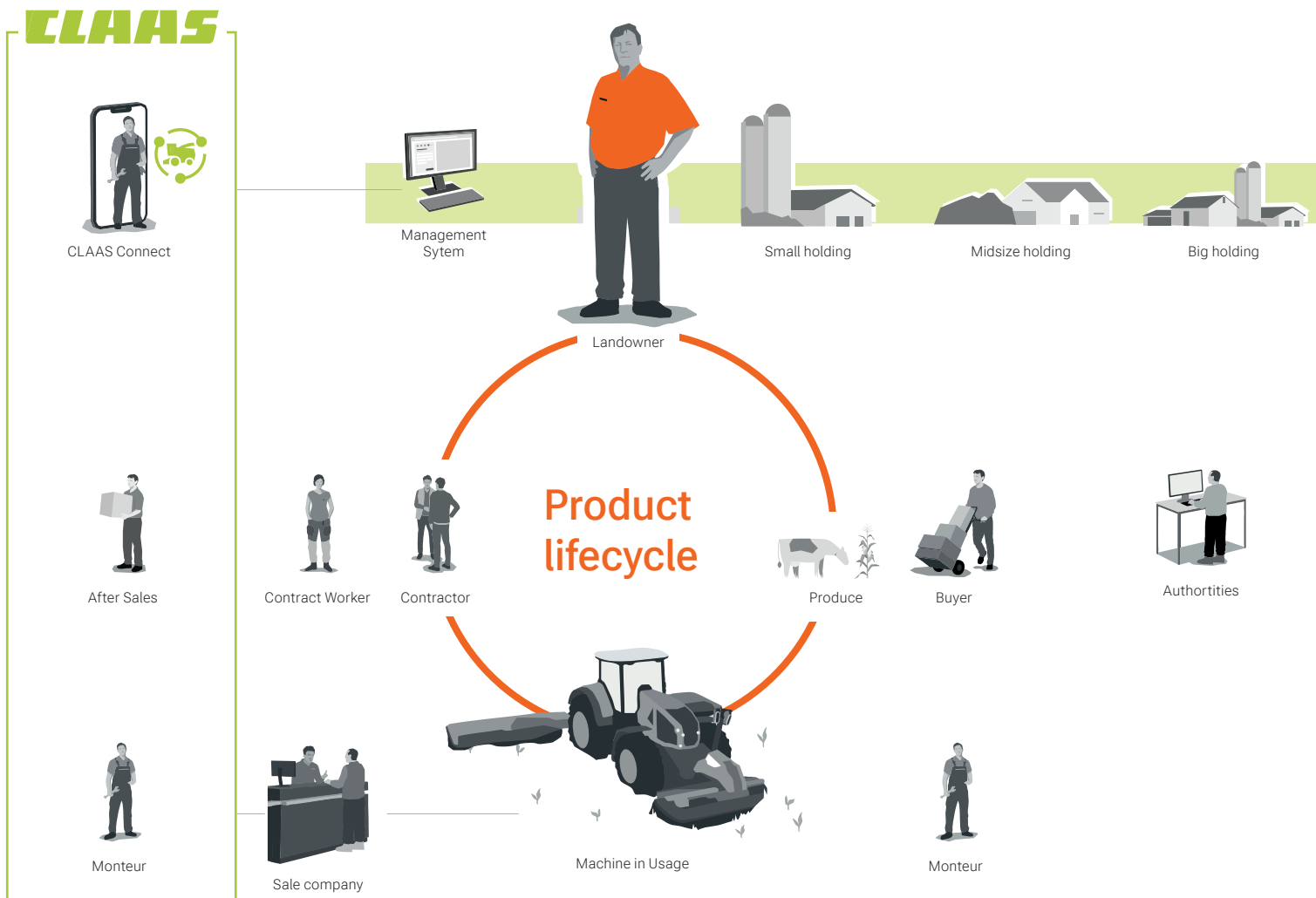
Control units can be categorized with stationary and mobile, depending on the control mode. Mobile units often have physical steering units and a viewport screen. For stationary control, predetermined paths are more common.



4. User

Drones are not unheard of in the Agricultural context, but no widespread adoption can be seen. To better understand this, this chapter will highlight the work of people within the Agricultural process, the Enduser of CLAAS products and see what chances lie here for drones.

4.1 The User



4.1.1 User of CLAAS products

Most agricultural holdings in Germany are sole proprietorships, accounting for about 217,800 farms that manage an average of 46.1 hectares each. Partnerships and legal entities, though fewer in number, operate on significantly larger areas. Partnerships average 118.7 hectares, while legal entities—especially registered cooperatives and private limited companies—manage some of the largest holdings, with averages exceeding 1,000 hectares in certain cases. This indicates a strong concentration of land among corporate structures, reflecting the growing professionalization and scaling of agricultural production.

While the farm owner is often seen as the central customer for agricultural machinery, the actual user spectrum is much broader. In larger farming operations, contractors play a crucial role by offering specialized services to farmers. Purchasing a machine that is only used during a specific season is rarely economically viable and often requires extensive maintenance.

Contractors, therefore, enable greater specialization and efficiency. They typically operate under leasing agreements rather than ownership, with maintenance and service provided directly through the dealer. Dealers themselves represent the primary touchpoint between CLAAS and end users. Beyond sales, they play a key role in maintaining customer relationships and facilitating the distribution of after-sales products and services.

Legal form of the agricultural holding	Holdings	Agricultural used area	Agricultural used area per holding
	Number	hectare	hectare
Total	255,010	16,585,500	65.0
Sole proprietorships	217,800	10,038,300	46.1
Partnerships	30,970	3,676,400	118.7
Of which			
Company of civil law	28,000	2,844,300	109.4
Limited partnership	2,440	296,800	121.6
Company with limited liability ¹	1,820	500,900	275.2
Legal persons	6,240	2,870,900	460.1
Of which			
Registered cooperative	1,120	1,154,900	1,031.2
Company with limited liability	3,890	1,543,600	396.8
Private limited company	/	83,100	755.5

¹ Statistisches Bundesamt. Agricultural holdings by their legal form (2023)

4.1.2 Harvest coordination

Month	Jan	Mar	Apr	Apr – May	May	Aug	Sep	Sep – Dec
Actions	Obtaining information on plant protection products (PPP)	Seedbed preparation; Purchase of seedlings	Fertilization	Purchase of herbicides	Field inspections Purchase of fungicides	—	Purchase of desiccation products	Harvest Storage
			Sowing	Herbicide treatment	Fungicide treatments (8–10x) Insecticide treatment if necessary		Pre-harvest crop desiccation	
Needs and Aims	Good start into season	High quality portato seedlings	Right sowing timing		Good weather (around 20°C), reoccurring rain events Rain fasten PPP Reduce use of PPP Reduce field crossings	Successful maturation	No losses during storage	
Pain Points	Restrictions on existing PPP		Wind drift		Bad weather (heat & rain)	—	—	
			Late frost		Additional PPP spraying due to rain losses Time management			
Touch Points	Media Internet supplier		Supplier: Purchase of PPP		Supplier: Purchase of PPP	—	Supplier	Supplier
					Other farmers already using the technology			

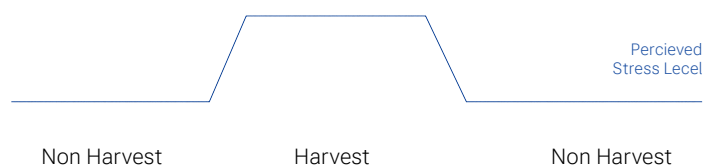
Fig.67 Farming calendar

Throughout the agricultural year, farmers follow a structured sequence of actions aimed at ensuring high yields and minimizing losses. The season begins in January with gathering information about plant protection products (PPP), followed by seedbed preparation and the purchase of seedlings in March to secure high-quality planting material. April focuses on fertilization and sowing, with timing playing a crucial role in establishing strong crop growth. Between April and May, farmers purchase and apply herbicides, and by May, attention shifts to field inspections and fungicide treatments—typically carried out 8–10 times per season, sometimes complemented by insecticide applications if needed.

In August, the goal is successful crop maturation under favorable weather conditions—around 20°C with periodic rainfall. By September, farmers purchase desiccation products and carry out pre-harvest treatments to prepare for harvesting and storage from September through December, aiming to prevent losses during storage.

Key pain points arise from restrictions on existing PPPs, wind drift, late frost, and adverse weather such as heat or heavy rain, which may require additional spraying and tighter time management. Touch points vary through the season: farmers rely on media and internet sources for PPP information early in the year, interact with suppliers during product purchases, and increasingly learn from peers who already use advanced technologies. The cycle highlights the balance between environmental conditions, regulatory constraints, and the need for precision and timing in every stage of crop production.

During winter, farmers focus on maintenance, logistics, and preparation for the next season. In contrast, the harvest months are the most demanding period, when multiple services and operations must run simultaneously to ensure smooth and timely production.



4.1.5 Stakeholder Journey

- Product Lifecycle
- 21 Expert interviews
- 8 User Interviews

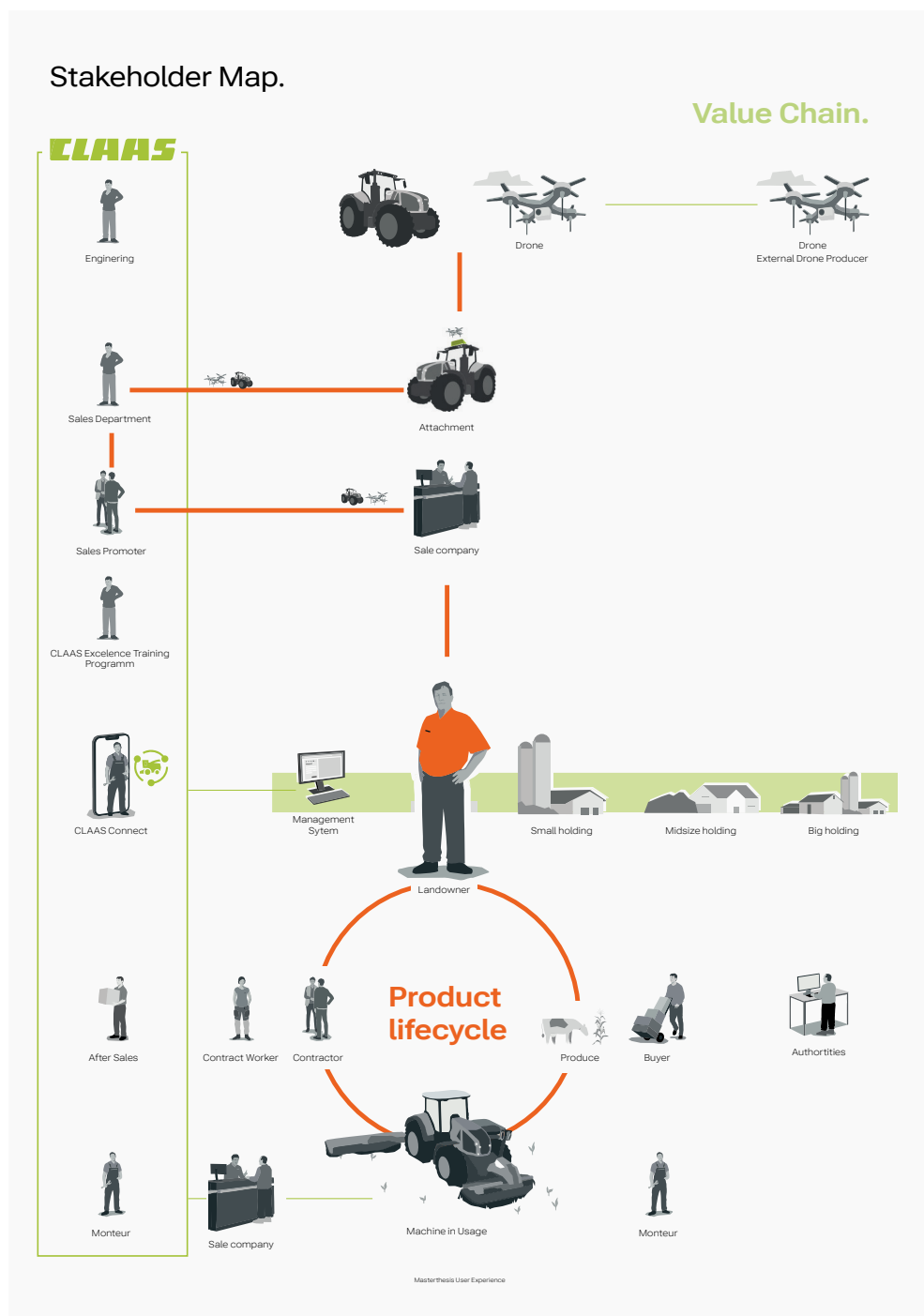
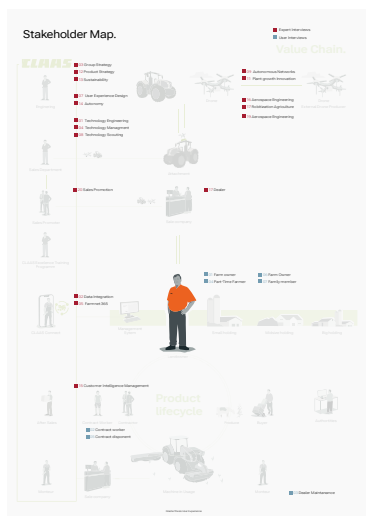


Fig.70 Overview of interviews along the value chain

The stakeholder map reveals that CLAAS products must perform effectively not only for the end user but also within the broader service network. After Sales plays a crucial role, as it maintains the most consistent and direct contact with customers throughout the product's lifecycle.

21 expert and 8 user interviews were conducted to understand the broader spectrum of drones at CLAAS.

4.1.8 Persona and User journey creation



Social background and age strongly influence attitudes toward drones. The ability to act intuitively and remain flexible in different situations is essential in daily work.



Fig.74 Personas (Placeholder images)

- 85 Bernd, Family farm
- 87 Lukas, Contractor
- 88 Keith, Dealer mechanic
- 89 Benedikt, Farmowner
- 90 Thomas, Contractor
- 91 Matthias, Big farm chief
- 92 Lara, Family farm

Bernhard. Optimistic family guy.

Price pressure [Progress bar]

Importance of digitalization [Progress bar]

Preference for one dealer [Progress bar]

Goals

- Plan and manage harvests efficiently without complicated technology
- Ensure quality grain storage and feed supply for own animals
- Optimize paperwork for yearly inspections and tax returns

Generation

Grew up with analog machines

- Prefers stable, proven tools (e.g., Laptops, iGOSULT)
- Would like his son to take over the farm eventually

Needs

- Paperwork pipeline, often pushed to evenings
- Fertilization must now be pre-planned and documented – no longer intuitive
- Smartphone apps feel irrelevant or confusing
- Unclear machine data or errors require dealer support

Machines

- Tractor with implements (plow, cultivator, seeders, fertilizer spreaders)
- Mix combine harvester for sample testing
- Storage and cleaning equipment
- Occasional use of iGOSULT-enabled harvesters via contractor

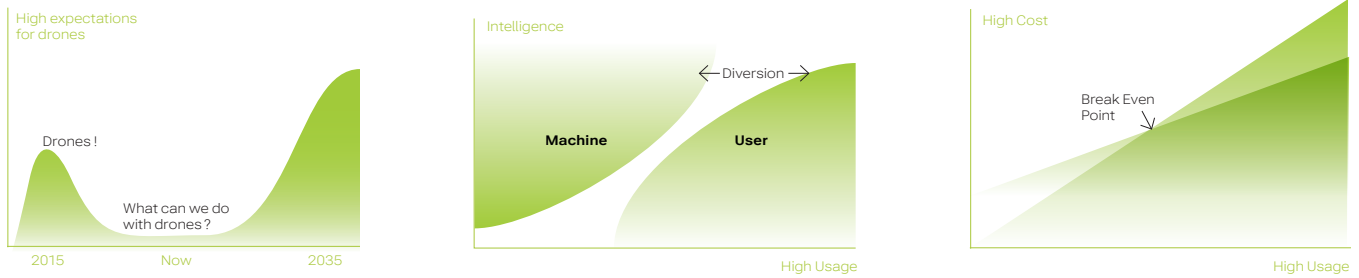
User Journey 01.

Needs	Possible Drone Implementation
<p>01 Farm overview</p> <p>Managing a 130ha farm with clay soil. Crops include soy, beets, rapeseed, and wheat. Barley is avoided due to soil conditions.</p> <p>Laptop</p>	<p>Fertilization must be pre-planned</p> <ul style="list-style-type: none"> Moving fertile earth Safe field work Water quality monitoring Recognizing garbage Monitoring hazardous materials (e.g., weeds/weeders) Service requirement in high or inaccessible areas Grabbing of multiple dirt samples <p>Checking on water inlets</p> <p>Detection of drying stress</p> <p>Disaster alert</p> <p>Wildfire detection</p>
<p>02 Planning orders</p> <p>Uses apps provided by dealer and checks stock exchanges to estimate grain purchasing for winter. Planning is crucial for coordinating with contractor's and anticipating needs.</p> <p>Smartphone</p>	<p>Has to speculate on price development</p> <ul style="list-style-type: none"> Watching plants characteristics Detection of drying stress Transporting fertilizer Checking on water inlets Grain yield forecast Moving fodder around <p>Moving bales</p>
<p>03 Testing the ground</p> <p>Drives out with own small car to take field samples, checking if grain is dry enough for harvest. This supports decisions about harvest timing and his sowing schedule.</p> <p>Tractor</p>	<ul style="list-style-type: none"> Removing ground for testing Locking off straw return and straw distribution Monitoring hazardous materials (e.g., weeds/weeders) Watching multiple fields Watch prevention via tractor Grabbing of multiple dirt <p>samples <p>Moving away stones <p>Recognition of garbage <p>Wildfire detection <p>Detection of drying stress <p>Disaster alert <p>Marking different heights </p></p></p></p></p></p></p>
<p>04 Creating field task</p> <p>Field tasks are based on structured planning – especially for fertilization, which must be pre-planned and distributed across all plots. Availability and capacity of his older father is considered.</p> <p>Laptop</p>	<p>Keeping the digital field book organized</p> <ul style="list-style-type: none"> Road traffic monitoring Watching road entries Marking spots in fields <p>Marking machine damage</p>
<p>05 Organising contractors</p> <p>Orders external harvesters via contractor services. Needs clear field overview and schedules, especially since fields are small and numerous. Travel time depends on external availability.</p> <p>Laptop, Smartphone</p>	<p>Adjusting to new personnel</p> <ul style="list-style-type: none"> Making weather predictions Moving After Sales items Adding communication <p>points for a network</p>
<p>06 Supervising harvest</p> <p>Harvest is outsourced. The farmer ensures it's performed uniformly using iGOSULT feedback from the machines. He supervises remotely, ensuring data quality.</p> <p>Laptop</p>	<p>Managing other workers effectively</p> <ul style="list-style-type: none"> Safe field work Watching multiple machines mechanical aspects Watching multiple machines Wildfire detection
<p>07 Cleaning grain</p> <p>Grain is cleaned manually after harvest, before being stored. The goal is to maintain quality, especially for feeding pigs through winter. Certification standards must be met.</p> <p>Cleaning machine</p>	<ul style="list-style-type: none"> Marking dirt on machines Cleaning out beddings Removing dirt Cleaning of machines with pressure
<p>08 Storage and Usage</p> <p>Grain is stored primarily and used for feed until winter. Quality and traceability matter due to sustainability certification. Storage tracking done via spreadsheets.</p> <p>Laptop, Storage measurement</p>	<ul style="list-style-type: none"> Moving Bales Moving implements Moving implements around on the field Moving away stones
<p>09 Refertilization</p> <p>Farmer registers estimates for yearly usage and adjusts based on field condition. Weed control is done early, if at all.</p> <p>Laptop</p>	<p>Requires detailed upfront planning</p> <ul style="list-style-type: none"> Planting in between plants Weed removal Watching multiple fields Moving fertile earth Transporting fertilizer Moving away stones

Fig.73 Excerpt of personas and user journeys

4.2 User Interviews

4.2.1 Interview Derived



Many farmers were initially interested in drones, but early expectations were not met, and imaging alone proved to be too limited as a use case.

The balance between cost and practical use must align for drones to be seen as a worthwhile investment.

Farmers often struggle to keep pace with the new technologies integrated into their equipment.

4.2.2 Interview Comments

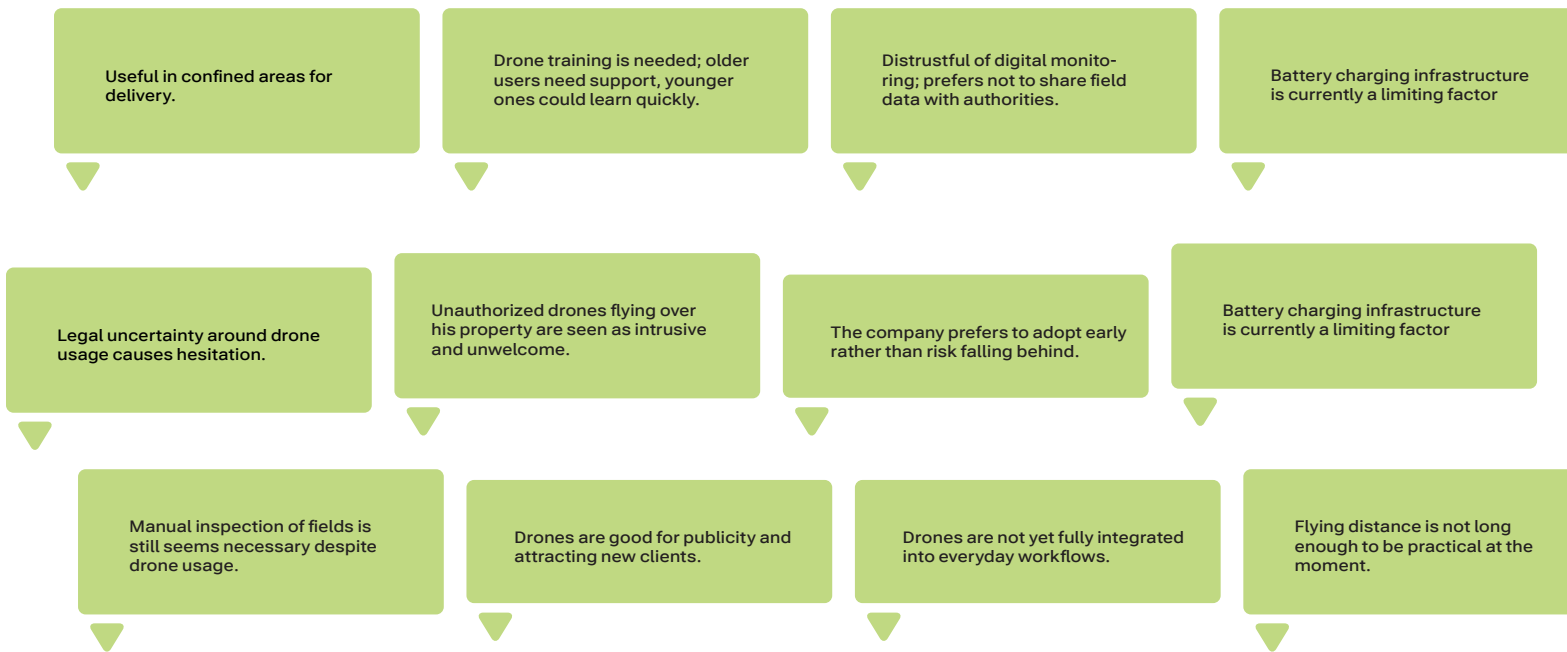


Fig.75 Summarizing statements interviews

While drones attract attention and serve as effective publicity tools, some farmers remain skeptical about their necessity and impact. Unauthorized drone flights are viewed as intrusive, and there's uncertainty about whether clients truly value such technologies. Building trust is key to broader acceptance.

High initial costs and uncertain returns make farmers cautious about drone investment. While companies prefer stable progress over risky adoption, drones can improve planning efficiency—especially during tight harvest schedules—if integrated effectively and supported financially.

Drone use is heavily affected by weather conditions, making operations unreliable during certain seasons. Farmers tend to rely on predictable weather patterns and are cautious about investing in technology that depends on stable weather, limiting drone use primarily to harvest periods.

Although drones promise improved field management and decision-making, they are not yet fully embedded in daily workflows. Older workers often struggle with new systems, and smartphone apps are seen as impractical. Proper onboarding and simplified tools are needed to ensure usability in the field.

Farmers see strong potential in drones for data collection, fertilization, and early-stage weed control, particularly for large or high-value fields. However, once crops mature, manual inspection often remains necessary. As digital tools evolve, drone-based monitoring could reduce field scouting efforts and enhance efficiency.

Legal restrictions and licensing requirements remain major barriers to drone adoption. Many farmers distrust data sharing with authorities and worry about privacy violations. Clearer regulations and stronger data protection assurances could help overcome current hesitation.

4.3 Acceptance of Autonomous Systems

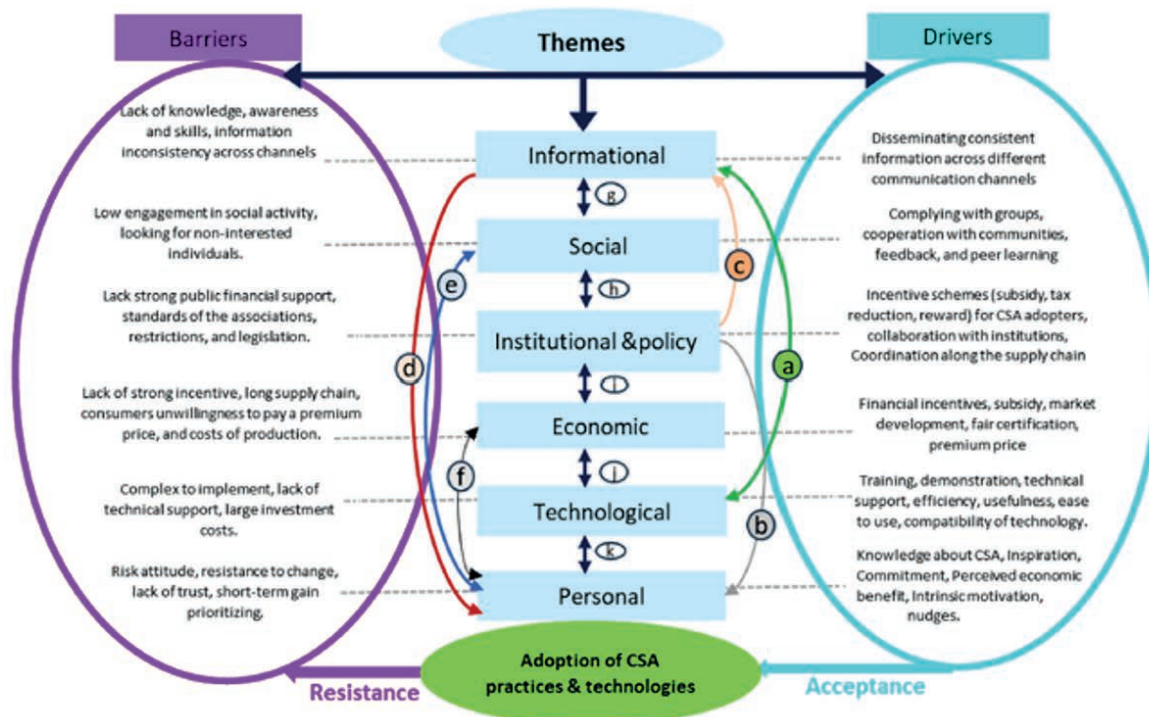


Fig.76 Drivers and barriers smart agriculture

4.3.1 Drivers for Smart agriculture

Providing consistent and transparent information across communication channels helps build understanding and trust among farmers. Collaboration within communities, along with peer learning and feedback, further encourages participation and knowledge exchange. Strong incentive schemes—including subsidies, tax reductions, and rewards for adopters—combined with institutional support and coordination along the supply chain, make implementation more attractive.

Additionally, financial incentives, market development, and fair certification systems strengthen motivation to adopt sustainable practices. Training, technical demonstrations, and reliable support enhance confidence by ensuring that technologies are efficient, easy to use, and compatible with existing systems.

Awareness, inspiration, intrinsic motivation, and perceived economic benefits play a decisive role in creating long-term commitment to smart agriculture.

4.3.2 Barriers for Smart Agriculture

Several barriers restrain the adoption of new agricultural technologies. A major challenge is the lack of knowledge, awareness, and technical skills, along with inconsistent information across channels. Social factors also play a role, as there is often low engagement and limited interest among individuals.

In addition, insufficient public financial support, restrictive regulations, and unclear industry standards slow down implementation. Economic factors further intensify these challenges: weak incentives, high production costs, and consumer reluctance to pay premium prices make innovation less appealing.

The complexity of implementation, lack of technical assistance, and large investment requirements pose practical obstacles. Risk aversion, resistance to change, and low trust—combined with a focus on short-term gains—further reinforce hesitation toward adopting new solutions.

4.3.3 Barriers for UAM

Citizens' acceptance and user confidence will be crucial for the successful rollout of Urban Air Mobility (UAM) in Europe. According to recent surveys, 83% of respondents expressed a positive attitude toward UAM, with the highest public interest found in applications such as medical supply transport and grocery delivery.

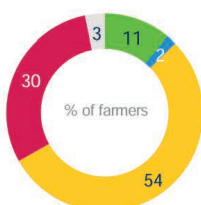
People primarily expect improved responsiveness and reduced traffic congestion as key benefits. Safety remains their greatest concern—particularly regarding drones—followed by worries about security, environmental impact, and noise. Importantly, public expectations for UAM safety are benchmarked against the high standards of today's aviation industry.

4.3.5 AI within Agriculture

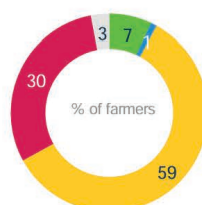
Awareness / use of AI applications in agriculture

- use it
- have used it but stopped
- heard of it but never used it
- never heard of it
- don't know / unsure

Imagery tools
 that automatically recognize certain weeds, diseases or pests



Sprayers
 that recognize weeds and apply an herbicide automatically only on them



Chatbots
 that provide automated recommendations for the use and timing of application of inputs like seeds, fertilizers, crop protection products or irrigation

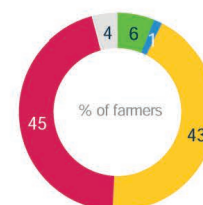


Fig.78 AI awareness of farmers

Awareness and adoption of AI applications in agriculture remain limited among farmers. Most are familiar with the existence of such technologies but have not yet used them. Imagery tools that automatically recognize weeds, diseases, or pests are the most well-known, though active usage remains low. Similarly, AI-powered sprayers that selectively apply herbicides are recognized by many but implemented by few.

Chatbots, which offer automated recommendations for crop management or irrigation, are the least known and least used, with nearly half of farmers having never heard of them. While awareness is growing, practical integration of AI technologies into daily farming routines is still at an early stage.

© Westerlund. Social acceptance of autonomous food delivery robots, 2021

4.3.4 Farm benefitting factors

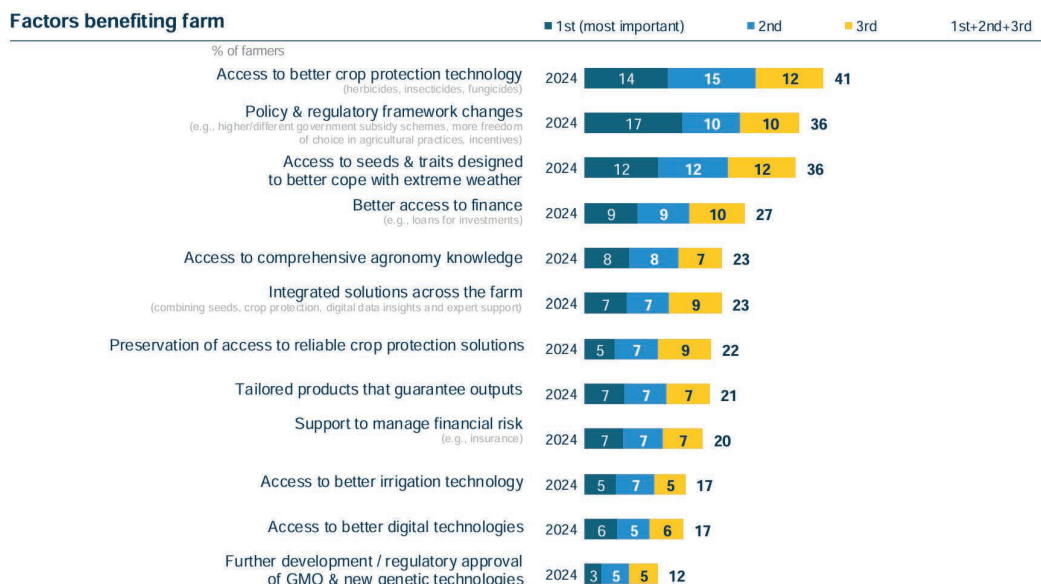


Fig.77 Farm benefitting factors mentioned by farmers

The top priority is access to better crop protection technology (41%), including herbicides, insecticides, and fungicides. This is followed by policy and regulatory framework changes and access to seeds and traits designed to cope with extreme weather, both at 36%. Better access to finance ranks next at 27%, reflecting the ongoing need for investment support.

Other relevant factors include comprehensive agronomy knowledge, integrated farm solutions, and reliable crop protection access, each cited by around 22–23% of farmers. Lower on the list are tailored products, financial risk management, and improved irrigation and digital technologies, while new GMO and genetic technology development ranks last (12%). The results highlight that farmers currently prioritize resilience, regulation, and financial stability over emerging technologies.

© Kynetec & Kekst CNC, 2024

4.3.6 Designing an accepted robot

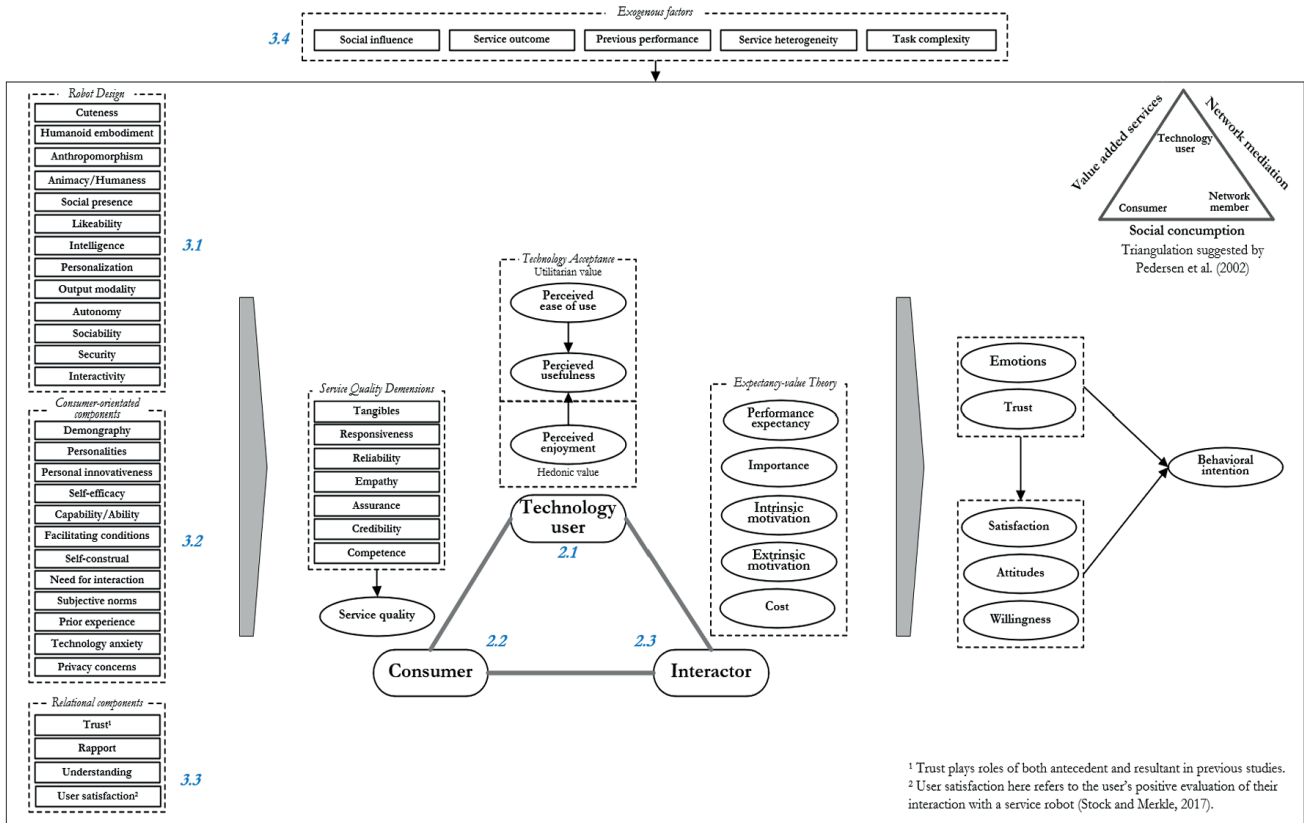


Fig.79 Framework for robot acceptance

Designing a service robot requires balancing technical functionality with human-centered interaction qualities. Beyond performance and reliability, acceptance depends heavily on how the robot is perceived—its appearance, movement, and communication style shape user trust and comfort. A well-designed robot should align its physical form and behavior with the environment and task: friendly but not overly human-like, expressive enough to signal intent, and intuitive to use without demanding effort.

Clear feedback, responsiveness, and consistency in actions reinforce reliability, while subtle social cues, like gaze direction, tone of voice, or gestures—help build emotional connection.

Successful robot design merges engineering precision with empathy for human expectations, ensuring that the robot feels competent, approachable, and contextually appropriate in every interaction.

4.4 Research Summary

4.4.1 Adoption Barriers

- Insurance uncertainty in the event of a crash
- An inability to carry a large amount of weight
- A time-consuming process for integrating drones
- Limited flying area
- Insufficient navigation accuracy
- Poor data transfer
- Poor communication between drones
- The risk of damaging assets and people
- The complexity of integrating drones and the Internet of Drones
- Long battery charging time
- Lack of ATEX-certified drones
- Risk of explosion
- High failure rate

The study by Askerbekov et al. (2024) identifies numerous barriers hindering the integration of drones and Internet of Drones systems into manufacturing environments. These obstacles range from technical limitations, such as restricted payload capacity, limited flying areas, long charging times, and insufficient navigation accuracy, to operational and safety concerns, including the risk of damaging assets, explosion hazards, and high failure rates due to maintenance issues.

Regulatory and legal challenges—like unclear insurance coverage and the absence of ATEX certification—further complicate adoption, while communication and data transfer problems hinder reliable multi-drone coordination. Additionally, the complexity of system integration and the time-consuming nature of incorporating drones into existing workflows slow down industrial implementation.

Together, these barriers reveal that while drone technology holds transformative potential for manufacturing, significant advancements in regulation, technology, and system design are still required to achieve large-scale, safe, and efficient integration.

4.4.2 Desirability

There is a significant gap between technology and user understanding. Push of farmers toward making machine performance less dependent on user expertise. Goal is to free up farmers' time for social interaction and value-creating task.

The most pressing issue is infrastructure, particularly the absence of efficient charging solutions that allow continuous drone or machine operation. Frequent returns for recharging interrupt workflow efficiency, making autonomous night operations unrealistic under current conditions.

A second challenge lies in user adaptation and training. Many farmers and drivers still rely on hands-on guidance to operate advanced systems like Xemos or automated cutting mechanisms. This dependency slows the adoption of semi-autonomous features, as effective use still depends on the operator's understanding and initiative. Despite regular workshops and peer-learning platforms (PEER, PU), knowledge gaps persist—especially among those transitioning from other brands.

4.4.3 Feasibility

CLAAS Connect aims to make a mixed fleet manageable. Machines could provide central energy supply and processing power. Some measuring sensors in machines could be utilized in the drone.

Data utilization and decision-making automation also remain limited. Drones could theoretically help optimize harvest logistics by assessing soil firmness or guiding route planning across hundreds of parcels, but this potential is unrealized due to the lack of integrated, real-time systems that translate aerial insights into autonomous machine actions.

4.4.4 Viability

Drone deployment in Germany faces regulatory challenges, including mandatory human supervision. Production numbers need to be sufficient. CLAAS positions itself in the technology-driven premium segment for bigger farmers.



RQ2 What are the barriers to adopting drones as an agricultural company?



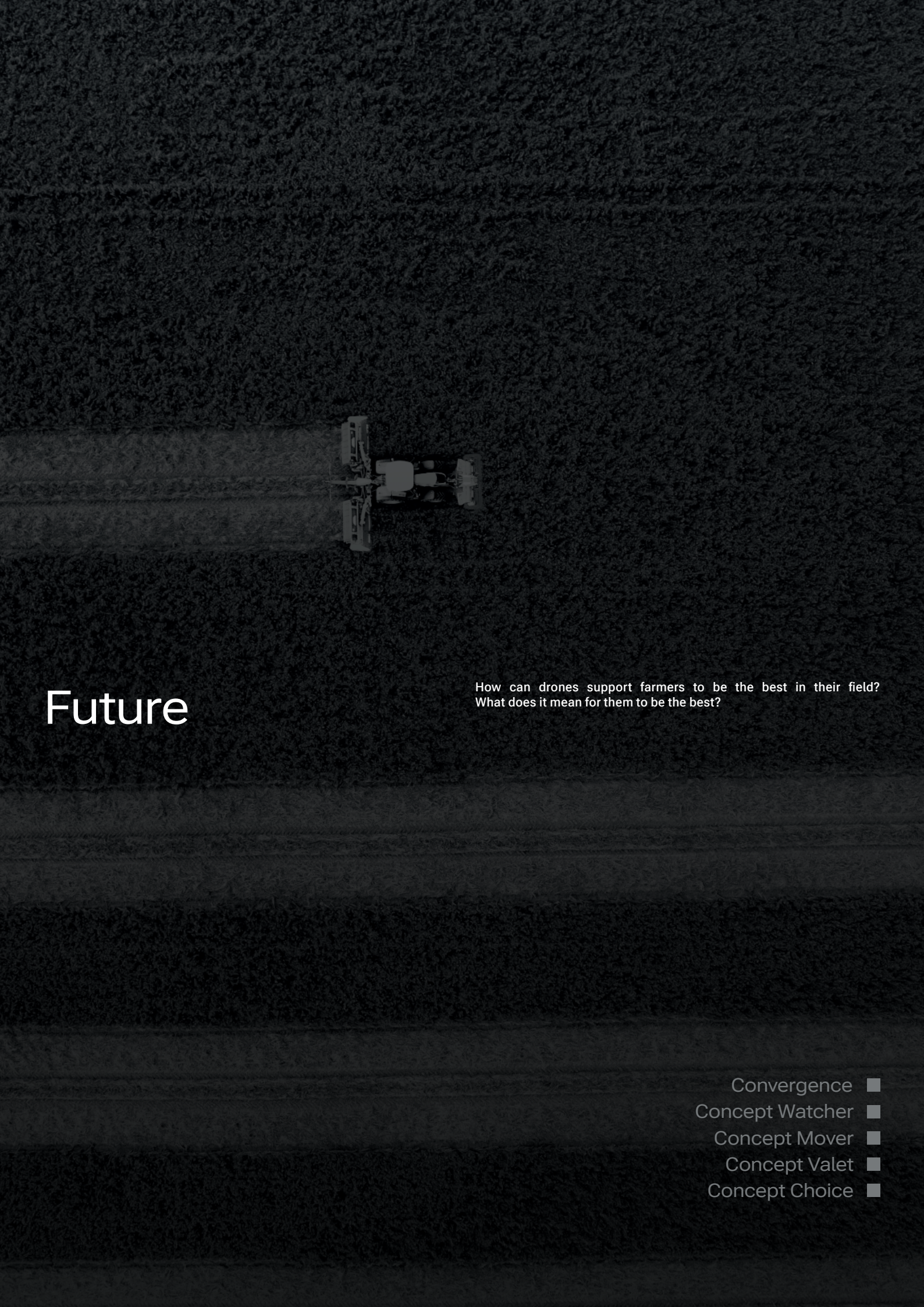
RQ2 What are the technologies inside the CLAAS system that can be used for drones?



RQ3 What are the primary barriers to adopting drones systems in the Claas company?

¹⁰⁰ Askerbekov et. al. Embracing drones and the Internet of drones systems in manufacturing

¹⁰¹ Flessner, Sales Promoter



Future

How can drones support farmers to be the best in their field?
What does it mean for them to be the best?

- Convergence
- Concept Watcher
- Concept Mover
- Concept Valet
- Concept Choice



5. Concept Convergence

The gathered functions were measured against different parameters, to see what they would require from a drone. Afterwards, these functions were grouped to gather ones with similar requirements.

5.1 Use case categorisation

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

5.1.1 Farm specification

Even though there is a diverse field of farmers there can be an image created of the average farms in specific countries and also CLAAS customers.

The farm size and land distribution are the defining factors when it comes to land distribution. Factors like business model as well as farming plan influence the daily operation and lead to diverse structures.

The average German farm covers around 60 to 65 hectares, with the 2020 average at 63 hectares. Most farms are either forage-based, focusing on dairy or livestock, or arable farms producing crops. Approximately 85% operate as family-run single-owner businesses, reflecting the strong tradition of independent farming.

More than half of all farms are part-time operations, generally smaller in size, while full-time farms average around 73 hectares. Land ownership is highly concentrated—just 14% of farms manage about 62% of all agricultural land. Many farmers diversify their income sources, with over half earning additional revenue through renewable energy, direct product sales, or contract work. Around 10% of all farms are certified organic, indicating a growing but still modest shift toward sustainable farming practices.



Fig.81 Average farm

5.1.2 Drone specifications

Light drones (0–2 kg) are used for cameras, sensors, or small sample tasks. Medium drones (2–10 kg) handle marking, tool transport, or seed dispersal. Heavy models (10–25 kg) are needed for fertilizer or equipment transport, while very heavy drones (>25 kg) typically require single-rotor or hybrid systems.

Small drones (<0.7 m) serve scouting purposes. Medium models (0.7–1.5 m) carry moderate payloads, such as the DJI Matrice. Large drones (1.5–3 m) are designed for industrial use, and extra-large systems (>3 m) are custom-built for heavy-lift operations like bale transport.

Short endurance (15–25 min) applies to multi-drones with heavy loads. Medium (25–40 min) covers lighter multi-drones or single-rotor types. Long duration (40–60 min) fits lift-and-cruise drones, while very long (1–2 h) applies to fixed-wing models used for area surveillance.

5.1.3 Drone specifications



Rotor and Fixed Wing



Multi Rotor



Single Rotor



Fixed Wing

	Rotor and Fixed Wing	Multi Rotor	Single Rotor	Fixed Wing
Lift	Vertical lift via rotors; cruise supported by aerodynamic wings.	All rotors provide lift; flight is controlled by varying individual rotor speeds.	Main rotor provides lift and propulsion.	Uses aerodynamic wings for passive lift
Efficiency	More energy-efficient in cruise mode than multi-rotors; less than pure fixed-wing.	Less energy-efficient due to constant rotor thrust; limited flight time (typically 20–40 minutes).	Generally more efficient than multi-rotors, especially for longer flights.	More energy-efficient and longer flight time than rotary-wing drones.
Strength	Efficient forward flight, flexible take-off/landing, range	Precise hovering, easy to operate, agile	Shorter flight time, lower payload, wind-sensitive	Long range, high efficiency, wide coverage
Weakness	More complex, higher cost, more technical challenges	Shorter flight time, lower payload, wind-sensitive	More complex mechanics, higher cost	No hover capability, needs more space to operate

Fig.80 Parameter for drone architecture

5.2 Concept Convergence

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

5.2.1 Parameter convergence

Payload range describes the functional capacity of drones, from light tasks such as sensing and sample collection, to field work like seed dispersal, up to transporting materials and performing heavy-duty operations.

Size indicates the physical scale of drones, ranging from compact scouting models for observation, to medium and large work drones for agricultural tasks, up to extra-large systems designed for heavy industrial or transport operations.

Battery duration reflects how long drones can operate per flight, from short missions under heavy load, to medium and long durations for standard work, up to very long endurance suited for wide-area surveillance.

5.2.2 Sensor convergence

Acoustic sensors detect pest populations or monitor fruit harvesting. Electromagnetic and electrochemical sensors measure soil nutrient levels (NPK), salinity, and organic matter content. Light detection and ranging (LiDAR) supports 3D mapping, topography analysis, and crop height measurement. Optical sensors, including fluorescence-based ones, help assess leaf chlorophyll and monitor crop health or orchard canopies. Mechanical and mass flow sensors measure soil resistance, compaction, and yield during harvest. Eddy covariance and airflow sensors record gas exchange (methane, water vapor) and assess soil permeability. Ultrasonic sensors assist in pest detection and crop height measurement.

Environmental monitoring uses soil moisture and humidity sensors for water content analysis, barometer sensors for altitude, and thermal or infrared sensors for temperature and heat detection. Gas sensors detect harmful gases for air-quality monitoring.

For navigation and positioning, radar, GPS, inertial measurement units (IMU), and geomagnetic sensors ensure precise motion tracking, stability, and orientation. Camera sensors capture visual imagery for mapping and crop inspection. (See Chapter XX)

Sensors require different levels of exposure towards test material. Some sensors keep occurring together.

User. Use case functionalities.

	Payload	Size	Duration	Frequency
01	Looking at straw pattern and straw distribution	Medium	Medium	Medium
02	Safe field work	Medium	Medium	Medium
03	Monitoring hazardous materials (e.g. wastewater)	Low	Small	Long
04	Water quality monitoring	Low	Small	Long
05	Road traffic monitoring	Low	Small	Long
06	Planting in between plants	Medium	Medium	Medium
07	Forest mapping	Medium	Medium	Long
08	Weed removal	Medium	Medium	Medium
09	Watching the field for obstacles	Low	Small	Long
10	Watching livestock in the shed	Low	Small	Long
11	Watching livestock on open fields	Low	Small	Long
12	Watching multiple fields	Low	Small	Long
13	Watching multiple machines mechanical aspects	Low	Small	Long
14	Watching road entries	Low	Small	Long
15	Moving bales	High	Large	Medium
16	Sensor Deployment in high or inaccessible areas	Medium	Medium	Medium
17	Weed prevention via Cellulose	Medium	Medium	Medium
18	Moving fertile earth	High	Large	Medium
19	Transporting fertilizer	High	Large	Medium
20	Moving implements	High	Large	Short
21	Herding livestock	Medium	Medium	Medium
22	Moving implements around on the field	High	Large	Medium
23	Moving fodder around	High	Large	Medium
24	Grabbing of multiple dirt samples	Medium	Medium	Medium
25	Moving away obstacles	High	Large	Medium
26	Moving After Sales items	High	Large	Medium
27	Moving bedding	High	Large	Medium
28	Delivering After Sales items	High	Large	Medium
29	Carrying the equipment of one specific person	High	Large	Medium
30	Fire scene assessment	Medium	Medium	Medium
31	Construction sites status	Medium	Medium	Medium
32	Inspection of Air Area like Overhead Power Lines	Low	Small	Long
33	Making weather predictions	Medium	Medium	Medium
34	Checking on water supplies	Medium	Medium	Medium
35	Adding communication points for a network	Medium	Medium	Medium
36	Fire extinguishing	Medium	Medium	Medium
37	Changing other electronic components	Medium	Medium	Short
38	Adding sensors temporarily to a system	Medium	Medium	Medium
39	Adding personal objects	Medium	Medium	Medium
40	Recognition of garbage	Medium	Medium	Medium
41	Disaster alert	Medium	Medium	Medium
42	Documentation of property damage	Medium	Medium	Medium
43	Identification of weed nests	Medium	Medium	Medium
44	Temperature mapping	Low	Small	Long
45	Detection of dying areas	Low	Small	Medium
46	Wildlife detection	Medium	Medium	Medium
47	Marking work place hazards	Medium	Medium	Short
48	Marking different heights	Medium	Medium	Short
49	Marking boundaries to work	Medium	Medium	Short
50	Marking spots in fields	Medium	Medium	Short
51	Marking machine damage	Medium	Medium	Short
52	Marking dirt on machines	Medium	Medium	Short
53	Removing dirt	High	Large	Medium
54	Cleaning of machines with pressure	Medium	Medium	Medium
55	Cleaning out buildings	Medium	Medium	Medium
56	Watching plants characteristics	Low	Small	Short

- Low: 0-2 kg
- Medium: 2-10 kg
- High: 10-20 kg
- Very High: >20 kg

- Small: < 0.7 m
- Medium: 0.7-1.5 m
- Large: 1.5-3 m
- Extra Large: >3 m

- Short: 15-25 min
- Medium: 25-40 min
- Long: 40-60 min
- Very Long: >2h

User. Use case functionalities.

	Sensors	Drone Type	Frequency
01	Looking at straw pattern and straw distribution	Multi Rotor	Medium
02	Safe field work	Multi Rotor	Medium
03	Monitoring hazardous materials (e.g. wastewater)	Rotor + Fixed	Long
04	Water quality monitoring	Pro Sensor CO2 Sensor	Long
05	Road traffic monitoring	Rotor + Fixed	Long
06	Planting in between plants	RGB, Multispectral	Multi Rotor
07	Forest mapping	LiDAR	Multi Rotor
08	Weed removal	RGB, Multispectral	Multi Rotor
09	Watching the field for obstacles	LiDAR, CO2 Sensor	Multi Rotor
10	Watching livestock in the shed	RGB, Thermal	Multi Rotor
11	Watching livestock on open fields	RGB, Thermal	Multi Rotor
12	Watching multiple fields	RGB, Thermal	Multi Rotor
13	Watching multiple machines mechanical aspects	RGB, Thermal	Multi Rotor
14	Watching road entries	Rotor + Fixed	Long
15	Moving bales	Load sensor	Single Rotor
16	Sensor Deployment in high or inaccessible areas	Multi Rotor	Medium
17	Weed prevention via Cellulose	Multi Rotor	Medium
18	Moving fertile earth	Load Sensor, Tactile Sensor	Single Rotor
19	Transporting fertilizer	Load Sensor, Tactile Sensor	Single Rotor
20	Moving implements	Load Sensor, Tactile Sensor	Single Rotor
21	Herding livestock	Multi Rotor	Medium
22	Moving implements around on the field	Load Sensor, Tactile Sensor	Single Rotor
23	Moving fodder around	Load Sensor, Tactile Sensor	Single Rotor
24	Grabbing of multiple dirt samples	Tactile Sensor	Multi Rotor
25	Moving away obstacles	Load Sensor, Tactile Sensor	Single Rotor
26	Moving After Sales items	Load Sensor, Tactile Sensor	Single Rotor
27	Moving bedding	Load Sensor, Tactile Sensor	Single Rotor
28	Delivering After Sales items	Load Sensor, Tactile Sensor	Single Rotor
29	Carrying the equipment of one specific person	Load Sensor, Tactile Sensor	Single Rotor
30	Fire scene assessment	Rotor + Fixed	Medium
31	Construction sites status	Multi Rotor	Medium
32	Inspection of Air Area like Overhead Power Lines	LiDAR	Multi Rotor
33	Making weather predictions	Optical	Multi Rotor
34	Checking on water supplies	Pro Sensor, CO2 Sensor	Multi Rotor
35	Adding communication points for a network	Thermal, Gas, Optical	Multi Rotor
36	Fire extinguishing	Thermal, Gas, Optical	Rotor + Fixed
37	Changing other electronic components	Tactile Sensor	Multi Rotor
38	Adding sensors temporarily to a system	Tactile Sensor	Multi Rotor
39	Adding personal objects	Load Sensor, Tactile Sensor	Multi Rotor
40	Recognition of garbage	RGB, LiDAR	Multi Rotor
41	Disaster alert	Rotor + Fixed	Medium
42	Documentation of property damage	Multi Rotor	Medium
43	Identification of weed nests	RGB, LiDAR	Multi Rotor
44	Temperature mapping	Rotor + Fixed	Long
45	Detection of dying areas	Rotor + Fixed	Medium
46	Wildlife detection	RGB, LiDAR	Multi Rotor
47	Marking work place hazards	Multi Rotor	Short
48	Marking different heights	Multi Rotor	Short
49	Marking boundaries to work	Multi Rotor	Short
50	Marking spots in fields	Multi Rotor	Short
51	Marking machine damage	Multi Rotor	Short
52	Marking dirt on machines	Multi Rotor	Short
53	Removing dirt	Single Rotor	Medium
54	Cleaning of machines with pressure	Multi Rotor	Medium
55	Cleaning out buildings	Multi Rotor	Medium
56	Watching plants characteristics	Multi Rotor	Short

- Acoustic based sensors
- Electromagnetic sensors
- Light detection and ranging (LiDAR)
- Optical sensors
- Mechanical sensors
- Mass flow sensors
- Electrochemical sensors
- Eddy covariance based sensors
- Air flow sensors
- Ultrasonic sensors
- Soil Moisture
- Soil Nutrient Sensors (NPK)
- Gas Sensors
- Thermal imaging
- Humidity sensor
- Infrared sensor
- Barometer sensor
- Load sensor
- Tactile sensor
- CO2 sensor
- Inertial Measurement Unit (IMU)
- Geomagnetic sensor

- Rotor + Fixed Wing
- Multi Rotor
- Single Rotor
- Fixed Wing

Fig.82 Assignment parameters towards extracted functions

Fig.83 Assignment sensors towards extracted functions

5.2.3 Drone type convergence

Multidrones allow for the most precise steering with less intelligence than single rotor, while fixed wing and cruise drones offer more energy efficiency.

As the architecture is the most defining factor for a drone grouping the different scenarios in terms of manoeuvrability gives a good indication of possible drone concepts for the agricultural context.

	Sensors	Drone Type	Frequency
01	Looking at straw pattern and straw distribution	Multi Rotor	
02	Safe field work	Multi Rotor	
03	Monitoring hazardous materials (e.g. wastewater)	Rotor + Fixed	
04	Water quality monitoring	Fixed Wing	
05	Road traffic monitoring	Rotor + Fixed	
06	Planting in between plants	Multi Rotor	
07	Fence mapping	Multi Rotor	
08	Weed removal	Multi Rotor	
09	Watching the field for obstacles	Lift & Cruise	
10	Watching livestock in the field	Fixed Wing	
11	Watching livestock on open fields	Fixed Wing	
12	Watching multiple fields	Fixed Wing	
13	Watching multiple machines mechanical aspects	Fixed Wing	
14	Watching road sensors	Rotor + Fixed	
15	Moving bales	Single Rotor	
16	Sensor Deployment in high or inaccessible areas	Multi Rotor	
17	Wasp prevention via Cellulose	Multi Rotor	
18	Moving fertilizer	Single Rotor	
19	Transporting fertilizer	Single Rotor	
20	Moving implements	Single Rotor	
21	Harvesting livestock	Multi Rotor	
22	Moving implements around on the field	Single Rotor	
23	Moving tractor around	Single Rotor	
24	Grabbing of multiple dirt samples	Multi Rotor	
25	Moving away obstacles	Single Rotor	
26	Moving After Sales Items	Single Rotor	
27	Moving bedding	Single Rotor	
28	Delivering After Sales Items	Multi Rotor	
29	Carrying the equipment of one specific person	Single Rotor	
30	Fire location assessment	Rotor + Fixed	
31	Construction sites status	Multi Rotor	
32	Inspection of Air Lines like Overhead Power Lines	Fixed Wing	
33	Making weather predictions	Multi Rotor	
34	Checking on water supplies	Multi Rotor	
35	Adding communication points for a network	Multi Rotor	
36	Fire extinguishing	Rotor + Fixed	
37	Changing other electronic components	Multi Rotor	
38	Adding sensors temporarily to a systems	Multi Rotor	
39	Adding personal objects	Multi Rotor	
40	Recognition of garbage	Multi Rotor	
41	Disaster alert	Rotor + Fixed	
42	Documentation of property damage	Multi Rotor	
43	Identification of weed nests	Multi Rotor	
44	Temperature monitoring	Rotor + Fixed	
45	Detection of drying stress	Rotor + Fixed	
46	Wildfire detection	Multi Rotor	
47	Marking work place hazards	Multi Rotor	
48	Marking different heights	Multi Rotor	
49	Marking boundaries to work	Multi Rotor	
50	Marking spots in fields	Multi Rotor	
51	Marking machine damage	Multi Rotor	
52	Marking dirt on machines	Multi Rotor	
53	Removing dirt	Single Rotor	
54	Clearing out machines with pressure	Multi Rotor	
55	Clearing out beddings	Multi Rotor	
56	Watching plants characteristics	Multi Rotor	

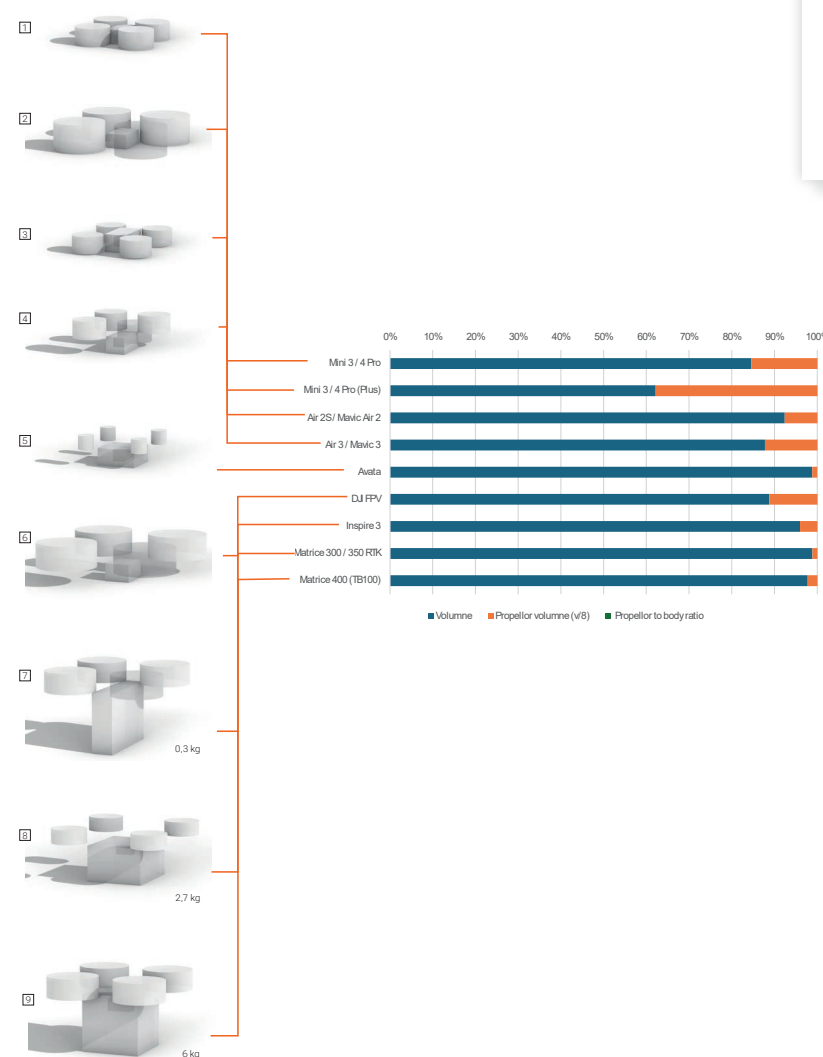


Fig.84 Assignment sensors towards extracted functions

5.3 Concept specification

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

5.3.1 Functionality grouping

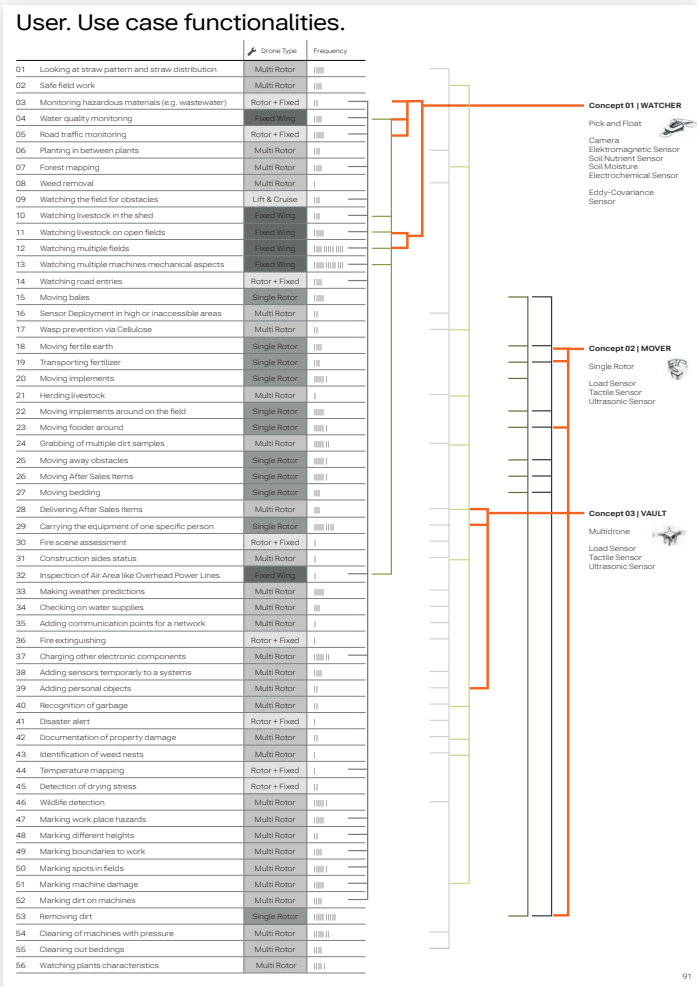


Fig.85 Assignment sensors towards extracted functions

The functionalities were clustered and grouped into three concepts. These are Watch, Pull and Valet.

The identified user functionalities were systematically clustered into three distinct drone concepts—Watch, Pull, and Valet—each tailored to specific operational roles. The Watch concept, based on the DJI Mini 3/4 Pro, focuses on observation and monitoring tasks, emphasizing compactness and agility with a hexacopter setup optimized for visual coverage.

The Pull concept, derived from the DJI M400, addresses transport and delivery operations requiring a higher payload capacity of around 4 kg, balancing aerodynamic efficiency and structural strength for short-range logistics missions.

Lastly, the Valet concept is designed for precise maneuvering and moderate lifting, bridging monitoring and payload capabilities. Together, these concepts translate user needs into targeted design directions, aligning drone specifications and sensor configurations with distinct field use cases.

Concept. 01 Watch.

Based on DJI Mini 3/4 Pro

Hexacopter Specs in cm

Prop diameter: 45.72 cm

Prop radius: 22.86 cm

Total disc area (all 6 props combined): ~9 850 cm²

Concept. 02 Pull.

Based on DJI M400

A minimum 15 min trip
The payload was determined with 2500 g

Center body (LxWxH): 25 x 20 x 12 cm

Payload shape: keep frontal area small and corners rounded; target ≤ 25x20x20 cm box for 2.5 kg (dense materials like soil/fertilizer).

Total mass (example): ~4.5 kg (2.0 kg airframe incl. ~133 Wh pack + 2.5 kg payload + ~0.1 kg hook).

31.75 cm*4 propellers

Concept. 03 Valet.

Based on DJI M300

2,7 weight limit



6. Future Scenario Watcher

The concept watcher focusses on field observation. But rather than soely relying on remote measurements, This drone is supposed to work with contact measurements.

6.1 Concept

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■



Sales Promotion

There's a push toward making machine performance less dependent on user expertise on field characteristics.



Technology Management

Farmers show strong interest in stock management and fawn rescue use cases.



preparing for harvest



field monitoring & preparation



setting up field route



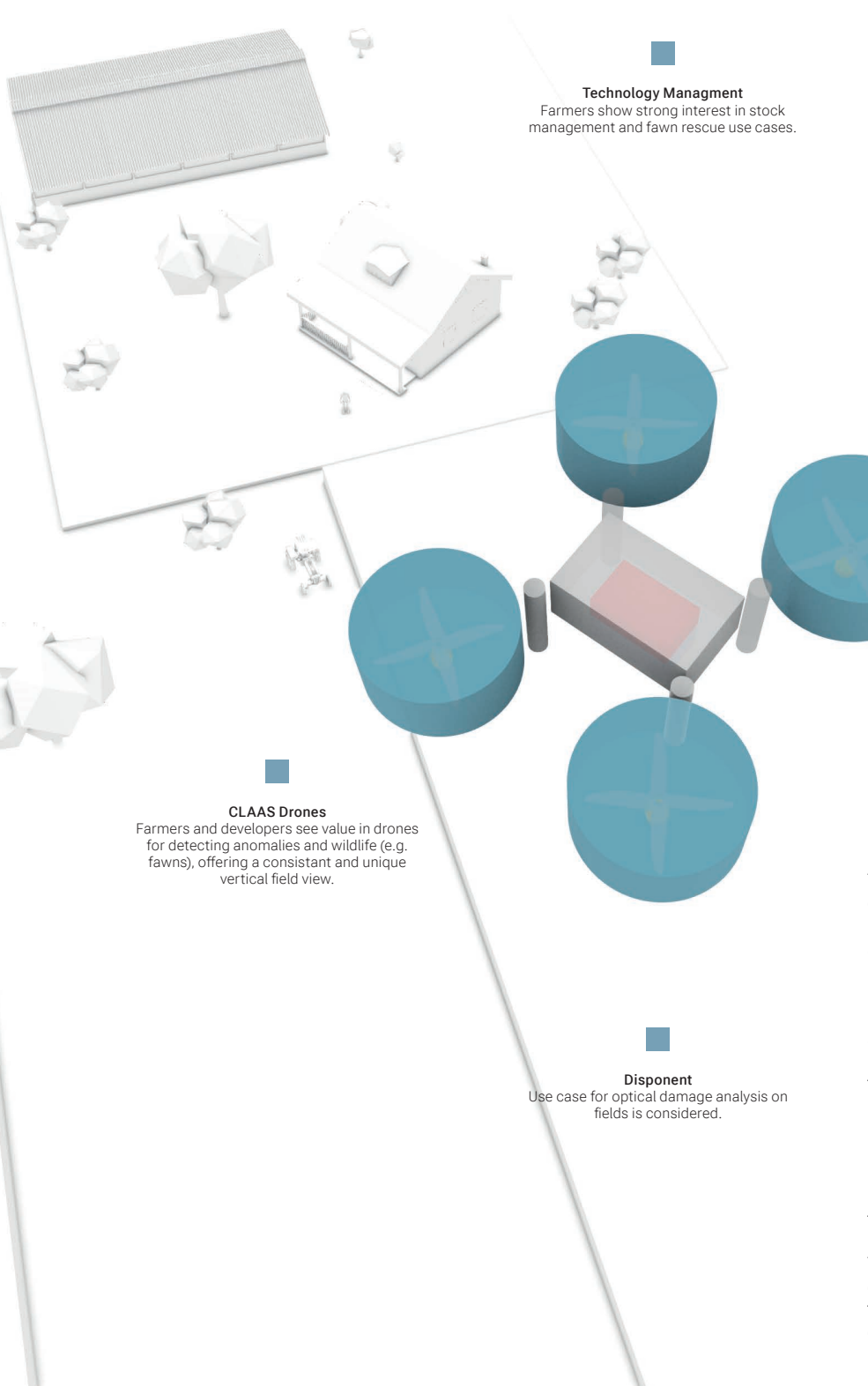
CLAAS Drones

Farmers and developers see value in drones for detecting anomalies and wildlife (e.g. fawns), offering a consistent and unique vertical field view.



Disponent

Use case for optical damage analysis on fields is considered.



The concept watcher is supposed to help get a better overview on the farmland itself. Drones have the advantages of getting into areas that are otherwise difficult to approach.

Farmers and developers increasingly recognize the value of drones for detecting anomalies and wildlife such as fawns, providing a consistent and unique vertical perspective on fields. Within technology management, there is a growing interest in using such tools for stock monitoring and fawn rescue applications.

From a sales promotion perspective, the industry is moving toward making machine performance less dependent on individual user expertise and more adaptive to specific field characteristics.

The disponent role is expanding to include the use of optical analysis for assessing field damage, further integrating digital and aerial insights into everyday farm operations.

6.2 User Journeys

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

6.2.1 User Journeys

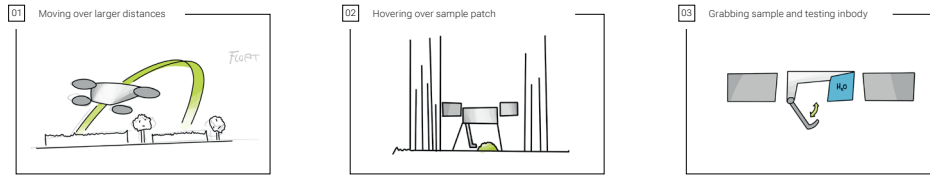


Fig.86 Assignment sensors towards extracted functions

The process begins with the drone moving over larger distances to reach specific field locations efficiently. Once it arrives at a targeted area, it hovers precisely over the sample patch, using its sensors to identify the correct spot for data collection. In the final step, the drone grabs a sample

and conducts in-body testing, analyzing the material directly within its onboard system before transmitting the results digitally. This sequence enables autonomous sampling and real-time field diagnostics with minimal human intervention.

“ Anticipating wait times and terrain conditions is important for me. ”

“ I believe drone use would be justifiable during the harvesting season. ”

“ Manual inspection of fields is still seems necessary despite drone usage. ”

“ Watching livestock and fields at night is stressful and takes from my break. ”

Advanced Operator
Bernhard. Optimistic heritage.

Professional Operator
Hendrik. Hands-On Strategist.

Fig.87 Assignment sensors towards extracted functions

6.2.2 Opinions

Operators emphasize the importance of anticipating wait times and adapting to varying terrain conditions to maintain efficient workflows. Drone use is considered particularly valuable during the harvesting season, when time and precision are critical.

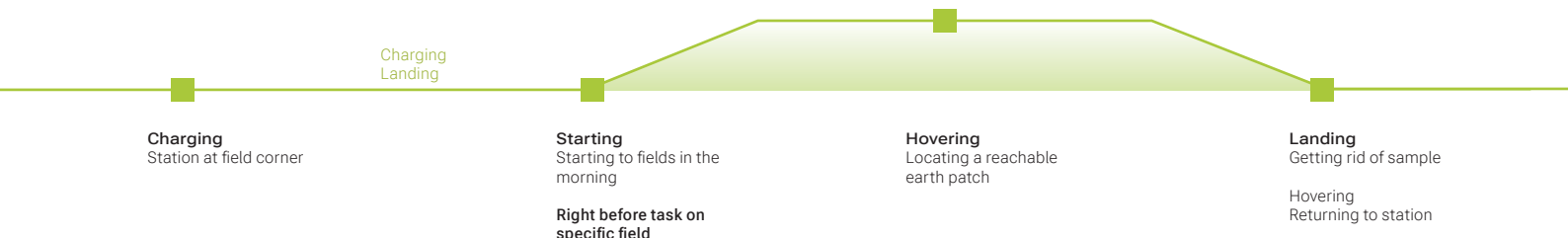
Manual inspection of fields is still regarded as necessary despite the growing integration of drone technology. Monitoring livestock and fields at night remains a demanding task, suggesting potential for drones to reduce workload and stress in future operations.

6.2.3 Disadvantages

A limitation of the system is that the sample still needs to be physically reached, requiring manual intervention. Water must be added to the sample before testing, which introduces an extra preparation step.

6.2.4 Advantages

The system allows operators to decide flexibly each morning which field to work on, offering greater planning freedom. It also enables testing in remote or hard-to-access areas, expanding its usability across diverse field conditions. The floating design supports longer flight times, enhancing operational efficiency and coverage.



6.3 Functionalities

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

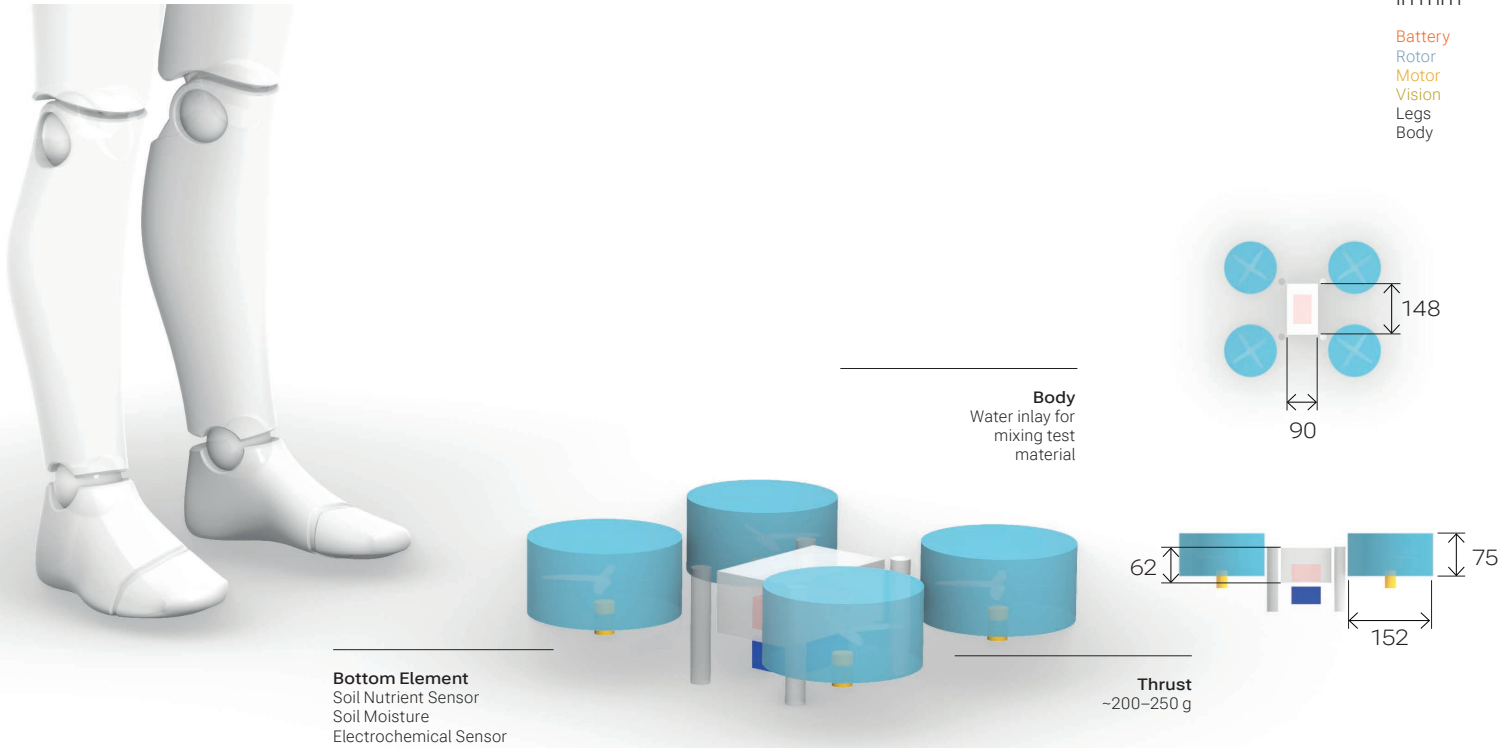


Fig.88 Assignment sensors towards extracted functions

6.3.1 Funtionalities

The drone system combines precise sampling, on-site testing, and stable flight performance for agricultural soil analysis. It features scooping rakes that collect soil samples directly from the surface, enabling accurate nutrient and moisture readings.

The water container integrated into the body allows controlled mixing of soil and water to achieve the correct testing ratio for electrochemical measurements. The floating shape of the drone ensures balance and stability during low-altitude hovering and sampling operations.

Together with the bottom element—which houses sensors for soil nutrients, moisture, and electrochemical properties—and the body’s water inlet for mixing test materials, the design enables autonomous soil diagnostics.

The compact frame (approximately 152 × 148 mm) and thrust capacity of 200–250 grams support agile movement and precise positioning. Overall, the system allows drones to collect, mix, and analyze soil samples directly in the field, reducing manual effort and improving the efficiency of agricultural monitoring.

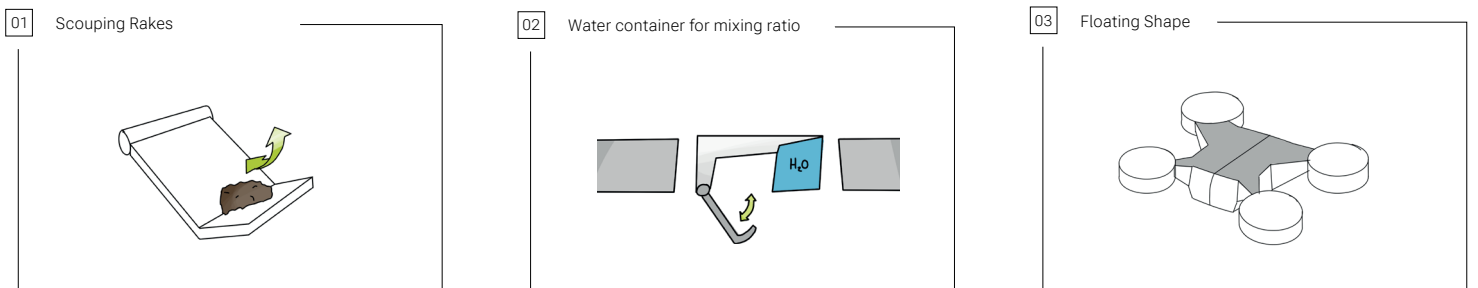


Fig.89 Assignment sensors towards extracted functions



7. Future Scenario Mover

This concept focuses on physically moving objects during farming operations.

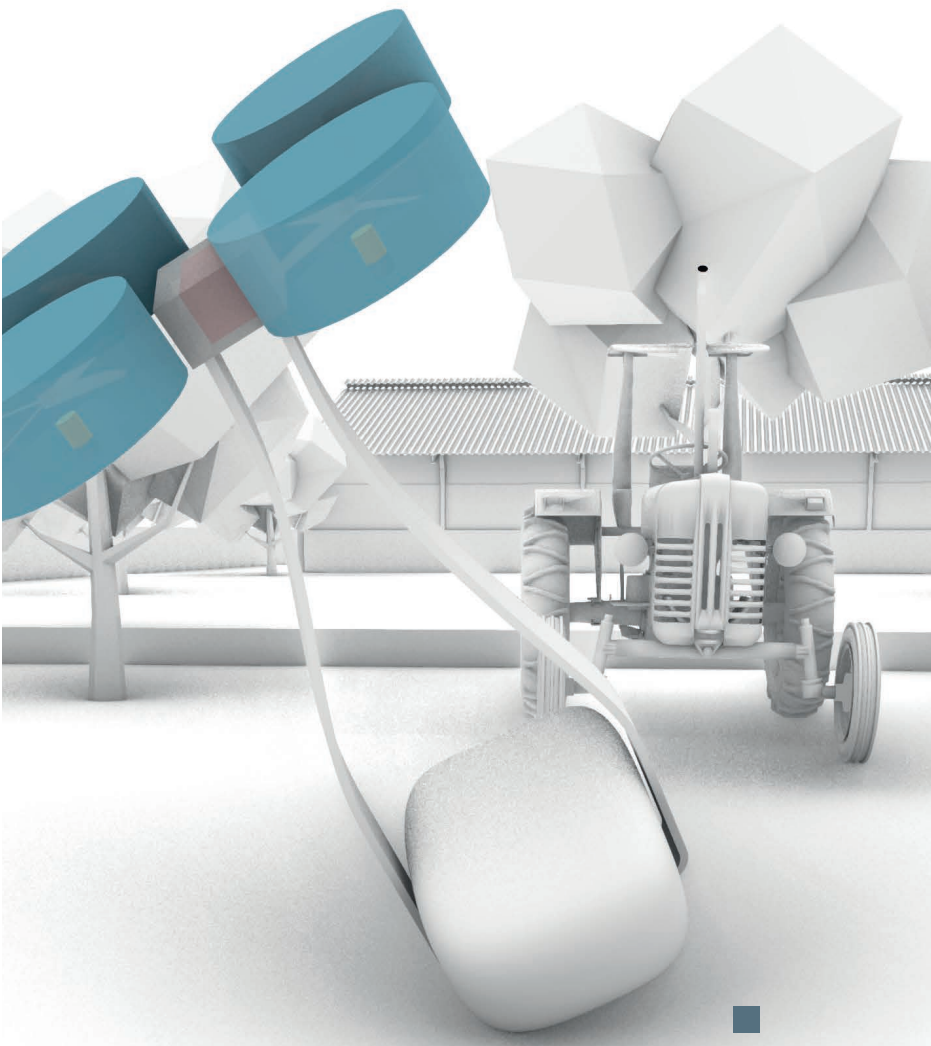
7.1 Concept

- Convergence ■
- Concept Watcher ■
- Concept Mover ■**
- Concept Valet ■
- Concept Choice ■



Robotization

Use of robotics to reduce labor costs, making sustainable methods more financially viable.



Technology Management

Buying an existing drone and adding specific hardware is the most viable option for CLAAS.



Autonomy Farming

There are efforts to recultivate farm land more sustainable through strip farming and in between plants.



morning animal care



Driving to the worksite



Supervising harvest

The integration of robotics in agriculture aims to reduce labor costs and make sustainable methods more economically viable. From a technological perspective, purchasing an existing drone and equipping it with specialized hardware is considered the most feasible approach for CLAAS.

At the same time, efforts in autonomous farming focus on recultivating farmland in a more sustainable way, for example through strip farming and managing areas between plants. These developments support farmers in daily tasks such as morning animal care, traveling to the worksite, and supervising the harvest, ultimately increasing efficiency and flexibility in farm management.

7.2 User Journeys

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

7.2.1 User Journeys

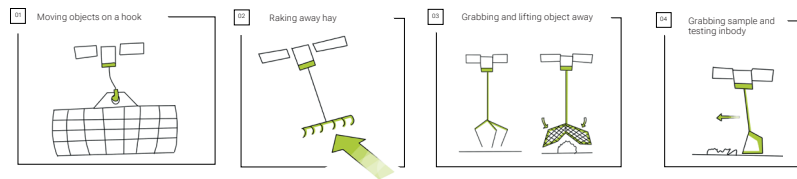


Fig.90 Assignment sensors towards extracted functions

The drone system is designed to perform a range of agricultural and maintenance tasks autonomously. It can move objects using a hook, enabling the transport of lightweight tools or materials across the field. Equipped with a raking mechanism, it is capable of clearing or spreading hay to support field preparation and maintenance.

The system can also grab and lift small objects, allowing flexible handling of materials or debris. Additionally, it features a sampling function that collects soil and conducts in-body testing, providing real-time data on soil conditions. These combined functions make the drone a versatile tool for efficient and adaptive field management.

“ Sometimes I need to stop my field work to move obstacles out of the way. ”

“ Drones seem useful to reach confined area. ”

“ Anticipate wait times and terrain conditions are important for the operation. ”

“ I would find it drones helpful for observing fields and rain drainages. ”

Basic operator:
Katharina, Resilient Multitasker.

Advanced Operator:
Martina, Sustained Hobbyist.

Fig.91 Assignment sensors towards extracted functions

7.2.2 Opinions

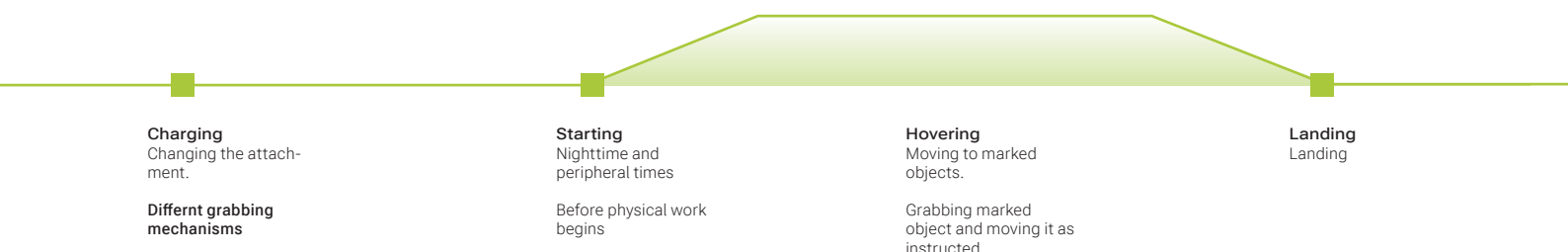
Operators emphasize the need for tools that can assist with practical field challenges. They often have to interrupt their work to move obstacles out of the way, making remote or automated assistance valuable. Drones are considered useful for accessing confined or difficult-to-reach areas and for monitoring terrain conditions, rain drainage, and field accessibility. Anticipating wait times and adapting to terrain conditions are seen as important factors for ensuring efficient and uninterrupted operations.

7.2.3 Advantages

Using the drone reduces wear and tear on agricultural machinery by taking over smaller transport and handling tasks. It also enables faster movement of objects over greater distances, improving efficiency and reducing manual workload during field operations.

7.2.4 Disadvantages

The system is limited by the maximum weight it can lift and transport, restricting the range of objects that can be handled efficiently.



7.3 Functionalities

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

in mm
 Battery
 Rotor
 Motor
 Vision
 Legs
 Body

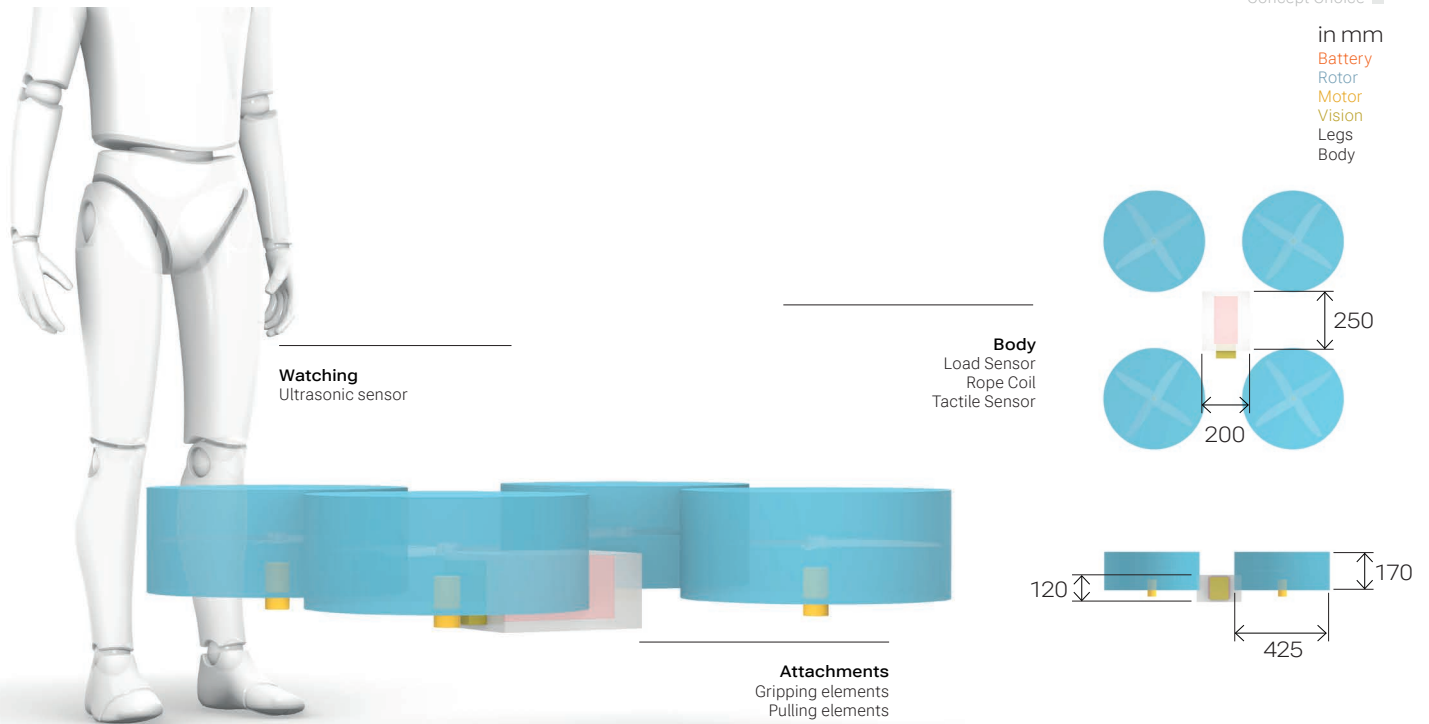


Fig.92 Assignment sensors towards extracted functions

7.2.5 Funtionalities

The drone is designed to support physical interaction and manipulation tasks in agricultural environments. Equipped with ultrasonic sensors, it can monitor surroundings and maintain precise positioning while observing objects or terrain. The body integrates a load sensor, a rope coil, and tactile sensors, enabling it to detect applied forces and interact safely with various materials or structures.

Different attachments expand the drone's functionality: gripping and pulling elements allow it to move or lift objects, adjust equipment, or remove obstacles from the field. The pulling element is used for towing or repositioning items, while interchangeable attachments adapt the system for specialized tasks, such as lifting, dragging, or securing objects.

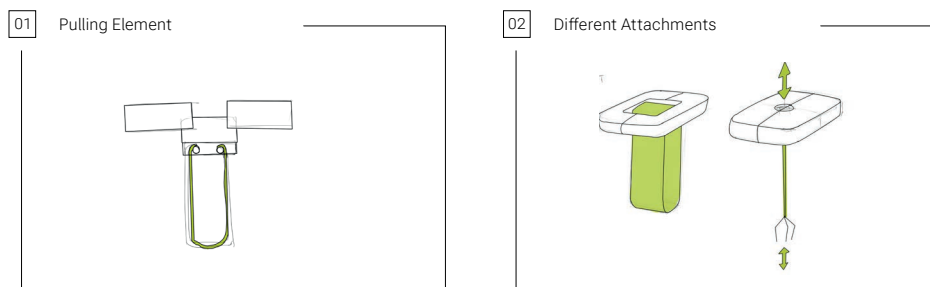


Fig.93 Assignment sensors towards extracted functions



8. Future Scenario Valet

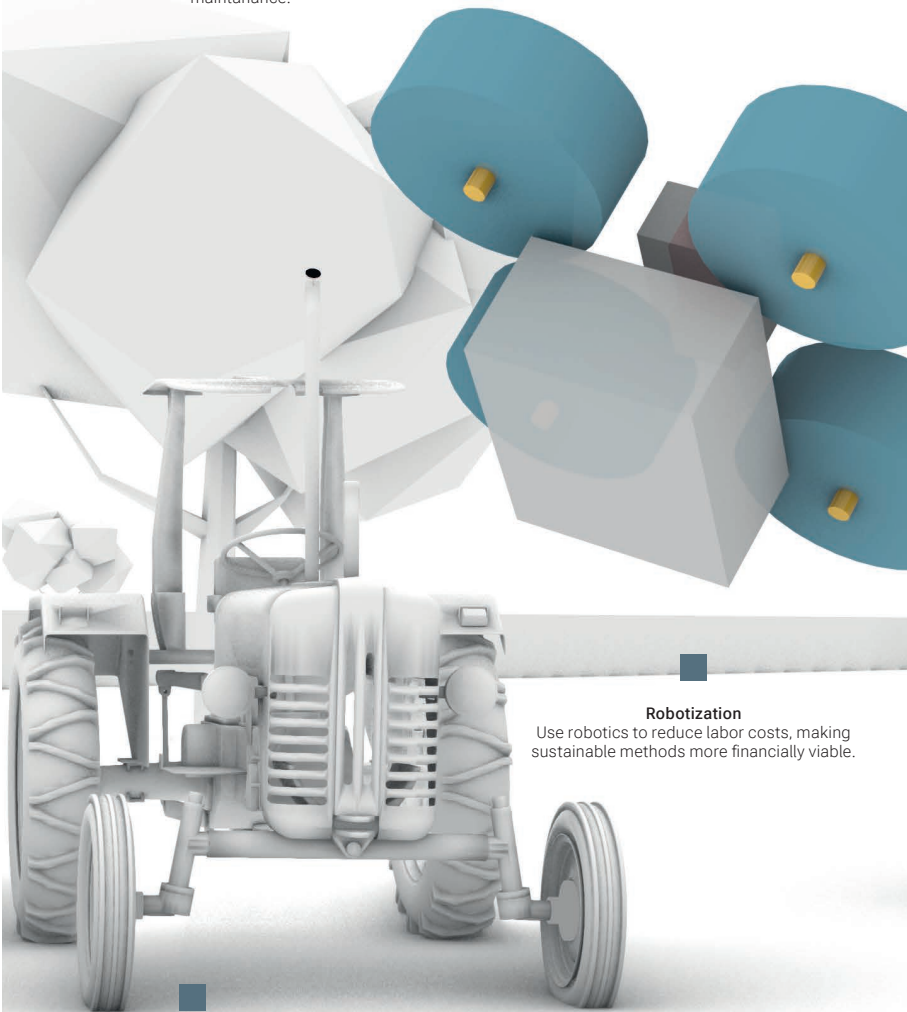
This concept can carry various items in the entire operation.

8.1 Concept

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

Amazone

Drone docs need energy supply and maintenance.



Robotization

Use robotics to reduce labor costs, making sustainable methods more financially viable.

Sales Promoter

There's a push toward making machine performance less dependent on user expertise.

Deer Rescue

Drones are implemented for deer rescue regardless of the available machines. The car that is carrying the drone carries a self made charger unit.



harvest or seasonal work



managing staff



technical maintenance

Bundle	Contents	Total_kg
A – After-sales drop	parts box (1.0), docs (0.1), compact driver (0.3)	1,4
B – Technician light kit	tablet (0.9), tool roll (0.8), PPE (0.3), powerbank (0.3)	2,3
C – Tech kit + personal add-ons	bundle B + jacket (0.6)	2,9
D – Personal carry	lunch + bottle (0.7), jacket (0.6), small pouch (0.2)	1,5
E – Heavy service kit	small laptop (1.3), full tool roll (1.2), water (0.5)	3

The integration of drones into agricultural practice highlights several emerging fields of application. Within robotization, the use of autonomous systems aims to reduce labor costs while making sustainable farming methods more economically viable. From a sales perspective, there is an ongoing shift toward making machine performance less dependent on operator expertise, simplifying complex processes for broader user accessibility.

Drones are also gaining importance in deer rescue operations, where they help locate and protect wildlife before fieldwork begins. The carrier vehicle includes a self-made charging unit, ensuring operational independence in remote areas. Energy supply and regular maintenance are essential for keeping drones functional and efficient over time. These developments complement tasks such as seasonal fieldwork, staff management, and technical maintenance, marking a step toward a more automated and interconnected farming ecosystem.

8.2 User Journeys

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

8.2.1 User Journeys

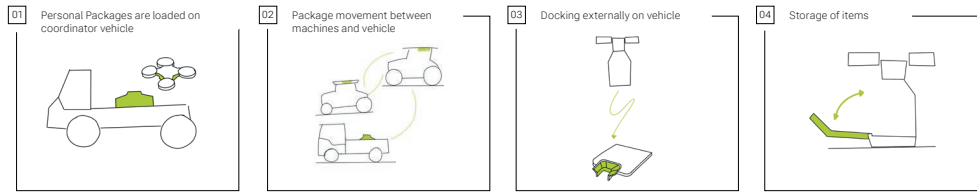


Fig.94 Assignment sensors towards extracted functions

The concept illustrates a coordinated logistics system between drones and agricultural vehicles. Personal packages are first loaded onto a coordinator vehicle, which serves as a mobile base for distribution. From there, packages are transported between machines and the vehicle using autonomous drone flights, ensuring efficient delivery of tools, spare parts, or personal items directly to the point of need.

The drones are designed to dock externally on vehicles, enabling quick loading and unloading without interrupting ongoing operations. Once the items are delivered, they can be stored securely either on the vehicle or in designated compartments. This system enhances mobility and workflow continuity across the farm, minimizing downtime and improving the coordination between human operators and autonomous systems.

“ Aid is needed in logistical coordination during high-stress harvest phases. ”

“ Repairs and support availability are a concern, we need a local and available service partner. ”

“ Farmers are used to weather—weather is not a major concern, but repairs are. ”

“ Different tools are needed as a service provider to ensure the proper use of machines. ”

Experienced Operator
Keith, Driving Service.

Experienced Operator
Juliana, Contractor Disponent.

Fig.95 Assignment sensors towards extracted functions

8.2.2 Opinions

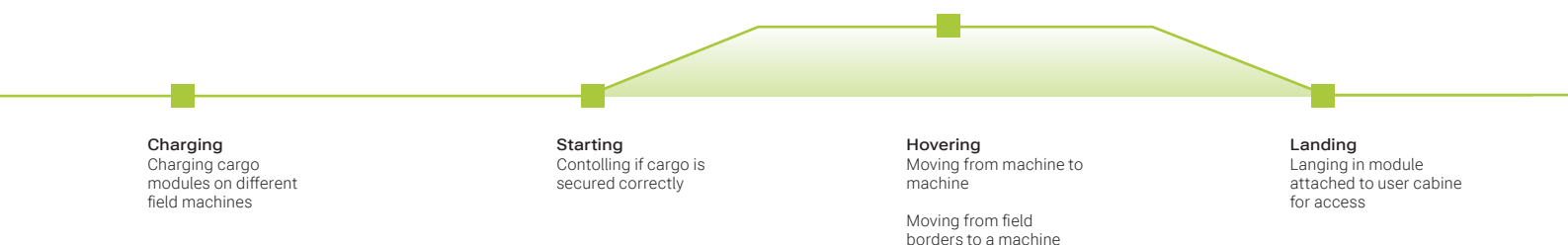
Efficient logistical coordination is crucial during high-stress harvest periods, where rapid response and clear communication can significantly improve workflow. Reliable repair and support services are essential, as downtime caused by technical issues has a direct impact on productivity. While weather conditions are generally manageable for most operators, equipment failures remain a key concern. Ensuring the availability of local service partners and specialized tools helps maintain machine performance and guarantees that technology is used effectively throughout the farming process.

8.2.3 Advantages

The system allows flexible decision-making, enabling operators to choose which field to work on each morning. It also supports testing in remote or hard-to-reach areas, expanding its usability across different field conditions. Furthermore, the floating design contributes to longer flight times, increasing overall efficiency and coverage.

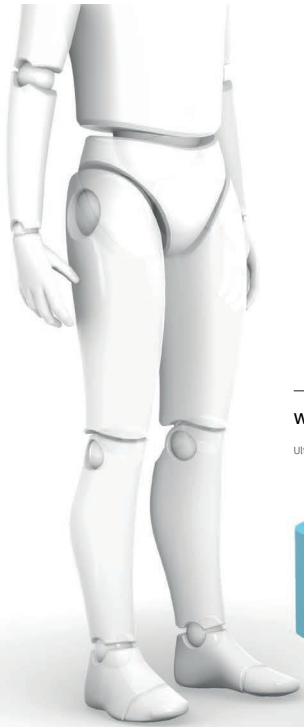
8.2.4 Disadvantages

The system requires the sample to be physically reached, which can limit accessibility in certain areas. Water must be added to the sample for testing, creating an extra preparation step that may slow down the process.

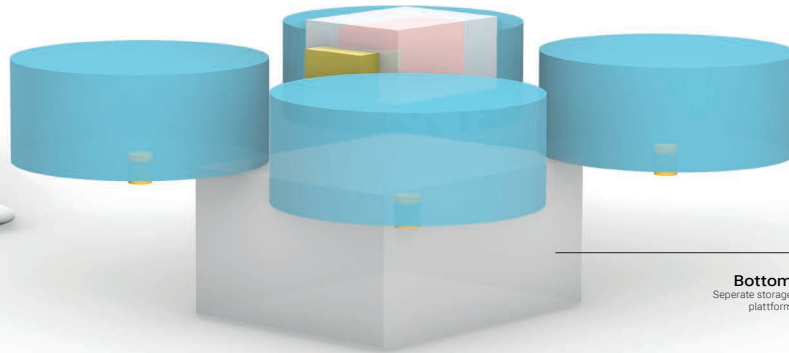


8.3 Functionalities

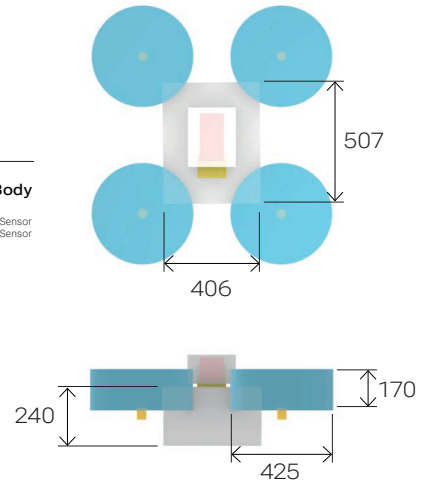
- Convergence ■
 - Concept Watcher ■
 - Concept Mover ■
 - Concept Valet ■**
 - Concept Choice ■
- in mm
- Battery
 - Rotor
 - Motor
 - Vision
 - Legs
 - Body



Watching
Ultrasonic Sensor



Body
Load Sensor
Tactile Sensor



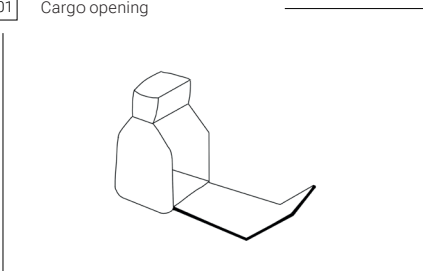
Bottom
Separate storage platform

8.2.5 Funtionalities

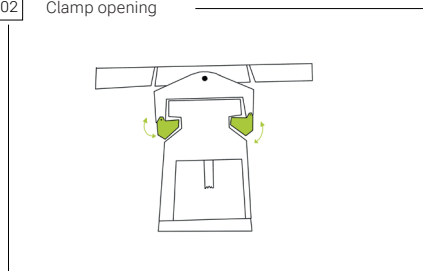
The drone system is designed for precise handling and transport operations in agricultural and industrial environments. It features a cargo opening mechanism that enables the secure loading and unloading of packages or materials. This design allows the drone to efficiently deliver or collect items directly from the ground or designated platforms. A clamp opening system provides an additional gripping function, allowing the drone to hold, lift, and release objects with stability. This mechanism makes it suitable for tasks such as transporting tools, handling samples, or repositioning lightweight materials in the field.

The axis element adds flexibility to the structure, allowing controlled tilting or rotation of the gripping components. This ensures better adaptability to uneven surfaces and various object shapes. Technically, the drone integrates ultrasonic sensors for spatial awareness and obstacle detection, and load and tactile sensors within the body to measure interaction forces during handling. The bottom section serves as a storage platform for carrying or depositing objects. With a compact form factor of approximately 507 × 425 × 240 mm, the system combines precise manipulation, stable flight, and intelligent sensing—enabling autonomous logistics and sampling operations in complex environments.

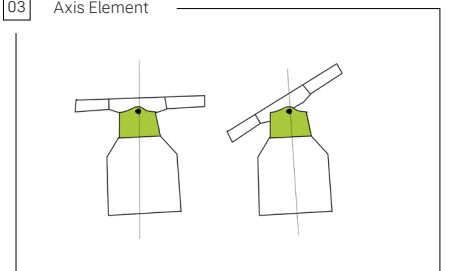
01 Cargo opening



02 Clamp opening



03 Axis Element





9. Concept Choice

9.1 Concept Choice

- Convergence ■
- Concept Watcher ■
- Concept Mover ■
- Concept Valet ■
- Concept Choice ■

Among the developed concepts, the Valet concept was selected for further development. It features a physical component that allows for a lower entry barrier for CLAAS in terms of data management. Moreover, interviews with CLAAS dealers indicated a strong interest in improving logistical processes, further supporting the relevance of this concept.

👁️ Concept. 01 Watch.

+
The user can decide each morning which field to work on.

Enables testing in remote areas.
Floating capability leads to long flight time.

-
The sample must be accessed.
Water must be added to the sample.
Long distances requires remoter charging ports.

👉 Concept. 02 Move.

+
Less wear and teare on the machines, since less weare and teare.

Less interruptions for the entire operation.
Attachment on existing drone.

-
Weight limit
Weight compensation

📦 Concept. 03 Valet.

+
Supplying workers on field with smaller items during their work.

Landing machines could include charging points.

-
Weight limit
Weight compensation
Complex landing required



Fig.96 Drone Concepts Watch, Move and Valet



Concept

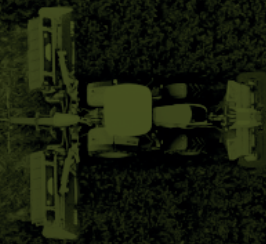
After the initial research and concept development, this chapter is about verifying. A finalization of the concept will also happen.

Desirability

Feasability

Viability

Finish



10. Desirability

What are the barriers to adopting drones as an agricultural company?
This includes farmers as well as contractors.

10.1 Szenario Specification

Desirability ■
 CLAAS ■
 Drones ■
 User ■

10.1.1 Machine specification

CLAAS offers machines for different tasks which accompany workers along the general harvesting cycle. For increasing the desirability as well as the viability, using a machine that is used year round like a tractor instead of CLAAS most popular machine th ecombined harvester makes sense. This also aligns with the overall CLAAS group strategy.

Bundle	Contents	Total_kg
A – After-sales drop	parts box (1.0), docs (0.1), compact driver (0.3)	1,4
B – Technician light kit	tablet (0.9), tool roll (0.8), PPE (0.3), powerbank (0.3)	2,3
C – Tech Kit + personal add-ons	bundle B + Jacket (0.6)	2,9
D – Personal carry	lunch + bottle (0.7), jacket (0.6), small pouch (0.2)	1,5
E – Heavy service kit	small laptop (1.3), full tool roll (1.2), water (0.5)	3

Fig.99 Scenario based packages



Fig.97 Overview of CLAAS machines along the harvesting process

While many different components are required during field work, it is assumed for these use cases that the needed item is not already available in the machine cabin. This situation often occurs when machines are frequently exchanged, preventing personal items from being left behind, and when maintenance essentials are not consistently checked or restocked between uses

10.1.3 Cargo variants

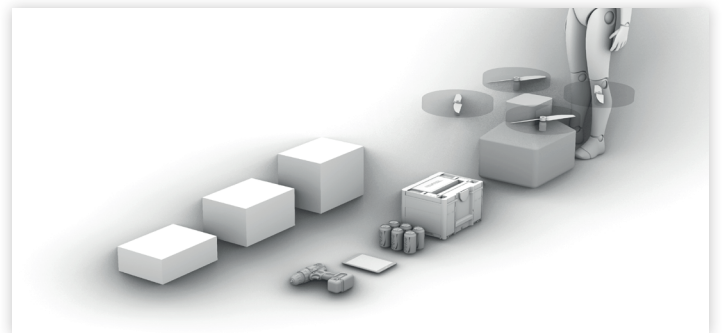


Fig.100 Package sizing comparison

10.1.2 Cargo definition

Electrical Components

- Fuses and relays
- Light bulbs (work lights, indicators)
- Small wiring harness sections
- Sensors (temperature, pressure, proximity)
- Switches and connectors

Filters & Fluids

- Fuel filters
- Oil filters
- Air filters (cabin or engine, compact types)
- Hydraulic filter elements
- Grease cartridges

Drive & Engine Parts

- Fan belts / V-belts
- Small tensioner pulleys
- Spark plugs / glow plugs
- Injector nozzles
- Hose clamps and small hoses

Hydraulic & Pneumatic

- Quick-coupling adapters
- O-ring kits
- Seals and gaskets
- Small hydraulic hoses (short lengths)
- Pressure gauges

Wear & Tear Items

- Knife sections (for cutter bars)
- Small bearings
- Chain links / chain repair kits
- Bolts, nuts, pins, clips
- Shear bolts

Cabin & Operator Comfort

- Seat cushions / armrest pads
- Cabin air filters
- Small mirror replacements
- Wiper blades

Work Essentials

- Tool roll
- Powerbank + charger
- Tablet / small laptop
- Documentation / service manuals
- Parts box
- Spare components

Safety & Protection

- Helmet, gloves, safety glasses, ear protection
- High-visibility jacket or vest
- First aid kit
- Fire extinguisher

Personal Carry

- Lunch & snacks
- Water bottle / hydration
- Jacket

Field Service

- Diagnostic equipment (sensors, testers)
- Compact driver
- Grease, lubricants, cleaning cloths
- Fuel card

Documentation & Communication

- Notebook & pens
- Mobile phone + radio
- Checklists / service records
- Maps

Fig.98 Personal and Machine related items during harvest

The toolbox has a ground footprint of approximately 30 x 40 cm. Its enclosure is made of ABS with 3.5 mm thick walls and a 6 mm ribbed bottom that is about 60% solid. The lid and locking mechanism are part of a fixed 0.5 kg module, and the design includes an additional 0.5 kg for the battery.

The drone itself can hold up to 5kg, while being based on the DJI M400.

Size	Height	Inner Volume	Weight with ABS	Payload	Payload to Weight
S	130	14.4 l	1.11 kg	3.89 kg	4.75
M	210	23.5 l	1.51 kg	3.49 kg	3.5
L	290	32.7 l	1.91 kg	3.09 kg	2.6

Fig.101 Sizing of cargo and their efficiency

CLAAS After Sales Products

A comprehensive product portfolio for our customers and dealers!

CLAAS ORIGINAL
Parts, accessories and consumables for CLAAS products (machines)

MAXI CARE FLEX
MAXI CARE Service Contracts

CLAAS FARM PARTS
Parts and accessories for All-Makes products (machines) and complementary products for farmers (offer limited to Europe)

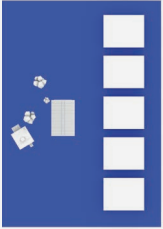
10.2 Szenario Specification

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

10.1.1 User Models

very much lower than average
 lower than average
 about average
 higher than average
 very much higher than average

Model 1- Small farm private

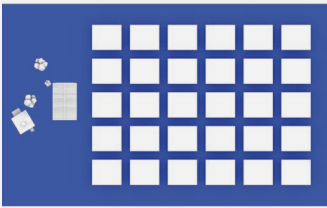


distances		number of trips per field	
Farm area	100	Within farm premise	350
Number of fields	5	Daily way from farm premise	250
Mean field distance	1.3 km	Field edge to machine	600
Dealer to farm	18 km	Farm premise to machine	400
Field corner to machine	0.25 km	After Sales to farm premise	20
farm to field	1.34 km	After Sales to Machine	60
dealer to farm	18 km	Machine to Machine	300

> 55 years
 200 ha
 Mixed farming

Cautious Traditionalist

Model 2- Average Farm

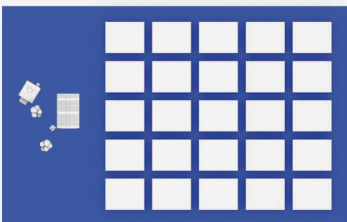


distances		number of trips per field	
Farm area	300	Within farm premise	350
Number of fields	30	Daily way from farm premise	250
Mean field distance	2.5 km	Field edge to machine	600
Dealer to farm	15 km	Farm premise to machine	400
Field corner to machine	0,2 km	After Sales to farm premise	20
farm to field	2,5 km	After Sales to Machine	60
dealer to farm	15 km	Machine to Machine	300

18-44 Years
 500+ ha
 Arable farming contractor

Experienced operator

Model 3- Big farm organization



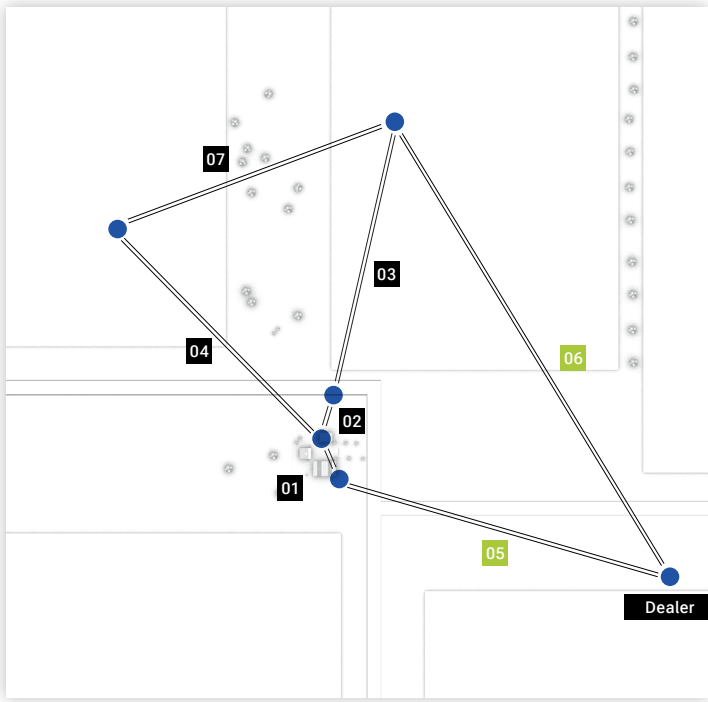
distances		number of trips per field	
Farm area	500	Within farm premise	350
Number of fields	25	Daily way from farm premise	250
Mean field distance	3.0 km	Field edge to machine	600
Dealer to farm	18 km	Farm premise to machine	400
Field corner to machine	0.25 km	After Sales to farm premise	20
farm to field	3.0 km	After Sales to Machine	60
dealer to farm	18 km	Machine to Machine	300

< 65 years
 200 ha
 Forage farming

Optimistic Pioneer

In comparison to the baseline, distances in Model 2 (500 ha) increase by roughly 20 %, reflecting the larger spatial distribution of fields typical for medium to large-scale farms. Conversely, Model 3 (100 ha) shows a distance reduction of about 40 %, consistent with the more compact layout of smaller farms.

These variations align with spatial spread principles found in rural GIS models, where internal field distances tend to scale proportionally to the square root of the total farm area, illustrating how operational logistics expand non-linearly with farm size.



- 01** Within farm premise
- 02** Daily way from farm premise
- 03** Field edge to machine
- 04** Farm premise to machine
- 05** After Sale to farm premise
- 06** After Sales to Machine
- 07** Machine to machine

10.2.1 Distance definition

The comparison of three farm models illustrates how scale and structure influence operational distances and logistics. The small private farm covers around 100 hectares divided into 5 fields, with an average distance of 1.3 km to each field and 18 km to the nearest dealer. The average farm, spanning 300 hectares and 30 fields, has greater internal distances—2.5 km between fields—but slightly closer dealer proximity at 15 km.

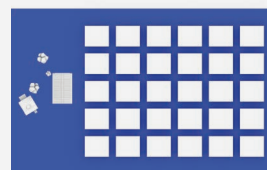
In contrast, the large farm organization manages 500 hectares across 25 fields, with fields averaging 3 km apart and dealers again located roughly 18 km away. As farm size increases, internal distances grow significantly, impacting transport efficiency, time management, and the potential benefits of autonomous or drone-based logistics solutions for optimizing operations between fields and dealer locations.

Model 1- Small farm private



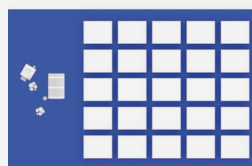
distances	
Farm area	100
Number of fields	5
Mean field distance	1.3 km
Dealer to farm	18 km
Field corner to machine	0.25 km
farm to field	1.34 km
dealer to farm	18 km

Model 2- Average Farm



distances	
Farm area	300
Number of fields	30
Mean field distance	2.5 km
Dealer to farm	15 km
Field corner to machine	0.2 km
farm to field	2.5 km
dealer to farm	15 km

Model 3- Big farm organization



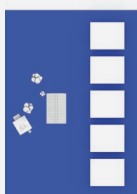
distances	
Farm area	500
Number of fields	25
Mean field distance	3.0 km
Dealer to farm	18 km
Field corner to machine	0.25 km
farm to field	3.0 km
dealer to farm	18 km

10.2.2 Time savings

operation speeds

Average drone speed 60 km/h
 Average vehicle speed 35 km/h

Model 1- Small farm private



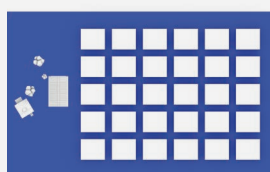
per field

	distance	time without drone	time with drone	time saved per trip	trips per year	time saved per year
01	0.36 km	0.6 min	0.36 min	0.26 min	12	3.12 min
02	1.12 km	1.92 min	1.12 min	0.8 min	9	7.2 min
03	0.18 km	0.31 min	0.18 min	0.13 min	20	2.6 min
04	1.30 km	2.23 min	1.30 min	0.93 min	13	12 min
05	35 km	60.00 min	35.00 min	25 min	1	25 min
06	36 km	61.71 min	36.00 min	26 min	2	51 min
07	0.8km	1.37 min	0.80 min	0.6 min	10	5.7 min

per farm

	trips per year	time saved per year
01	60	15.6 min
02	45	36 min
03	100	13 min
04	65	60.45 min
05	5	125 min
06	10	260 min
07	50	30 min

Model 2- Average Farm



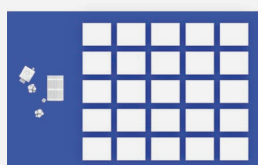
per field

	distance	time without drone	time with drone	time saved per trip	number of trips per year	hours saved per year
01	0.2 km	0.21 min	0.12 min	0.9 min	12	10.8 min
02	2.5 km	4.17 min	2.30 min	1.47 min	9	13.23 min
03	0.2 km	0.21 min	0.12 min	0.9 min	20	18 min
04	2.7 km	4.38 min	2.42 min	1.56 min	13	20.28 min
05	15 km	25.43 min	15.00 min	10.43 min	1	10.43 min
06	17.7 km	30.21 min	17.42 min	12.39 min	2	25 min
07	3.6 km	6.10 min	3.36 min	2.34 min	10	23.4 min

per farm (30 fields)

	trips per year	time saved per year
01	350	5.40 h
02	250	6.62 h
03	600	9.00 h
04	400	10.14 h
05	30	5.22 h
06	60	12.50 h
07	300	11.70 h

Model 3- Big farm organization



per field

	distance	time without drone	time with drone	time saved per trip	number of trips per year	hours saved per year
01	0.5 km	0.86 min	0.5 min	0.36 min	12	4.32 min
02	3.00 km	5.14 min	3.00 min	2.14 min	9	19.26 min
03	0.25 km	0.43 min	0.25 min	0.18 min	20	3.60 min
04	3.00 km	5.14 min	3.00 min	2.14 min	13	27.82 min
05	18.00 km	30.86 min	18.00 min	12.86 min	1	12.86 min
06	21.00 km	36.00 min	21.00 min	15.00 min	2	30.00 min
07	0.25 km	0.43 min	0.25 min	0.18 min	10	1.80 min

per farm (25 fields)

	trips per year	time saved per year
01	300	1.8 h
02	225	9.04 h
03	500	1.5 h
04	325	11.6 h
05	25	5.35 h
06	50	12.5 h
07	250	0.75 h

In comparison to the baseline, distances in Model 2 (500 ha) increase by roughly 20 %, reflecting the larger spatial distribution of fields typical for medium to large-scale farms. Conversely, Model 3 (100 ha) shows a distance reduction of about 40 %, consistent with the more compact layout of smaller farms.

These variations align with spatial spread principles found in rural GIS models, where internal field distances tend to scale proportionally to the square root of the total farm area, illustrating how operational logistics expand non-linearly with farm size.

10.3 Cost Specification

10.2.3 Saved Costs

operationassumptions

salary worker 50 € per hour

Occurrence per field trip

- low= 0,5x
- base= 1x
- high= 2x

Model 2- Average Farm

scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	175	0.09 h	2.63 h	131.50 €
	12	350	0.18 h	5.25 h	262.50 €
	24	700	0.36 h	10.50 h	525.00 €
02	4	125	5.88 h	3.06 h	153.00 €
	8	250	0.196 h	6.13 h	306.50 €
	17	500	0.4 h	12.25 h	612.50 €
03	10	300	0.15 h	4.50 h	225.00 €
	20	600	0.30 h	9.00 h	450.00 €
	40	1200	0.60 h	18.00 h	900.00 €
04	7	200	0.18 h	5.20 h	260.00 €
	13	400	0.34 h	10.40 h	520.00 €
	27	800	0.70 h	20.80 h	1040 €
05	0	10	0 h	1.74 h	87.00 €
	1	20	0.17 h	3.48 h	174.00 €
	2	40	0.35 h	6.95 h	347.50 €
06	1	30	0.21 h	6.19 h	309.50 €
	2	60	0.41 h	12.38 h	619.00 €
	4	120	0.83 h	24.76 h	1238.00 €
07	5	150	0.20 h	6.10 h	305.00 €
	10	300	0.41 h	12.15 h	607.50 €
	20	600	0.81 h	24.3 h	1215.00 €

Model 1- Small farm private

scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	30	1.56 min	7.8 min	6.50 €
	12	60	3.12 min	15.6 min	13.00 €
	24	120	6.24 min	31.2 min	26.00 €
02	5	25	4 min	20 min	16.67 €
	9	45	7.2 min	36 min	30.00 €
	18	90	14.4 min	72 min	60.00 €
03	10	50	1.3 min	6.5 min	5.42 €
	20	100	2.6 min	13 min	10.83 €
	40	200	5.2 min	26 min	21.67 €
04	7	35	6.51 min	32.55 min	27.13 €
	13	65	12.09 min	60.45 min	50.38 €
	27	135	25.11 min	125.55 min	104.63 €
05	0	0	0 min	0 min	0 €
	1	5	25 min	125 min	104 €
	2	10	50 min	250 min	208 €
06	1	5	26 min	130 min	108 €
	2	10	52 min	260 min	216 €
	4	20	104 min	520 min	433 €
07	5	25	5 min	15 min	12.50 €
	10	50	6 min	30 min	25.00 €
	20	100	12 min	60 min	50.00 €

Model 3- Big farm organization

scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	150	0.04 h	0.9 h	45 €
	12	300	0.07 h	1.8 h	90 €
	24	600	0.14 h	3.6 h	180 €
02	4	112.5	0.143 h	4.01 h	200.5 €
	8	450	0.29 h	16.05 h	803 €
	17	225	0.61 h	8.03 h	402 €
03	10	250	0.03 h	0.75 h	38 €
	20	500	0.06 h	1.5 h	75 €
	40	1000	0.12 h	3 h	150 €
04	7	162.5	0.25 h	5.8 h	290 €
	13	325	0.46 h	11.59 h	580 €
	27	675	0.96 h	24.08 h	1204 €
05	0	0	0 h	0 h	0 €
	1	25	0.214 h	5.4 h	270 €
	2	50	0.43 h	10.72 h	536 €
06	1	25	0.25 h	6.25 h	313 €
	2	50	0.5 h	12.5 h	625 €
	4	100	1 h	25 h	1250 €
07	5	125	0.02 h	0.38 h	19 €
	10	250	0.03 h	0.75 h	37.5 €
	20	500	0.06 h	1.5 h	75 €

The potential in saved time and therefore labor cost depends on the farm size, the number of fields, the distances and the occurrence of a specific trip per field. The table highlights that automation through drones can lead to savings, especially in scenarios where transport tasks are repetitive, time-sensitive, or require frequent attention across multiple fields.

01: This scenario represents short internal movements—retrieving small tools or parts within the yard. The time per trip is low, but because such trips happen often, the cumulative effect is noticeable.

02: These are medium-distance errands—e.g., to nearby suppliers or storage points. The savings per trip are higher, and if such errands happen daily

03: This involves moving small tools or parts from the field's edge to the machine operating inside. Trips are very frequent but extremely short, so savings stay limited even in the high case.

04: This is one of the most valuable scenarios, as each trip takes notable time. A drone deployment here provides meaningful operational relief, especially if machines are distributed over multiple fields.

05: Each event involves longer trips meaning that even at low frequency, the time saved per occurrence justifies drone support in urgent situations.

06: This scenario shows the highest potential per trip, representing emergency deliveries directly to the machine in the field.

07: Short inter-machine trips—sharing tools or supplies between harvesters or tractors. Needs a low time per event but has a high repetition rate.

Fig.103 Saved time per field with different assumed occurrences

10.3.1 Scenario occurrence

Scenario low occurrence (0.5x)



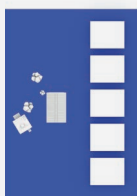
Scenario base occurrence (1x)



Scenario base occurrence (2x)



Model 1- Small farm private

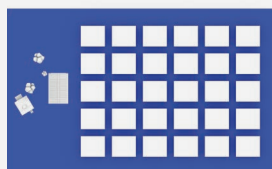


salary saved
176.2 €
 time saved
3.53 h

salary saved
449.2 €
 time saved
9.00 h

salary saved
903.3 €
 time saved
18.08 h

Model 2- Average Farm

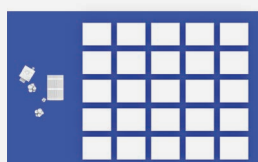


salary saved
1 471 €
 time saved
29.42 h

salary saved
2 939.5 €
 time saved
58.79 h

salary saved
5 878 €
 time saved
117.56 h

Model 3- Big farm organization



salary saved
905.5 €
 time saved
18.09 h

salary saved
2 210.5 €
 time saved
44.19 h

salary saved
3 261 €
 time saved
65.21 h

There were assumptions made regarding the number of trips in each model environment. To get a better understanding of real life conditions different trip occurrence were considered. As can be seen, even with a high trip occurrence on bigger farm, the time and cost savings are quite marginal.

By transporting multiple things at the same time as well as sharing a drone for multiple farms this cost calculation could be improved.

10.3.3 Fixed Costs

Investment Investment of around 10.000 Euros for the drone and cargo element is assumed.	10.000 € for drone	investment 11.115 €
Charging station Additionally a charging station has to be purchased one time.	1.115 € for charger	
Regulatory One time operator registration. Pilot operation fee. SORA paperwork.	1.150 € per year	Fixed cost 1380 €
Insurance	180 € per year	

Fig.104 Overview fixed costs

10.3.2 Variable Costs

Electricity TB100 recharge energy = 0.977 kWh ÷ charger eff. (85%) = 1.15 kWh. Cost per full charge at 0.30 €/kWh ≈ 0.35 €	0.24 € per mission	variable costs 14.3 € per mission
Battery depreciation TB100 price 1,800 €; rated life ≈ 400 cycles → 4.50 € for a full cycle	3.15 € per mission	
Propellor wear 1 set 80 €, replace each 200 flights	0.40 € per mission	
Routine maintenance allowance screws, payload latch, landing gear checks	0.40 € per mission	
Data handling LTE/SIM/cloud logs	0.20 € per mission	
Operator handling time 10 min at €50/h	8.33 € per mission	

Fig.105 Overview variable costs

10.3.5 Vehicle reference

investment 20.000€	Fixed costs 5000 €	variable costs 32€ per mission
---------------------------	---------------------------	---------------------------------------

10.3.4 Break Even Point Vehicle

m	missions per year	N	planning of usage in years	i	one time invest
F	Fixed costs per year	v	variable costs per mission		

$$\text{Drone} = i_d + N(F_d + m \cdot v_d)$$

$$\text{Car} = i_c + N(F_c + m \cdot v_c) \quad \rightarrow \quad m = \frac{i_d - i_c}{N} - (F_c - F_d) / (v_c - v_d)$$

Pin load

$$N = \frac{i_d - i_c}{(F_c - F_d) + m(v_c - v_d)} \quad \rightarrow \quad m > \frac{F_d - F_c}{v_c - v_d}$$

10.3.6 Break Even Point Models

scenario	fixed costs car	variable costs car	investment	fixed costs drone	variable costs drone	investment	Break -Even point
	€	€	€	€	€	€	years
167.5	5.000 €	5.360 €	20.000 €	1380 €	2.395 €	11115 €	1.4 years
335		10.720 €			4790 €		0.9 years
670		21.440 €			9580 €		0.6 years
995		31.840 €			14370 €		0.4 years
1990		63.680 €			28.750 €		0.2 years
3980		127.360 €			57486 €		0.1 years
837.5		26.760 €			11975 €		0.5 years
1675		53.600 €			23950 €		0.3 years
3350		107.200 €			47905 €		0.1 years

Fig.106 Overview fixed costs

The economic advantage of a cargo-drone system over a car is contingent upon mission volume and handling efficiency. Under current assumptions, the per-mission cost differential is €17.7 in favor of the drone (car: €32.0; drone variable cost: €14.3), with annual drone fixed costs of €1,380 and recoverable capital expenditure of €11,115.

A minimum utilization threshold arises from fixed costs: when no car fixed costs are allocated, the drone requires more than ~80 missions per year to be economically viable; allocating €500 or €1,000 in car fixed costs reduces this threshold to ~50 and ~21 missions per year, respectively.

At 200 missions per year, the break-even horizon is approximately 5.15 years (4.18 years with €500; 3.52 years with €1,000), and at 300 missions per year it declines to about 2.83 years (2.51; 2.25). Achieving a four-year payback necessitates roughly 235 missions per year if the car bears no fixed allocation, ~207 missions with €500, or ~178 missions with €1,000. Sensitivity analysis indicates that operator handling time is the dominant driver of drone variable cost; introducing a dock or equivalent process optimization that reduces handling from 10 to 3 minutes lowers the drone's variable cost to ~€8.5 per mission, thereby decreasing the utilization threshold and reducing the missions required to achieve a four-year payback to ~177 (or ~158/~139 with €500/€1,000 car fixed).

Consequently, accurate attribution of car fixed costs and credible estimates of annual mission counts—preferably ≥200 missions or accompanied by automation—are prerequisites for establishing the drone's economic superiority.

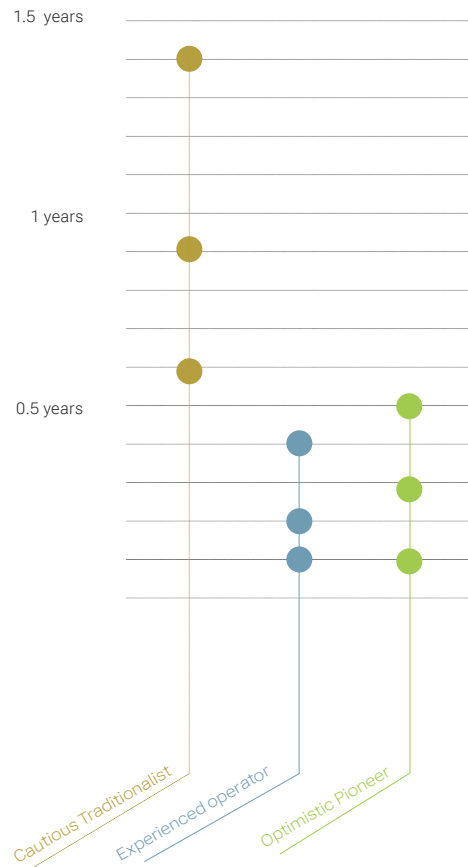
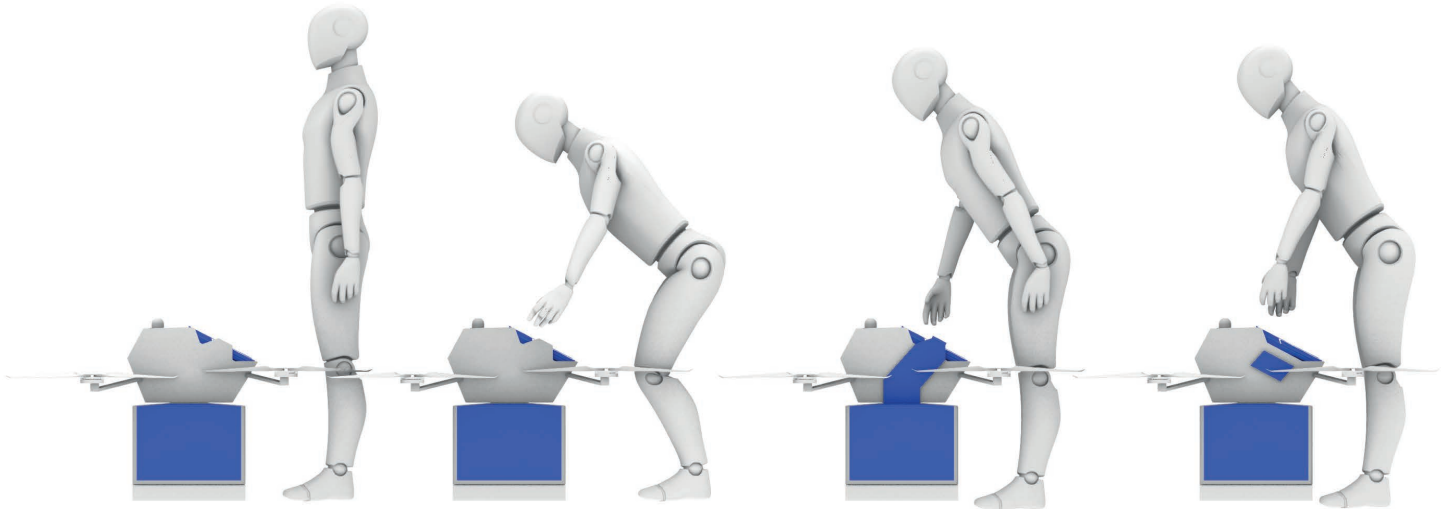


Fig.107 Overview fixed costs

10.4 Interaction Specification

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

10.3.8 Handle specification



Handle on door element
 Handle at battery

No handle element

- + flush exterior design possible
- no specified grabbing elements

Top Handle element
 6 mm width

- + battery handle could be utilized twice
- indent necessary; taller drone
- battery handle has to be integrated or changed-> higher costs

Side handle element
 6 mm width

- + Flush top design possible undisturbed battery access
- two hands required

Fig.110 Handle interaction variants

A no-handle approach enables a fully flush exterior but leaves users without a defined grasp point. A top handle (≈6 mm width) allows the battery handle to serve double duty, yet requires an inset that raises overall height and necessitates redesign or integration of the battery handle, increasing cost. A side handle (≈6 mm width) preserves a clean top surface and provides unobstructed battery access, but typically demands two-hand operation. A handle on the door or at the battery offers direct reach but can interfere with access paths and may complicate the door mechanism. Overall, side handles favor service access and a flush top, top handles favor single-point lifting at the expense of height and tooling, and the no-handle option optimizes appearance while sacrificing clear ergonomics.

Anthropometric constraints from DIN data indicate proximal finger widths of roughly 1.2–1.9 cm (5th–95th female) and 1.5–2.3 cm (5th–95th male), with index-finger proximal widths near 1.7–2.3 cm and hand breadths around 7.0–9.4 cm; typical grip (hand) lengths span ~11–15.5 cm for females and ~12–15.5 cm for males.

A through-slot or recessed handle should provide ≥ 35 mm clear height and ≥ 120–150 mm clear length to accommodate a four-finger power grip. If using a top handle, an external bar Ø 30–40 mm (female) to Ø 35–45 mm (male) supports a neutral wrist and strong grip.

Abmessungen in cm	Perzentile*					
	männlich			weiblich		
	5 %	50 %	95 %	5 %	50 %	95 %
22. Kleinfingerbreite, proximal (nahe dem Handteller)	1,5	1,7	1,9	1,2	1,4	1,7
23. Kleinfingerbreite, distal (nahe der Fingerspitze)	1,4	1,5	1,7	1,1	1,3	1,6
24. Ringfingerbreite, proximal	1,7	2,0	2,1	1,5	1,7	1,9
25. Ringfingerbreite, distal	1,5	1,6	1,8	1,3	1,6	1,8
26. Mittelfingerbreite, proximal	1,9	2,1	2,3	1,7	1,9	2,2
27. Mittelfingerbreite, distal	1,6	1,7	1,9	1,4	1,7	1,9
28. Zeigefingerbreite, proximal	1,9	2,1	2,3	1,7	1,9	2,1
29. Zeigefingerbreite, distal	1,7	1,8	2,0	1,4	1,6	1,8

22 bis 29 jeweils am Gelenk gemessen

nach DIN 33402, Teil 2

Abmessungen in cm	Perzentile*					
	männlich			weiblich		
	5 %	50 %	95 %	5 %	50 %	95 %
30. Kleinfingerlänge	5,7	6,4	7,2	5,1	5,9	6,6
31. Ringfingerlänge	7,2	8,0	8,7	6,5	7,3	8,1
32. Mittelfingerlänge	7,6	8,4	9,3	7,1	7,7	8,6
33. Zeigefingerlänge	6,8	7,5	8,3	6,2	6,9	7,7
34. Daumenlänge	5,9	6,8	7,5	5,3	6,0	6,9
35. Handflächenlänge	10,4	11,1	12,1	9,2	10,0	10,8
36. Handlänge	17,5	18,9	20,7	16,2	17,7	19,3
37. Daumenbreite	2,0	2,2	2,4	1,6	2,0	2,2
38. Handdicke	2,4	3,0	3,1	2,1	2,6	3,2
39. Handbreite m. Daumen	9,8	10,7	11,7	8,2	9,0	9,9
40. Handbreite	8,0	8,7	9,4	7,0	7,7	8,4
41. Griffumfang der Hand	12,0	13,5	15,5	11,0	13,0	15,5
42. Handumfang	19,5	21,0	23,0	17,5	19,5	21,0
43. Handgelenkumfang	16,0	17,5	19,0	15,0	16,5	18,0

37 am Gelenk gemessen

nach DIN 33402, Teil 2

Fig.111 Handle sizing

10.4.1 Usability validation

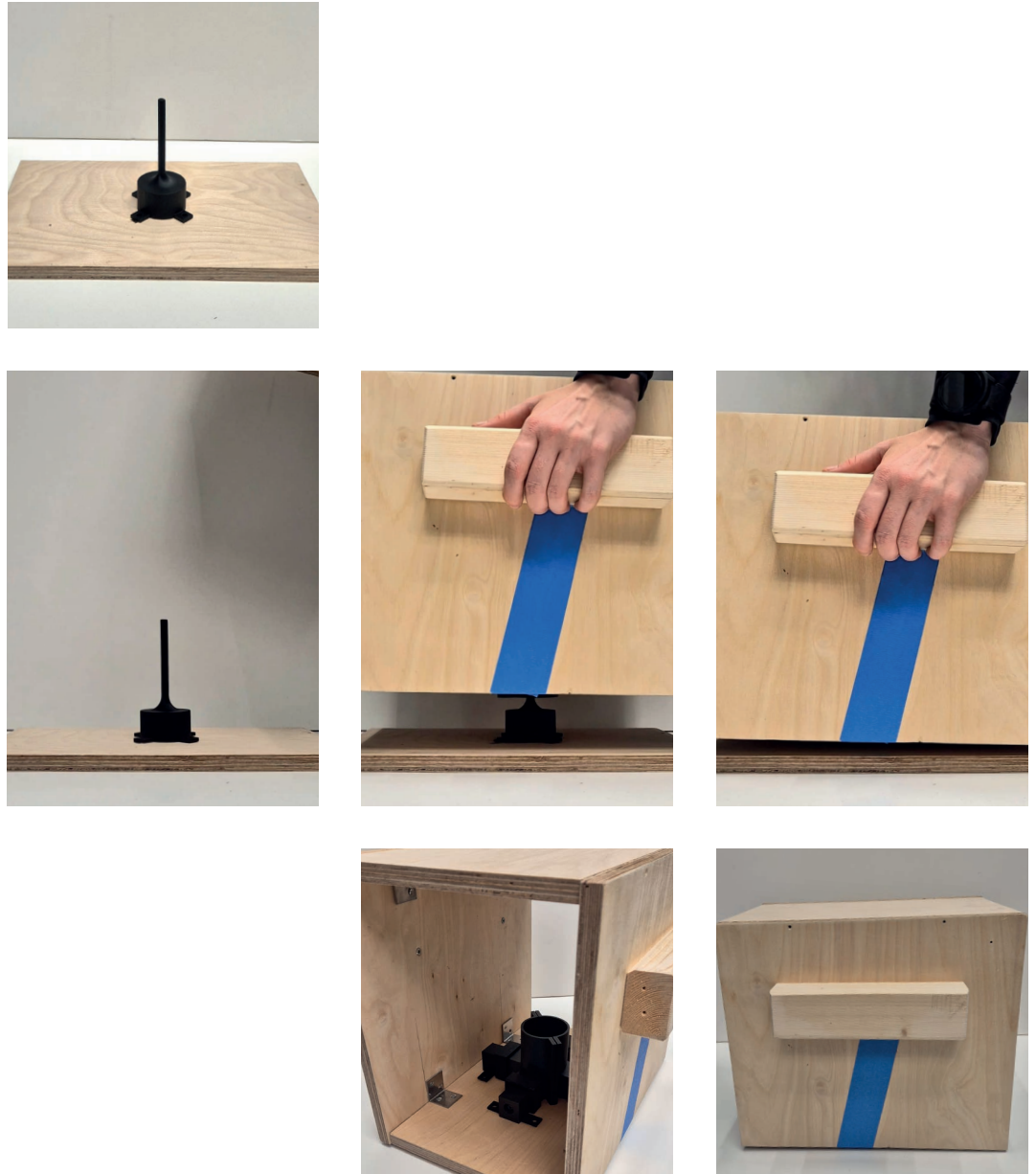


Fig.112 Usability prototype

A larger centering surface is required, and clear graphics on both the top and side should be added to make the centering point immediately recognizable.

After adding the drone frame the force needed to push down the Push and release mechanism seems reasonable.

The push-to-release mechanism should have its detent surfaces chamfered to promote a positive, repeatable engagement with smooth actuation and clear tactile feedback. This bevel will reduce edge wear, lower the risk of jamming from minor misalignment or debris, and help guide the parts into lock under load. The

same chamfer treatment should be applied to the fail-safe latch so both mechanisms behave consistently and remain reliable across tolerance stack-ups, temperature changes, and real-world contamination.



11. Feasibility

What are the technologies inside the CLAAS system that can be used for drones? It's important to consider external expertise and the overall Technology Readiness.

11.1 Requirements

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

11.4.1 Light requirements

DAYTIME

The only legally required light is the green flashing strobe at night.

EASA guidance notes that drones may carry lights to support orientation, position awareness, and visibility, **but there's no obligation during daylight.**

Operators can choose to fit lights for extra conspicuity (e.g., in busy airspace or near people).

Germany (LBA): Reiterates EU baseline—lights are only compulsory at night.

NIGHTTIME

At least one green flashing light must be activated at night so people on the ground can distinguish the drone from a manned aircraft. This applies EU-wide in the Open (and, via cross-reference, Specific) category.

Drones should be equipped with lights for controllability (pilot orientation/awareness). The "green flashing" is additionally for conspicuity at night.

Germany (LBA/DE): Mirrors the EU rule—night ops require a green flashing light.

TYPES OF LIGHT

Even though not legally required, manufacturers/operators often add lights for safety and usability:

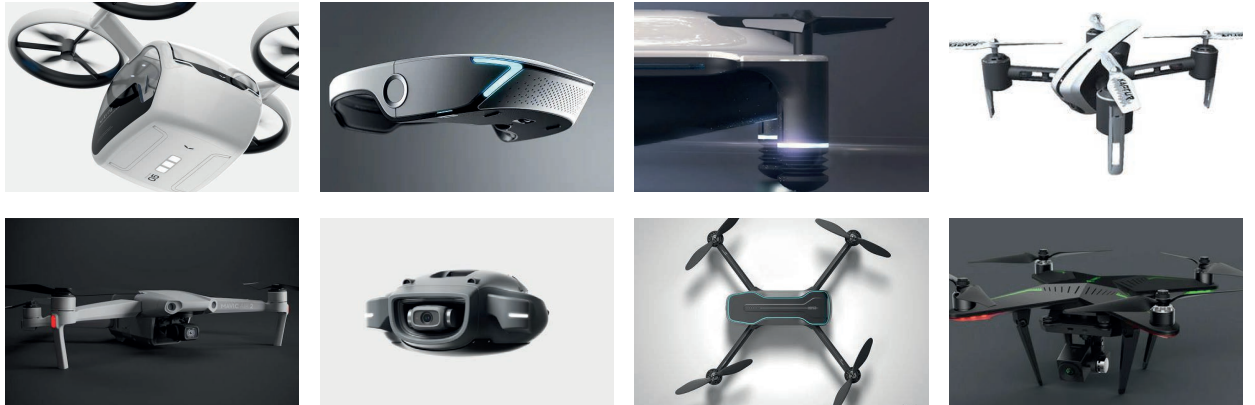
Navigation lights to indicate drone heading.
 → Not mandated, but improves operator orientation and helps bystanders.
 → Regularity of light is solid (i.e., do not blink/strobe)
 → Color of light is white, green (right) or red (left)

Anti Collision Lights to make the drone more visible.
 → Common in professional/commercial fleets (e.g., DJI Enterprise).
 → Regularity of light is blinking/strobe
 → Color of light is white or red

Operator feedback lights
 → Purely functional, not regulatory.



BEST PRACTICE



REQUIREMENTS

No mandated intensity (candela/lumen), visibility range, blink rate, beam spread, or exact placement in the EASA rules.

Fig.113 Regulations and design guidelines for drone lighting

Drones use several types of lights, each serving distinct functions related to navigation, visibility, and operator feedback. Navigation lights, typically mounted on the front or sides, indicate the drone's heading and orientation. Although not legally required during the day, they improve visibility for both operators and bystanders, often using solid white, green (right), or red (left) lights. Anti-collision lights are strobing white or red lights designed to make the drone more visible, especially in professional or commercial operations, and are mandatory at night under EASA regulations. At least one green flashing light must be active during nighttime flights so

people can distinguish the drone from manned aircraft. Operator feedback lights, such as battery or system status indicators, are functional components—often positioned at the rear—and communicate operational states like low battery, errors, or GNSS activation. While the intensity and placement of lights are not explicitly defined by law, consistent and visible lighting is considered best practice for both safety and user orientation.

11.2 Attachment

11.1.1 Latch Attachment

Mechanical attachments	Electronic actuator attachments	Electronic attachments
<p>Push and Release System Spring-Loaded Latch – automatic locking when inserted, manual release by pressing.</p> <p>Twist-Lock Mechanism – bayonet-style twist-to-lock, commonly used in lenses and connectors.</p> <p>Hook & Loop – Velcro-type system for quick fastening.</p> <p>Cam Lock – eccentric lever for tightening/loosening without tools.</p> <p>Snap Fit – elastic deformation of parts for easy assembly/disassembly.</p> <p>Threaded Fasteners – screws/bolts for rigid, high-strength connections.</p> <p>User needs to physically interact with the cargo for every discharge.</p>	<p>Servo-Controlled Locking Pin – pin slides into place on electronic signal.</p> <p>Motorized Screw Clamp – tightening via small DC motor.</p> <p>Shape Memory Alloy (SMA) Clip – attachment engages/release when heated electronically.</p> <p>Linear Actuator Push-Latch – actuator extends to lock and retracts to release.</p> <p>Rotary Solenoid Lock – rotating hook/armature to secure/release connection.</p>	<p>Elektromagnetic System</p> <p>Electromagnetic Clamp – holds metal objects magnetically, releases when power off.</p> <p>Electrostatic Adhesion – like gecko-inspired pads powered by voltage.</p> <p>Magnetorheological Fluid Lock – stiffens fluid under magnetic field for temporary bonding.</p> <p>Piezoelectric Grip Pads – surface adhesion activated via voltage.</p> <p>Vacuum Suction Pads (electronically controlled) – negative pressure generated by micro-pumps.</p> <p>Constants energy supply necessary</p>

Fig.114 Overview electronic components categorized by actuator type

	Self centering	Payload	Dirt Resistance	Moisture Resistance
Servo-Controlled Locking Pin pin slides into place on electronic signal.	Needs chamfered lead-ins or conical bush for centring	Pin and housing must be sized	Enclosed pins	Stainless steel pin
Motorized Screw Clamp tightening with DC motor.	Threads do not self-centre unless guided Funnel or floating nose required	Screw wear must be controlled	Threads vulnerable to grit and wear	Corrosion risk unless coated and sealed
Linear Actuator Push-Latch actuator extends to lock and retracts to release.	geometry can funnel parts together	Latch has to be mechanically locked	Sliding parts require seals to avoid jamming	Dependent on actuators IP rating and sealing
Rotary Solenoid Lock rotating hook/armature to secure/release connection.	Requires accurate alignment Lead-in horns improve positioning	Suitable for 6 kg with robust hook/lock armature design	Pivot tolerates some debris	Coil and housing can be sealed to IP standards

Fig.115 Types of electronic actuator attachments

The decision was made to use an electronically activated attachment for the fail-safe mechanism, since it cannot be disengaged manually. In contrast,

The push-and-release mechanism should ensure that the load is properly fixed and that the drone’s handling remains purposeful. Manual insertion could also be performed by the drone itself using its propellers.

11.2.2 Connector architecture

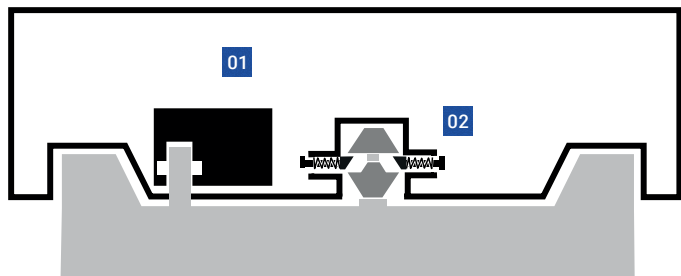


Fig.116 Views attachment system of drone and cargo

The drone-side interface houses the electronic fail-safe unit and the female push-and-release component. The cargo unit carries the male push-and-release component. As shown in cross-section the geometries overlap to ensure a secure fit. In the top view, the push-and-release is positioned centrally, while the off-center fail-safe defines the required cargo orientation.

The cargo attachment assembly is coupled to the main body with two degrees of freedom, allowing the primary load to self-center vertically during flight. This arrangement supports reliable engagement, orientation control, and stable load alignment.

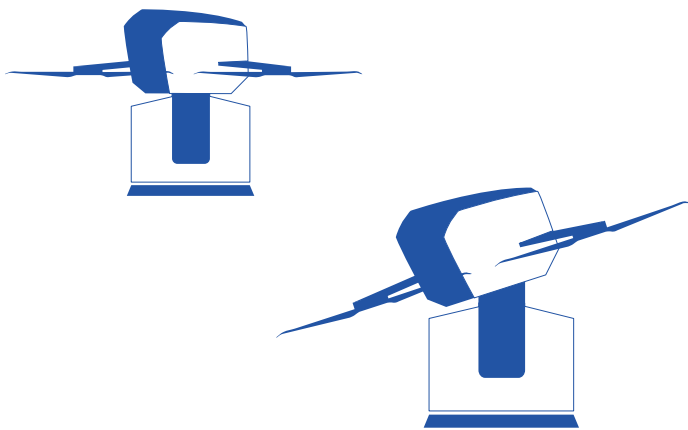


Fig.119 2 DOF of the cargo element

To ensure stable flight performance, the cargo box is designed with a 2-degree tilt. This slight inclination helps maintain the center of gravity in an optimal position, allowing it to compensate for forward motion during flight and ensuring smoother, more controlled drone behavior.

11.2.1 Fail Safe mechanism

Power-to-hold latches prioritize safety by releasing the payload if power fails, ideal for emergency drops. In contrast, power-to-open latches keep the load secured even during a failure, ensuring safety when flying over people or fragile goods.

Dual spring-loaded pins offer robust mechanical retention for secure docking, while magnetic kinematic couplings provide fast, self-aligning connections suited for efficient and automated operations.

	Function	If system fails to ...	Best When ...
Power-to-hold latch	Magnet/servo keeps a hook closed; spring opens it if power fails	Release payload	Safer to drop load than risk being stuck (e.g., snag, emergency jettison)
Power-to-open latch (spring closes)	Pin/bolt stays locked by spring; actuator must pull it open	Keep payload	Cargo must never fall (e.g., flying over people or fragile goods)
Dual spring-loaded pins (mechanical docking)	Pins slide into bushings, held by springs	Retain	Secure, robust docking
Magnetic kinematic coupling	Magnets + cone/ball guides align and hold load	Release to magnets only	Very fast, self-aligning docking

Fig.118 Overview fail safe mechanisms

It is crucial that the cargo remains securely attached at all times, which is why a power-to-open latch was chosen. This mechanism ensures the payload stays locked even in case of a power failure, guaranteeing maximum safety during flight.

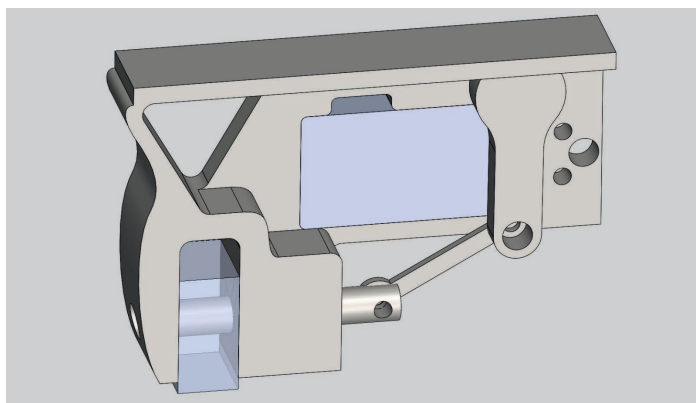


Fig.117 Fail safe latch

11.2.3 Push and release mechanism

$$m = 1.11 \text{ kg} + 3.89 \text{ kg} = 5 \text{ kg}$$

$$F = m \cdot g = 5 \text{ kg} \cdot 9.81 \text{ m/s}^2 = 49.05 \text{ N}$$

$$s > 0.05 \text{ m}$$

$$F = k \cdot s \rightarrow k = F/s = 981 \text{ N/m}$$

D: 15 mm
 Wire/d: 1,4 mm
 active convolutions n: 9,5

spring rate k: 1,59 N/mm
 block length: 16mm

length: 52 mm

Fig.120 Spring calculation

The spring is sized for a 5 kg load ($m = 1.11 + 3.89 = 5 \text{ kg}$), giving a required force of $F = m \cdot g \approx 49.05 \text{ N}$.

For the intended stroke $s > 50 \text{ mm}$, the target stiffness is $k = F/s \approx 49.05/50 = 0.98 \text{ N/mm} (\approx 981 \text{ N/m})$.

The use of four springs in parallel results in a combined stiffness approximately 1.5 times higher than the target value, making the overall system mechanically stiffer. Under a 5 kg load, this configuration yields a deflection of about 33 mm instead of the intended 50 mm.

Despite the reduced stroke, the setup remains mechanically feasible and operates safely within the permissible compression range, provided that the shorter displacement is acceptable for the application.

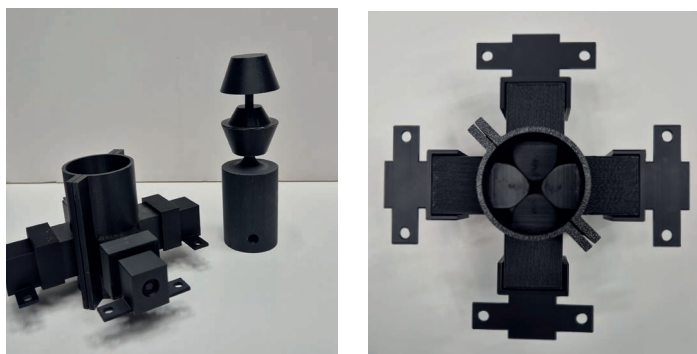


Fig.121 Push and Release mechanism Prototype 01

The principle model reveals several mechanical issues and corresponding fixes. The current springs are too strong and even touch in the middle at the 0-state, so the springs should be shortened. The available vertical travel is excessive; reduce it by shortening both the cargo connector and the drone's cylinder. The movable element offers too much resistance, introducing curvature to the movable element to lower friction is possible.

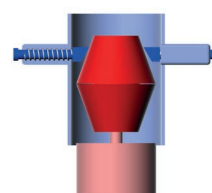
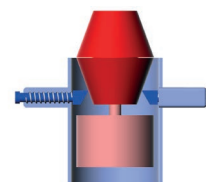
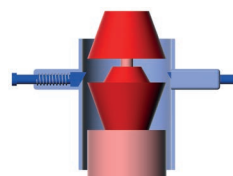
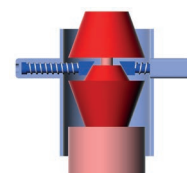
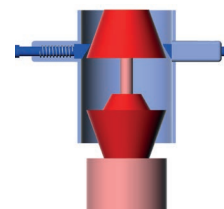
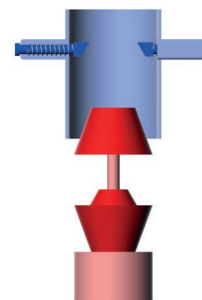
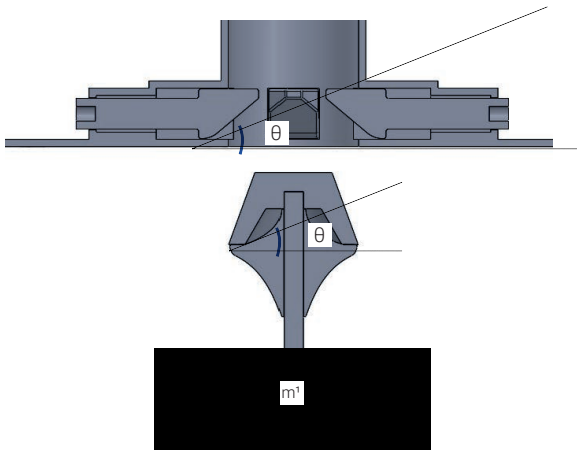


Fig.122 Push and Release mechanism functionality

11.2.4 Calculating surfaces

The goal is to define an angle that creates a ammount of force that is possible to overcome for a person.



Friction coefficient μ

Seperated on 4 pins

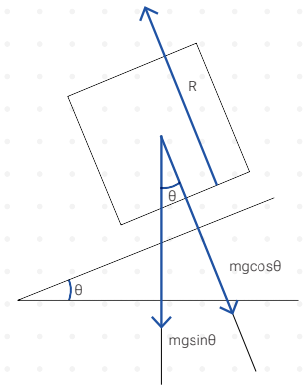
$m^1=6\text{kg}$
 $\theta=20\text{ Grad}$

$F=4 \times F_s$

$\Delta x=25\text{ mm}$

Spring
 $c=0,372\text{ N/mm}$
 $L_0=59,7\text{ mm}$
 $L_1=9,07\text{ mm}$

Block length = 9.07 mm



Pin load

$$F_{\text{pin}} = F_g/4 = 58,9\text{N}/4 = 14,7\text{ N}$$

Reaction force geometry

$$R_{\text{geo}} = \frac{F_{\text{pin}}}{\cos(\theta)} = \frac{14,7\text{ N}}{0,94} = 15,6\text{ N}$$

Reaction force

$$R_{\text{total}} = R_{\text{geo}} + F_s = 34,2\text{ N}$$

Friction Force

$$F_f = \mu \times R_{\text{total}} = \mu \times 34,2$$

Angle	sin	Push force per pin	Total push force	Feels like	Comment..
10°	0.173	3.98	15.9	1.6 kg/f	very easy, smooth slide
15°	0.256	5.96	23.8	2.4 kg/f	low effort, realistic
20°	0.342	7.87	31.5	3.2 kg/f	moderate
■ Chosen Angle 25°	0.423	9.73	38.9	4.0 kg/f	starting to feel firm
30°	0.500	11.5	46.1	4.7 kg/f	heavy, requires body weight
35°	0.574	13.2	52.8	5.4 kg/f	high effort, two hand push
40°	0.643	14.85	59.3	6.0 kg/f	too steep for ergonomic press

11.2.5 Improved setup

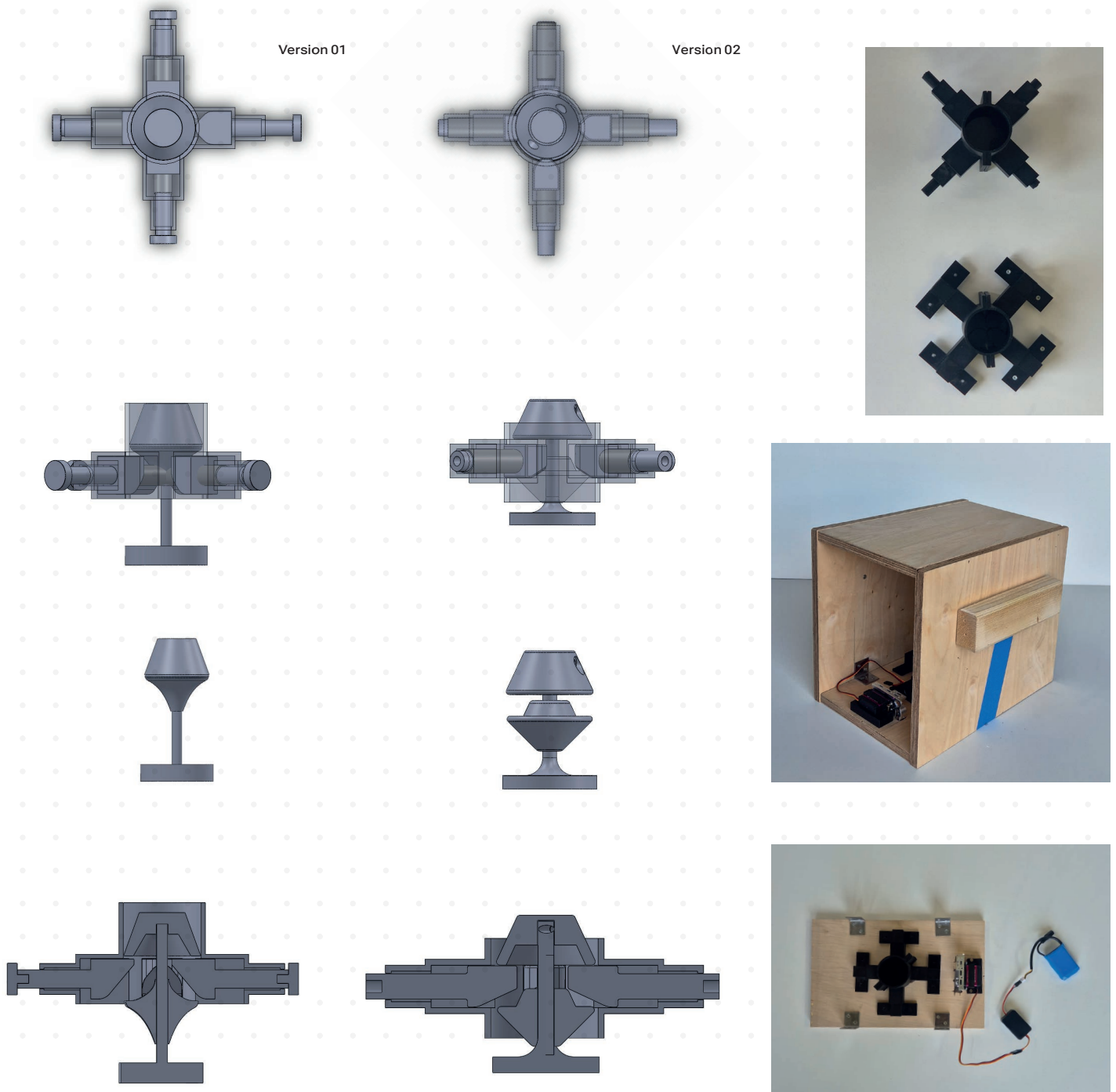


Fig.123 Push and Release mechanism functionality

The force required in the first setup was acceptable, but the next step was to introduce greater initial tension to the entire mechanism. In the first version, the downward pressure applied to engage the system worked well, but the outward-pushing geometry was too rigid.

In version 2, the pins were reduced in size, which improved the inward movement and overall responsiveness. The angle was adjusted based on

the calculated requirements, yet achieving a smooth outward motion remained challenging. It can be concluded that using a different material, such as POM or even a non-printed component, could have significantly improved the sliding properties and provided the necessary flexibility for reliable operation.

11.3 Sensor Integration

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

11.3.1 Referenced sensors

GNSS Antennen

Clear line of sight to the sky
 avoid shadowing from frame
 15 *30*10 mm



LIDAR

Obstacle detection in poor visibility/weather

Must face forward, unobstructed FOV.
 Needs stable mount to avoid vibration artifacts.
 50*50*50



Vision Cameras
 Surrounding visual sensing

100–120° FOV per unit.
 12*15

Rotating LiDAR

360° horizontal obstacle detection

Unobstructed 360° FOV at horizon



Battery

31* 15.*23.0 cm

Infrared

Ground distance

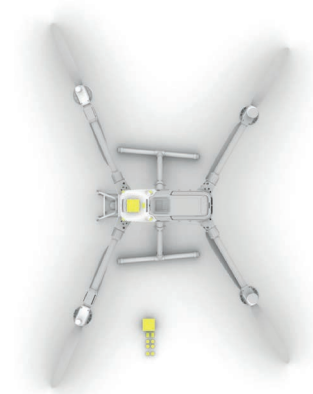
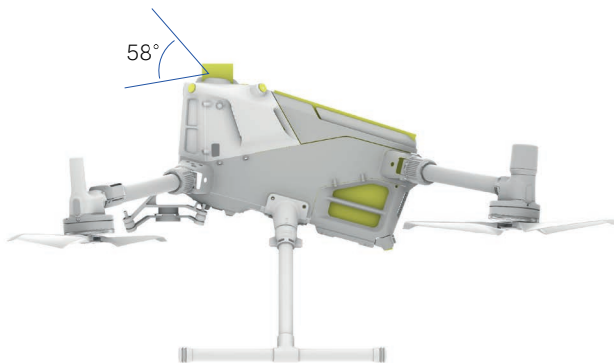
Mounted on underside
 12*20*8

Downward Vision Cameras
 Surrounding visual sensing

100–120° FOV per unit.

Fig.124 Referenced needed sensors

11.3.2 Sensor specifications



The drone's sensor layout is strategically designed to ensure comprehensive environmental awareness and safe operation in all directions. The bottom sensors, which combine infrared and downward vision, enable precise ground detection for stable hovering, terrain following, and pinpoint landing accuracy.

The side-mounted stereo vision pairs continuously scan the surroundings to identify nearby walls or lateral obstacles, preventing collisions during horizontal movement or in tight spaces.

Meanwhile, the top-mounted LiDAR system, featuring both rotating and time-of-flight capabilities, detects overhead obstacles such as tree branches, ceilings, and power lines—crucial for safe flight in complex or cluttered environments. Together, these sensors create a 360-degree safety shield that supports reliable autonomous navigation.

Sensors	Main Purpose
GNSS	Global positioning and navigation
Vision-surround sensors	Relative motion, hovering, ground detection in low-GNSS environments
Rotating LiDAR	3D obstacle detection all around the drone
Upper LiDAR (ToF)	Distance measuring above the drone for clearance / obstacle avoidance
Infrared 3D (down)	Precise height above ground, safe landing/takeoff
mm-wave radar	Obstacle detection in challenging conditions (dust, low light)

11.3.3 Design Guidelines

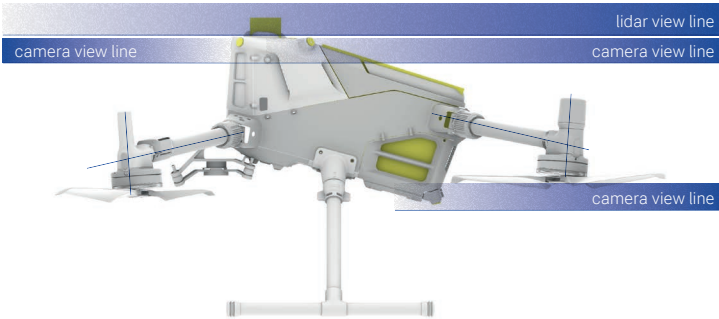


Fig.125 Viewlines Cameras

The top surfaces should have a flat, stable areas for the cameras, while the Li-DAR is positioned at the highest point with a fully unobstructed field of view.

Overall envelope dimensions are constrained by the energy pack and attachment hardware. The height is set by the combined battery and mechanism stack-up, and the width is likewise defined by the battery plus the mechanism.

The rotor arms are intentionally tilted so the propellers operate at staggered heights, reducing prop wash and turbulence to enhance stability under load. This slanted stance also streamlines the airflow around the airframe, lowering drag for higher aerodynamic efficiency and longer flight times.

Under heavier payloads, the geometry distributes forces more evenly, while the offset arrangement aligns thrust vectors to maintain precise pitch response and overall control.



Fig.126 Push and Release mechanism functionality

11.4 Production

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

11.4.1 Product architecture

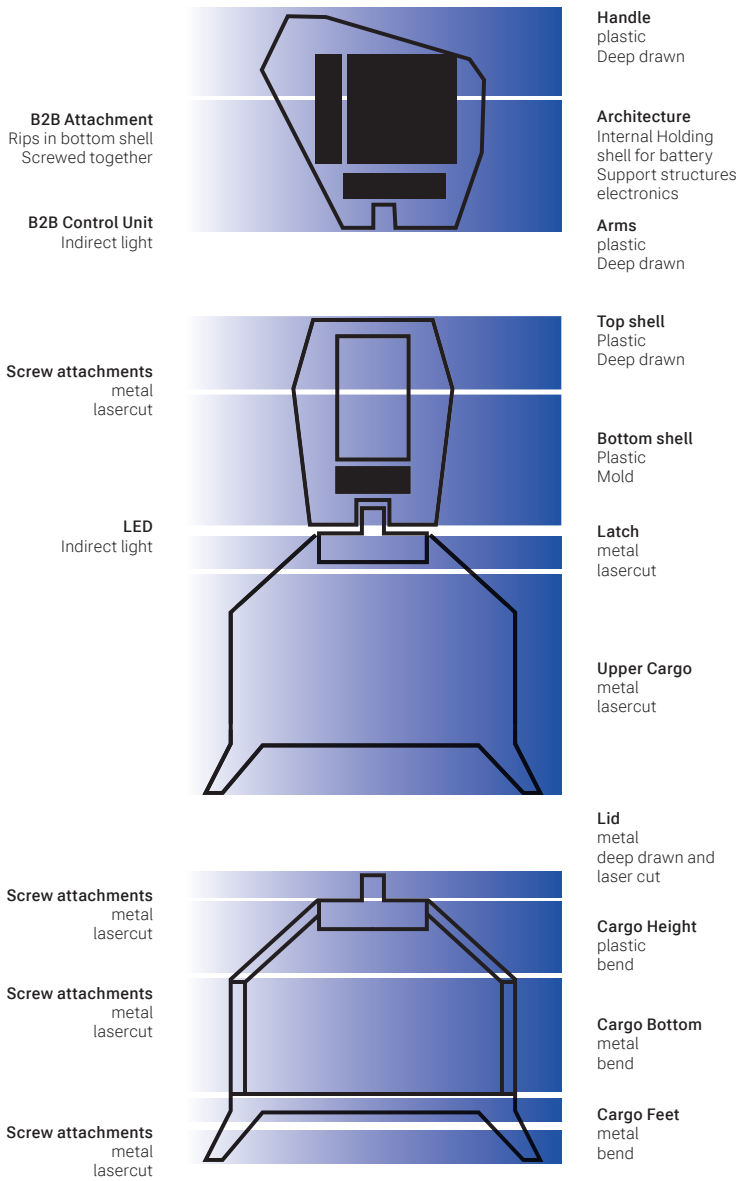


Fig.127 Parts and production methods

11.4.2 Skeleton

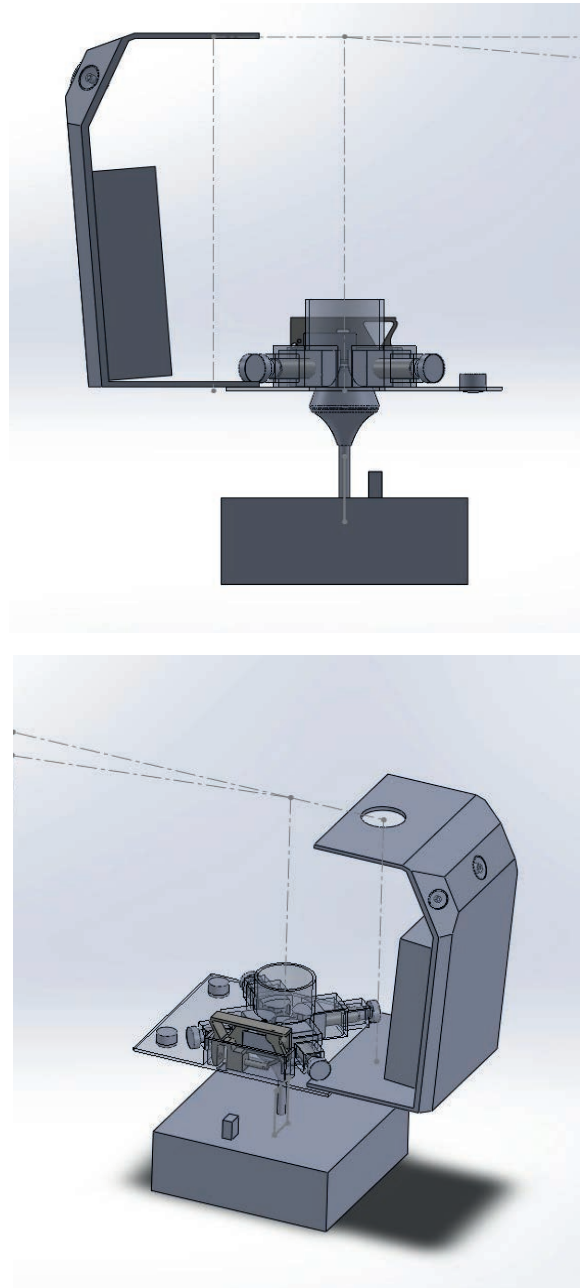


Fig.128 Building of inner skeleton in solidworks

For the cargo the main attachments are made reversible as different sized cargo heights can be used with the same top and bottom. This also heightens repairability.

The drone there will be holding structures integrated in the Bottom shell through more complex injection molding.

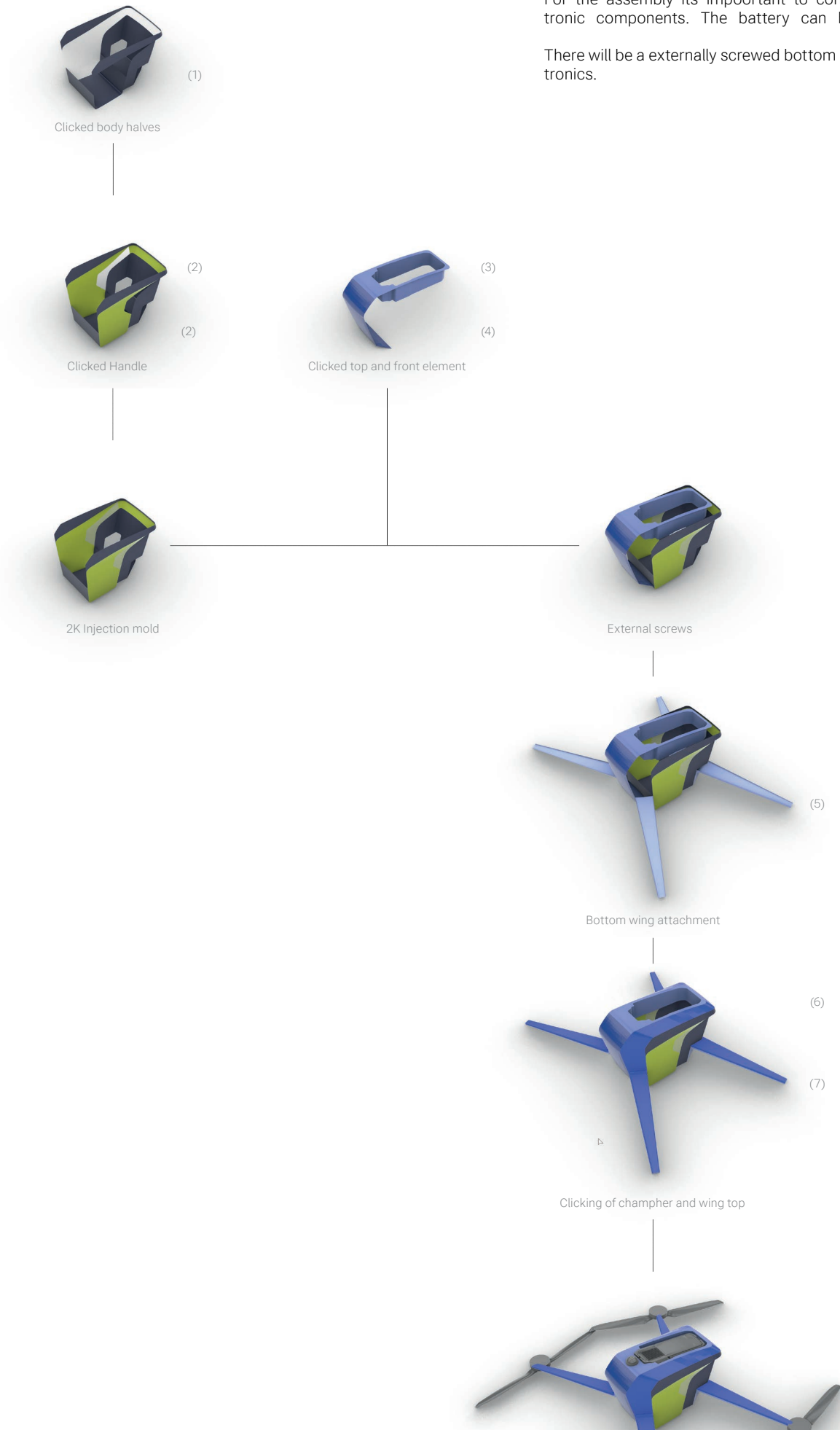
The chosen processes—deep drawing, molding, bending, and laser cutting—balance stiffness, precision, and cost while enabling replaceable latch and bracket hardware.

The inner skeleton was modeled so that anchors the electronic and attachment assembly to a rigid base and carries the upper housing, which externally holds the battery. The upper cover is hinged/boss-mounted to allow access from above. This layout separates structural and electronic components.

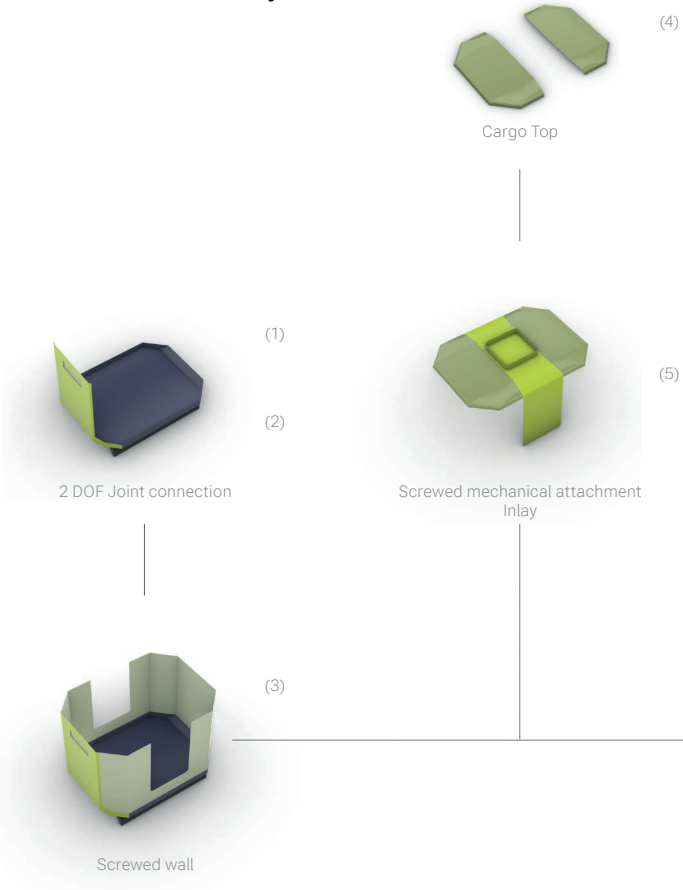
11.4.3 Product assembly

For the assembly its important to consider the acces to all elec-
 tronic components. The battery can be removed from the top.

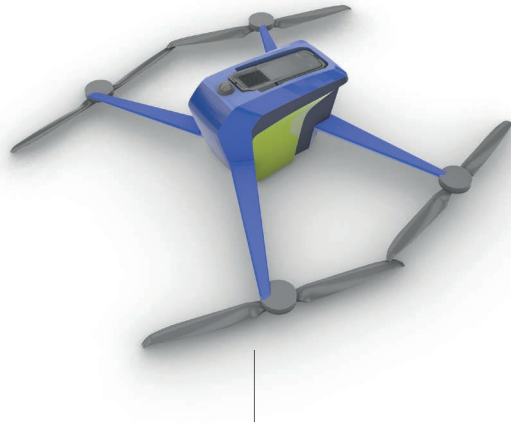
There will be a externally screwed bottom element to reach all the elec-
 tronics.



11.4.4 Product assembly

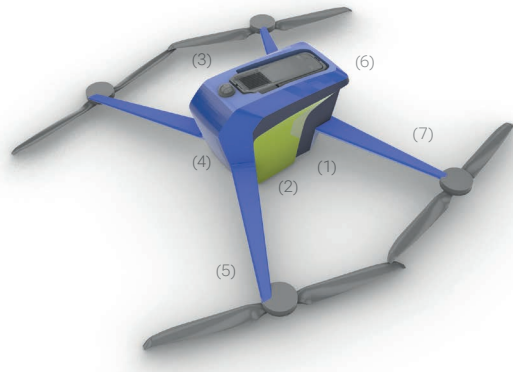


For the cargo system, it is essential to accommodate various sizes of transported items. The door mechanism operates using a push-and-release system with two degrees of freedom (DOF) and features an integrated handle element for easy and secure operation.



11.4.5 Materials

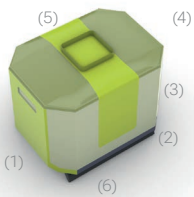
Desirability ■
 Feasibility ■
 Viability ■
 Finish ■



There is a trade-off between using separate materials, which increases sustainability but also assembly costs. In this design, sustainability was prioritized, resulting in a higher number of individual components.

During assembly, it is important to ensure easy access to all electronic components. The battery is removable from the top, while an externally screwed bottom panel allows convenient access to the internal electronics for maintenance and repair.

	Material	Production process	Material thickness	Weight	Key properties	Finish	Fastening
(1) Body Halves	PC-ABS	Thermoformed	2.5 mm	400 g	Tensile Strength, Fatigue Strength, Impact Strength	one sided mate Top Coat	Screwed
(2) Handle	PA6	2K-Injection Mold	3.5 mm	280 g	Tensile Strength	one sided Top Coat	Clicked
(3) Top	PC ABS	Injection Mold	2.5 mm	220 g	Toughness, Ductility	one sided mate Top Coat	Clicked
(4) Front	PC ABS	Thermoformed	2.5 mm	90 g	Toughness, Ductility	one sided mate Top Coat	Clicked
(5) Bottom Wing	PC	Thermoformed	2.5 mm	110 g	Toughness, Hardness	one sided Top Coat	Screwed
(6) Champher	PPGF20	Injection Mold	2.5 mm	250 g	Toughness, Hardness	one sided Top Coat	Screwed
(7) Wing Top	PC	Thermoformed	2 mm	110 g	Hardness	one sided Top Coat	Clicked



The wall and top elements should be made partially transparent to visually showcase the internal components and highlight the technical functionality of the design.

	Material	Production process	Material thickness	Weight	Key properties	Finish	Fastening
(1) Cargo Door	PC ABS	Thermoformed	2.5 mm	140 g	Hardness	one sided Top Coat	Screwed
(2) Bottom	PA6	2K-Injection Mold	3.5 mm	430 g	Compressive Strength	one sided Top Coat	Screwed
(3) Wall	PC	Thermoformed	3 mm	640 g	Fatigue strength, Yield Strength	-	Screwed
(4) Cargo Top	ABS-PC	Thermoformed	3 mm	270 g	Stiffness	one sided mate Top Coat	Screwed
(5) Mechanical Attachment	PA66	Injection Mold	3 mm	350 g	Fatigue Strength	one sided Top Coat	Screwed
(6) Feet	Aluminium	Bend Metal	1.5 mm	100 g	Fatigue Strength	Galvanised	Screwed

11.4.6 Production Costs

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

	Material	Production process	Price	Quantity	Summed Price	Labour time	Machine investment
Drone body							
Body Halves	PC-ABS	Thermoformed	0.004€/g	400 g	1.60 €	5 min	100000 €
Handle	PA6	2K-Injection Mold	0.006 €/g	280 g	0.84 €	4 min	220000 €
Top	PC-ABS	Injection Mold	0.004€/g	220 g	0.88 €	4 min	180000 €
Front	PC-ABS	Thermoformed	0.004€/g	90 g	0.36 €	7 min	100000 €
Bottom Wing	PC	Thermoformed	0.004€/g	110 g	0.44 €	5 min	90000 €
Champher	PP	Injection Mold	0.005€/g	250 g	1.25 €	4 min	160000 €
Wing Top	PC	Thermoformed	0.004€/g	110 g	0.44 €	5 min	90000 €
Cargo Body							
Cargo Door	PC-ABS	Thermoformed	0.004€/g	160 g	0.56 €	4 min	100000 €
Bottom	PA6	Thermoformed	0.003€/g	430 g	1.29 €	5 min	110000 €
Wall	PC	Thermoformed	0.004€/g	640 g	2.56 €	5 min	110000 €
Cargo Top	PC-ABS	Thermoformed	0.004€/g	270 g	1.08 €	5 min	100000 €
Mechanical Attachment	PA	Injection Mold	0.0035€/g	350 g	1.23 €	7 min	150000 €
Feet	Aluminium	Bend Metal	0.006€/g	100 g	0.60 €	4 min	70000 €
Attachment components							
Servo Module	-	-	9899 €	1	9899 €	-	-
Push and Release Mechanism	-	-	2 €	1	2 €	-	-
Feature							
Ventilation Mesh	-	-	0.005 €/g	100 g	5 €	-	-
Propulsion							
Propellor	-	-	34.35 €	1	34.35 €	-	-
Motors							
Sensors							
DJI LiDAR Range Finder (RS)	-	-	578.99 €	1	578.99 €	-	-
Infrared Sensor	-	-	1.75 €	1	1.75 €	-	-
Vision Camera	-	-	100.8 €	8	100.8 €	-	-
GNSS Antenna	-	-	14.95 €	1	14.95 €	-	-
Electronics							
Power Button	-	-	1.50 €	1	1.50 €	-	-
Cargo LED	-	-	0.8 €	1	0.8 €	-	-
Status LED	-	-	0.3 €	1	0.3 €	-	-
Auxiliary Light	-	-	2.00 €	1	2.00 €	-	-
PCB	-	-	8.00 €	1	8.00 €	-	-
Energy supply							
DJI TB 100 Battery	-	-	1039.99 €	-	1039.99 €	-	-
	-	-	-	-	-	69 min	-
	-	-	-	-	11.703 €	16.00 € (15 €/5)	1.580000 €

For the assembly its important to consider the acces to all electronic components. The battery can be removed from the top.

There will be a externally screwed bottom element to reach all the electronics.

11.4.7 Break Even Point

Desirability ■
Feasibility ■
 Viability ■
 Finish ■

With the two cases studies, it can be seen that at the current aestimated material and production costs the ROI is not sufficient, considering the desired price from the user questionnaire. With a ROI of 20 % the drone would need to be more expensive.

One client buy multiple machines and uses them over multiple years. The same has to be assumed for drones, leading to a rough aestimation of 5 00 Units per year. This is based on the 3.5 Billion per year.

There are no internally accesible numbers in regards to CLAAS clients per year. CLAAS themself operate in 26 different countries and made 3.5 Billion in the fical year 2024.

		5 000 Units per year 5 years
Materials	13.2 €	
Components	10 690 €	
Machine Investment	1 580 000 €	
Labour	16 €	
Packaging	10 €	
COGS (Sum of Variable costs)	68 800 000 €	
Investments machines (Assembly only)	1 800 000 €	

Target ROI 20%		Target Price 12000 €	
Taxes (VAT-19 % of EBIT)	54 533 000 €	Taxes (VAT-19 %)	1 345 200 €
Transportation	10 734 000 €	Transportation	12 00 000 €
Sales	75 138 000 €	Sales	84 000 000 €
Marketing	10 734 000 €	Marketing	12 000 000 €
Units sold	5 000	Units sold	
Selling price per Unit	15 450 €	Selling price per Unit	12 000 €
Revenue	77 250 000 €	Revenue	1 200 000 000 €
Gross Margin (Revenue-COGS)	7 720 000 €	Gross Margin	127 080 000 €
OPEX (10 % of revenue)	7 720 000 €	OPEX (anually)	120 000 000 €
EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization, Gross Margin- OPEX)	710 000 €	EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization)	7 080 000 €
Deprications	316 000 € / year	CAPEX (Capital Expenditure)	1 345 000 €
EBIT (EBITDA-Deprications)	390 000 €	Deprications	316 000 €/yr
CAPEX (Capital Expenditure)	1 580 000 €	ROI	3.2 % per year
Net Profit	316 000 €		
ROI	20 %		

Fig.129 ROI Calculation with two cases

Case	Selling price	Sold Units	Ammortization Period	Revenue	Variable Costs	Fixed Costs	Operating Profit	Gross Margin	Breack Even	ROI
1	15 450 €	100 000	5 years	1 530 000 000 €	1 135 920 000 €	680 €	393 401 501 €	25.7 %	170 Units	11.6 %
2	12 000 €		5 years	1 200 000 000 €	1 135 920 000 €	680 €	63 401 501 €	5.3 %	1060 Units	1.8 %



12. Viability

What are the primary barriers to adopting drones systems in the CLAAS company?

12.1.3 The business case for CLAAS

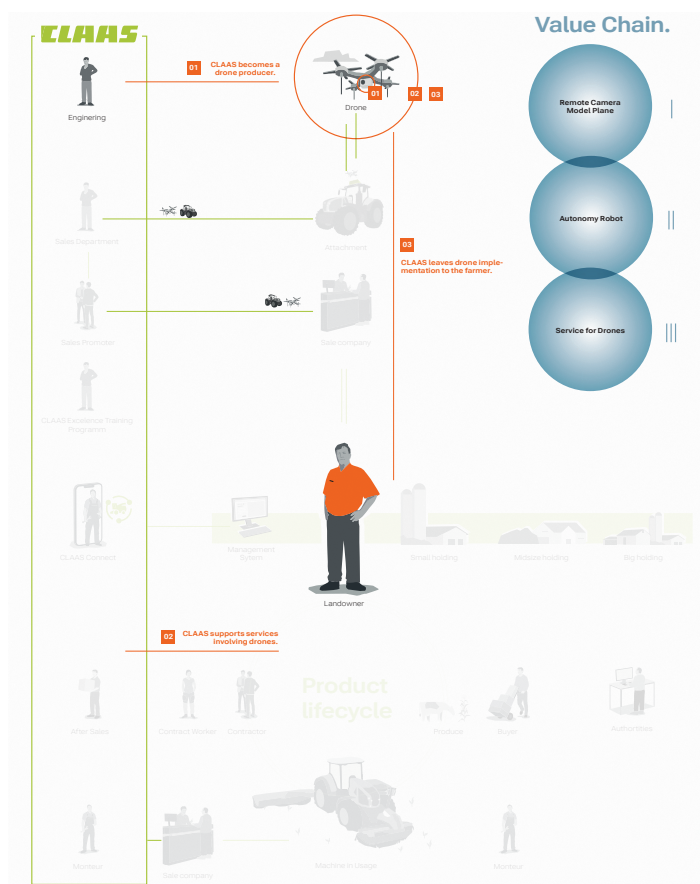


Fig.132 Value chain CLAAS

There are three possible levels of involvement for drones.

Path 01—Drone Production

Assuming full ownership of the drone platform enables maximum control over safety, performance, and integration with existing machinery and digital services. It also concentrates risk and capital requirements. The potential upside is brand authority and tighter system economics. The trade-off is a multi-year investment and the need to operate with aerospace-grade processes and quality systems.

Path 02 — CLAAS as Service and Enablement Provider

Acting as the service provider and working with approved partner drones, prioritizes recurring value while limiting hardware exposure. This approach leverages the dealer and After Sales network to deliver uptime, drive parts and services pull-through, and establish subscription revenues for maintenance, connectivity, and data operations. Success depends on clear technical standards, robust integration with CLAAS digital products.

Path 03 — Farmer-Led Implementation

Deferring platform selection and integration to farmers minimizes corporate cost and accelerates experimentation, but minimizes control over user experience, safety, and brand consistency. This pathway is appropriate for low-risk applications when bounded by explicit policies to prevent disproportionate operational burden without corresponding revenue.

For CLAAS, drone technology presents long-term strategic potential but limited short-term economic viability. The technology aligns with CLAAS's innovation-driven vision to enhance efficiency and automation in agriculture

Drones could eventually complement existing sensor systems by providing real-time environmental and crop data, supporting the automation of harvesting and crop monitoring processes. Yet, the study found that replacing onboard sensors with drones would currently increase manufacturing costs rather than reduce them, especially when accounting for the need for landing and charging infrastructure.

Additionally, regulatory restrictions in the EU prevent full deployment of autonomous drones in conjunction with agricultural machinery. The most promising near-term opportunity lies in "Stock Management", where drones can collect crop health and growth data for precision farming. CLAAS could leverage partnerships with companies like Bayer or agri-tech startups to accelerate development and share expertise.

In summary, while drone integration is not yet cost-effective, it represents a strategic investment area for CLAAS to strengthen its digital ecosystem, support automation, and secure a competitive edge in future smart farming markets.

12.2 Market readiness

12.1.4 Cost list

$$ROI = \frac{\text{Savings} - \text{Total cost (fixed + variable)}}{\text{Fixed Investment}} \times 100$$

5 000 Units per year
5 years

Taxes (VAT-19 % of EBIT)	54 533 000 €
Transportation	10 734 000 €
Sales	75 138 000 €
Marketing	10 734 000 €
Units sold	5 000
Selling price per Unit	15 450 €
Revenue	77 250 000 €
Gross Margin (Revenue-COGS)	7 720 000 €
OPEX (10 % of revenue)	7 720 000 €
EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization, Gross Margin- OPEX)	710 000 €
Depreciations	316 000 € / year
EBIT (EBITDA-Depreciations)	390 000 €
CAPEX (Capital Expenditure)	1 580 000 €
Net Profit	316 000 €
ROI	20 %

Fig.133 ROI Calculation

The presented calculation serves as an indicative assessment rather than a complete financial forecast. It simplifies several dynamic factors such as market fluctuations, production scalability, and long-term operational costs. External influences — including supplier price changes, energy costs, or shifts in labour availability — could alter the COGS and profitability significantly. Furthermore, the model assumes full sales of all produced units and excludes financing costs, maintenance, and post-launch support.

While these assumptions allow a clear evaluation of the viability dimension within the IDE framework, the resulting ROI and margin figures should be interpreted as directional indicators rather than precise economic outcomes.

12.2.1 Technical Readiness (TLR)

A functional prototype of the connector mechanism has been built; its long-term performance still needs to be evaluated.

The general production methods have been defined at a theoretical level, but in-house manufacturability remains to be clarified. Metal components can be produced internally, whereas plastic parts are not currently manufactured on site.

12.2.2 Customer Readiness

Market research and early user trials indicate broadly positive reception. While full automation is not yet commonplace—making the concept less immediately tangible for some stakeholders—expert evaluators were similarly favorable.

Reported willingness-to-pay aligns with the targeted price range, suggesting commercial viability if the value proposition (reliability, uptime, and service integration) is communicated clearly during adoption.

12.2.3 Business Readiness

The cost structure is largely understood and a target price range has been established. Partnerships still need definition, as CLAAS does not operate in-house drone manufacturing.

Given this constraint, an external production model with CLAAS-specific customization appears most appropriate, with the next steps focused on selecting qualified suppliers, defining quality and certification requirements, and mapping the service and spare-parts flow into the dealer network.

12.2.6 Market Timing

The competitive landscape is growing as multiple firms move to deploy drones, and broader automation with drones and robots is accelerating across industry.

Demand growth appears robust, supported by maturing complementary technologies—navigation, perception (LiDAR/cameras), docking/charging, and fleet management software—that lower integration risk.

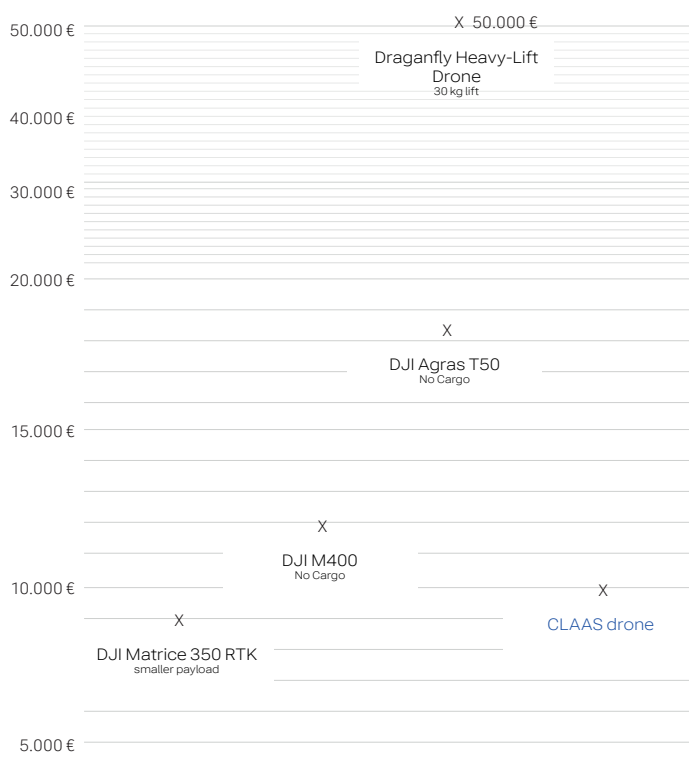
12.2.4 Regulatory Readiness

Each mission currently requires registration and real-time observation by personnel. While this approach can support oversight across multiple drones, it also necessitates developing in-house competencies for operation and maintenance. Certification pathways must be planned accordingly.

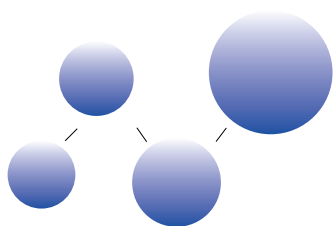
12.2.5 Organizational Readiness

There is no organizational readiness within CLAAS for this particular drone. Some research project regarding drones are undertaken but no initial steps for actual drone implementation.

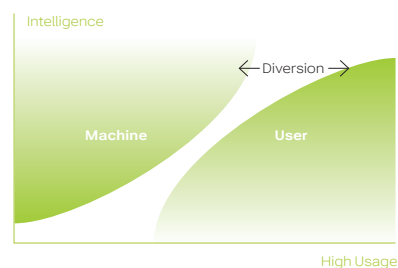
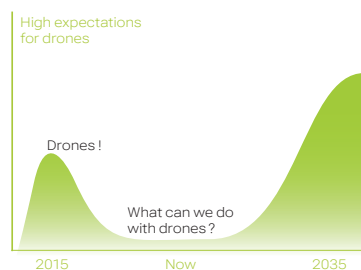
12.2.8 Benchmarking



The drone concept can be viewed as a relatively low-threshold entry point into drone systems, offering multifunctional capabilities. By being deployed across different farms, it could encourage broader technology adoption and support the further advancement of drone technology through modular add-ons.

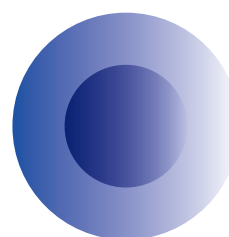


12.2.7 Summary Viability



Many farmers initially showed strong interest in drone technology; however, early expectations were not fully met, as imaging alone turned out to be too limited as a practical use case. Over time, many users have struggled to keep pace with the rapid technological advancements integrated into their equipment, leading to hesitation toward adopting yet another digital tool.

For drones to become a meaningful part of daily agricultural work, their cost and practical benefits must be balanced, ensuring that the investment provides tangible value in farmers' operations.

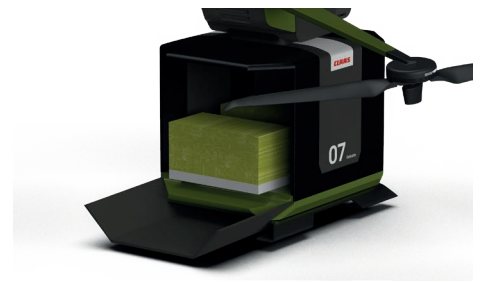




13. Finish

Alligning the concept with the CLAAS Design Vision was the focus of the final project phase.

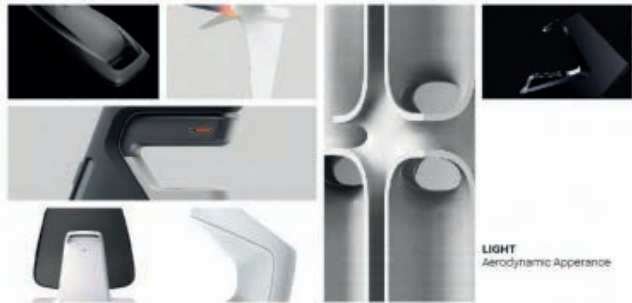
- Desirability ■
- Feasibility ■
- Viability ■
- Finish ■



13.1 Product Design

- Desirability ■
- Feasibility ■
- Viability ■
- Finish ■

13.3.1 Design Language



The drone's design is primarily driven by functionality, as it must comply with strict hardware parameters to carry the required payload. Nevertheless, four distinct design expressions were chosen to guide the development process.

First, a light yet aerodynamic appearance should emphasize the drone's flight capabilities—particularly in the main body. Varying wall thicknesses and introducing subtle openings will help convey a sense of lightness and agility.

In contrast, the drone must also express its ability to perform physical labor and bear substantial weight. An asymmetric design element can serve as a bridge between these two opposing qualities—lightness and strength.

Given the large number of sensors required for autonomous flight, chamfered surfaces will be used to emphasize the technical nature of the product while aligning with the CLAAS design philosophy.

The overall shape must reflect the duality of the drone's structure: two distinct entities that operate both independently and in unison. The connecting element between them should visually communicate this relationship through both form and color.

Fig.134 Moodboards for shape development

13.2 Design Features

- Desirability ■
- Feasibility ■
- Viability ■
- Finish ■

13.1.1 Visual hierachy

The overall theme of the shape is latch- a central highlighted element that refers to the CLAAS Y and includes the central handle and attachment mechanisms.

Primary element

- 10 m

The champher element highlights the overall carrying shape as well as the four rotors as the essential function.



Secondary element

- 1 m

Carrying the load through a connecting element is central for this drone. The involved elements are therefore emphasized with a y- shaped element as well as a differently valued grey



Tertiary elements

- 0.5 m

The Handle is the central physical touch point for the user. For the cargo, the integrated door handle is central.



Quaternary elements

- 0.25 m

The intelligence of the drone is reflected in the exposed sensors and connection elements.



Fig.135 Visual hierachy

13.3 Product Design

Desirability ■
Feasibility ■
Viability ■
Finish ■

13.3.1 Shape Development



Fig.137 Parallel development 2D and 3D

The shape was developed with the realistic sizing and proportions in mind.

13.3.2 Shape Refinement

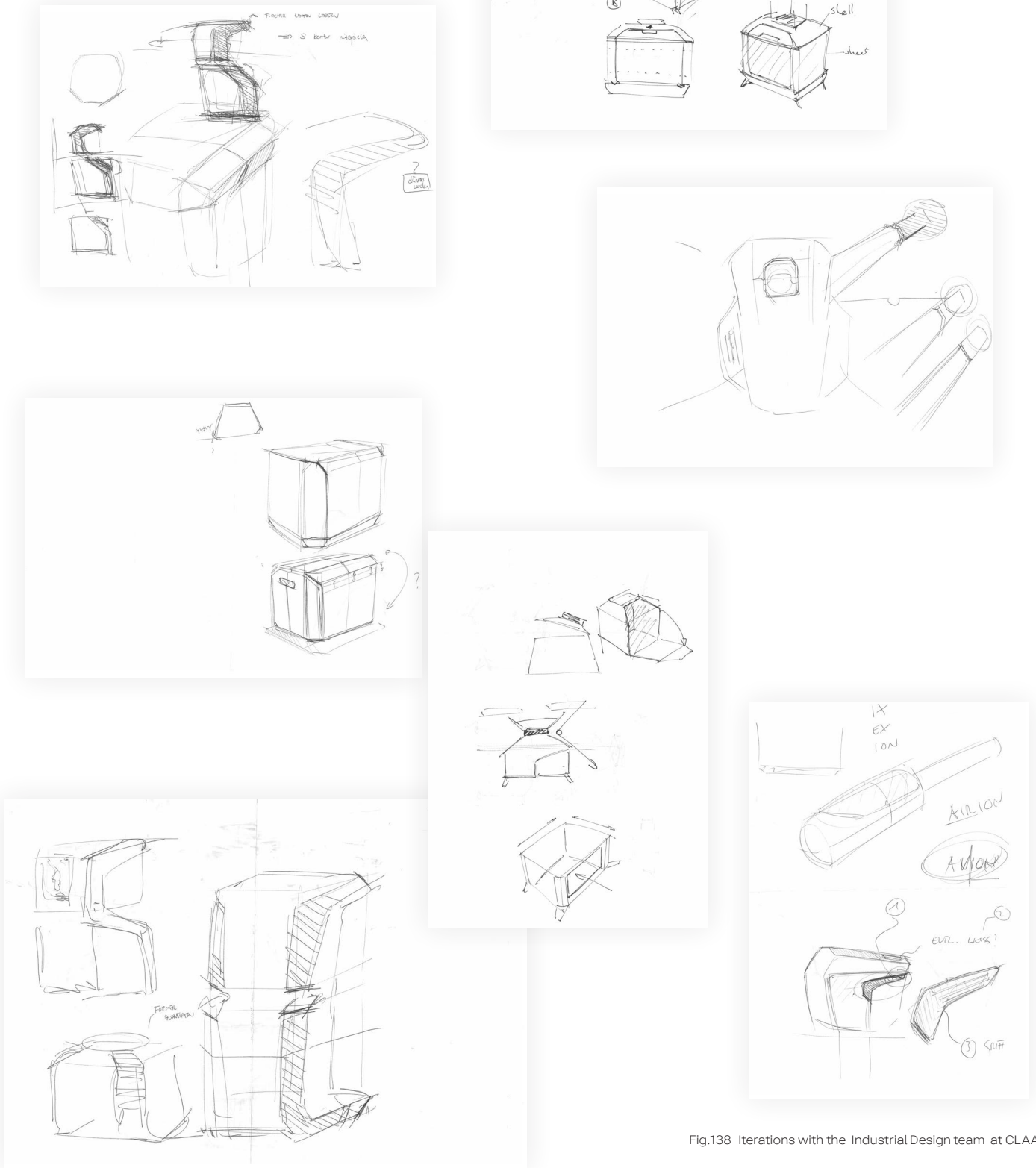


Fig.138 Iterations with the Industrial Design team at CLAAS

Different features and overall shapes were iterated.

13.4 Features

Desirability ■
Feasibility ■
Viability ■
Finish ■

13.3.6 Graphic Element

To get a better understanding of the overall shape, black and white illustrations were used. This helped to determine the overall shapes.

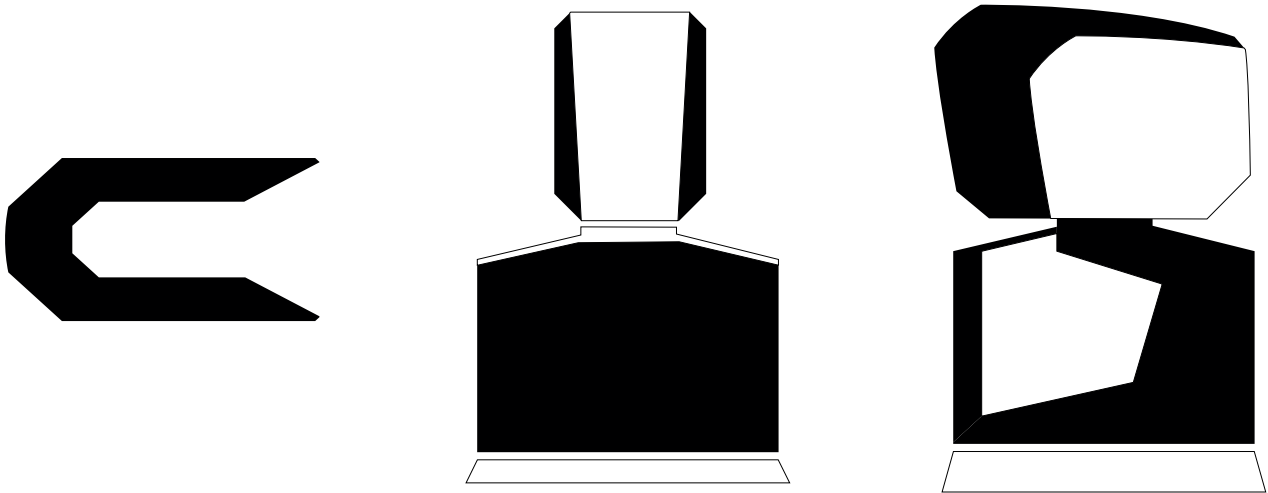


Fig.139 Graphic abstraction of drone shape

13.3.3 Hand Element

At first the hand element was fully integrated in the latch element and highlighted through color and shape. Looking at the ergonomics though, it became apparent that the handle element would need to be sitting higher and face outwards. The indent feature could not be used due to difficult surfacing.

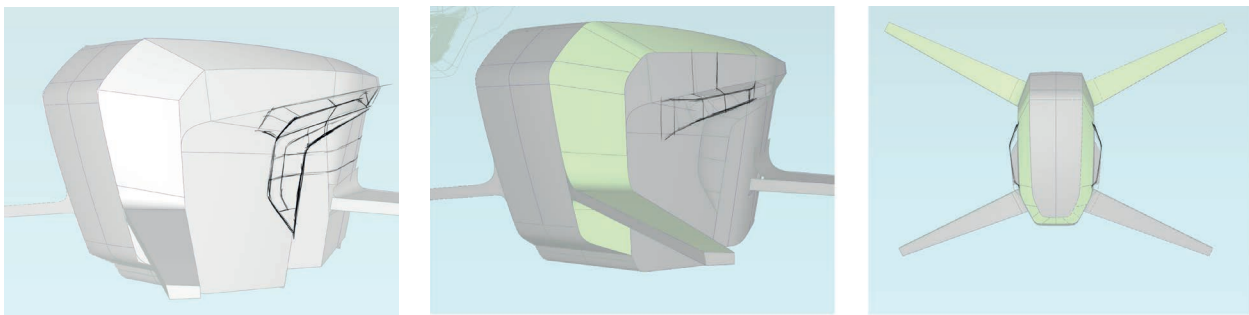


Fig.140 Handle iterations

13.3.4 Feet

The drone should be able to stand independently. The feet are integrated underneath the moving rotors and are designed with an outward curvature.

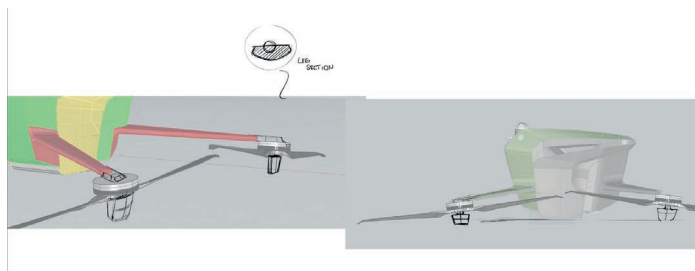


Fig.141 Feet iterations

13.3.5 Wings

The wings have a straight top surfaces that is integrated within the body.

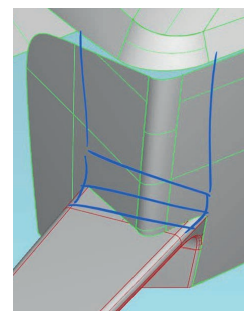


Fig.142 Wing chamfer integration

13.4.1 Air ventilation

The internal electronic components as well as the battery need air circulation, which is enabled through front and top ventilation elements.



Fig.143 Air ventilation detail in the front and in top

13.4.2 Sensors

The lidar sensor needs the most exposed position within the drone architecture. The other sensors (camera and infrared) can be integrated more subtle.



Fig.144 Front and back view

13.4.3 Light

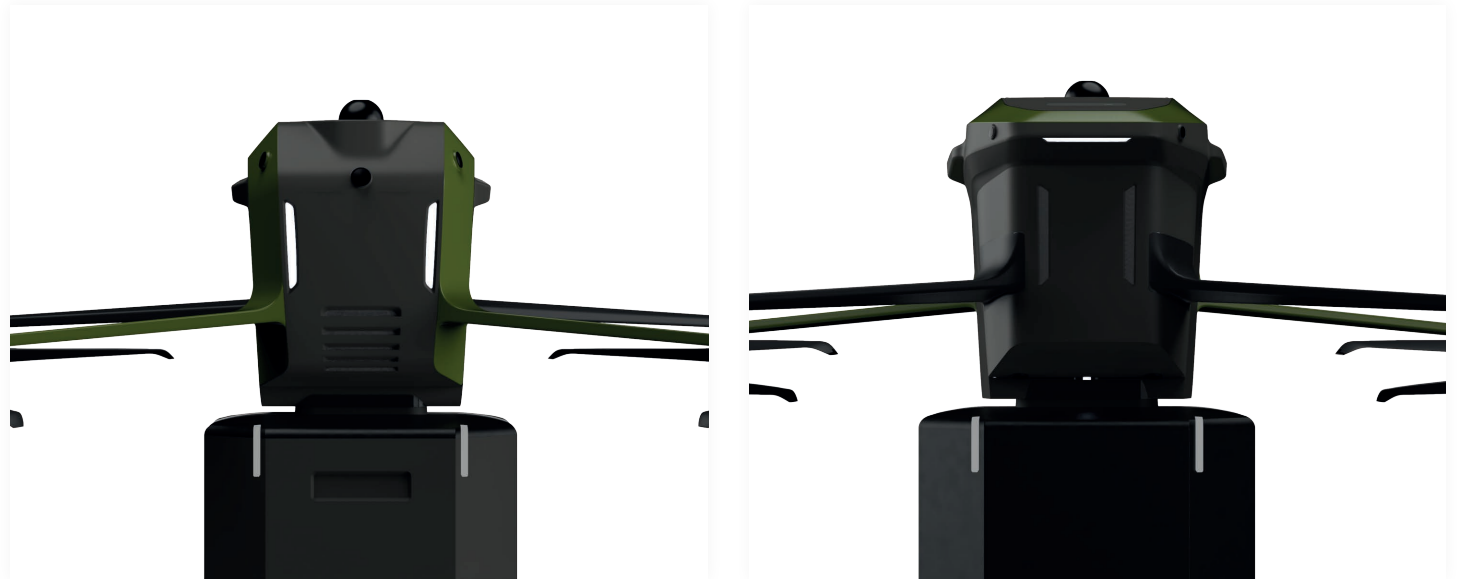
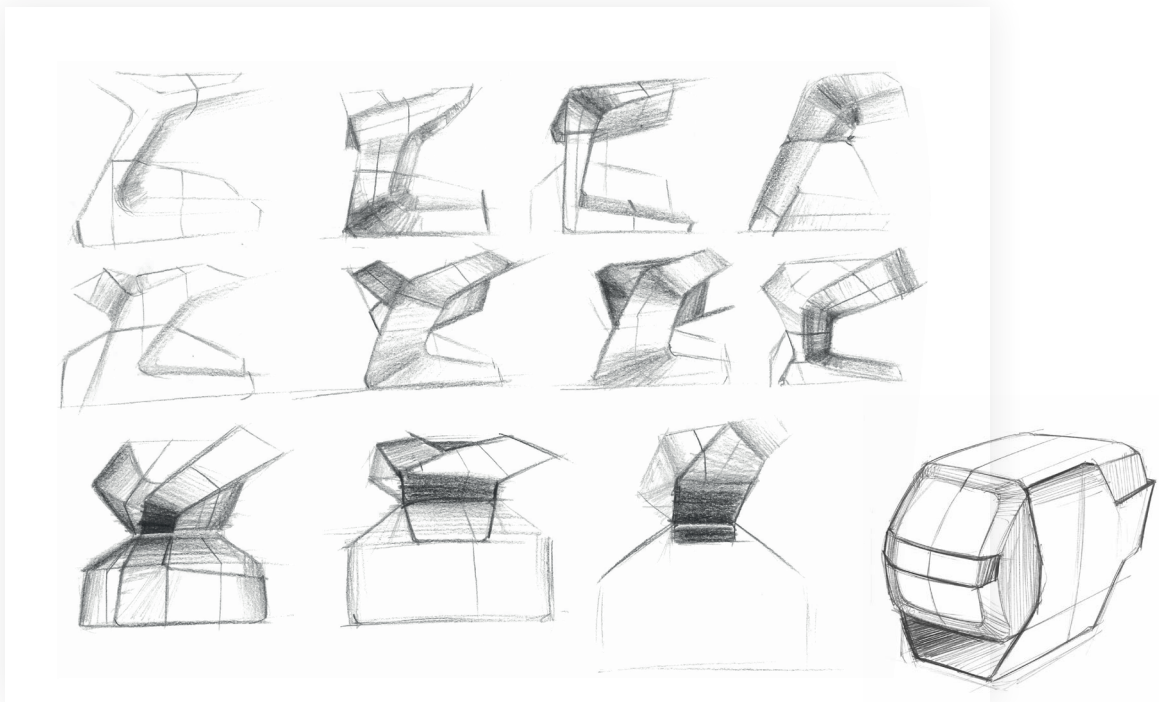
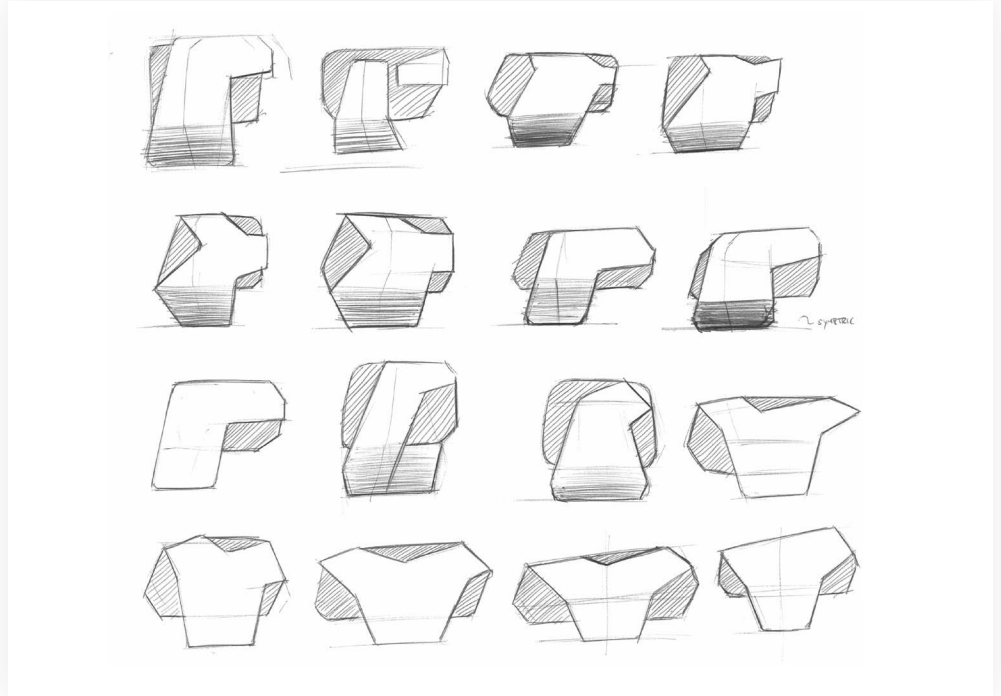
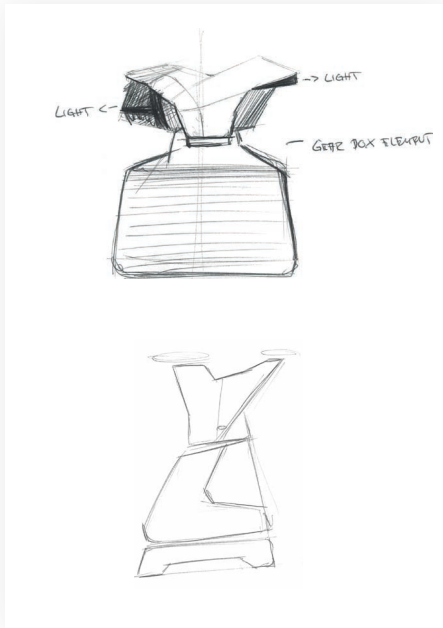


Fig.145 Front and back view

The drone has lights at the rotors and on the front and back of the body to indicate the direction as well as the direction. As the cargo elements do not contain electronic components, reflectors on the edges have to be sufficient.

13.4.4 Cargo integration



As the drone has to function with different sized cargos and also without an attachment, it is important to refer to the drone within the cargo through shape and extending of graphical features.

Fig.146 Graphical connection element

13.4.5 Technical attachment



As the drone has to function with different sized cargos and also without an attachment, it is important to refer to the drone within the cargo through shape and extending of graphical features.

As the drone has to function with different sized cargos and also without an attachment, it is important to refer to the drone within the cargo through shape and extending of graphical features.

13.4.6 CMF

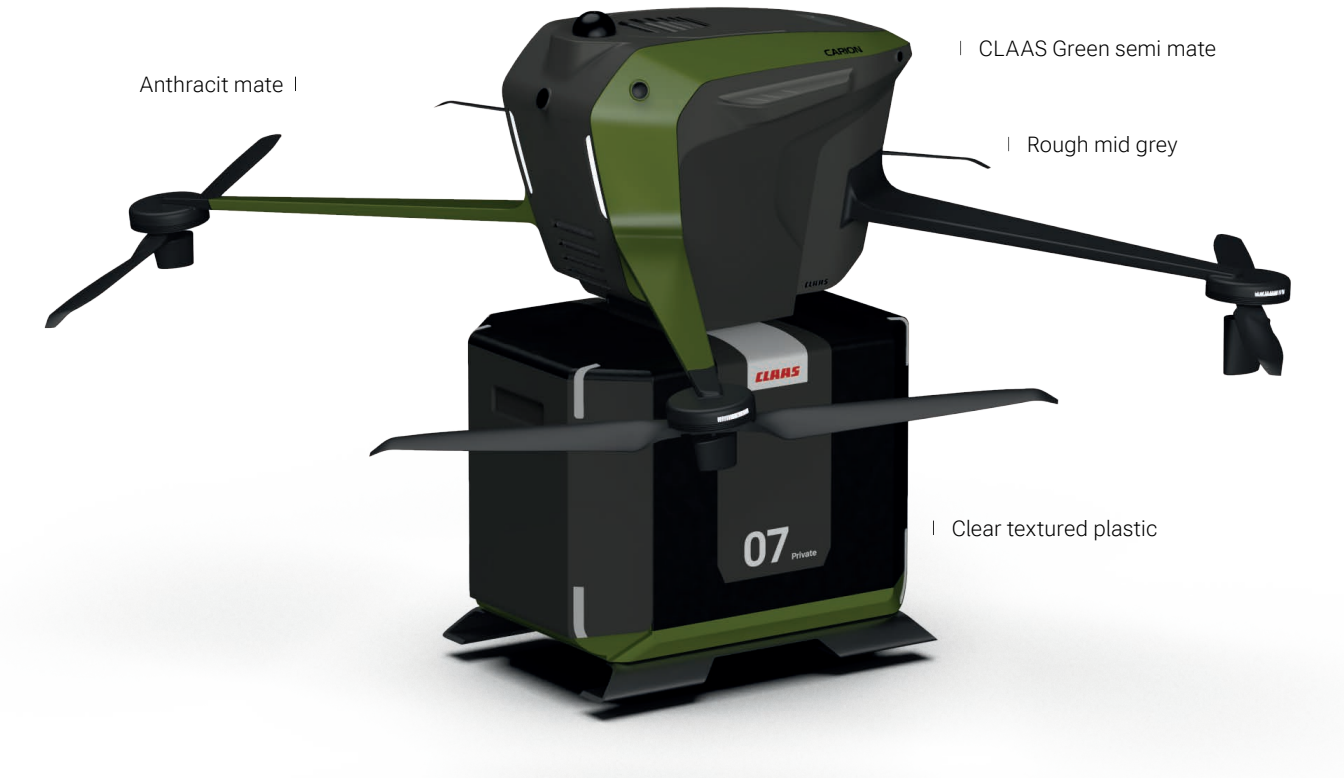


Fig.148 CMF Variants

The drone body employs two differently textured plastics: the primary chassis uses a darker, low-gloss matte finish, while the propeller-phase element also features a matte surface. This pairing maintains a cohesive look while providing subtle material contrast.

The color scheme follows the CLAAS palette (Fig. XXXX), dominated by the signature green and anchored by a dark grey to establish clear visual hierarchy. Because the cargo module serves multiple purposes and can carry different contents, differentiated lid colors are a viable option for fast recognition. The main cargo body remains transparent, allowing the contents to be easily visible to the user.



Fig.147 CLAAS Colors

13.4.7 Interaction zones



Designated action zones guide safe user interaction by clearly indicating where the drone may be touched and operated. This includes the side handle as well as the battery handle on top. The on off button will also be marked through red and green.

To reinforce status awareness, red markings are applied to the portion of the cargo attachment that becomes covered when the system is fully locked.

When the push-and-release mechanism is disengaged, the red area is exposed. This creates an immediate visual cue of lock state—hidden red indicates secured, visible red indicates released.

Fig.149 Interaction zones through color

13.4.8 Product graphic

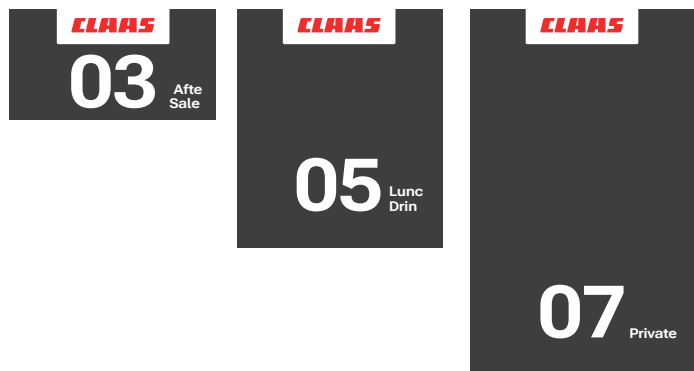
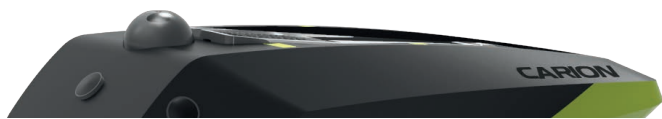


Fig.150 CMF Rendering

For product graphics, both the drone and the cargo module should be clearly branded with the CLAAS logo to ensure immediate recognizability and brand cohesion.

The cargo should additionally carry a distinct numeric identifier and a concise descriptor of its specific purpose (e.g., "Tool Kit," "Sensors," "Spare Parts") to support fast identification.

13.4.9 Naming



CLAAS names often end on -ion like the XERION, AXION, LEXION and TRION, Considering this the naming considered this pattern.

Central for the drone are the packaging capabilities, Lifting up different sized cargos and transporting in to where it is needed.

13.4.10 Functional graphics

While putting on the drone from the top the shapes centre the two parts against each other. A top mark should furthermore make the positioning clear



13.5 Final User Scenario

Feasibility ■
 Viability ■
 Finish ■

13.4.11 Interaction specification

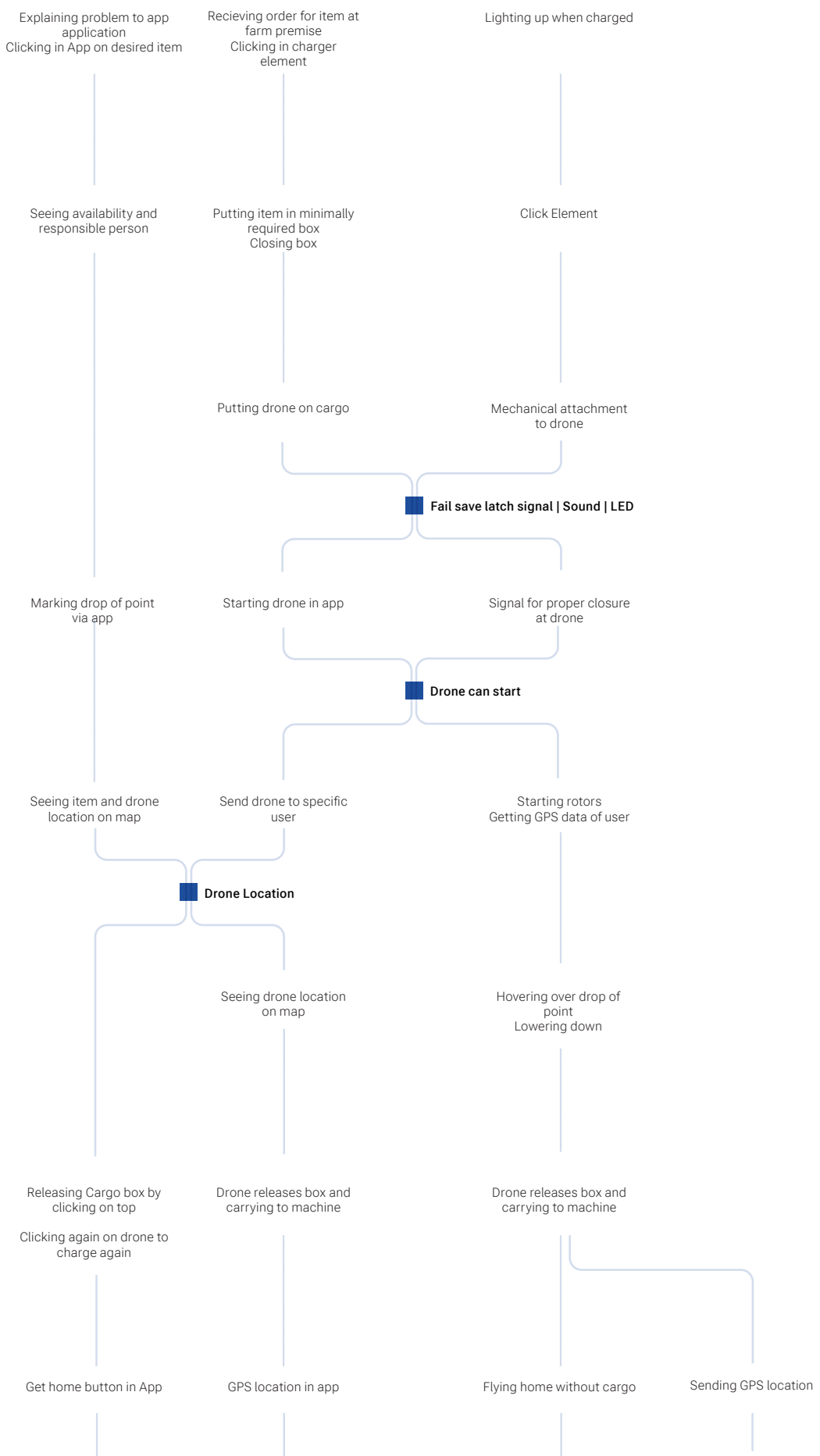
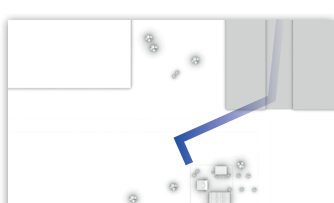
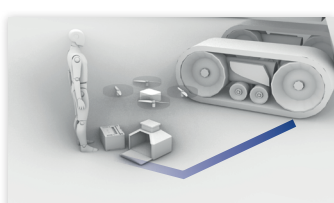
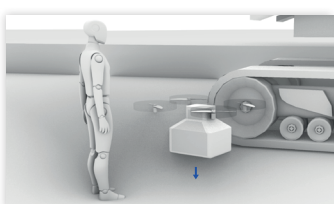
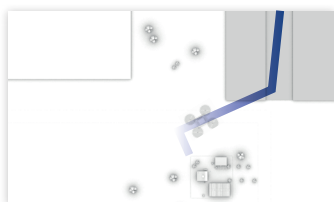
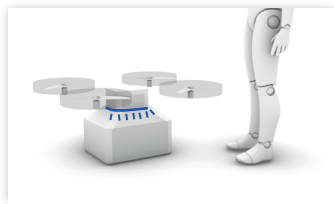
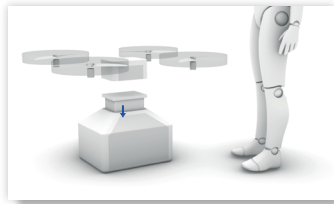
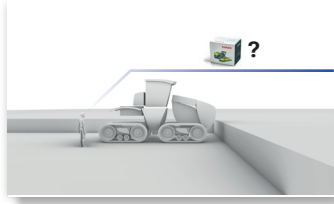


Fig.151 User Journey Drone

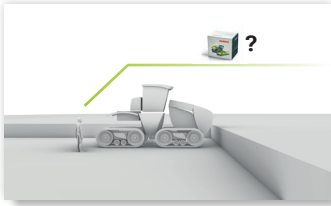
13.5.1 Interaction comparison

Desirability ■
 Feasibility ■
 Viability ■
 Finish ■

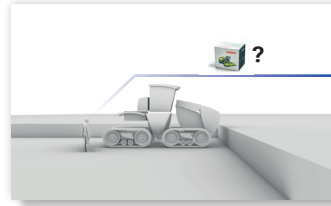


No logistic support

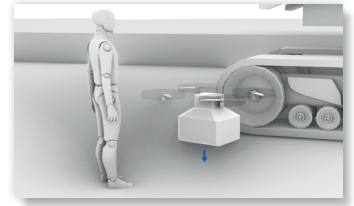
With logistic support



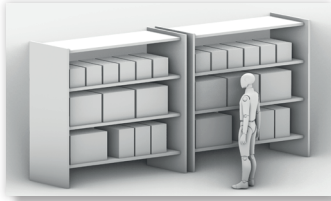
Calling worker in the farm to look for part



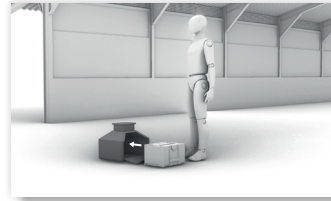
Needing spare part during work on field



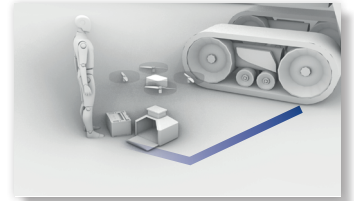
Drone landing on field



Looking for part in shelves or going to after sales store



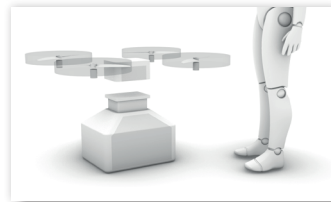
Putting requested item in attachment cargo in farm storage



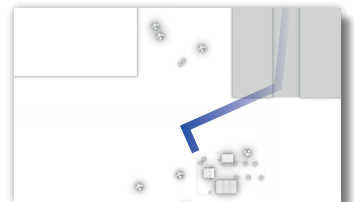
Drone releases box and carrying to machine



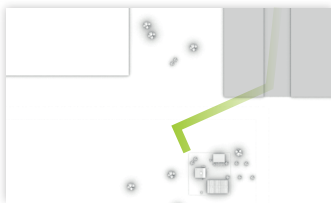
Looking for part in shelves or going to after sales store



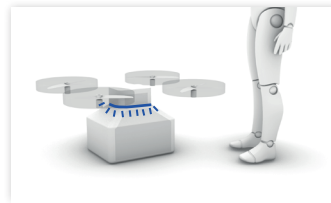
Puttin drone on cargo and mechanical attachment to drone



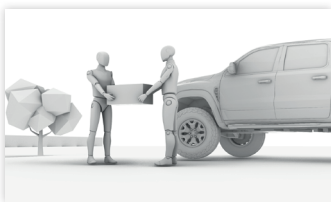
Get home button in App



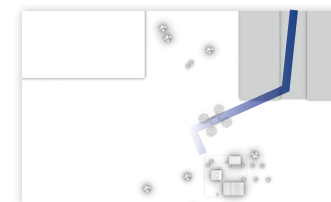
Driving with farm vehicle to field corner



Signal for proper closure at drone- Starting drone in app



Physically dropping of package



Send drone to specific driver

Fig.152 User Journey Comparison

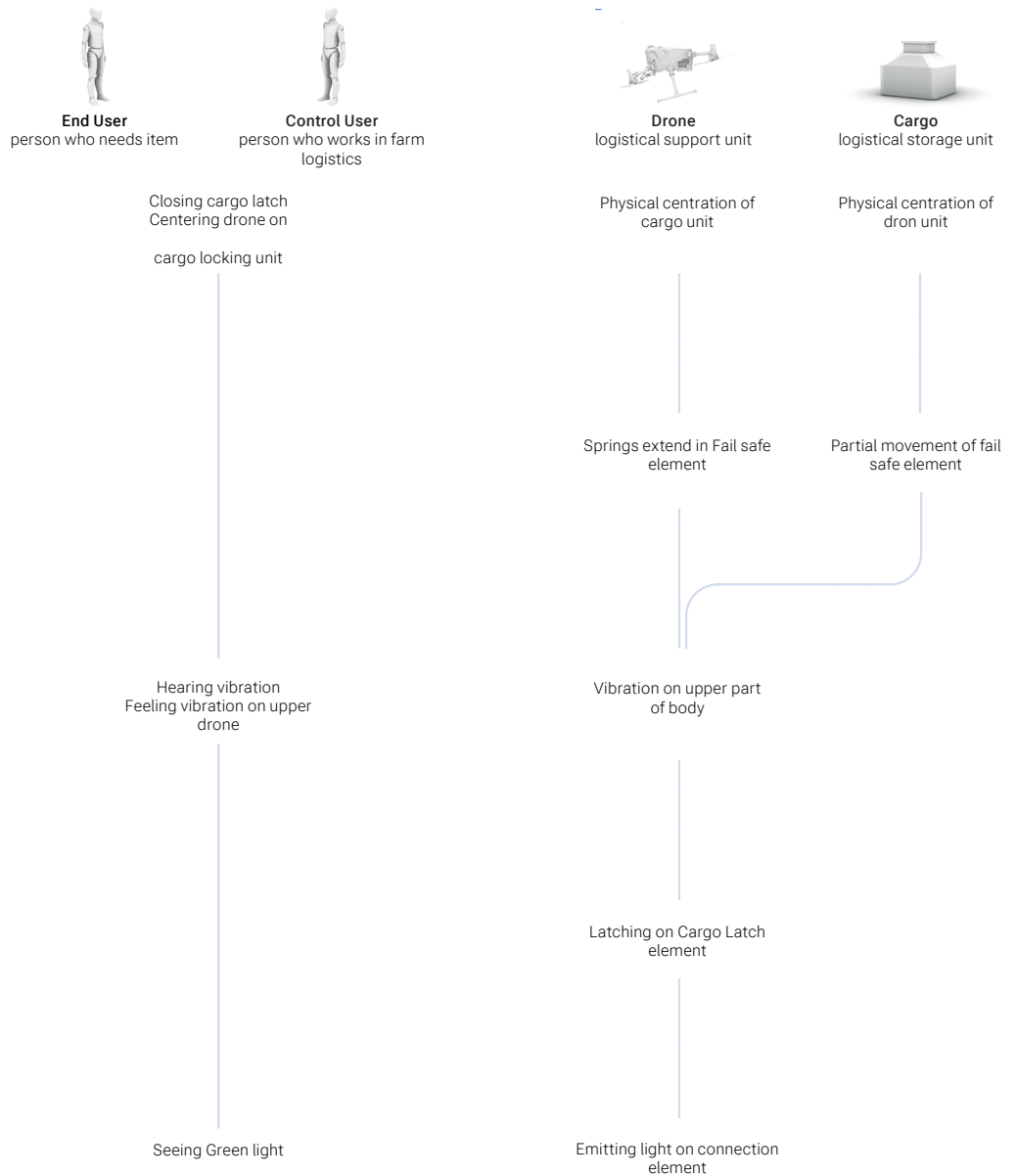
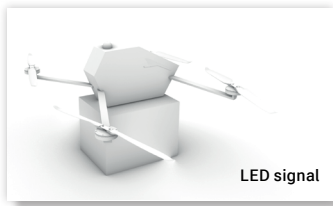
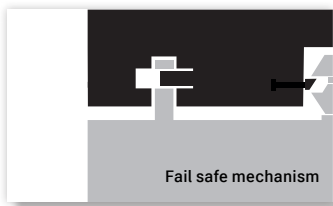
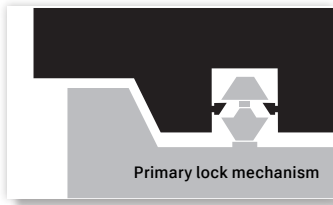
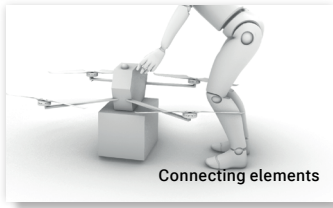
The manual run ties up a worker and a vehicle for search, pick-up, driving, and handover, so total time is dominated by travel and coordination and error risk rises with multiple handoffs.

The drone run compresses the flow to pick-pack-launch: the part is loaded into the cargo, closure is confirmed, the drone flies directly to the recipient, auto-releases, and returns home.

This removes the drive entirely, cuts handling to a few minutes at origin, reduces variability, and lowers cost drivers from labor and vehicle use to battery cycles and brief operator time. In practice, the drone path outperforms when urgent runs are frequent or distances are relevant.

13.5.2 Latch interaction

Attach System



Release System



Fig.153 Latch Interaction system

The drone–cargo connection is central to the concept: it enables reliable drop-off of a load and, if needed, pickup of a different cargo on the return leg. The primary interaction involves grasping the drone by its two handles and guiding it onto the standing cargo’s attachment points.

Although the push-and-release mechanism is circular and centered on the interface, the fail-safe uses an off-center pin, so there is only one correct orientation in which drone and cargo can be coupled. This ensures quick alignment and prevents incorrect attachment.





CARION

Logistical Support 24 hours a day.



CARION

Logistical Support saving you time on the road



CLAAS

CARION

Coming to your field.



CLAAS

CARION

Reaching every corner

13.6 Discussion and Future Recommendations



RQ2 What are the barriers to adopting drones as an agricultural company?

13.6.1 Desirability

During the initial and also follow up interviews regarding the drone it became clear that farmers and connected professionals like After Sales Disponents and contracors areopen to the idea of automated delivery systems. There are still a lot of uncertainties regarding safety, operation and organisational background , which leads to the proposal of intituiak user briefing.

When looking into the different scenario occurrences it can be said that the actual time savings are not as high as expected from farmers. Looking at the saved time , it there also needs to be a consideration of additional costs through organizational operation and observation of drone path, even considering taht one worker could observe multiple routes.



RQ2 What are the technologies inside the CLAAS sytem that can be used for drones?

13.6.2 Feasibility

There was no initial mechanism on the market that met the requiremnets for the cargo that should be held.

Through intitial prototipess it was shown that the mechanism itself fufills its function, but needs further development regarding surface properties and angle.

For electronic hardware as wel as rotors, the DJI

M400 was referenced, making this structure init of itself feasible. An additional bought latch component can be connected to the existing system.

It was central that the desig´n references CLAAS machines to make the visual connection, which requires most components to be produced one way or the other.



RQ3 What are the primary barriers to adopting drones systems in the Claas company?

13.6.3 Viability

Even thogh drones do not seem viable right now for CLAAS, having CLAAS as a service provider would help themexpanding their system towards automation and maybe furthermore their tractor system by connection the drone physically towards it. There are no further startegic steps for drones in sight.

Considering themself as data users, this drone could lead as a low tech entry pointzs before teh user can dive into more complex applications that require data management.

The drone could help gather data on after sales and machine care scenarios. So what happens with the machine after it goes into the field.

13.6.4 Future Recommendation

The attachment could be used to articulate different components while recognizing them within the closing mechanism. However, the connection system still requires further refinement.

In future iterations, multiple drones could be combined to transport heavier payloads. The cargo latch could also be motorized and transformed into a grabber, allowing the transport of differently sized objects. Both the drone and the cargo module could integrate attachment points compatible with one or multiple CLAAS machines, enabling closer system integration.

For more remote operations, the push-and-release mechanism could be activated by a downward force, eliminating the need for direct physical interaction.

There are ongoing initiatives in logistics systems that could potentially be connected with CLAAS to establish a larger, integrated infrastructure. The current drone concept should therefore be viewed as a foundation—both for technical exploration and for sparking further discussion.

As noted in Jonas Schöne’s thesis, the break-even point can be reached more quickly when the drone incorporates greater intelligence. However, several challenges remain, particularly concerning integration into the CLAAS Connect ecosystem.

At present, the technological focus in agriculture is shifting toward plant recognition and spot farming, while deer rescue remains the most common drone application. Both use cases could be incorporated into the system through dedicated attachments.

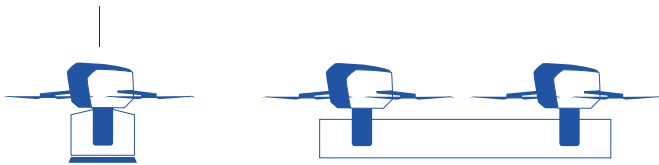
Major barriers persist for autonomous flight. Certification is required for operation, and drones must still be supervised during missions. Additionally, the current political climate surrounding drone technology—largely shaped by its military applications—negatively influences public perception and acceptance of autonomous flying systems.

Machine attachment

The drone itself or the cargo could integrate an attachment point that could attach to one specific or even multiple CLAAS machines.

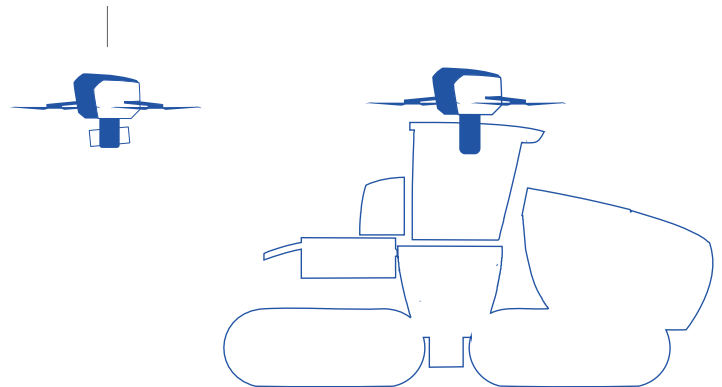
Remote Push and Release activation

For a more remote operation the Push and release mechanism could be triggered by a downward force itself. This could eliminate the need for physical interaction.



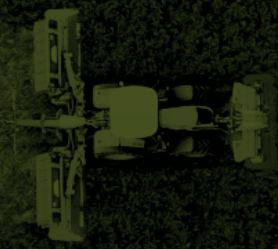
Expanding function

The attachment could be used to articulate different components, while recognizing them within the closing mechanism.



Swarm function

Multiple drones could be combined and used to carry heavier loads. The cargo latch could be motorized and turned into a grabber to ensure that different sized items



Project Brief ■

Project Summary ■

Appendix

Figure Sources ■

Functionality grouping ■

Content Sources ■

Stakeholder Analysis ■

Drone Architectures ■

Expert Interviews ■

Form sketches ■

User Interviews ■

Validation questions ■

After Sales Strategies ■

Expert concept interviews ■

Drone Comments ■

User concept interviews ■

Personas ■

User Journeys ■

Personal Project Brief – IDE Master Graduation Project

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title

Designing a company use case for Drones in Agricultural Contexts for Connected Farming Solutions

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

As climate conditions become increasingly extreme and rural labor shortages deepen, agricultural automation is shifting from a valuable tool to a necessary solution. In this context, data-driven technologies empower farmers to monitor their land more effectively and take preventative action.

Autonomous farming vehicles further support this shift by saving time and resources when tending to large and complex fields. Drones, in particular, offer a promising extension to farming operations—especially in areas where traditional machinery falls short due to terrain challenges, high costs, or environmental sensitivities.

However, to unlock their full potential, drones must evolve beyond their technical capabilities. They need to become more adaptable to the specific environments, routines, and workflows of the users operating them.

The main stakeholder in this context is CLAAS, a global leader in agricultural machinery. CLAAS is already developing a connected ecosystem of data platforms and intelligent hardware. Integrating drones into this system presents a clear opportunity to deliver a cohesive and scalable solution for modern farmers.

Farmers are the end-users, depending on these tools to improve operational efficiency, crop health, and sustainability under growing pressure. Regulatory bodies also play a critical role, as they are responsible for overseeing safety standards, environmental compliance, and data governance.

This project lies at the intersection of precision agriculture and autonomous systems. It aims to explore how drones can be seamlessly integrated into existing machinery ecosystems, overcoming current limitations such as uncoherent platforms and uncertain legal frameworks surrounding autonomous aerial operations.

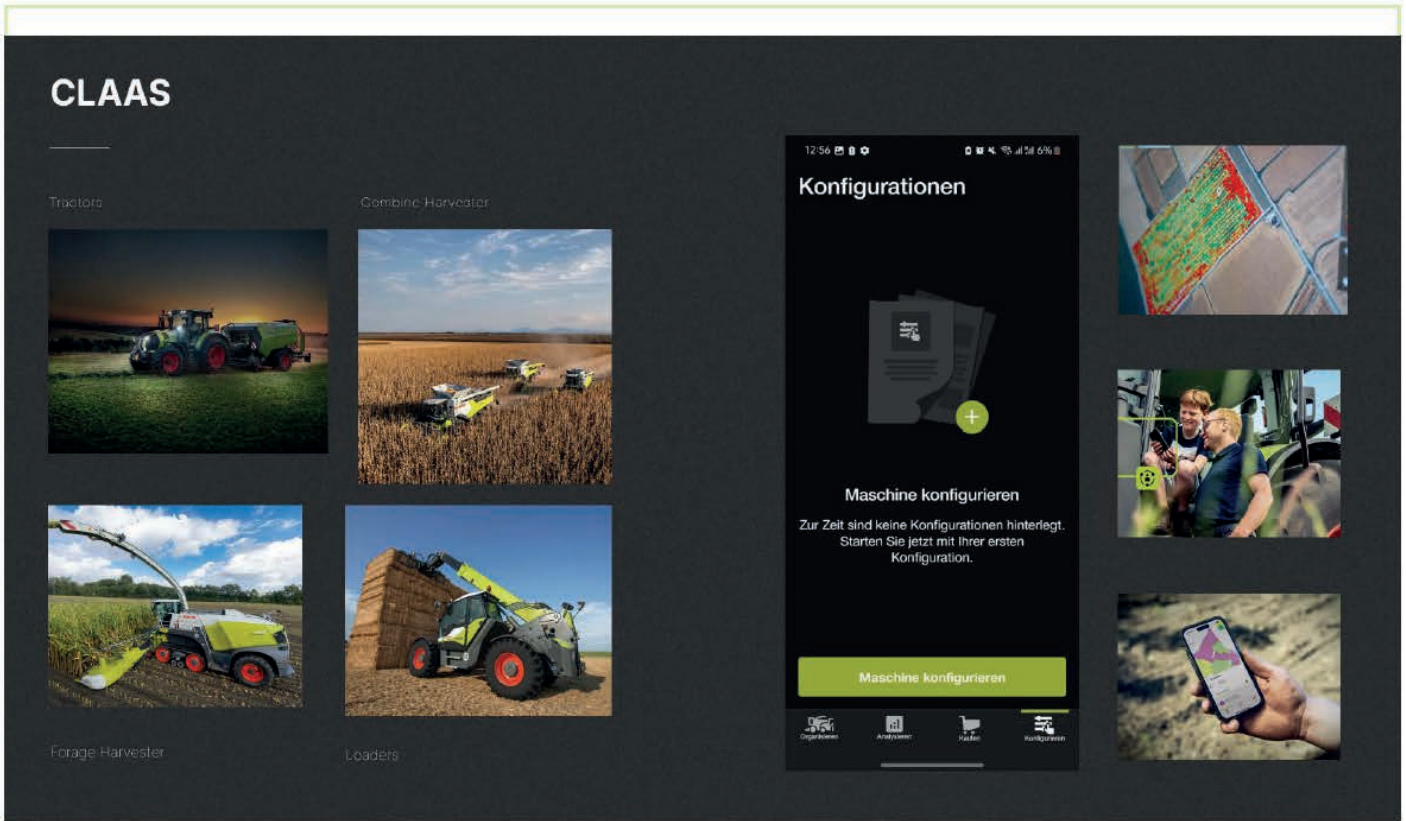


image / figure 1 Overview of current claas portfolio

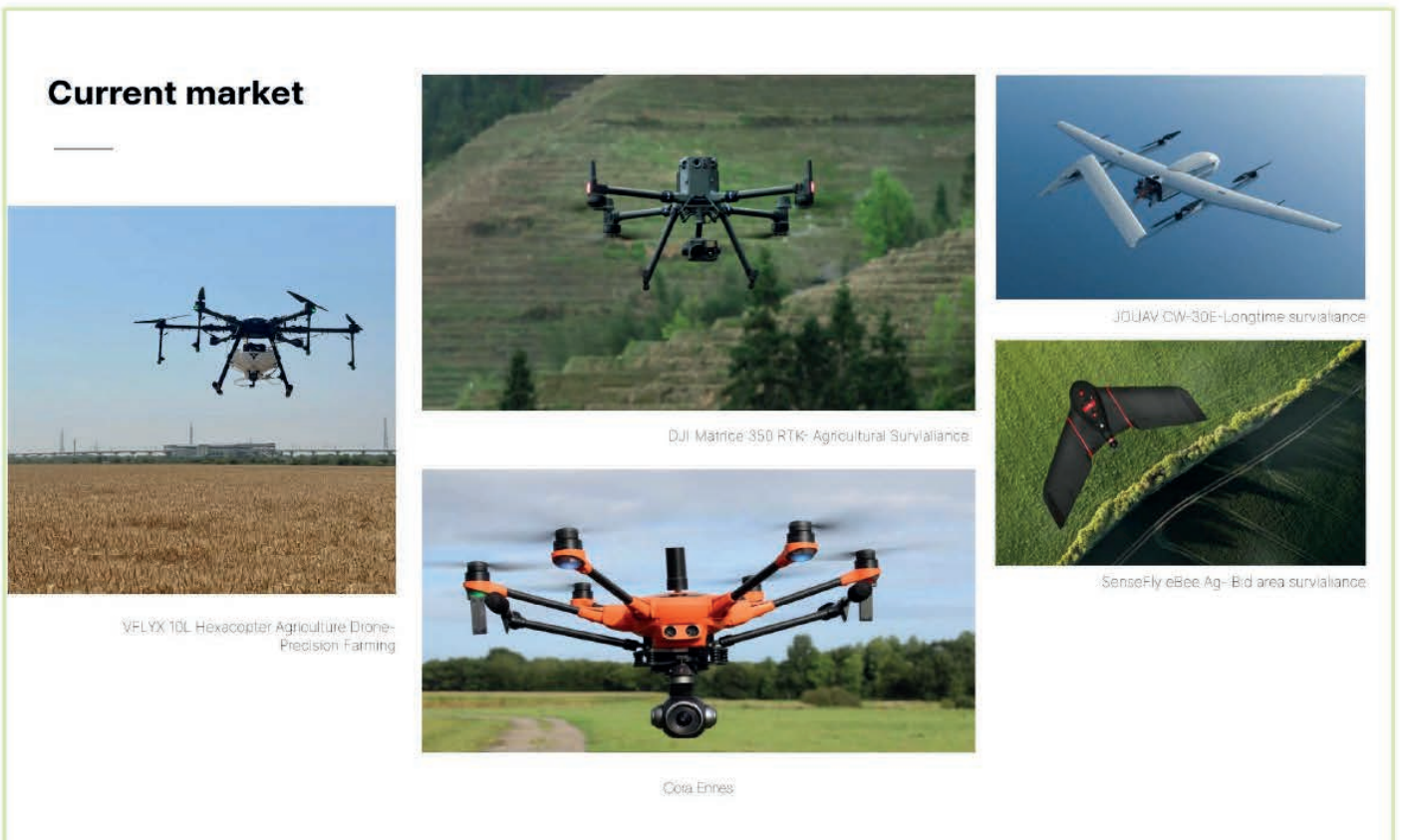


image / figure 2 Current agricultural drone landscape.

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.

(max 200 words)

In connected autonomous systems requires a division of tasks into more cognitive and less cognitive components. and an effectiveness in volume. Agricultural drones have the potential to significantly enhance field operations by increasing precision, faster workflows and further reach. Their successful integration into existing farming ecosystems is often hindered by a lack of adaptability—to both established systems and diverse environmental conditions. To be a viable option, multiple use cases must be included.

Current drone systems are perceived as technical tools, rather than intuitive, collaborative systems. This limits long-term acceptance and trust from farmers.

While current drones offer clear functional benefits—such as high-resolution imaging and targeted spraying—they often fall short in complex terrain where traditional ground sprayers or agricultural aircraft cannot operate effectively.

Drones need to demonstrate precise path planning, sufficient battery range, endurance, and adaptability to different terrains. Charging systems near the space of drone operation are missing, leading to longer operation ways.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for.

Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence)

As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design an agricultural drone with new applications to explore the use and system-integration of drones in a agricultural context by the company claas.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

This graduation project takes place primarily on-site in Harsewinkel and is supported by mentoring sessions with TU Delft. The Project will be aligned around desirability, feasibility and viability along the phases of discover define develop and deliver.

For desirability the user research and stakeholder interviews will uncover the practical needs of farmers. For feasibility internal interviews will be held for understanding the CLAAS' ecosystem. An analysis of existing drone systems will highlight mobility strategies and challenges. These insights will shape design principles focused on adaptability and integration. The viability will be iterated by business modeling and product concept evaluation. Discover phase aims for journey mapping and function analysis, while the define phase entails future vision, list of requirements and business modelling.

The development includes iterative sketching, system mapping, and 3D modeling aimed to integration within CLAAS' digital and hardware systems. The deliver phase with a conceptual prototype and integration proposal aimed at enhancing human-drone interaction and advancing drone use in future agricultural applications.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	2 Jun 2025
Mid-term evaluation	29 Jul 2025
Green light meeting	23 September 2025
Graduation ceremony	22 Oct 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	<input type="checkbox"/>
For how many project weeks	<input type="text"/>
Number of project days per week	<input type="text"/>

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.

(200 words max)

I am fascinated by how people interact within autonomous systems. This project offers a valuable opportunity to merge my interests in mobility and usability with technical functionality, using the drone as a platform to explore human-machine relationships beyond industrial settings.

Collaborating with CLAAS also gives me the chance to engage in interdisciplinary work and learn from experienced professionals, grounding my design practice in real-world expertise and application. It also allows me to immerse in the field of agriculture. One of my goals is to strengthen my ability to communicate complex ideas through visual storytelling. Tools such as sketching, system diagrams, and scenario-based storyboarding will help translate abstract interactions into clear narratives towards different stakeholder.

In addition to physical design and systems thinking, I want this project to support my academic development. Through literature review, structured reflection, and scientific writing, I aim to build a coherent narrative around emotionally intelligent technology. As drones are already an established field of research, I need to focus my efforts purposefully to address my specific knowledge gap.

This allows me to integrate creativity, analysis, and strategic thinking—key strengths I seek to grow as a designer working at the intersection of robotics and future systems.

Abstract

Carion | CLAAS Drone



This work explores the integration of drone systems within an agricultural context, focusing on their potential to enhance logistics, efficiency, and connectivity between farmers, companies, and service providers such as CLAAS. While there is a clear technological push toward automation across the agricultural workforce, the application of drones as complementary products beyond traditional machinery remains underdeveloped. This research investigates the role of drones from a user-centered perspective, assessing their desirability, feasibility, and viability while acknowledging the broader challenges facing automation in agriculture.

Several barriers currently hinder the adoption of new agricultural technologies. Among the most significant are limited knowledge, technical skills, and awareness among users, along with inconsistent information across communication channels. Social factors—such as low engagement, skepticism toward innovation, and resistance to change—also play a key role. On the economic side, weak incentives, high production costs, and limited willingness among consumers to pay premium prices further reduce the appeal of adopting advanced technologies. Practical challenges, including complex implementation processes, insufficient technical support, and high investment requirements, contribute to hesitation. Finally, regulatory uncertainties, unclear industry standards, and limited public funding reinforce risk aversion and a short-term decision-making mindset among farmers.

During interviews with farmers, After Sales representatives, and contractors, it became evident that the overall attitude toward automated delivery systems is cautiously positive. Stakeholders are open to the idea but express concerns regarding safety, operational procedures, and organizational responsibilities. These uncertainties led to the proposal of a structured user briefing to ensure trust and safe adoption. Although the actual time savings achieved through drone use were lower than expected, the qualitative value of improved connectivity, reduced waiting times, and potential task automation remains promising. Observing multiple drones per operator could further enhance efficiency and compensate for limited immediate time savings.

In terms of feasibility, drones currently appear to have limited short-term viability for CLAAS. However, by positioning itself as a service provider, CLAAS could leverage this technology to expand its automation portfolio. Integrating drones with existing tractor systems—either physically or digitally—could enable a more connected ecosystem. The drone may serve as a low-threshold entry point for farmers into data-driven operations, collecting valuable insights on machine use and maintenance. Prototyping demonstrated that the developed mechanism fulfills its function, though further refinement is required regarding surface friction, angles, and material behavior. By referencing the DJI M400 for electronic and structural components, the concept maintains a feasible foundation while visually aligning with CLAAS's product identity.

Future development could focus on refining the cargo mechanism, introducing motorized grabbers, and enabling modular attachments to connect with various CLAAS machines. Multiple drones could work collaboratively to transport heavier payloads, extending operational flexi-



Model	Salary saved (€)	Time saved (h)	Salary saved (€)	Time saved (h)	Salary saved (€)	Time saved (h)
Model 1- Small farm private	176.2	3.53	449.2	9.00	903.3	18.08
Model 2- Average Farm	1 471	29.42	2 939.5	58.79	5 878	117.56
Model 3- Big farm organization	905.5	18.09	2 210.5	44.19	3 261	65.21

A. Figure Sources



- Fig.1 Bildunterschrift
- Fig.3 Agricultural Trends, CLAAS Group
- Fig.4 Future Worlds Agriculture, Group Strategy CLAAS
- Fig.5 Challenges for farmers
- Fig.6 Average farm sizes, CLAAS KGaA mbH, 2025
- Fig.7 Farming incomes
- Fig.8 Bundesministerium für Ernährung und Landwirtschaft, 2024
- Fig.9 Average farm sizes, CLAAS KGaA mbH, 2025
- Fig.11 Average field proportions, Machl, Analyse landwirtschaftlicher Transportbeziehungen
- Fig.10 Farmstructure centralized and decentralized
- Fig.12 Functionalities of swarm robotics
- Fig.13 Nextat
- Fig.15 SAM Dimensions
- Fig.14 AgBot 5.115T2, Agxeed
- Fig.16 GROTHAUS
- Fig.17 CLAAS company philosophy
- Fig.18 Combine Harvester | Lexion, Tiron, Evion
- Fig.19 Forage Harvester | Jaguar
- Fig.22 Tractors | Xerion, Axion, Arion, Axos, Elios, Nexos
- Fig.20 Wheel loaders & Telehandler | Scorpion, Torion
- Fig.23 CLAAS Connect
- Fig.21 Implements | Mowers, Tedders, Swathers, Balers
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- Fig.25 Service Ecosystem CLAAS
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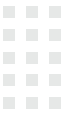
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C. Agricultural functions overview



👁 Watching

Documentation for public institutions
Straw distribution
Documentation for public institutions
Safe field work
Thermal imaging for hotspot detection
Monitoring hazardous materials
Water quality monitoring
Biodiversity conservancy
Forest mapping
Road traffic monitoring

Weed control

Watching the field for obstacles |
Watching livestock in the shed |
Watching livestock on open fields |
Watching multiple fields ||
Watching multiple machines at the same time |||
Watching livestock on open fields |
Watching road entries |

↘ Moving

Autonomous baling
Sensor Attachments on Lines (APG, 2024)
Wasp Prevention via Cellulose (Tree Copter)
Drone Delivery

Drug Delivery for Wildlife Medicine (Brügmann, 2024)

Moving fertile earth
Transporting fertilizer
Moving implements in tight locations
Moving items with drones
Moving attachments around on the field
Moving fooder around
Moving of multiple dirt samples
Moving away stones
Moving After Sales Items
Delivering After Sales Items

🔍 Transparentize

Fire scene assessment
Grain yield forecast
Construction sites
Woods mapping
Inspection of Overhead Power Lines
Weather Predictions (Meteomatics GmbH)
Strow forecast

Drying stress

Making weather predictions
Hovering over water supplies

+ Adding

Swarm drones
Adding communication points
Sensor Deployment in High or Inaccessible Areas (APG, 2024)
Fire extinguishers

Multiple drones to cover bigger area
Completing otherwise incomplete networks
Charging other electronic components
Adding familiar sensors to one system
Adding sensors to temporarily to a system

Adding personal objects
Adding charging opportunity

*≡ Single out

Recognition of garbage
Recognition of marine divers

Recognition of garbage
Ranking the fields

⚠ Warning

Disaster alert
Aerial reconnaissance & monitoring
Documentation of weather
Documenting of wild animal damage

Disaster alert
Aerial reconnaissance & monitoring

Documentation of weather

Documenting wild animal damage

📍 Locating

Bales logistics
Identification of weed nests

Temperature mapping
Accident victim tracing
Automated forest restoration
Search and rescue operations

Hovering around the machine

📄 Sorting

Interpretation of yield maps
Autonomous weed control
Detection of drying stress
Online determination of fertilizer

Sorting plant characteristics

⚠ Marking

Wildlife detection
Safe field work

Marking different heights

Marking boundaries to work at night
Marking spots in fields
Marking possible damages on machines
Marking dirt on machines

— Subtract

Drone Interceptor
Cleaning

Removing ground for testing

Cleaning of machine with compressor

Cleaning with wipers
Cleaning with sprayer

Cleaning out beddings

🔄 Changing

Autonomous baling

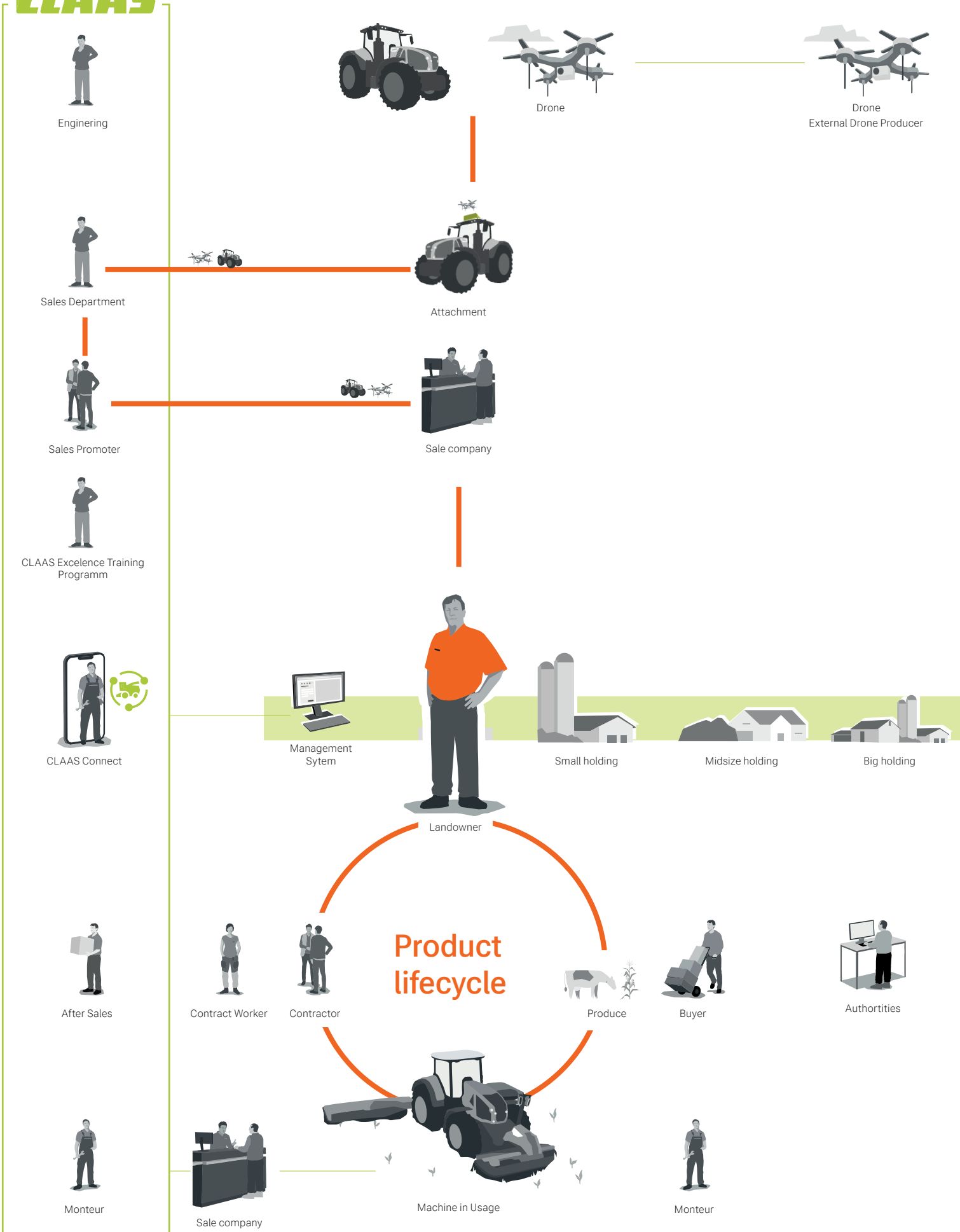
Carrying the equipment of one specific person

D. Stakeholder Analysis



Value Chain.

CLAAS



■ Expert Interviews

■ User Interviews



CLAAS

- 03 Group Strategy
- 12 Product Strategy
- 13 Sustainability

- 07 User Experience Design
- 14 Autonomy

- 01 Technology Engineering
- 04 Technology Management
- 08 Technology Scouting

- 09 Autonomous Networks
- 11 Plant growth Innovation

- 16 Aerospace Engineering
- 17 Robitization Agriculture
- 19 Aerospace Engineering



- 20 Sales Promotion

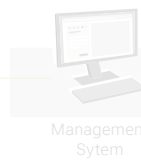
- 17 Dealer



- 02 Data Integration
- 05 Farmnet 365

- 01 Farm owner
- 04 Part-Time Farmer

- 06 Farm Owner
- 07 Family member

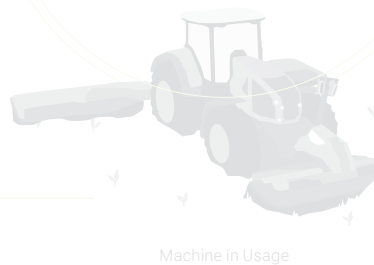


- 15 Customer Intelligence Management

Product lifecycle



- 02 Contract worker
- 05 Contract disponent

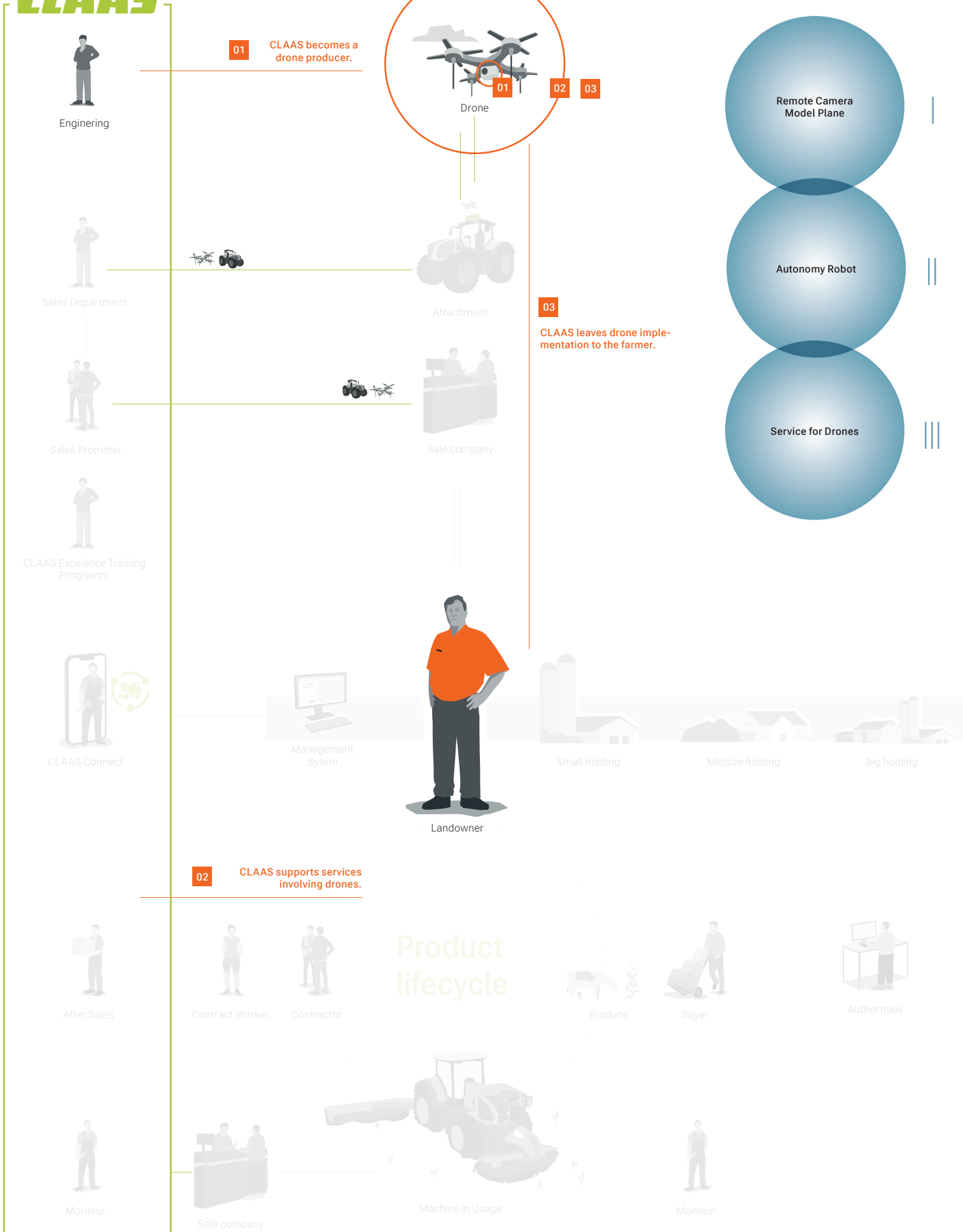


- 03 Dealer Maintenance



CLAAS

Value Chain.



E. Expert Interviews



Name	Role and Topic	Date	What does that mean for drones?
01	Technology Management; Drones at CLAAS, rones as Cost Improvement method	30.05	<p>Farmers show strong interest in stock management and fawn rescue use cases. Detecting points of interest like waterholes or stones is also appealing, especially for autonomous systems.</p> <p>Integrating drone data into CLAAS Connect aligns with CLAAS's digital strategy. Collaborating with Bayer avoids redundant development and strengthens the business case.</p> <p>While algorithms are essential for data interpretation, partnerships make development more feasible. Some regulatory barriers remain, especially for integrating drones into combine harvester workflows</p> <p>Drones are on the radar of CLAAS.</p>
02	PM Greenline & Material Handling; CLAAS Drones – Integration and Data format	05.06	<p>Farmers and developers see value in drones for detecting anomalies and wildlife (e.g. fawns), offering a unique vertical field view that machines and satellites cannot consistently provide.</p> <p>Implementing drones requires significant processing power, sensor positioning near the ground, and backend integration; coordination and real-time data comparison (e.g. via API) are still under development.</p> <p>CLAAS current focuses on data usability and integration rather than building drones in-house, with collaborations (e.g., FH Kiel, AgXeed) and external development offering faster and more economical paths to market.</p> <p>Platform integration is crucial.</p>
03	Manager Competitive Intelligence; Group Strategy	05.06	<p>Through all of the worlds there are different painpoints within agriculture which makes the field broad.</p> <p>Different sensor packages are needed for different applications, which make for a more expensive drone.</p> <p>The two Innovate Strategies sound the most promising for the Drone implementation.</p>
04	Technology management; Technology Push	06.06	<p>Drones could help farmers communicate on their sustainability efforts in terms of biodiversity.</p> <p>Specific system architecture (Tree plan) is needed for the use case.</p> <p>A lot of the ongoing projects are basic research, which is only done in collaboration with external partners.</p>
05	Digital System Telematics; Farmnet 365	06.06	<p>Farmers value drones for precise imaging and weed detection, especially when weather permits effective use.</p> <p>Coordinating drone data requires high computational power and faces interference issues, making real-time processing complex and time intensive.</p> <p>Drones can support yield analysis and straw distribution insights.</p>
06	Hunter; Young Deer Rescue	10.06	<p>There is a fear of the farmers to kill animal and there are efforts to recultivate their land with them.</p> <p>The organisation of drone coordination data takes time.</p> <p>Drones are implemented for deer rescue regardless of the available machines. The car that is carrying the drone carries a self made charger unit.</p>
07	Head of UX; Design at CLAAS	11.06	<p>There is a clear need to harmonize user experiences across CLAAS products by addressing the gap between user expectations and internal company perspectives, especially through a unified visual and interaction design.</p> <p>UI development faces complexity due to layered systems (UI, software, electronics), and regulatory constraints like emissions and permits remain major internal blockers to rethinking interfaces and physical components.</p> <p>To align UX work with business goals, introducing metrics like a UX Score could help quantify improvements and support strategic growth, particularly in the North American tractor segment where customer loyalty is a key long-term asset.</p>
08	Manager Technology Scouting; Innovation Management at CLAAS	12.06	<p>CLAAS is technology PULL driven.</p> <p>CLAAS as a drone producer CLAAS supports services CLAAS leaves drones to the farmer</p> <p>greater internal motivation for sensor production.</p>
09	Researcher Autonomous Networks; Drones	16.06	<p>Drones offer meaningful value in surveillance applications for logistics, forestry, and resource monitoring, especially when used agnostically across machine types.</p> <p>Takeaway from Feasibility: Drone deployment in Germany faces regulatory challenges, including mandatory human supervision, which complicates continuous or autonomous operations.</p> <p>Takeaway from Viability: The break-even point between drone deployment scale and cost efficiency is crucial; energy usage and integration into existing infrastructure (e.g., parking systems, radar for pipelines) influence the business case.</p>



Name	Role and Topic	Date	What does that mean for drones?
10 Julian Austermann	Hunter; Deer Rescue	17.06	<p>There is a fear of the farmers to kill animal and there are efforts to recultivate their land with the...</p> <p>The organisation of drone coordination data takes time.</p> <p>Drones are implemented for deer rescue regardless of the available machines. The car that is carrying the drone carries a selvemade charger unit.</p>
11 Amazone	Field Day Plant growth Innovation	17.06	<p>There is a AHA moment missing for farmers, after the rapid popularity of drones. Saving material varies from plant to plant. Giving the farmers the tool for field research.</p> <p>It is a complex system that involves Data aquisition, Data handling and drone operation. Economic success is an accumulation of plant growth, ground coverage and ground characteristics (moisture, force)</p> <p>Drone docs need energy supply and maintanance. Drones for application are bought and modified with additional hardware.</p>
12 Martin Leinecker	Senior Manager Product strategy	23.06	<p>Technology benchmarking is performed every two years. Drone developements can be considered.</p> <p>Trying to reduce the complexity of feature configurations. Nine fields of technology where drones can be filled in.</p>
13 Max Wirth	Sustainability at CLAAS	24.06	<p>Motivated externally. Sustainability needs to be activated along the supply chain and while the product is in use.</p>
14 Marc Boekh	Road to Automation and Autonomy; Autonomy at CLAAS	25.06	<p>Goal is to free up farmers' time for social interaction and value-creating task. Field measurement is one relevant use case linked to both sales and after-sales services. Shortage of technical expertise among available workers.</p> <p>Ensuring realistic application of autonomous systems through dealer channels.</p>
15 Katharina Fueller	Customer Intelligence Management; Customer Satisfaction	26.06	<p>CLAAS focuses particularly on Optimistic Pioneer and the Demanding Innovator. CLAAS positions itself in the technology-driven premium segment. Target group: Farms with 50+ hectares</p>
16 Marja Popovic	Assistant professor Aerospace engineering;Software restrictions drone	30.06	<p>Effective drone deployment outdoors requires interaction of multiple variables, such as lighting, surface conditions, and flight stability.</p> <p>Restricted memory requires algorithms to operate on scaled-down data, reducing resolution and complexity.</p>
17 Marius Monen	AgriTech Innovation in Europe and The Netherlands; Robotization in Agriculture	01.07	<p>Use robotics to reduce labor costs, making sustainable methods more financially viable. Drones are seen as highly effective scouting tools</p> <p>Swarm robotics are promising, but algorithms remain difficult to implement reliably. Strong local engagement— aesthetics and visibility matter.</p>
18 Tobias Dorsch	Disponent	07.07	<p>Use case for optical damage analysis is considered, but complex damage cases would still require human expertise. Existing dealer network ensures proximity, with each branch reachable within one hour.</p>
19 Mojib Shi	Aerospace Engineering and Cyber Zoo	11.07	<p>Static environments are easier to manage and yield more stable performance. Data handling decisions depend on operational vs. analytical needs.</p>
20 Hendrick Flessner	Sales Promoter combined Harvester	23.07	<p>There's a push toward making machine performance less dependent on user expertise.</p> <p>Drones are envisioned as tools for real-time decision-making, e.g., whether to drive left or right on a given parcel.</p> <p>Drones should help anticipate field conditions, like soil firmness or upcoming wait times. For example: "Will the cultivator sink in?"—an input drones could help assess.</p> <p>Charging infrastructure—returning for recharging frequently becomes disruptive and inefficient.</p>
21 Shlomit Falvel	Digital User Experience; CLAAS Connect	25.07	<p>Managing a mixed fleet remains challenging: in some cases, data input still requires physical media, such as USB sticks.</p> <p>We rely on users having a degree of technical affinity, as some features require expert-level input</p>



01. CLAAS. Technology Management.

CLAAS Core Business: Focused primarily on grain harvesting.

Motivation for Drone Use: High production costs drive the exploration of multiple drone use cases.

Main Use Case Categories:

Scanning (e.g., sensing, data collection)
Application (e.g., spraying, seeding)

Regulatory Barriers: Current drone regulations are not user-friendly and restrict broader implementation.

Sensing Use Cases for Drones
Drones can act as:

Sensors themselves, or Carriers for advanced data-gathering sensors.

The most practically relevant use case for farmers: Stock Management (e.g., monitoring crop growth or biomass).

To make drone data usable, it must be translated through suitable algorithms.

CLAAS Connect (formerly 365FarmNet) could serve as the interface for data integration and visualization.

Algorithm Development & Partnerships
Developing proprietary algorithms may not be efficient—other companies like Bayer are already active in this space.

Recommendation: Collaborate with Bayer to explore integration of their algorithms into CLAAS Connect and develop a shared business case.

Additional Use Cases with Value
Deer/Fawn Rescue: A highly appreciated feature among farmers.

Detection of Points and Areas of Interest (POIs/AOIs):

Past research involved thermal DRONES GmbH and AgXeed BV, focusing on fawn detection. This detection approach could be extended to identify:

Stones (risk for equipment damage)
Waterholes (relevant for autonomous vehicle navigation)

Other Emerging Use Cases
Flexible Tillage: Promising potential but requires further investigation.

Harvest-Related Use Cases:

Crop ripeness monitoring
Straw distribution analysis

These require deeper technical exploration and validation.

Constraints
Despite technological readiness, integration of drones into combine harvester workflows is limited by regulatory restrictions, delaying full deployment and value creation.

02. Drone Data Integration.

FH Kiel Projects & Anomaly Detection
Twofold collaboration projects at FH Kiel focus on:

Anomaly detection in fields through drone imagery

Wildlife detection using thermal drones (Terminal Drone project)

Key contributors include Patrick Ahlbrand, Jan Hendrik Ferdinand, and Christoph Molitor.

FH Kiel supports digitization and field analysis to enable better agronomic decision-making.

Primary goal: Highlight anomalies and support automation across workflows.

Thermal Drones & Wildlife Detection
Thermal drones are used to identify young deer and ground-nesting birds.

CLAAS aims to integrate thermal drone data into its UI and backend systems.

Visualization of data points should ideally occur within CLAAS Farm Connect.

New requirements may emerge beyond just data analysis (e.g., alert systems).

Goal: Automate data comparison via API integration into CLAAS systems.

Drone System Considerations
Product managers are responsible for defining drone integration specifications.

Drones must contribute to overall machine efficiency, e.g., reducing downtime.

A key benefit: drones can offer a vertical view into dense crop canopies—unlike ground-based sensors.

Compared to satellites, drones provide more up-to-date, high-resolution imagery, although satellites are currently more widely used.

AgXeed uses thermal drones for object surveillance, with precise geolocation via RTK.

Backend integration of drone data into CLAAS platforms is a central development goal.

Automation, Communication & Backend Integration
Christoph Molitor is focused on tractor automation and developing European standards for machine-to-machine communication.

Felix Bistrütz oversees CLAAS's digital system architecture in Dissen.

There is active collaboration with external equipment manufacturers (e.g., Amazone, Bosch) to ensure attachment compatibility.

Use cases like spot spraying are technically more demanding and require more sophisticated control systems.

Data use cases are predominantly backend-oriented, with a strong focus on intuitive usability for farmers.

Automation and route planning depend on reliable field anomaly detection (e.g., for obstacles, crop health zones).

Differentiated Farm Requirements & Technology Drivers
Requirements may vary across different types and scales of farms (e.g., commercialized vs. family farms).

The push for drone integration is a technology-pull rather than a market-push.

Large-scale drone applications like 3D scanning require substantial processing power and backend infrastructure.

Specific Use Cases and Business Models
Pesticide application could form a distinct business case—likely suitable only for specialized drones.

Young deer detection is currently one of the few universally accepted and socially supported drone applications.

AI may support these applications by enhancing detection accuracy in cases with minimal temperature differences.

Strategic Focus & Development Outlook
CLAAS does not currently have sufficient in-house capability to develop a cost-effective drone platform.

Rapid development cycles by drone leaders (e.g., DJI) suggest external partnerships may be more efficient.

CLAAS's strategic focus is on data integration and usability for end-users rather than building hardware.

Some sensors (e.g., multispectral, radar, lidar) require very low flight altitudes—close to the crop level—for accurate data capture.



03. CLAAS. Group Strategy.

Implementation Strategy

The overall goal is to implement strategic developments within the company through project management (PM).

Focus lies on areas where relevant teams are already operational or active.

Trend Analysis & Scenario Planning

A systematic trend analysis is conducted to identify potential future developments.

Based on this analysis, three different future scenarios are created.

Scenarios are color-coded to differentiate between them—however, determining which one is most likely is intentionally avoided.

The purpose is not to predict but to prepare for multiple plausible outcomes.

Scenario-Based Preparation

Strategic planning focuses on addressing outcomes that are relevant across all three scenarios.

Identified actions are categorized as:

Should: Essential actions that must be taken

Could: Recommended but optional actions

Nice-to-have: Beneficial if feasible, but not critical

This approach ensures preparedness for diverse future developments, regardless of which scenario materializes.

Additional Notes

Ulla Wellenstein is involved in marketing aspects of the strategic scenario planning process.

Future direction will follow a scenario triad model, guiding long-term strategy across uncertainty.

04. CLAAS. Technology Management.

Research & University Network

Responsible for maintaining connections between research and university networks.

Occasionally participates in young deer rescue missions using drone technology.

Imaging & Sensing Capabilities

Uses thermal imaging to analyze absorption behaviors in roots and seeds.

Operates a multispectral drone for capturing detailed field data.

Interested in changing sensor packages, which requires adaptable drone structures and leads to varied hardware configurations.

Photogrammetry (photo clouds) is used to observe discrete objects and potentially measure features like swath size („Schwadgröße“).

Functional & Technical Considerations

Emphasis on drone functionality as a core development driver.

Drones have a minimum flight speed requirement at launch, which influences operational design.

Different drone structures may be needed depending on the sensor package and application.

In autonomous systems, the absence of human operators introduces new challenges, particularly in observation and decision-making.

Vertical heat analysis enables inspection of thermal patterns in living things (e.g., animals, nests, or individual plants).

Detecting plant location and height can support more efficient workflow design.

Broader Applications of Drone Technology

Drone use goes beyond agriculture—also applied to AGRI PV:

Monitoring and inspection of photovoltaic (PV) field structures

Control of infrastructure and component wear

Can also be applied for biodiversity assessment, such as analyzing insect diversity across landscapes.

Environmental & Operational Challenges

Drones are capable of detecting environmental obstacles, including wind and weather conditions, which affect autonomous navigation and safety.

Strategic Considerations

A central question in drone deployment: What do I want to answer with this system?

Emphasis on system architecture tailored to specific drone use cases.

Both system design and question clarity are crucial for meaningful application and integration.

Notable Contributors

Key individuals involved: Jens Vogt and Torsten Starck.



05. CLAAS. Farmnet 365.

Background & Collaboration

Participates in a university project with Jena focused on agricultural drone data.

Works at FarmNet365, contributing to digital farming initiatives and platform integration.

Sensor and Imaging Technologies

Various service sensors are used in farming applications, including:

Steering sensors

Plant sensors for crop health and nitrogen management

CLAAS has in-house drones equipped with infrared sensors, supporting precision farming tasks such as fertilizing, plant protection, and disruption detection.

Radar-based drone testing has been conducted internally.

Satellite imagery is widely available and affordable, but developing a CLAAS-specific satellite service requires:

Sales infrastructure

Partner training

After-sales support

Drone Use Cases & Applications

Drones are used for:

Precision imaging, Weed detection, Route planning

Crows have interfered with drone flights during past tests, indicating risks in real-world usage.

Drones with RTK (Real-Time Kinematic) positioning have been used in robotic innovation projects for:

Obstacle detection

Cartation (mapping and movement planning)

Drones complement satellites by offering:

More up-to-date and targeted data

Vertical perspective through dense canopies

Technical & Operational Considerations

3D imaging with drones requires substantial computational power.

External image quality and lighting must be considered when analyzing data.

It takes time to learn the required software and upload the data reliably.

Environmental factors (e.g., wind, weather) and field infrastructure (e.g., charging stations) affect drone operation.

The application must be clearly defined:

What is the use case?

Which angle is most useful?

What are the time and cost implications?

Costs and Efficiency

Outsourcing a drone-based field analysis costs around €1500 per operation.

Operational flexibility is essential, including:

Adjusting flight areas and operational modes

Managing legal documentation

Internal CLAAS efforts have explored use cases such as:

Straw distribution analysis

Grain yield estimation (still difficult to quantify accurately)

Digital Strategy & Software Integration

Key question: Who holds expertise in system, software, and technology development within CLAAS?

CLAAS aims to scale its systems internationally while maintaining software efficiency.

30 years of software experience exist within CLAAS, but the internal development team is relatively small.

Current efforts are focused on integrating telematics functions into CLAAS Connect.

The strategic emphasis is on data integration and using existing digital tools to avoid redundant development.

John Deere is seen as a current leader in digital farming efficiency.

06. Hunter.

Voluntary Drone Operations

Young deer surveillance is conducted entirely on a voluntary basis.

Additional use cases include:

Escaped livestock such as beef cattle

Lost dogs

Wildlife accident support

Equipment & Maintenance

Drones currently in use are not water-resistant; there are plans to 3D print protective covers.

Maintenance needs mainly relate to the propulsion system.

Various drone models require different charging modules, which adds logistical complexity.

A portable charger is used, capable of charging four batteries simultaneously, ensuring operational readiness.

Due to battery charging cycles and wear, batteries can bloat over time and must be replaced regularly.

Operational Infrastructure

A custom wooden landing pad has been built to:

Mark drone landing zones clearly

Improve operational safety and coordination

Field operations primarily occur from April to August, aligning with the active wildlife season.

Flight Planning & Execution

A programmed flight altitude of 50 meters and a speed of 4 m/s is used during missions.

Quick response to weather conditions is essential, particularly because cold temperatures pose a risk to young animals.

A high level of pre-planning is required, which has led to a field categorization system that allows areas to be communicated quickly and clearly.

Summary

Drones are actively used as a community tool during the summer season, supporting both animal welfare and local coordination efforts.



07. CLAAS. User Experience.

Role & Department Focus

Main responsibility is to identify opportunities for UX design within CLAAS products and processes.

The department operates within a diverse team, with various backgrounds, disciplines, and personalities.

Design Direction & Product Consistency

Historically, CLAAS had a heterogeneous product design; the current goal is to create more homogeneity across the product portfolio.

For industrial design, a Y-shape design language was introduced across machines.

The next area of focus is the "face" of the machine, aiming for further visual and functional unification.

User Interface & System Architecture

CLAAS introduced CEBIS in 2010 to establish a holistic interface, particularly through consistent symbol usage.

There is no universal user journey that applies across all CLAAS products.

The cab environment presents significant complexity due to:

UI and display layout

Software capabilities

Electronic signal processing

System architecture

Key figures in UI development include Erik Bachmann and Schlumit Feiwil.

UX and Organizational Strategy

A central challenge is the tension between the user's perspective and CLAAS's internal viewpoint.

The User Experience department sees its role as connecting UX outcomes with business KPIs.

A potential approach could be the development of a UX Score, which would allow tracking improvements over time.

Currently, customer loyalty KPIs do not reflect the impact of UX work effectively.

Persona Development & Use

Existing marketing personas are primarily focused on market segmentation, not on user behavior or needs.

Project-specific personas have been developed, for example in autonomy-related initiatives.

Strategic Involvement by Innovation Area

In the "Grow" strategy sector, the tractor is a major focus—especially for the North American market, where it holds the most growth potential.

In the "Innovate" sector, the User Experience team is involved in all relevant topics.

In the "Sustain" sector, cabin-related design and usability are key areas of involvement.

Constraints & Cultural Factors

Internally, pain points are needed to drive change, including rethinking both the exterior and first-level interior components.

Regulations (e.g., emission limits and permits) are seen as some of the biggest internal constraints.

The technological ceiling for tractors may have been reached, making longevity and quality more important differentiators for CLAAS.

Interdisciplinary collaboration is essential; each discipline must be given space and respect for productive teamwork.

08. CLAAS. Technology Scouting.

Role and Technology Scouting

Main responsibility is technology scouting and aligning emerging technologies with internal company knowledge.

The topic of drones has appeared and disappeared multiple times within internal discussions.

Key question remains: What role should CLAAS play in drone technology?

Decision-Making Framework

A threefold decision matrix is used to evaluate new technologies from the perspective of:

CLAAS (company)

Dealer network

End user (farmer)

Based on this, there are three levels of possible involvement in drone technology:

CLAAS becomes a drone producer

CLAAS supports services involving drones

CLAAS leaves drone implementation to the farmer

User & Market Understanding

Internally, there are many opinions about drones, but few direct conversations with actual users.

Jonas Schöne conducted interviews with farmers, considering different regions and farm sizes in Germany, but dealers were not included in that process.

Drones are seen open-mindedly, especially given that satellites can already perform some overlapping tasks.

Internal Innovation Culture

No further development has occurred due to internal cost-cutting measures.

Innovation is usually pull-driven:

Internal pain points are identified

External solutions are then explored

Push-driven innovation is rare and typically lacks internal support unless an internal advocate is present.

A current internal project is exploring hay distribution, indicating targeted innovation around specific agricultural workflows.

Positioning of Drone Technology

Drone technology is inconsistently classified—sometimes seen as an independent topic, and sometimes as part of the sensor category, with the drone acting solely as a carrier for sensing equipment.

There is no fixed position for drone development within the company's strategy.

Strategic and Competitive Context

Technology strategy is embedded in the "Innovate" strategy track, overseen by Felix Giesker, within a group-level tech strategy unit.

8–9 technologies are currently being tracked as push factors in innovation.

CLAAS's core business remains focused on grain and food harvest machinery.

Compared to competitors (e.g., AGCO), CLAAS is seen as more conservative and grounded.

At Agritechnica, many competitor concepts were bolder and more experimental, even if only 5% were market-ready.

Other companies are more likely to tell clients what they might need, whereas CLAAS tends to respond to identified needs.

This is seen as an area for potential improvement at CLAAS.

Evaluation of Drone Relevance

For investment decisions, a central question is: How close is the technology to CLAAS's core business?

Drone use cases are most relevant when tied to food harvesting, which aligns directly with CLAAS's expertise.

It may be beneficial to reframe the approach by asking:

What can I observe better from above?

What specific problems can drone-based perspectives solve in the field?



09. Autonomous Networks.

10. Young Deer Rescue.

Context and Setting

The narrator took part in a wildlife rescue operation aimed at detecting and relocating fawns (Rehkitz) before mowing and other agricultural activities.

The effort was organized by a local hunting and conservation group, involving:

Volunteer drone pilots and runners

Supporters and local landowners

Organization and Roles

The operation followed a structured schedule and clear role distribution:

Drone pilots (approx. 7 certified individuals)

Field runners (Läufer), often working in pairs with a drone pilot

Support volunteers and landowners occasionally assisted on foot

Participants were equipped with:

Flashlights or headlamps

Gloves

Walkie-talkies for field communication

Plastic laundry baskets to safely transport rescued fawns

Process and Workflow

Meeting Point and Coordination:

Volunteers met at a predetermined location; drone teams were assigned specific fields for the morning.

Drone Setup:

Drones were transported in designated vehicles and required manual wing assembly before takeoff.

Flight paths were pre-programmed, typically in a zigzag pattern, flying at 50 meters altitude.

Field Operations:

In large fields, runners entered while the drone was flying; in smaller fields, they waited for a sighting first.

Items like plastic bags or deodorant spray were used in attempts to repel animals, with mixed effectiveness.

Communication relied on walkie-talkies, often using directional cues (e.g., "90 degrees" or "left of the tree line").

Fawn Rescue Procedure:

When a fawn was detected, runners carefully approached and placed it into a basket.

Animals were carried to adjacent safe zones to prevent return to the original field.

Rescuers occasionally encountered resistance from the fawns, requiring calm handling.

Observations and Challenges

Human Dynamics:

Volunteers ranged from retirees and hunters to younger participants.

Many were affiliated with shooting or hunting clubs.

Team spirit was strong, supported by shared breaks, casual conversations, and mutual assistance, despite occasional conflicts or miscommunication.

Technical Issues:

Drones experienced startup failures or landing problems, often due to nearby people or obstacles.

Inaccurate field maps led to navigation errors and mismatched expectations on site.

Animal Behavior:

Fawns showed varied reactions: some remained motionless; others fled immediately.

Screaming during handling indicated stress in some animals.

Other species (e.g., birds, pheasants) were also encountered and manually chased off to prevent injuries.

Reflections

The operation demonstrated both the potential and limitations of drone-assisted wildlife rescue.

It was a highly community-driven effort, relying on volunteer engagement, donations, and local knowledge.

Despite technical and logistical obstacles, the initiative proved to be a realistic and scalable model for wildlife protection during the mowing season.



11. AMAZONE. Field Day.

Focus: Drone-based field management, agronomic insights, and spot spraying.

AmaSpot, AmaSelectspot (spot spraying systems)
SmartSprayers from Bosch & BASF – showcasing varying approaches
Farmdroid – automated farming platform
Dronewerkers – drone use in vegetable farming
Fertisplot – localized fertilization technology

Scout drones – essential part of field operations
Crop Focus: Sunflowers and maize highlighted as relevant crops for drone integration.

Spot spraying applications are currently limited to vineyards.

Acknowledged complexity and variability of real-world conditions as a challenge.

Emphasis placed on careful evaluation of effort vs. benefit in drone deployment.

M2xexpert / M2x
Focus: IT-based drone workflows and drone service provision.

Technologies and Tools:
Farmtune – centralized drone management platform
Integration of drones, robots, and AI
Use of thermal and multispectral imaging

Drone docks (stationary/mobile) with inductive charging
DJI-based flight planning, adjusted dynamically by time and weather

Panorama imaging used for insurance damage assessments

Operational Insights:
Drone docks require frequent recalibration

Remote access must align with regulatory requirements; human intervention remains necessary

Operations depend on stable power (230W) and internet access
Data & Performance:
Imaging resolution: 1mm/px, with RGB and zoom capabilities

Offers affordable automation for field scouting
Employs geostatistics for simplifying data extraction

Long-term goal: Enable regionally comparable, simplified datasets

Phenoinspect
Focus: AI-powered visualization tools for smarter, more efficient farming.

Technologies and Capabilities:

Distel mapping (thistle identification and management)

Coverage rate: 10 hectares in 10 minutes
User-controlled self-service spraying options

Commitment to explainable AI – moving away from “black box” algorithms

“Farm smarter, not harder” – highlights simplicity and precision over intensity

SAM Dimensions
Focus: AI-enhanced aerial mapping and spot spraying.
Process Workflow:
Initial contact → Aerial flight → Data analysis → Targeted application

Technology:

SAM CAM AI Mapping System
Multi-camera rig providing 3x image resolution
Object detection down to 21x object size precision
Compatible with multiple sprayer formats

Practical Notes:

Requires lead time to configure sprayers and match data output
Especially valuable for large-scale operations and herbicide efficiency

AgDoit
Focus: Transforming agricultural data into usable agronomic knowledge
Platform: Built on ISO Farm Research standards
Application maps for field trials and agronomic planning

Simplified plot setup and test design
Yield mapping and crop observation tracking (Bonituren)
Integrated documentation and flight mission logging

Strategic Goal:

Convert operational data into context-aware, actionable knowledge for improved farm decision-making

12. CLAAS. Product Strategy.

Product Strategy – Tractors & Implements
Focuses on product strategy, including:

Roadmapping, product management, and complexity management

Involved in the Boost Baler Project

Conducts market segmentation per machine type

Technology benchmarking is performed every two years

Applies the MTA (Market–Technology Alignment) framework

References VDMA as an external information source

Uses milk and meat prices as indicators for market conditions

Strategic focus remains on food harvest machinery, core to CLAAS’s identity



13. CLAAS. Sustainability.

ESG Reporting at CLAAS

ESG activities are driven by Omnibus regulation, requiring structured sustainability documentation.

Out of 1000 initial data points, 500 were identified as relevant for CLAAS.

The EU provides a scoring model, but not the process for achieving the score.

Two-thirds of the report focuses on qualitative methods and assessments; the final third covers CSDR data points (mandatory disclosures).

Internal stakeholder discussions involve departments like Sales, HR, and Work Security.

Focus Areas and Strategic Positioning

ESG reporting emphasizes internal company processes, with attention to both acquisition and end-of-life cycle phases.

Current reports do not suggest concrete actions, but aim to promote transparency and initiate internal dialogue.

CLAAS is internally aligned with Goal 2 (e.g. food security); Goal 15 (biodiversity) is not currently addressed.

Key Challenges and Opportunities

The supply chain is the primary source of emissions, making the dealer department central for CO2 reduction strategies.

The long-term objective is to create mutual value and rethink operational processes through a sustainability lens.

14. CLAAS. Autonomy.

Autonomy in After Sales – Sales Management Perspective

Located within the After Sales department, focusing on Sales Management for autonomy implementation.

Responsibility: Ensuring realistic application of autonomous systems through dealer channels.

Dual perspective:

Product vision (technical possibilities)

Market vision (customer relevance and usability)

Personal emphasis is placed on maintaining a user focus, balancing innovation with real-world needs.

User Needs and Value Creation

Goal: Free up farmers' time for social interaction and value-creating tasks, such as:

Spending more time with family

Engaging in strategic or knowledge-intensive work

Recognizes:

Limited labor force in agriculture

Shortage of technical expertise among available workers

Strategic Use Cases & Setup

Field measurement is one relevant use case linked to both sales and after-sales services.

Autonomy project structures are still in early development phases.

Touchpoints exist with ongoing work led by Jonas, particularly in user research and pilot programs.

Long-Term Integration

Emphasis on aligning autonomy with sales strategies to enable continuous revenue generation and sustainable dealer involvement.



15. CLAAS. Customer Intelligence Management.

BUSS – Market Engagement and Customer Insight
Acts as an internal service provider for CLAAS, conducting market studies on focused topics.

Primary goal: Understand user experience with CLAAS machines across different markets.

Supports market-specific product engagement and feedback cycles.

Customer Loyalty & Strategic Use
Manages the CLI – Customer Loyalty Indicator to track whether customers return to CLAAS products.

CLI is used strategically as a benchmark and target for improvement.

Conducts win-loss studies to understand customer decisions.

Segmentation and Target Groups
Customer base is classified into segments, each making up approx. 25%.

CLAAS focuses particularly on:

The Optimistic Pioneer
The Demanding Innovator

Departmental Integration and Surveys
Other departments (e.g., After Sales, Hand Over) further define customer journeys based on BUSS findings.

BUSS runs online surveys at 3 months and 1 year after purchase.

Uses a 5-point Likert scale

Covers 33 countries

Sends 5,300 survey templates, generating approx. 10,000 responses/year

Market Orientation
CLAAS positions itself in the technology-driven premium segment.

Market perception varies by country and product category.

Target group: Farms with 50+ hectares, aligning with CLAAS's product offerings.

16. TU DELFT. Aerospace Engineering.

Application Scenarios for Drones
Recognition of marine divers

Detection of garbage
Monitoring of weed infestation

Temperature mapping for agricultural and environmental analysis
Identification of firewood concentrations in forests for wildfire risk assessment

Considerations for Outdoor Use
Effective drone deployment outdoors requires interaction of multiple variables, such as lighting, surface conditions, and flight stability.

Drone usage should be understood along a spectrum of automation, depending on environmental control and data processing capabilities.

Technical Challenges
Limited onboard computational speed constrains real-time processing capacity.

Restricted memory requires algorithms to operate on scaled-down data, reducing resolution and complexity.

Outdoor environments introduce uncontrolled noise, such as light reflections and shifting weather conditions, which compromise sensing accuracy.

Achieving resilience in performance under varying environmental conditions remains a core difficulty.

Software Limitations
DJI software is not fully open source; although integration bridges exist, implementation is complex and often limited in flexibility.



17. Robotization in Agriculture.

Research Focus – Sustainable Farming in North Brabant
Researcher specializes in sustainable farming systems and biodiversity in North Brabant.

Works ahead of the market with innovative farmers to explore new agricultural methods.

Biodiversity and Labor Substitution
Biodiversity-focused farming is labor-intensive.

Goal: Use robotics to reduce labor costs, making sustainable methods more financially viable.

Robots can operate continuously (day and night), increasing efficiency over human labor.

Consequence of increasing biodiversity: introduces more complex and laborious systems.

Technologies and Practices
Drones are seen as highly effective scouting tools; satellites are considered less precise for ground-level monitoring.

Strip cropping is a practical entry point for sustainability at scale.

3 meters is considered the ideal strip width.

Pixel cropping offers more biodiversity but is even more labor-intensive.

Machinery and Robotics
Large machines can be adapted for strip cropping with minor modifications.

Smarter machines or robotic systems are essential for managing heterogeneous environments, such as:

- Strip cropping
- Mixed cropping
- Pixel cropping

Swarm robotics are promising, but algorithms remain difficult to implement reliably.

For grain, large machines will still be needed, even in future mixed systems.

Socioeconomic and Systemic Factors
Many conventional farmers are locked into previous investments, making transition difficult.

Optimization rhetoric („feeding the world“) is seen as outdated and disconnected from local realities.

Current high productivity models with low input often result in nutrient-poor food.

Sustainable change must include:

- Adjustments in the food chain
- Institutional incentives to support biodiversity
- Strong local engagement— aesthetics and visibility matter:

“Why should I care for strip farming?“ → It must be visible, local, and emotionally engaging

18. Disponent.

Vision for the Future – Dealer Ecosystem
Part of a Germany-wide collaboration of six groups shaping a future vision for agricultural dealer ecosystems.

Projects prioritize client-oriented processes, especially in service and development.

Drone-Based Logistics Concepts
Concept: Drones deliver spare parts directly to customers in the field (e.g., belts or urgent components).

Alternative use case: Transporting parts between branch locations.

Estimated cost: ~€50,000 per drone system

Range: 20–30 km

Idea remains on hold as other projects currently take priority.

Operational and Regulatory Challenges
Drone operation would require a setup similar to an airline:

- Company head, certified operator, and spotter
- Licensing is the most significant barrier.

Key questions driving the project:

- How does it work?
- What does it cost?
- Only later: Is it desirable?

Dealer Network and Proximity
Existing dealer network ensures proximity, with each branch reachable within one hour.

Use case for optical damage analysis is considered, but complex damage cases would still require human expertise.

Future Technologies & Learning
There's interest in personally learning new skills to support future drone service operations.

Related exploration: use of Apple VR to support field maintenance, providing visual repair instructions directly in workers' view—comparable to an “Iron Man” interface.



19. TU DELFT. Aerospace Engineering.

Drone BOM and Technical Setup
Building an entire drone was considered out of scope; focus was placed on key components.

Project duration: ~2 months, with significant challenges around parameter calibration.

Cost Breakdown (Approximate)
Processor: €2,000

Additional components: €500

High computational demands increased overall system cost.

Communication & Data Handling
Transmission via dedicated protocols is more secure than Wi-Fi.

Trade-off consideration: Does the operator need real-time access to the data?

Data handling decisions depend on operational vs. analytical needs.

Environmental Interaction & Navigation
Equipped with a depth sensor to analyze surroundings.

Works in dynamic environments, though response remains relatively slow.

Static environments are easier to manage and yield more stable performance.

Drone positioning relies on reflective markers scanned by a system of 9 cameras.

Power & Thermal Management
Flight time: Approx. 15 minutes per battery package

Aluminum used as a cooling element for heat-intensive components

20. CLAAS. Sales Promoter.

Role of the Sales Promoter

Acts as a field contact after machine purchase, visiting each customer to ensure proper use and understanding.

Positioned near After Sales, but does not provide mechanical or electrical support.

Offers low-level technical support, primarily by listening to farmers' general concerns—often in informal settings (e.g., "over a cold one").

Training and Knowledge Transfer

From January to May, two farmers per farm are invited to participate in machine workshops.

Key topics include:

How to use the machine correctly

What features are available and how to operate them

Clients transitioning from other brands are given priority in onboarding and support.

Xemos automatic system frequently requires additional explanation.

Particular focus on:

Cutting mechanisms and error troubleshooting

Teaching drivers basic operational knowledge

Ensuring a clean setup to reduce plant loss

User Adaptation and Technology Growth

As technology evolves, drivers must keep up; ongoing support and training are essential.

There's a push toward making machine performance less dependent on user expertise.

Long-term aim: partially automate decision-making, enhancing consistency and efficiency.

Dealer Interaction and First Impressions

Local dealers are the main communication link for farmers—integral to follow-up and support.

CLAAS benefits from a broad local dealer network rather than relying on fewer, centralized locations.

First impressions are seen as crucial to long-term satisfaction.

Each new machine delivery is logged in a list by end of May.

Learning Systems and Peer Interaction

Driver learning is often peer-driven, supported by internal systems like PEER and PU (product updates).

The learning process relies heavily on individual interest and initiative.

Harvest Logistics and Drone Use

A 25-day harvest window requires precise planning and support.

Drones are envisioned as tools for real-time decision-making, e.g., whether to drive left or right on a given parcel.

Farms often manage 200–300 parcels, requiring effective route planning.

Drones should help anticipate field conditions, like soil firmness or upcoming wait times.

For example: "Will the cultivator sink in?"—an input drones could help assess.

Automation Vision and Constraints

Vision: Monitor during the day, let machines operate autonomously at night.

Main barrier: Charging infrastructure—returning for recharging frequently becomes disruptive and inefficient.



21. CLAAS. CLAAS Connect.

Farmnet 1.0 featured a clear separation between machine management and farm management.

Today, the two areas are visually integrated, but further development is required to fully merge them on the software level. Certain datasets still need to be migrated.

The system remains technologically monolithic—new functionalities are embedded in a web of interdependencies.

A guided support feature is available, providing users with contextual feedback.

We rely on users having a degree of technical affinity, as some features require expert-level input.

Basic functionalities are now established. The next steps include robust reporting and advanced analytics.

Managing a mixed fleet remains challenging: in some cases, data input still requires physical media, such as USB sticks.

The goal is to create a globally functional tool, although local differences are currently not fully considered.

Data input complexity stems from ISO standards and varying requirements across manufacturers and regions.

From her perspective, the system appears to be a complex and continuously evolving structure.

While technical affinity is generally present, users with high digital affinity often end up creating their own tools to meet specific needs.

F. User Journey Interviews



Number	Description	Date
01	family farm	25.06
02	contractor	29.06
03	Dealer mechanic	04.07
04	Farmowner Parttime	10.07
05	Disponent for Contractor	21.07
06	Big farm chief	22.07
07	Family Farm	23.07



General Notes

Fertilization planning has become more complex. Amounts must now be estimated and recorded in advance instead of being applied intuitively.

Most organizational tasks are done via laptop, including coordination with contractors and checking grain prices on stock exchange apps.

Although the farm is highly digitalized (ISOBUS system in the harvester), smartphone apps are considered impractical.

Contractor coordination is well-established; finding workers via contractors is not an issue.

Maintenance of machines is often outsourced due to

complexity, especially with electrical components.

The farm is certified for sustainable grain production.

Drone usage is seen as potentially beneficial for harvest, fertilization, and weed control—but perceived as complex.

Weed control is easier in earlier growth stages; dealing with tall weeds is significantly more challenging.

There is a desire to pass the farm on to the next generation.

01. What size does your farm have ?

130 hectares in total
Heavy clay soil: unsuitable for barley
Main crops: soy, sugar beet, rapeseed, wheat
Machines include: tractors, cultivators, ploughs, seeders, fertilizer spreaders, injection systems

02. What is your position within the farm ?

Operations Manager and Owner of a multi-generational farm
Responsible for long-term planning, paperwork, and coordination
Occasionally supports fieldwork

03. Can you walk me through the typical steps in your harvesting cycle ?

Harvest season includes around 10 days of grain harvesting per year

Frequent tasks: organizing contractors and coordinating timings

Conducting field tests with a mini combine harvester to check grain dryness

Monitoring stock levels, using digital tools to plan grain

sales and purchases

Cleaning harvested grain and storing it privately

Grain is used for pig feed throughout the winter

Documentation: index cards sorted by field and measurement

Actual fieldwork is minimal and mostly observational

04. Which daily tasks on your farm take up the most time during a non-harvesting season ?

Paperwork: Scanning receipts, organizing purchase documents, and preparing for inspections

Tax-related tasks

Field planning and fertilizer registration

General operational coordination

Paperwork takes up the majority of time; only ~5% of time is spent on-field

05. How does your workload shift during harvest season? Which tasks become the most time-consuming ?

Administrative workload remains high, often completed in the evenings

Occasionally assists on neighboring fields

Manual tasks still include helping on own fields when needed

Increased demand for coordination with contractors

Maintaining documentation remains critical during the season

06. What challenges or issues do you typically face during the harvest period ?

Fertilization practices have shifted from intuitive application to data-driven planning. The total amount of fertilizer to be used must now be estimated and registered in advance for the entire year.

Workforce availability is not a concern, as workers are reliably sourced through established contractor networks.

Maintaining an up-to-date overview of all fields requires

careful planning and coordination, particularly during peak times.

Machinery maintenance has become more complex due to increased integration of electronic components. As a result, repairs are often handled directly by specialized dealer service teams equipped with their own diagnostic tools.



07. What are your long-term goals for your farm ?
The farmer would like to see the farm passed on to his son, should he express interest. He values the continuation of the family tradition but emphasizes that the decision will be entirely up to the next generation.

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08. Are you implementing any measures to improve sustainability in the operation ?
The farm holds a sustainability certification for its grain production. Beyond that, no additional structured sustainability measures have been implemented.

09. Do you make use of any digital tools like Tablets in your farming operations ?
All organizational tasks are handled on a laptop. The farm machinery is equipped with an ISOBUS system, which provides field-specific data to the operator. While contractors are expected to harvest fields uniformly based on this information, the farmer sees little value in using smartphone applications, considering them impractical for his workflow.

10. What would be your hesitations for using a drone ?
The farmer perceives drones as complex and not immediately intuitive to operate. He believes their use would be more justifiable during the harvesting season. However, he expresses interest in the data drones could provide—particularly for applications in fertilization and early-stage weed control.

11. What benefit would you promise yourself from using a drone?
The farmer sees potential in using drones for early-stage weed control, when plants are still small and manageable. He notes that once weeds have grown too tall, effective removal becomes significantly more difficult.



General Notes

Some of the technical stuff is difficult to implement because all of the machines need it

Machines from different brands help a contractor to stay independent maybe get better service and even get better deals when purchasing a new machine

The types of fields vary even in their area of action

Customer involved in official agriculture (registered farm)
 Contract work (custom farming), few animals
 High use of tractors: mowing grass, chopping, pressing, threshing
 Yield: approx. 10 tons per hectare (100 dt/ha)
 Small field structure: 3–4 hectares per plot
 Located in East Germany, previously part of a large LPG (agricultural production cooperative)
 The manager is also a machine operator
 Equipment includes tractors, loaders, partly manual labor
 Work rhythm: pressing, using the bulldog (tractor), taking vacation

Spring frost between March–May (7–8°C to 10–11°C)
 RTK signal (GPS correction) often disrupted
 Uses a cross-track handler (for uneven field structure)
 „Trip-Trill“ is an additional attachment used
 Refueling typically between 8:00–20:00
 GPS tracking quality varies greatly
 Tractor can detect overlap by itself
 Limit of 3–4 turns when chopping (efficiency issue)
 Soil compaction due to heavy equipment (especially near field borders)
 Groundwater is clean, low pollution
 Many machines in use, but few with camera systems
 No clear operating limits when chopping
 Turns at intersections are done with triangle maneuvers

Common mindset: We know what we have to do and we have the experience!

01. What size does your farm have ?

No own farm, drives for a friend and occasionally for a contractor besides work
 3–4 hectares per field
 Yield: 10 tons per hectare

02. What is your position within the farm ?

Family friend and machine operator
 Responsible for coordination, equipment, and driving the machine
 Drives mainly tractor and chipper for cutting grass and making bales
 Threshing is mainly done by the farmer himself

03. Can you walk me through the typical steps in your harvesting cycle ?

Very unorganized planning process:
 Working during the day
 Getting a call the day before to help out
 Leaving work early to tend to a field
 Going to the contractor location
 Checking machine
 Checking Ipad for task and field location
 Winter: Machine maintenance
 Spring until late autumn: Harvest and tending to the field in different orders
 When it is further away: combining it with a holiday in that area
 Maintenance can be supported by blackbox
 A straight line is driven at the beginning of the field to define the rest of the driving route
 Threshing → chopping → pressing
 Has to go down while being on the field to look at different things:

Yarn is empty or loading wagon drives different
 Camera is needed when the front of the machine has to much distance towards the driver
 Typically goes from 7 to 10
 After 10 they want to be more quiet for the neighborhood even though they would be allowed to drive
 Plans harvest quantities based on inventory and grain exchange
 Harvest itself is 2-3 days: most important task is harvesting, which is mostly done by the farmer himself
 Cleaning of the machine with a compressor on the field
 Removing dust
 Maintenance: Sharpening cutters and
 The invoice is sometimes only done at the end of the year
 Threshing is mainly done by the farmer himself

04. Which daily tasks on your farm take up the most time during a non-harvesting season ?

Maintenance and repair of machinery- like replacing worn off parts
 More maintenance is done at the contractor than in the private environment
 Transport tasks
 Forage harvesting, spraying, and care activities
 Threshing is mainly done by the farmer himself

05. How does your workload shift during harvest season? Which tasks become the most time-consuming ?

Threshing becomes extremely time-intensive
 Daily adjustments depending on weather
 Limited machine availability can cause delays
 Some machinery operates autonomously



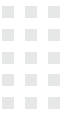
06.	What challenges or issues do you typically face during the harvest period ?	Smaller fields lead to more driving that has to be actively done by the driver Fields with an incline need a different approach and more time in planning the driving route Spring frost can impact crops There is a big uncertainty due to the weather: Equipment breakdowns RTK signal loss disrupts GPS accuracy Insects and morning dew increase stress Difficult turns and maneuvering at intersections Fields vary greatly in size, complicating planning Some harvests don't yield fully — fragmented into 3–4	separate patches During the summer there are more unlearned staff on the field For the contractor it is ideal to have people that grew up on a farm Safety regulations of the tractor are annoying but can be evaded Dry fields are needed Slow rain is needed but the rain now is typically very fast and heavy
07.	What are your long-term goals for your farm ?	I have fun doing it I do not have as much time as before since I have an excavator business with a friend Some clients switch for For service providers: they also buy stock for cheap prices and then speculate on a good price to sell it again!	
08.	Are you implementing any measures to improve sustainability in the operation ?	Minimized soil compaction through targeted driving paths Only mineral-based fertilization (to stay within legal limits) Crop protection products used only when necessary There are limitations for fertilizer usage In my opinion the experience is better than the regulations There are a lot of difficulties due to climate change	
09.	Do you make use of any digital tools like Tablets in your farming operations ?	Tablets used for track planning and field navigation RTK-GPS system in use Apps to track market prices and grain exchange trends „Blackbox“ device for measuring hydraulic performance Radio can only be used for short distance You can see where your colleagues are on the map Swath can be mapped for the next day so the driver can see where he must go 3-4 weather apps for comparison Does not miss cameras	
10.	What would be your hesitations for using a drone ?	Weather dependency Legal uncertainty No immediate, obvious benefit seen Not suitable for all field types	
11.	What benefit would you promise yourself from using a drone?	Heard about usage for European corn borer Better overview of large fields Monitoring pests and diseases Verifying fertilization and crop growth conditions	



General Notes

After Sales organization and oversight
 Coordination of workshops
 Internally motivated to improve

01.	What size does your farm have ?	No own farm himself
02.	What is your position within the farm ?	<p>90 Percent of my work is personal Organizing trucks of deliveries</p> <p>Budgeting supplies for the workshops Bigger reclamations</p>
03.	Can you walk me through the typical steps in your harvesting cycle ?	<p>Client relationships are often based on long-standing dealer connections, especially with large contractors. Customers include both commercial farms and hobby farmers.</p> <p>Machine leasing is available, offering flexible options.</p> <p>Warranty flexibility is granted in some cases, particularly for experienced clients who can handle minor repairs themselves.</p> <p>Mechanical knowledge among smaller clients varies widely.</p> <p>Each workshop includes at least one electronics-trained specialist.</p> <p>Peak season starts with fertilizer application in February-March.</p> <p>First grass cut begins around May 1st and runs through July/August. After that, workshops must stay flexible due to time-critical service demands.</p> <p>Workshops typically operate until 22:00 during busy periods, with awareness of community noise concerns after that.</p>
05.	How does your workload shift during harvest season? Which tasks become the most time-consuming ?	Harvesting damages are: drum damage, fires or drive off damages
06.	What challenges or issues do you typically face during the harvest period ?	At night and after long workhours the concentration is not great
07.	What are your long-term goals for your farm ?	<p>Sustainability is not really a big topic-> Packaging is the biggest topic There is a balance sheet</p> <p>Reduction of storage times Improving availability of parts-> has to be internally motivated by CLAAS</p>
09.	Do you make use of any digital tools like Tablets in your farming operations ?	SAP for to plan times and connect with the service office
10.	What would be your hesitations for using a drone ?	<p>Flying distance is not long enough Regulations disturb flying route Another expertise needed which others might be able to do better</p>
11.	What benefit would you promise yourself from using a drone?	<p>Fast delivery to the client without traffic and human component Inside of a confined area</p>



General Notes

Owns a tractor but borrows specialized equipment from the dealer when needed.

Actively engages in Telegram groups to explore his growing interest in direct seeding.

Hopes his son will one day take over the farm and continue the family tradition.

Uses different machinery setups for summer and winter conditions.

Currently views the future of farming with concern due to the decline of small farms, increasing competition from larger operations, and rising imports from abroad.

His personal goal is to remain self-sufficient and provide everything his family needs through the farm.

Compared to peers, he is more open to experimenting with new agricultural methods.

The farmland has only a few boundary points, limiting flexibility in some aspects.

01. What size does your farm have ?

Farming on the side
Handed down from family after siblings did not want it
Having the home alone is not enough
Daughter who is interested in biology and chemistry

25 ha and around 40 pigs

02. What is your position within the farm ?

Farm handed down from parents
Now running it with the wife who also comes from an agricultural background

03. Can you walk me through the typical steps in your harvesting cycle ?

Starts the day by walking the dog, often along the edges of his own fields

Discusses daily farm tasks with his wife before leaving for work

Main workload involves animal care, particularly feeding

Sells growing pigs to larger farms to diversify his business portfolio

Plants cover crops (e.g., sunflowers) between main crops to regenerate soil and improve humus

Most fields are leased rather than owned

Handles simple tasks like flattening his own field inde-

pendently, as they require no special equipment

Regularly checks on the pigs in the shed at night to ensure their well-being

Operates on a three-week livestock care cycle, with recurring major tasks

Adjusts care routines based on the different needs of younger and older animals

Acknowledges a social stigma around livestock farming and animal sales

04. Which daily tasks on your farm take up the most time during a non-harvesting season ?

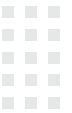
The farmer's primary concern is the well-being of his animals, which includes monitoring for disease, addressing social behavior issues within the herd, and maintaining a clean and healthy environment.

05. How does your workload shift during harvest season? Which tasks become the most time-consuming ?

Sorting out where to get helpers and material is the most time consuming



-
- 06.** What challenges or issues do you typically face during the harvest period?
- The farmer faces increasing challenges due to unpredictable weather conditions.
Monitoring the entire pig stable at once is difficult, limiting full oversight.
There is a noticeable rise in pests, particularly mice and snails.
Other farmers depend on his production—both in terms of crops and livestock.
-
- 07.** What are your long-term goals for your farm?
- The farmer values the freedom to enjoy his work and make independent decisions on his own land. His goal is to find satisfaction in farming by doing what he enjoys on his property.
-
- 09.** Do you make use of any digital tools like Tablets in your farming operations?
- The farmer uses an older 10 PS tractor, which is incompatible with most modern agricultural systems.
He is cautious about digital monitoring and prefers not to share field data with the government or the EU.
He acknowledges that fully understanding the technical complexity of tractors—especially newer models—is a challenge.
-
- 10.** What would be your hesitations for using a drone?
- The farmer has noticed unauthorized drones flying over his property, which he finds intrusive and unwelcome.
He lacks specific knowledge on how to properly maintain a drone, which adds to his hesitation toward using such technology.
-
- 11.** What benefit would you promise yourself from using a drone?
- Watching my livestock at night would be interesting for me
Interesting for me and I also have one for like 300 euros
Nice to look at fields from above
- Also nice for other areas on the property like rain drainages
- Quality is already like smartphone
Sees potential in these maps
- Babymonitor for animals if I am in bed already



General Notes

A supportive private environment is essential for managing the demands of the job.

It's important to listen to workers' concerns, even if they seem minor at first.

Neighbors often call to ask about field conditions or characteristics—sharing knowledge is common.

Peak working periods are challenging, as everyone needs machines and services simultaneously.

Some technologies remain unused but are still difficult to sell. While certain tools can be shared between workers, others—like RTK—require individual setups. Understanding

clients requires reading between the lines; it's not always clear if their request is immediate.

Staying current with technology is crucial to remain competitive with other contractors.

NIR sensors have become standard equipment.

Field surveillance is gaining importance, especially for tracking silage incidents.

Weather remains a major unknown; even with multiple weather apps, past weather events often shape decisions.

01. What size does your farm have ?

The company serves both small fields (as small as 0.3 ha) and large ones up to 200 ha, though larger fields are more profitable due to reduced maneuvering.

While the core area is in North Rhine-Westphalia, operations are expanding into eastern Germany to serve even larger fields.

The service radius is extensive, with machine transport times of up to six hours.

The client base includes up to 10,000 customers.

Primary crops handled include barley and corn, with additional operations linked to biogas production.

02. What is your position within the farm ?

Despondent- Girl for everything

Navigating between Company Client and worker to keep everyone happy

Trying to acquire new clients
Talking about prices increase as well as decrease

100 employees in the company
Introducing technologies to clients

03. Can you walk me through the typical steps in your harvesting cycle ?

The workday starts at 7:00, with a drive to the office.

In the morning, emails and missed calls are reviewed. The urgency and complexity of each message are assessed before responding.

Daily task planning is handled at the office, including scheduling assignments for drivers and identifying areas where additional support may be needed.

Most of the day is spent traveling between fields to check in with clients and drivers, addressing any on-site concerns.

For more significant issues, in-person meetings with clients are arranged—often involving discussions about pricing or compensation.

Driver activity is monitored via GPS to ensure operations run smoothly.

Currently, the role is fully externally focused, with full responsibility for managing all combine harvester operations.

04. Which daily tasks on your farm take up the most time during a non-harvesting season ?

Acquiring new clients and talking about their previous harvest
Purchasing new machines

05. How does your workload shift during harvest season? Which tasks become the most time-consuming ?

Ensuring machines go smoothly
Keeping everyone satisfied and working with different characters
Ensuring that workers get controllable working hours
Dealing with unlearned staff in peak hours

Keeping a recent overview of machine status
Drivers can drive too fast, and the harvesting image can end up being bad
Dealing with the community: driving too fast in villages or cleaning up the road too slowly



-
- 06.** What challenges or issues do you typically face during the harvest period?
- Many workers are drawn away by other companies offering higher wages, even for untrained personnel.
- Fewer employees now come from an agricultural background, leading to a noticeable decline in enthusiasm.
- A 24/7 operation schedule isn't feasible, as weather conditions constantly shift and directly impact harvest timing.
- Drivers value finishing the day clean, which influences shift planning and task distribution.
- Different soil types across the large operational area respond differently to weather. Due to time constraints, on-site verification isn't always possible—reliance on farmers' local knowledge is essential.
-
- 07.** What are your long-term goals for your farm?
- The company recently acquired an additional branch further east to expand its reach.
- There is a growing demand from clients for strip-till farming methods.
- Despite the expansion, a key goal remains to maintain and sustain the company's original location.
-
- 10.** What would be your hesitations for using a drone?
- It's still unclear whether clients truly want certain new technologies, but the company prefers to adopt early rather than risk falling behind.
- Some drivers are reluctant to engage with modern systems and prefer traditional methods.
- Keeping up with the rapid pace of technological change is challenging, especially for those without a technical background.
- Only a small portion of staff—roughly 2 out of 10—can confidently operate the RTK system.
- Communicating change can be difficult, particularly with individuals who have been in the profession longer than the current manager has been alive.
-
- 11.** What benefit would you promise yourself from using a drone?
- A dedicated position for this role is planned as soon as it becomes financially feasible—some decisions simply require a leap of faith.
- The use of application maps is expected to be implemented in the near future.
- It is good for publicity and acquiring new clients
- Just driving around with technologies creates an interest



General Notes

A supportive private environment is essential for coping with the high demands of the role.

Listening to workers' concerns—regardless of their perceived importance—is a key part of team management.

Neighbors frequently reach out for insights into field conditions, highlighting a culture of mutual support and knowledge exchange.

Peak periods create logistical challenges, as demand for

machinery and services spikes simultaneously.

Some technologies remain unused but are still difficult to sell; while certain tools can be shared among workers, systems like RTK require individual adaptation.

Client communication often requires reading between the lines, as urgency is not always clearly expressed.

01. What size does your farm have ?

Located in eastern Germany, the farm includes both original land and additional hectares from a recently acquired company.

Operates a circular farming system combining crop production and livestock management.

Employs approximately 65 workers.

Manages around 2,000 hectares of owned land and 450 hectares from the acquired company (which has no livestock).

Maintains 850 pigs and 230 cows, including breeding stock.

Manure from both farms is used for fertilizing the fields.

Specializes in pharmaceutical crops such as chamomile.

Maintains a broad crop portfolio: rapeseed, barley, corn, grassland, and sugar beet.

Involved in seed reduction processes.

Supplies fodder to a Dutch partner farm.

02. What is your position within the farm ?

Acts as the main disponent—nearly all decisions pass through this role.

Oversees all contractual decisions, with a focus on outsourcing animal-related operations.

Plans crop rotation across all fields and manages planting sequences for specific plots.

Handles contract design and coordination with external business partners.

Manages logistics, including seed ordering and storage allocation.

Responsible for marketing the farm's products and maintaining strong relationships with produce buyers and fellow farmers.

Develops and updates daily field action plans.

Makes key HR decisions such as salary adjustments and trainee management.

Organizes logistics for animal feed and schedules transportation.

Acts as a substitute during expert holidays to ensure continuity.

Responsible for field measurements required by municipal authorities.

Considers machinery a worthwhile investment, particularly for grain operations.

All machinery maintenance is handled externally by CLAAS.

03. Can you walk me through the typical steps in your harvesting cycle ?

During winter, the focus shifts to client acquisition and preparing for the upcoming season. Operational planning, resource allocation, and communication with partners take priority before fieldwork resumes in spring.

04. Which daily tasks on your farm take up the most time during a non-harvesting season ?

--very diverse every day
A lot of bureaucracy but fields always come first

05. How does your workload shift during harvest season? Which tasks become the most time-consuming ?

During harvest season, the farm relies heavily on seasonal workers, particularly for the labor-intensive cultivation and processing of pharmaceutical plants.



06. What challenges or issues do you typically face during the harvest period?

Fields must be checked manually—driving out, feeling the soil, and physically inspecting corn by hand.

On-farm tester kits are used to evaluate crop quality.

Produce is also taken to dealers for external assessment.

Standardized corn quality cards support consistent evaluation.

A key concern is whether harvested crops can be stored safely at the current time.

The process requires full sensory attention and regular presence in the field.

07. What are your long-term goals for your farm?

Proud to have a long-lasting unique feature of pharmacy plants and plants that will go into tea

Its also not really necessary to acquire new businesses, as the successors are mostly clear

09. Do you make use of any digital tools like Tablets in your farming operations?

The farmer is skeptical of weather apps but still makes use of cloud radar for monitoring.

Ultimately, he believes that real-time reaction to weather conditions is more important than forecasts.

10. What would be your hesitations for using a drone?

One employee on the farm is knowledgeable about drones and even owns a personal device.

However, drone usage is not yet widespread across the team, and expertise remains limited to that individual.

11. What benefit would you promise yourself from using a drone?

We already have one for 10-12 years

The drone is primarily used to detect weeds in pharmaceutical crop fields.

Expectations for its effectiveness were high, but the current level of accuracy is still insufficient.

As a result, manual inspection of the fields is still necessary.



Regular activities on the farm	The farm operates as a part-time dairy business, focusing on milk cows and their offspring. Most of the work is carried out during evenings and weekends.
Typical Day main season	<p>Morning (6:00–7:30): Milking cows and feeding all animals.</p> <p>Mid-morning: Preparing feed from the silo; calves receive warm milk.</p> <p>Midday: Lunch break; meals are prepared by the mother for family members working on the farm.</p> <p>Afternoon tasks:</p> <ul style="list-style-type: none"> Cleaning the milk tank (every other day) Replacing animal bedding (twice a week) Caring for sick animals and newborn calves Grinding homegrown grain into animal feed <p>Tending the vegetable garden and greenhouse</p> <p>Evening (17:30–19:30): Second round of milking and feeding.</p> <p>Late evening: Father performs repairs; mother handles data entry and bookkeeping.</p> <p>Harvest season: All regular duties continue, with added harvesting tasks supported by family and contractors.</p>
Demanding tasks	<p>The most time-consuming tasks on the farm are collecting stones—done to protect the machinery—and following the daily milking routine.</p> <p>The most physically demanding activities include handling silage covers with heavy sandbags, forking feed and manure, and spending long hours on the tractor during harvest, sometimes exceeding 17 hours a day.</p>
Barn inspections	<p>The farmer regularly checks crop emergence and ripeness, both for grain and grass.</p> <p>Barn rounds are conducted twice a day to monitor animal health and the condition of equipment.</p> <p>Special attention is given to sick animals or those that are calving.</p>
Weather	<p>Yes – Weather affects all farming stages.</p> <p>Long dry periods can ruin pasture yield, causing feed shortages and financial stress.</p> <p>Flexibility is essential.</p>
Terrain	<p>Yes – Steep or wet fields require manual work.</p> <p>Some areas can't be accessed by machines and must be mowed or harvested by hand (e.g. along creeks or steep slopes).</p>
Drone in operation	<p>Not direct workflow improvements, but better conditions.</p> <p>Benefits: Soil-friendly sowing, wildlife protection (e.g., fawns), yield mapping, weed detection.</p> <p>Could be used for spot spraying, but legal limitations exist in Austria.</p> <p>Weeds: Detecting and targeting herbicide application → saves resources.</p> <p>Hard terrain: Reaching inaccessible areas for seeding or spraying.</p> <p>Safety: Reduces risk from machinery in dangerous spots.</p> <p>Wildlife observation: Especially for saving fawns during mowing.</p> <p>Monitoring: For larger fields or areas with high weed pressure.</p> <p>Not relevant for pasture checks in this farm setup.</p>
Drone time saving	<p>Not relevant for fencing or pasture checks (no grazing).</p> <p>Relevant uses: Spot spraying, weed mapping, yield analysis, seeding in hard-to-reach areas.</p>
Difficult access	<p>Yes – Slopes, wet creek zones, steep land → not suitable for tractors.</p> <p>Drones would be beneficial here.</p>



Digital tools

Minimal use overall.

Kraffutterautomat (automatic feeder) settings are digital.

E-AMA platform: Used for livestock registration and subsidy applications.

E-Milk app: Tracks cow status (e.g. dry-off dates, calving).

Drone training

Yes, with some training:

Younger generation (e.g. 23-year-old brother) would manage well after a few practice flights.

Current operators need more support and a proper course.

For agricultural drones, a license („drone pilot certificate“) is required.

Service-based drone solutions may be more practical for many.

Drone concerns

Main concern: High cost vs. unclear return on investment.

Weather not a major issue (farmers are used to it).

Concern about repairs and support availability – having a local service partner is important.



General Notes

29 years old; whole family works on the farm (father 54 years old).
Wants to challenge the "we always did it like this" mentality.
Interested in learning from different cultures.

-
- 01.** What size does your farm have ?
- Keeps 75 milk cows and uses a robot milking system; animal raising and fertilization are outsourced.
Operates 95 hectares of corn and 50 hectares of grassland.
Owns a big silo.
Maximum field distance is 10 km from the farm.

-
- 02.** What is your position within the farm ?
- Maintenance is entirely handled by CLAAS.
Mother is responsible for bureaucracy and stable management.
Grandmother cooks and cares for calves.
Grandfather works in the workshop and takes care of the house surroundings.
Uses machines such as forage wagon, silage transport, winter road maintenance equipment, snow shovels, side rake, wheel loader, and roller.

-
- 03.** Can you walk me through the typical steps in your harvesting cycle ?
-

-
- 04.** Which daily tasks on your farm take up the most time during a non-harvesting season ?
- Repairs around the property and on machinery.

-
- 05.** How does your workload shift during harvest season? Which tasks become the most time-consuming ?
- Tending to calves and mixing fodder.
Stable work, including nightly checks.



06. What challenges or issues do you typically face during the harvest period ? Deciding which field to work on first—usually prioritizing sandy ground to avoid delays.

07. What are your long-term goals for your farm ? Receives subsidies for growing peas.

09. Do you make use of any digital tools like Tablets in your farming operations ? Camera installed at the milking apparatus.

10. What would be your hesitations for using a drone ? Usage and cost must be in balance.
Profitability might be easier to achieve with certain applications.
Concerns about collisions.

11. What benefit would you promise yourself from using a drone? Yes—could be faster in certain tasks.
Potential use for dropping wasp control agents.

Appeals to novelty ("sounds cool").
Particularly useful for larger fields.

G. Drone Comments



— Flying distance is not long enough to be practical.

+ Fast delivery to the client without traffic and the human component.

Useful within a confined area.

Aid in logistical coordination during high-stress harvest phases



Delivery and Logistics

— Watching livestock at night would be interesting.

+ Watching livestock at night would be interesting.

Could act like a baby monitor for animals at night.

Drone use offers soil-friendly sowing and wildlife protection (e.g. fawn detection).



Animal Monitoring

— Requires another area of expertise, which others might be able to handle better.

+ Only one employee on the farm is knowledgeable about drones and owns a personal device.

Some drivers are reluctant to engage with modern systems and prefer traditional methods.

Drone training is needed; older users need support, younger ones could learn quickly.

Keeping up with technological change is challenging, especially for those without a technical background.

Drone usage is not widespread across the team; expertise is limited. Require interpretation and user understanding for effective use



Training and Skills

— Distrustful of digital monitoring; prefers not to share field data with authorities.

+ Drone usage is not widespread across the team; expertise is limited.



Data

— Lacks specific knowledge on how to properly maintain a drone.

+ Can perform seeding and spot spraying in inaccessible areas.

Repairs and support availability are a concern; need for a local service partner.

Reduces machinery risks in dangerous terrain like steep slopes or creeks.

Farmers are used to weather—weather is not a major concern, but repairs are.



Maintenance and Reliability

— Role of the Sales Promoter Acts as a field contact after machine purchase, visiting each customer to ensure proper use and understanding.

+ Positioned near After Sales, but does not provide mechanical or electrical support.

Offers low-level technical support, primarily by listening to farmers' general concerns—often in informal settings (e.g., "over a cold one").

Battery charging infrastructure is currently a limiting factor



Battery Range



— Unauthorized drones flying over his property are seen as intrusive and unwelcome.

Unclear whether clients truly want certain new technologies.

+ Drones are good for publicity and attracting new clients.

Simply driving around with new technologies generates interest.

Public Perception and Trust

— Believes drone use would be more justifiable only during the harvesting season.

+ Weather dependency makes drone use unreliable.

Farmers are used to weather—weather is not a major concern, but repairs are.

Weather

— Interested in the data drones could provide—particularly for fertilization and early-stage weed control.

Sees potential in using drones for early-stage weed control when plants are small and manageable.

Notes that once weeds have grown too tall, effective removal becomes significantly more difficult.

Maybe not suitable for all field types

Manual inspection of fields is still seems necessary despite drone usage.

+ Believes drones offer a better overview of large fields.

Potential use for monitoring pests, diseases, and verifying fertilization and crop growth conditions. Already owns a €300 drone and finds it useful for observing fields and rain drainages

Sees potential in drone-generated maps for various areas on the property. Application maps expected to be implemented soon.

Field scouting support tool, especially for high-value crops. Useful for yield mapping, weed detection, and monitoring in larger fields.

Assist in assessing soil firmness (e.g., "Will the cultivator sink in?") Reduce the need for manual field scouting

Field Monitoring

— A dedicated position for drone usage is planned when financially feasible. High cost of drones vs. unclear return on investment.

+ The company prefers to adopt early rather than risk falling behind.

Support planning during tight 25-day harvest windows.

Cost and Investment

— Legal uncertainty around drone usage causes hesitation. Regulations disturb flying route and operations.

Distrustful of digital monitoring; prefers not to share field data with authorities.

Agricultural drones require a license (pilot certificate).

+

— Communicating technological change is difficult with older workers.

Drones are not yet fully integrated into everyday workflows

May add complexity without proper training or onboarding
Effectiveness is limited if not aligned with operational timing

+ Drone usage is seen as potentially beneficial but perceived as complex and not immediately intuitive to operate.

Smartphone apps are considered impractical for farm tasks.

Enable real-time decision-making during field operations
Help determine optimal driving direction on parcels
Improve route planning across 200–300 field parcels

Anticipate wait times and terrain conditions

Usability

Law and Privacy

H. Personas



01 Bernhard. Optimistic heritage.

„I find drones quite complex and not very intuitive to operate. Still, I'm interested in the kind of data they could offer—especially for fertilization and early weed control.“

„I see potential in using drones for weed control early in the season, when the plants are still small and manageable.“



Cautious Traditionalist



Price pressure



Importance of digitalization



Preference for one dealer



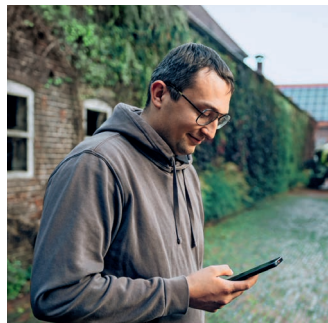
Preference for one dealer

Based on Interview 01.

02 James. Lifestyle Agriculture.

„I'm not sure what's actually allowed. The legal situation around drone use still feels unclear to me.“

„Not every field is suitable for drones—some areas are just too small, uneven, or surrounded by obstacles.“



Optimistic Pioneer



Price pressure



Importance of digitalization



Preference for one dealer



Based on Interview 02.

03 Keith. Driving Service.

„Operating a drone requires a whole new kind of expertise.“

„It would work best inside a limited or closed area where everything is nearby and under control.“



Cautious Traditionalist



Price pressure



Importance of digitalization



Preference for one dealer



Based on Interview 03.

04 Martina. Sustained Hobbist.

„I don't really know how to maintain a drone properly, and that makes me hesitant to use one myself.“

„I could also use it for other areas around the property, like checking the rain drainages.“



Demanding Performer



Price pressure



Importance of digitalization



Preference for one dealer



Based on Interview 04.



05 Julliana. Contractor Disponent.

„Keeping up with how fast technology is moving is tough—especially for those without a technical background.“

„We plan to create a dedicated role for this as soon as it’s financially feasible—some decisions just require a leap of faith.“



Demanding Performer



Price pressure



Importance of digitalization



Preference for one dealer

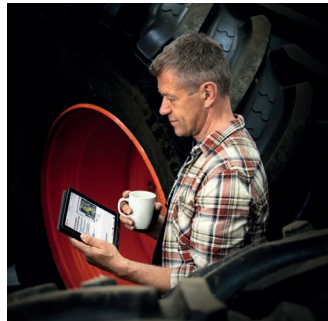


Based on Interview 05.

06 Hendrik. Hands-On Strategist.

„The expertise is limited to just that one person.“
„Our expectations were high—but the accuracy just isn’t where it needs to be yet.“

„We’ve actually had a drone for about 10 to 12 years now.“



Optimistic Pioneer



Price pressure



Importance of digitalization



Preference for one dealer



Based on Interview 06.

07 Katharina. Resilient multitasker.

„What worries me more is the repair and support—having a local service partner really matters.“

„Drones are useful on slopes, wet creek zones, and steep land where tractors can’t go.“



Optimistic Pioneer



Price pressure



Importance of digitalization

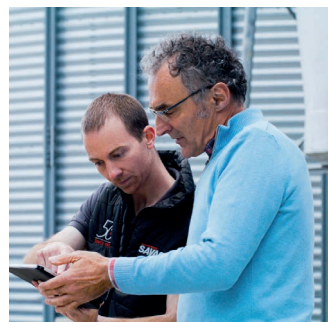


Preference for one dealer



Based on Interview 07.

08 Felix. CLAAS First Hand.



Based on Expert Interview 20.

Bernhard | Optimistic family guy



Price pressure



Importance of digitalization



Preference for one dealer



Cautious Traditionalist

 46 years
 learned farmer

Goals

Plan and manage harvests efficiently without complicated technology
 Ensure quality grain storage and feed supply for own animals

Optimize paperwork for yearly inspections and tax returns

Generation

Grew up with analog machines

Prefers stable, proven tools (e.g., laptop, ISOBUS)
 Would like his son to take over the farm eventually



Needs

Paperwork pipeline, often pushed to evenings

Fertilization must now be pre-planned and documented – no longer intuitive

Smartphone apps feel irrelevant or confusing
 Unclear machine data or errors require dealer support



Machines

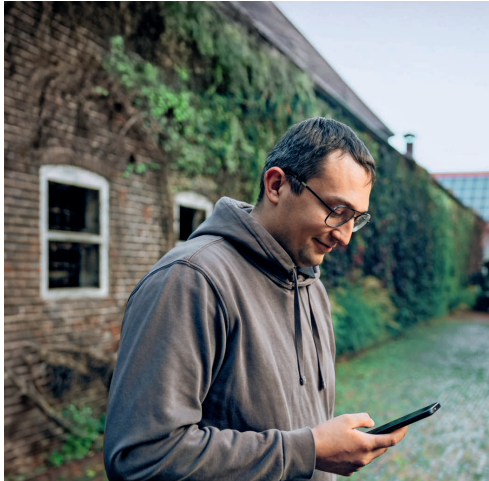
Tractor with implements (plow, cultivator, seeders, fertilizer spreaders)

Mini combine harvester (for sample testing)

Storage and cleaning equipment

Occasional use of ISOBUS-enabled harvesters via contractor





Price pressure



Importance of digitalization



Preference for one dealer



Optimistic Pioneer

26 years
machine operator

Goals

- Support efficient harvests for multiple clients
- Maintain machinery and reduce repair time
- Integrate farming into a flexible work-life setup
- Combine personal interest in machines with seasonal income

Take opportunities for side business (e.g., grain speculation)

Generation

- Grew up around large cooperative farming (LPG)
- Deep experience in field work; little patience for excessive regulation
- Practical thinker with interest in machine performance
- Uses digital tools only when they truly add value

Does not own a farm – values independence and flexibility

Needs

- Fragmented harvests across 3–4 ha plots → high maneuvering effort
- Weather uncertainty (spring frost, heavy rain) disrupts planning
- GPS signals (RTK) often unreliable

- Steep or uneven fields require complex driving patterns
- Legal and technical drone usage is unclear
- Inexperienced seasonal staff lead to coordination issues



Farm

- No own farm; supports a friend's and contractor's farm
- Former LPG region → small, fragmented fields
- Fields: hilly, clay-heavy, 3–4 hectares each
- Yield: approx. 10 tons/ha

- Fieldwork timed around main job and availability
- Enjoys merging work with leisure (fieldwork as holiday)



Machines

- Tractor with chipper for pressing, mowing, threshing
- Cross-track handler and "Trip-Trill" attachment

- GPS-equipped (but often disrupted)
- Occasional use of Blackbox (performance logging)



Keith | Driving Service



Price pressure



Importance of digitalization



Preference for one dealer



Cautious Traditionalist

42 years
Workshop and logistics manager



Goals

Improve internal service efficiency across workshops
Coordinate timely deliveries and reduce storage time
Ensure flexibility during peak seasons through precise planning

Offer reliable support to clients from hobby farms to large contractors
Continuously improve internal processes – driven from within

Generation

Long-time employee with deep CLAAS dealer connections
No own farm – focused on organizational and customer-facing tasks
90% of tasks are internal: planning, budgeting, truck coordination

Handles larger warranty claims and part deliveries
Internally motivated to enhance logistics, not externally pressured by sustainability trends

Needs

Logistics stress due to tight seasonal timelines
Mechanical damages during harvest: drums, fires, operational wear
Long working hours reduce focus and increase risk
Clients differ vastly in technical skills – requires tailored support
Drone use limited by short range, regulation, and training demand



Work rhythm

Early high season starts Feb–Mar (fertilizer use)
First major cut from May to July/August
Summer: long workdays often stretch to 22:00 – balancing community respect
Repairs must be timely and adaptive, especially during time-critical windows
Most tasks revolve around planning, supporting technicians, and reacting to seasonal shifts













Machines

Uses SAP to connect planning with the service office



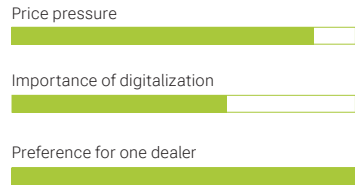
Martina | Sustained Hobbist



Demanding Performer

35 years
Part-Time Farmowner



Goals

Sustain a small-scale, independent farming lifestyle
 Provide for family needs through self-sufficient practices
 Experiment with regenerative farming (e.g. direct seeding, intercropping with sunflowers)

Maintain animal welfare through personal oversight
 Use technology to support—but not dominate—daily routines
 Enable a smooth generational transition

Generation

Inherited farm after siblings showed no interest
 Farming as a lifestyle and value, not as growth strategy

Open-minded to new methods (e.g., no-till, direct seeding), more than peers
 Sees modern EU frameworks with skepticism
 "I want to do what I want on my own land"

Needs

Weather unpredictability
 Lack of specialized equipment for modern digital tools

High dependency on borrowed fields and machines
 Struggles with increasing pressure from larger farms and international competition

Emotional and logistical challenges with livestock (disease, social behavior)
 Stigma surrounding animal husbandry
 Annoyance over unauthorized drone flights over his land

Farm

25 ha and approx. 40 pigs
 Home-owned land is limited; most fields are borrowed

Farm is co-managed with husband (also from an agricultural family)
 Harvest helpers and logistics must be coordinated ad hoc

3-week pig cycle dictates work rhythm
 Daughter shows interest
 Enjoys walking fields and monitoring animals personally

Machines

Owns one basic tractor (~100 hp), not compatible with modern ISOBUS systems
 Borrows specialized equipment from dealer (e.g., for direct seeding)

Opposes full digitalization due to tech limits and privacy concerns
 Maintains older machines out of necessity and independence

Julliana | Contractor Disponent



Price pressure



Importance of digitalization



Preference for one dealer



Demanding Performer
 35 years
 Client Management Contractor



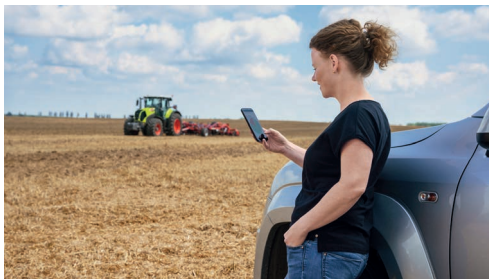
Goals

Sustain client satisfaction across large regions (up to 6h drive radius)
 Navigate harvest peaks through flexible staff & task management

Avoid falling behind local contractors technologically
 Maintain original location while scaling services eastward
 Acquire new clients and expand digital service potential

Generation

Grew into the role via experience, not heritage
 Strong communicator between internal teams and clients
 Balances empathy with assertive business decisions
 Digital multitasker (4 monitors, 2 phones)
 Empowers staff by introducing new technologies and practices



Needs

Personnel shortage & low staff retention during peak seasons
 Reliance on non-agricultural backgrounds leads to training gaps
 Time pressure from weather and field unpredictability
 RTK technology underutilized or misunderstood by older drivers

Community complaints (e.g. road cleanliness, village traffic)
 Difficulty matching machine needs across simultaneously busy fields
 Clients say things they don't fully mean → need for intuition



Company

Contractor with up to 10,000 clients
 Fields: 0.3 ha to 200+ ha; crops include barley, corn, silage
 Main operations in NRW, expansion to East Germany
 Biogas plant included in operations

Long machine travel times make real-time terrain assessment difficult
 Increasing relevance of field surveillance and weather interpretation



Machines

Responsible for all combine harvester operations
 Daily GPS monitoring of drivers

Digital planning & issue tracking
 New machine acquisitions and client training

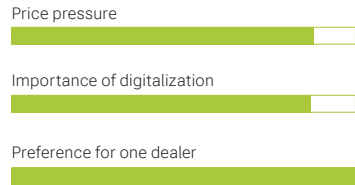
Tech challenges with RTK systems; 2/10 use it correctly
 NIR sensors now standard; drone support planned soon

Hendrik | Hands-On Strategist



Optimistic Pioneer

65 years
Farm owner and operator



Goals

Secure smooth operations across both own and newly acquired company
Maintain independence and profitability through diversification

Preserve traditional pharmacy plant cultivation while optimizing logistics
Build strong market ties with produce dealers and fellow farmers
Improve storage strategy and harvest quality decisions

Generation

Grew into the role over many years of practical and strategic involvement.
Emphasizes relationship-building with buyers and farmers.
Makes decisions on HR, field planning, and partner contracts.
Coordinates logistics for plant succession and seed procurement.
Markets farm products externally and negotiates contracts.
Uses digital tools selectively, preferring field experience for decision-making.

Needs

Manages a wide range of constantly shifting daily responsibilities.
Administrative tasks are time-consuming, but field operations take priority.
Relies on seasonal workers during harvest, especially for niche crops like camomile.

Crop quality requires on-site evaluation and sensory assessment.
Skeptical of weather prediction tools, relying instead on situational response.
Drone analysis lacks the accuracy needed for sensitive pharmacy plant fields.
Logistics coordination for feed and storage is demanding.

Company

Combined area of 2450 ha (2000 ha own fields, 450 ha via acquisition).
Employs 65 people, spread over two locations in Eastern Germany.
Operates with 850 pigs and 230 cows; dung is used across both farms.

Known for growing pharmaceutical plants such as camomile.
Crops include rapeseed, barley, corn, sugar beet, and grassland.
Also produces plant seeds and delivers fodder to Dutch partners.

Machines

Operates thresher, chipper, tractors, and fodder systems with a strong focus on grain efficiency.
Maintenance is handled entirely by CLAAS.
RTK technology is in use, though not always correctly applied.
A drone has been in operation for more than ten years but still lacks sufficient precision.

Digital field planning is used, but the user prefers reacting in real-time to weather changes.
NIR sensors are already implemented; manual crop evaluation remains essential, especially for camomile.

Katharina | Resilient multitasker



Price pressure



Importance of digitalization



Preference for one dealer



Optimistic Pioneer

30 years
Farm with Partner



Goals

Balance animal care and seasonal harvest efficiently
Maintain farm operations alongside family responsibilities
Support her children in gradually taking over parts of the farm

Generation

Transitioned from analog to partial digital (E-Milk, E-AMA)
Hands-on learner, values stability
Wants to reduce physical workload, especially in aging



Needs

Physically demanding tasks (e.g., silage covers, stone collecting)
Steep terrain and wet areas require manual effort
Paperwork and digital apps can be confusing or time-consuming
High effort for inspections and twice-daily animal checks



Farm

Dairy farm with milk cows and offspring
Part-time family operation (work done evenings/weekends)
Run collaboratively by multiple family members
Enjoys walking fields and monitoring animals personally



Machines

Tractor with implements (plow, cultivator, seeders, spreaders)
Combine harvester (occasionally used via contractor)

Digital Kraftfutterautomat + E-Milk app
Manual grain grinder



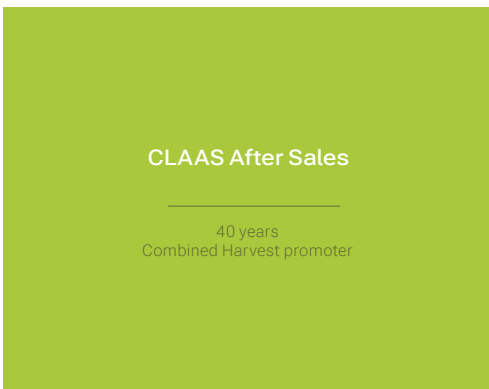
Price pressure



Importance of digitalization



Preference for one dealer



Goals

- Secure smooth operations across both own and newly acquired company
- Maintain independence and profitability through high diversification
- Preserve traditional pharmacy plant cultivation while optimizing logistics
- Build strong market ties with produce dealers and fellow farmers
- Improve storage strategy and harvest quality decisions
- Use drone and sensor tech for more precise weed control in specialty fields

Generation

- Ensure farmers can confidently operate new machines from day one.
- Reduce dependency on driver skills by offering practical guidance and simple explanations.

- Promote clean machine setups to avoid crop loss and improve efficiency.
- Translate innovation into everyday use through real conversations and local support.

- Make the first experience with CLAAS machines a positive and lasting one.



Needs

- Farmers' learning curves vary widely, especially after switching brands
- Misunderstandings about tech features like Xemos automation require repeated explanation
- Expectation to offer technical help without deep mechanical expertise
- Difficult to make wait times and drone battery limits relatable
- Communication chain via dealer slows down direct feedback loops

- Pressure to ensure quality operation under time constraints (e.g., 25-day harvest window)
- Needs to explain precision benefits without overwhelming users
- Balancing human autonomy and machine automation remains sensitive



Company

- Operates across multiple sites with a dense network of local dealers
- Workshop access limited to two farmers per yard in spring
- Machines delivered in bulk by end of May; onboarding must be fast and impactful
- Routes through 200–300 fields per farm require smart logistics and clear planning

- System is designed for night autonomy but day control—requires mindset shift



Machines

- Focus on harvester setups, cutting mechanisms, and smart guidance systems
- Aims to teach optimal calibration to reduce crop loss

- Pushes for standardization and substitution of manual decisions
- Discusses innovation over informal settings (e.g., "a cold one")

- Basic diagnostics and user knowledge shared via peer-to-peer systems
- Acts as an entry point into CLAAS's broader digital service ecosystem

I. User Journeys



01 Farm overview



Managing a 130 ha farm with clay soil. Crops include soy, beets, rapeseed, and wheat. Barley is avoided due to soil conditions.

Laptop

Needs

Fertilization must be preplanned

Possible Drone Implementation

Moving fertile earth
Safe field work
water quality monitoring
Monitoring hazardous materials (e.g. wastewater)
Sensor Deployment in high or inaccessible areas
Grabbing of multiple dirt samples

Checking on water supplies
Recognition of garbage
Disaster alert
Wildlife detection

02 Planning orders



Uses apps provided by dealer and checks stock exchanges to estimate grain purchasing for winter. Planning is crucial for coordinating with contractors and anticipating needs.

Laptop
Smartphone

Has to speculate on price development

Watching plants characteristics
Detection of drying stress
Checking on water supplies
Grain yield forecast
Moving fodder around
Transporting fertilizer

Moving bales

03 Testing the ground



Drives out with own small car to take field samples, checking if grain is dry enough for harvest. This supports decisions about harvest timing and his upcoming schedule.

Terminal

Keeping the digital field book organized

Removing ground for testing
Looking at straw pattern and straw distribution
Monitoring hazardous materials (e.g. wastewater)
Watching multiple fields
Wasp prevention via Cellulose
Grabbing of multiple dirt samples
Moving away stones

Recognition of garbage
Wildlife detection
Detection of drying stress
Watching plants characteristics
Marking different heights

04 Creating field task



Field tasks are based on structured planning—especially for fertilization, which must be pre-registered and distributed across all plots. Availability and capacity of his older father is considered.

Laptop

Adjusting to new personell

Road traffic monitoring
Watching road entries
Marking spots in fields

Marking machine damage

05 Organising contractors



Orders external harvesters via contractor services. Needs clear field overviews and schedules, especially since fields are small and numerous. Timely harvest depends on external availability.

Laptop, Smartphone

Managing other workers effectively

Making weather predictions
Moving After Sales Items
Adding communication points for a network

06 Supervising harvest



Harvest is outsourced. The farmer ensures it's performed uniformly using ISOBUS feedback from the machines. He supervises remotely, ensuring data quality.

Laptop

Managing other workers effectively

Safe field work
Watching multiple machines
mechanical aspects
Watching multiple machines

mechanical aspects
Wildlife detection

07 Cleaning grain



Grain is cleaned manually after harvest, before being stored. The goal is to maintain quality, especially for feeding pigs through winter. Certification standards must be met.

Cleaning machine

Managing other workers effectively

Marking dirt on machines
Cleaning out beddings
Removing dirt
Cleaning of machines with pressure

08 Storage and Usage



Grain is stored privately and used for feed until winter. Quality and traceability matter due to sustainability certification. Storage tracking done via spreadsheets.

Laptop, Storage measurement

Managing other workers effectively

Moving Bales
Moving implements
Moving implements around on the field
Moving away stones

09 Refertilization



Farmer registers estimates for yearly usage and adjusts based on field condition. Weed control is done early, if at all.

Laptop

Requires detailed upfront planning

Planting in between plants
Weed removal
Watching multiple fields
Moving fertile earth
Transporting fertilizer
Moving away stones

User Journey | 02



01 Farm work requests

Gets a call or message a day in advance from the contractor or a farmer. Availability depends on workload from his excavator business. Work schedule is often spontaneous and flexible.

Smartphone

Needs

Possible Drone Implementation

Making weather predictions
Road traffic monitoring
Carrying the equipment of one specific person

02 Preparing equipment



Checks the task and location on his tablet. Ensures the tractor is fueled and attachments (e.g., chipper, press) are mounted. Loads materials like yarn or netting if needed.

Tablet & Terminal

Different people use the same equipment

Carrying the equipment of one person
Watching machines mechanical aspects
Moving implements
Removing dirt
Charging other electronic

components
Adding sensors temporarily to a systems
Cleaning of machines with pressure
Adding personal objects

03 Driving to the worksite



Navigates to the field, sometimes combining the trip with a short vacation if the location is far. Fields vary in size and terrain, requiring manual adaptation of approach.

Tractor with RTK

Watching road entries

04 Setting up field route



Drives a straight line across the field to define the baseline route. Uses RTK-GPS, but signal can be unreliable. Overlap detection helps optimize coverage.

Tablet with GPS

Dependent on the technology

Completing otherwise incomplete networks
Marking boundaries to work
Marking spots in fields
Wildlife detection

05 Executing the task



Operates tractor or chipper to mow, press, or chop. Often monitors machine behavior in real-time. Sometimes needs to step down to check issues like yarn break or crop density.

Laptop

Fragmented fields lead to a lot of maneuvering

Working with less experienced people

Moving implements
Wildlife detection

Looking at straw pattern and straw distribution

Inspection of Air Area like Overhead Power Lines
Adding communication points for a network
Fire extinguishing
Disaster alert

06 Technical Maintenance



Solves minor breakdowns on-site (e.g., empty spool, blocked intake). Complex problems are addressed later at the contractor's workshop. Maintenance includes sharpening blades or checking hydraulics. ensuring data quality.

Laptop

Under pressure to safe costs

Watching multiple machines mechanical aspects

Moving implements around on the field

Carrying the equipment of one specific person

Marking machine damage

Removing dirt

Cleaning of machines with pressure

07 Harvest coordination



Harvesting usually done by the farm owner. Swathes and machine paths are recorded for better next-day planning.

Marking work place hazards
Moving implements around on the field
Charging other electronic components
Moving away obstacles

Marking different heights

08 Data & documentation



Checks Blackbox for hydraulic pressure data. Grain quantities and field performance are estimated manually. Invoicing may be postponed to year-end.

Tablet

09 Monitoring field condition



Tracks pest risks (e.g., corn borer) and crop health using weather apps and own observations. Fertilization is regulated, but experience trumps rigid guidelines.

Weather Apps & Field experience

User Journey | 03



01 Workshop preparation & planning



Checks SAP in the morning to review service tickets, expected deliveries, and internal part requests. Prioritizes urgent cases, especially those connected to seasonal cycles or recurring failures.

SAP system on office desktop

Needs

Possible Drone Implementation

Watching multiple fields

02 Coordinating deliveries



Organizes trucks to deliver replacement parts or pick up machines. Ensures materials like hydraulic fluid or bearings are stocked. Occasionally adapts delivery timing to accommodate customer needs or repair priorities.

Phone & Logistics software

Delivery times vary based on workshop region and client type

Moving items with drones
Moving After Sales Items

03 Supporting repair scheduling



Responds to calls from technicians or workshop leads. Coordinates additional support if electrical experts are needed. In peak season, keeps buffer time for emergency cases.

Tractor with RTK

Specialist availability varies – electronics-trained staff are limited

Charging other electronic components
Adding familiar sensors to one system
Marking machine damage
Charging other electronic components

Carrying the equipment of one specific person
Moving After Sales Items
Delivering After Sales Items

04 Warranty and budgeting



Handles larger warranty claims or cost exceptions. Reviews balance sheets and supports budgeting of workshop materials. Occasionally negotiates leeway on expired guarantees for loyal clients.

SAP, Excel

Watching multiple machines mechanical aspects

05 Midday progress check



Performs a midday check-in to assess workload distribution. Aligns with regional team leaders and adjusts timelines or deliveries accordingly. Keeps an eye on high-demand components.

Phone, SAP

Parts availability directly affects flexibility

Adding sensors to temporarily to a system

Charging other electronic components

06 Ad-hoc troubleshooting



Supports decision-making during peak times (e.g., drum fire, blocked hydraulic system). At times, helps coordinate emergency delivery of parts or external technician support.

Phone, SAP, Logistics software

Fast reactions are crucial during time-sensitive repair cases

Delivering After Sales Items

Carrying the equipment of one specific person

07 Feedback loop with service office



Documents delays, part shortages, and workshop bottlenecks. Suggests changes in supply chain or order planning to avoid repetition. Maintains close collaboration with the service office to improve workflows.

08 Digital documentation



Uses SAP to track timing, resources, and completed work. Documentation may be used for internal evaluation and budgeting purposes. Invoicing and task closure often happen the next day.

Tablet

Moving After Sales Items

09 Review & end-of-day adjustments



Before closing, checks for urgent part needs for the next day. If necessary, reorganizes deliveries or confirms late drop-offs. Flexibility ends around 22:00 due to community rules.

Weather Apps & Fiel experience

Workday ends only after all priority cases are stabilized

Marking boundaries to work at night

Marking boundaries to work

Marking work place hazards

User Journey | 04



01 Morning field walk & observation



Starts the day walking the dog through or alongside his fields. Uses this time to visually inspect crop and soil conditions, including moisture, plant health, and signs of pests or weather impact.

Personal observation, smartphone for photos

Needs

Thoroughness depends on time

Possible Drone Implementation

Marking spots in fields
Forest mapping
Watching the field for obstacles
Fire scene assessment

Construction sites status
Making weather predictions
Wildlife detection

02 Daily coordination with partner



Discusses the day's farm tasks with his wife, who co-manages the operations. Together, they decide on feeding schedules, pig care, minor fieldwork, or equipment needs.

Face-to-face planning over breakfast

Delivery times vary based on workshop region and client type

Moving items with drones
Watching multiple fields

Grabbing of multiple dirt samples

03 Animal care & pig cycle monitoring



Feeds pigs, checks on health conditions, social behavior, and cleanliness of stalls. Addresses problems (e.g. sick animals, aggressive behavior). Works in 3-week cycles, which define the rhythm of the day.

Watching livestock requires attention all day and night

Herding livestock around fields
Watching livestock on open fields
Grabbing of multiple dirt samples
Watching livestock on open

Moving fooder around
Moving bedding
Checking on water supplies
Cleaning out beddings

04 Equipment planning & machine sharing



Identifies equipment needs (e.g. for direct seeding or field flattening) and checks availability from local dealer networks. Communicates via phone to borrow required tools.

Phone

Equipment needs check up by knowledge

Marking possible damages on machines

Removing dirt
Moving implements

Marking dirt on machines

Cleaning of machines with pressure

05 Field & infrastructure maintenance



Performs hands-on tasks in owned or borrowed fields: soil regeneration (e.g. sunflower planting), field flattening, or drainage checks.

Tractor

Moving attachments around on the field

Marking spots in fields
Watching plants characteristics
Marking work place hazards

Planting in between plants
Moving fertile earth
Moving away obstacles

06 Midday check-in & livestock reassessment



Break and check-in with animals again. Ensures all feeding has gone well. Sometimes re-plans the day if weather shifts or an issue arises (e.g. sick pig, broken gate).

Hay fork

Moving fooder around

Water quality monitoring
Moving fooder around

Documenting weather development

Documentation of property damage

07 Reflection & future planning



Reflects on what went well or was frustrating (e.g. supply issues, poor weather). Considers what can be improved in soil health or herd conditions.

08 Evening shed check & wind-down



Uses a basic drone (approx. 300€) in the evening to survey fields, check livestock remotely, or inspect water drainage and damage.

Weather Apps & Fiel experience

Workday ends only after all priority cases are stabilized

Marking boundaries to work at night

Removing dirt

Documentation of property damage

Cleaning out beddings

Fire extinguishing

User Journey | 05



01 Morning Check-In



Starts the day at 7:00 with a review of emails and missed calls. Prioritizes based on urgency and complexity—some issues need immediate action, others can wait. Needs to interpret the client's tone and urgency intuitively.

Laptop, Phone

Needs

Needs to be at multiple points around the same time

Possible Drone Implementation

Watching multiple fields

02 Task assignment



Inputs driver schedules and coordinates machine allocation for the next day. Must assess where extra support is needed. Workload peaks make it difficult to satisfy all requests, as many clients need machines at once.

Laptop, Phone

Watching multiple machines at the same time Road traffic monitoring

Marking dirt on machines

03 Field Visits



Drives to different locations to check in with clients and workers. Handles issues directly in person, especially when large-scale problems arise or price adjustments need to be discussed.

Car, Smartphone

Watching livestock on open fields

Watching multiple machines mechanical aspects

04 Managing Staff



Listens to staff concerns to keep morale stable. Often deals with untrained seasonal workers or those pulled away by better offers. Ensures fair schedules and avoids burnout during peak times.

Phone

05 Technology Handling



Encourages use of technologies like RTK and NIR sensors, but adoption varies—especially among older staff. Trains clients and staff, though not all fully grasp the tools.

Laptop, Phone

Technology maintenance requires much knowledge

Watching multiple machines inaccessible areas

Carrying the equipment of one specific person Marking work place hazards
Sensor Deployment in high or

06 Live Machine Oversight



Constantly monitors combine harvester performance via GPS. Must stay responsive to technical problems, careless driving, or inefficient harvesting. Maintains up-to-date machine status across regions.

Laptop, GPS

Technology maintenance requires much knowledge

Watching multiple machines
Cleaning of machines with pressure
Removing dirt
Forest mapping

07 Community and Client Balance



Juggles machine coordination with maintaining good community relations. Responds to issues like dirty roads or fast driving through villages.

Phone, Webside

Roads need to be cleaned after machine usage

Watching road entries
Safe field work
Road traffic monitoring
Watching road entries

Moving away obstacles
Marking work place hazards
Removing dirt

08 Expansion & Innovation



Actively acquires new clients and oversees the company's growth eastward. Considers implementing strip-till and in the future. Innovation is driven by market competition and client interest.

Laptop

Watching multiple fields

User Journey | 06



01 Morning inbox check & crop status scan



Starts the day at 7:00 with a review of emails and missed calls. Prioritizes based on urgency and complexity. 

Laptop, Phone

Needs


Needs to gage the characteristics of each field in the morning

Possible Drone Implementation

Watching multiple fields

02 Operational planning & task assignment



Coordinates with staff to align field activities, logistics and animal feed schedules. Assigns machines, organizes fodder logistics, and ensures storage capacity. Delegates seed deliveries and trainee support. 

Phone, SAP, field logbooks

Equipping each machine with what the driver desires

Adding personal objects
Adding charging opportunity
Watching multiple machines mechanical aspects
Charging other electronic

components
Looking at straw pattern and straw distribution

03 Partner negotiation



Manages contracts for external partnerships and fodder trade. Prepares marketing briefs and discusses conditions with produce buyers.

Excel, contract database, phone

Moving bales
Moving fertile earth
Moving fodder around

Checking on water supplies
Cleaning out beddings

04 Machine readiness



Checks machine availability and usage schedules. Oversees maintenance coordination directly with CLAAS. Verifies availability of specialized equipment, especially for harvest and niche crops.


CLAAS support portal, service schedule

Watching multiple machines mechanical aspects
Moving implements
Carrying the equipment of one specific person

Marking machine damage
Marking dirt on machines

05 Flexibility management



Reassesses progress across crop and livestock operations. Responds to unpredictable events like weather shifts or transport delays. Adjusts field task schedules as needed. 


Laptop, Phone, GPS tools

Needs to gage the characteristics of each field in the morning

Watching multiple fields

06 On-site assessment



Visits key fields, especially pharmacy plant zones. Physically evaluates crop maturity and quality. Uses tester kits and senses (touch, sight, smell) to validate corn condition and harvest readiness. 

Tester cards, grain sample kits

Needs to gage the characteristics of each field in the morning

Watching plants characteristics
Marking different heights
Temperature mapping
Identification of weed nests
Recognition of garbage
Marking work place hazards
Grabbing of multiple dirt

samples
Watching the field for obstacles
Looking at straw pattern and straw distribution

07 Marketing alignment & buyer contact



Reaches out to produce buyers for quality assessments. Shares photos or brings physical samples. Maintains trusted buyer relationships, crucial for pharmacy crops and seed lines.

Handeling of multiple sections

Moving of multiple dirt samples
Watching plants characteristics

08 Administrative catch-up



Handles HR decisions like salaries or intern coverage. Logs updates, drafts contracts, and resolves bureaucratic tasks. Prepares resources for the next day.

Laptop

User Journey | 07



01 Morning animal care



Begins day at 6:00 AM with milking the cows and feeding all animals. Prioritizes animal well-being.

Hands-on/manual work.



Needs

Aestimating the water volume

Possible Drone Implementation

Hovering over water supplies shed
Moving bedding
Water quality monitoring
Watching livestock in the

02 Feed preparation



Retrieves and prepares silage from the silo. Brings feed to cows and calves. Uses homegrown grain. Calves receive warm milk based on age.

Tractor, silage cutter, buckets

Ensuring enough spread fodder

Moving fodder
Moving bales
Checking on water supplies

03 Work



Goes to part time work in office. Has smartphone for communication.

Private Cars



Watching multiple fields

04 Afternoon barn tasks



Cleans milk tank (every other day), lays fresh bedding (twice weekly), and checks on sick or newborn animals.

Manual Tools

Moving bedding
Cleaning out beddings
Removing dirt
Watching livestock in the

shed
Watching livestock on open fields

05 Field monitoring & preparation



Walks fields to inspect crop emergence, ripeness, or weed presence. In steep or wet areas, assesses if manual intervention is needed.

Phone, SAP



Looking at straw pattern and straw distribution
Forest mapping
Moving fertile earth
Grabbing of multiple dirt samples
Watching multiple fields
Wasp prevention via Cellulose

Marking spots in fields
Making weather predictions
Watching plants characteristics
Wildlife detection

06 Terrain challenges



Sloped or wet areas can't be accessed by machines. Needs to wait for the land to dry.

Weather Apps & Fiel mapping



Moving away stones
Marking spots in fields

Removing dirt
Marking boundaries to work

07 Harvest or seasonal work



If in harvest season, participates in mowing, compacting silage, or unloading grain. Often works with family or contractors in long shifts.

Tractor, harvester, silage trailer



Personalizing cabin for the short ammount of time

Moving implements around on the field
Planting in between plants
Safe field work
Watching multiple fields
Watching multiple machines

mechanical aspects
Moving implements around on the field

08 Evening routine



Second round of milking and feeding from 17:30–19:30. Animals are checked for health issues or behavior changes.

Watching livestock in the shed
Carrying the equipment of one specific person

09 Repairs & data tasks



Late evening: Partner handles repairs; mother logs records digitally (e.g., cow health, E-Milk app, subsidy info on E-AMA).

Laptop, smartphone, tools



User Journey | 08



01 First Contact After Purchase



Meets each farmer after the delivery of a new machine. Introduces core functions and explains usage basics tailored to farm needs.

Product manual

Needs

Possible Drone Implementation

Charging other electronic components
Carrying the equipment of one specific person

Watching multiple machines mechanical aspects

02 Understanding Farmer Needs



Listens to specific challenges—sometimes informally “over a cold one.” Identifies skill levels, working routines, and priorities to tailor explanations.



Watching multiple fields

03 Explaining Core Features



Focus on essential features such as cutting mechanisms, automation options (e.g., Xemos), and clean machine setup to reduce plant loss.

Tablet

Different aspects of the machine need to be considered

Watching multiple machines mechanical aspects
Marking machine damage
Marking dirt on machines

Cleaning of machines with pressure

04 Organizing Winter Workshops



Between January and May, invites up to two farmers per yard to hands-on training sessions. Topics include machine setup, feature usage, and optimization.

Laptop

05 Supporting Technology Adoption



Introduces peer learning systems and shares best practices to help drivers adapt to growing technical complexity. Promotes learning through own interest.



06 Preparing for Harvest



Coordinates with farmers ahead of the 25-day harvest peak. Emphasizes clean setup and feature readiness. Provides a list of new machines and updates in May.



Needs to show presence for all the clients

Watching multiple machines mechanical aspects

07 Explaining Route Planning



For large farms with 200–300 parcels, introduces digital route planning. Helps farmers understand traffic logic (left/right field order).

Quick decision of which field to take next

Watching multiple fields
Forest mapping
Watching road entries
Road traffic monitoring

08 Managing Expectations



Communicates limits like wait times. Explains what the machine can predict and where human supervision remains essential.

Laptop

Needs to show presence for all the clients

09 Building Long-Term Trust



Ensures the first impression is strong to create long-term loyalty. Reinforces CLAAS’s local dealer advantage by staying reachable and helpful post-delivery.

Phone

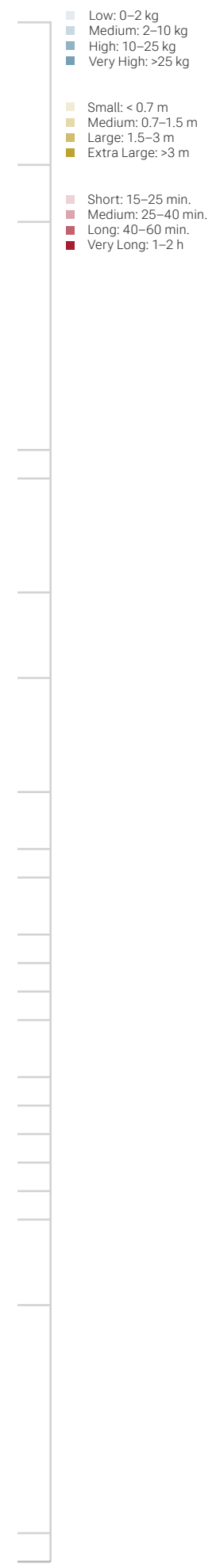
Needs to show presence for all the clients

Moving After Sales Items
Delivering After Sales Items

J. Functionality grouping



















































































		▲ Payload	+ Size	🕒 Duration	Frequency
01	Looking at straw pattern and straw distribution	Medium	Medium	Medium	
02	Safe field work	Medium	Medium	Medium	
03	Monitoring hazardous materials (e.g. wastewater)	Low	Small	Long	
04	Water quality monitoring	Low	Small	Long	
05	Road traffic monitoring	Low	Small	Long	
06	Planting in between plants	Medium	Medium	Medium	
07	Forest mapping	Medium	Medium	Long	
08	Weed removal	Medium	Medium	Medium	
09	Watching the field for obstacles	Low	Small	Long	
10	Watching livestock in the shed	Low	Small	Long	
11	Watching livestock on open fields	Low	Small	Long	
12	Watching multiple fields	Low	Small	Long	
13	Watching multiple machines mechanical aspects	Low	Small	Long	
14	Watching road entries	Low	Small	Long	
15	Moving bales	High	Large	Medium	
16	Sensor Deployment in high or inaccessible areas	Medium	Medium	Medium	
17	Wasp prevention via Cellulose	Medium	Medium	Medium	
18	Moving fertile earth	High	Large	Medium	
19	Transporting fertilizer	High	Large	Medium	
20	Moving implements	High	Large	Short	
21	Herding livestock	Medium	Medium	Medium	
22	Moving implements around on the field	High	Large	Medium	
23	Moving fooder around	High	Large	Medium	
24	Grabbing of multiple dirt samples	Medium	Medium	Medium	
25	Moving away obstacles	High	Large	Medium	
26	Moving After Sales Items	High	Large	Medium	
27	Moving bedding	High	Large	Medium	
28	Delivering After Sales Items	Medium	Medium	Medium	
29	Carrying the equipment of one specific person	High	Large	Medium	
30	Fire scene assessment	Medium	Medium	Medium	
31	Construction sides status	Medium	Medium	Medium	
32	Inspection of Air Area like Overhead Power Lines	Low	Small	Long	
33	Making weather predictions	Medium	Medium	Medium	
34	Checking on water supplies	Medium	Medium	Medium	
35	Adding communication points for a network	Medium	Medium	Medium	
36	Fire extinguishing	Medium	Medium	Medium	
37	Charging other electronic components	Medium	Medium	Short	
38	Adding sensors temporarily to a systems	Medium	Medium	Medium	
39	Adding personal objects	Medium	Medium	Medium	
40	Recognition of garbage	Medium	Medium	Medium	
41	Disaster alert	Medium	Medium	Medium	
42	Documentation of property damage	Medium	Medium	Medium	
43	Identification of weed nests	Medium	Medium	Medium	
44	Temperature mapping	Low	Small	Long	
45	Detection of drying stress	Low	Small	Medium	
46	Wildlife detection	Medium	Medium	Medium	
47	Marking work place hazards	Medium	Medium	Short	
48	Marking different heights	Medium	Medium	Short	
49	Marking boundaries to work	Medium	Medium	Short	
50	Marking spots in fields	Medium	Medium	Short	
51	Marking machine damage	Medium	Medium	Short	
52	Marking dirt on machines	Medium	Medium	Short	
53	Removing dirt	High	Large	Medium	
54	Cleaning of machines with pressure	Medium	Medium	Medium	
55	Cleaning out beddings	Medium	Medium	Medium	
56	Watching plants characteristics	Low	Small	Short	

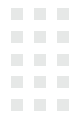
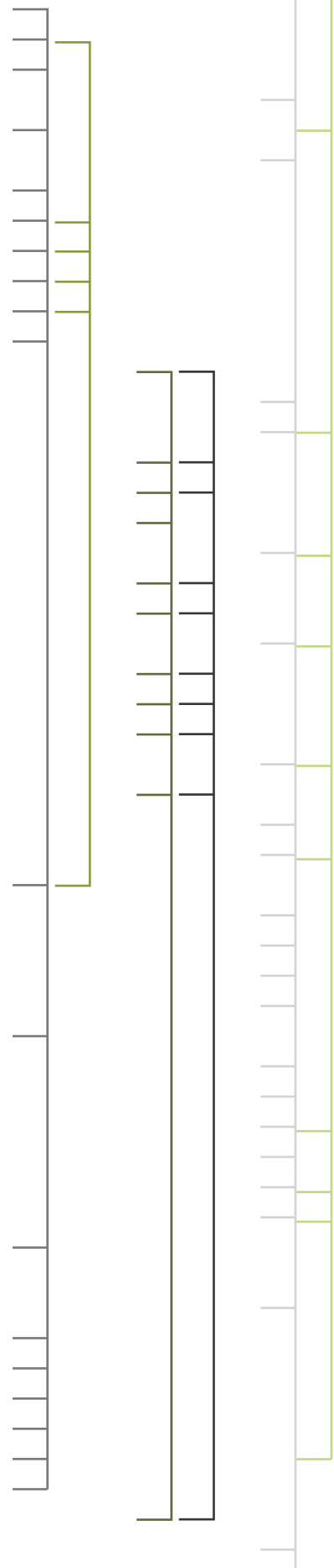




		Sensors		Drone Type	Frequency	
01	Looking at straw pattern and straw distribution			Multi Rotor		Acoustic based sensors
02	Safe field work			Multi Rotor		Camera sensor
03	Monitoring hazardous materials (e.g. wastewater)		 	Rotor + Fixed		Electromagnetic sensors Mechanical sensors Mass flow sensors
04	Water quality monitoring	PH Sensor, COD Sensor		Fixed Wing		Light detection and ranging (LIDAR)
05	Road traffic monitoring			Rotor + Fixed		Optical sensors
06	Planting in between plants	RGB, Multispectral		Multi Rotor		Camera sensor
07	Forest mapping			Multi Rotor		Thermal imaging
08	Weed removal	RGB, Multispektral		Multi Rotor		Camera sensor
09	Watching the field for obstacles		 	Lift & Cruise		Ultrasonic sensors Camera sensor Radar sensor
10	Watching livestock in the shed		 	Fixed Wing		Infrared sensor Camera sensor Thermal imaging
11	Watching livestock on open fields		 	Fixed Wing		Camera sensor Thermal imaging Optical sensors
12	Watching multiple fields			Fixed Wing		Camera sensor
13	Watching multiple machines mechanical aspects			Fixed Wing		Camera sensor
14	Watching road entries			Rotor + Fixed		Camera sensor
15	Moving bales	Load sensors		Single Rotor		Light bulb icon
16	Sensor Deployment in high or inaccessible areas			Multi Rotor		GPS sensor
17	Wasp prevention via Cellulose			Multi Rotor		Thermal imaging
18	Moving fertile earth	Load Sensor, Tactile Sensor		Single Rotor		Ultrasonic sensors
19	Transporting fertilizer	Load Sensor, Tactile Sensor		Single Rotor		Ultrasonic sensors
20	Moving implements	Load Sensor, Tactile Sensor		Single Rotor		Ultrasonic sensors
21	Herding livestock		 	Multi Rotor		Ultrasonic sensors Camera sensor Thermal imaging
22	Moving implements around on the field	Load Sensor, Tactile Sensor		Single Rotor		Ultrasonic sensors
23	Moving fooder around	Load Sensor, Tactile Sensor		Single Rotor		Ultrasonic sensors
24	Grabbing of multiple dirt samples	Tactile Sensor	 	Multi Rotor		Ultrasonic sensors Camera sensor
25	Moving away obstacles	Load Sensor, Tactile Sensor		Single Rotor		Camera sensor
26	Moving After Sales Items	Load Sensor, Tactile Sensor	 	Single Rotor		Ultrasonic sensors Camera sensor
27	Moving bedding	Load Sensor, Tactile Sensor		Single Rotor		
28	Delivering After Sales Items	Load Sensor, Tactile Sensor		Multi Rotor		Ultrasonic sensors
29	Carrying the equipment of one specific person	Load Sensor, Tactile Sensor		Single Rotor		Light bulb icon
30	Fire scene assessment			Rotor + Fixed		Thermal imaging
31	Construction sides status		 	Multi Rotor		Camera sensor Thermal imaging
32	Inspection of Air Area like Overhead Power Lines			Fixed Wing		Camera sensor
33	Making weather predictions	Optical	 	Multi Rotor		Humidity sensor Barometer sensor Infrared sensor Eddy covariance-based sensors
34	Checking on water supplies	PH Sensor, COD Sensor	 	Multi Rotor		Ultrasonic sensors Radar sensor
35	Adding communication points for a network			Multi Rotor		Thermal imaging
36	Fire extinguishing	Thermal, Gas, Optical		Rotor + Fixed		Thermal imaging
37	Charging other electronic components	Tactile Sensor		Multi Rotor		
38	Adding sensors temporarily to a systems	Tactile Sensor		Multi Rotor		
39	Adding personal objects	Load Sensor, Tactile Sensor		Multi Rotor		
40	Recognition of garbage		 	Multi Rotor		Camera sensor Thermal imaging
41	Disaster alert		 	Rotor + Fixed		Camera sensor Thermal imaging Humidity sensor Eddy covariance-based sensors
42	Documentation of property damage		 	Multi Rotor		Ultrasonic sensors Radar sensor Light bulb icon
43	Identification of weed nests		 	Multi Rotor		Camera sensor Thermal imaging
44	Temperature mapping			Rotor + Fixed		Thermal imaging
45	Detection of drying stress		 	Rotor + Fixed		Airflow sensors Humidity sensor Eddy covariance-based sensors
46	Wildlife detection		 	Multi Rotor		Thermal imaging Camera sensor Radar sensor
47	Marking work place hazards		 	Multi Rotor		Camera sensor GPS sensor
48	Marking different heights		 	Multi Rotor		Barometer sensor GPS sensor
49	Marking boundaries to work			Multi Rotor		GPS sensor
50	Marking spots in fields			Multi Rotor		GPS sensor
51	Marking machine damage			Multi Rotor		Camera sensor
52	Marking dirt on machines		 	Multi Rotor		Camera sensor Ultrasonic sensors Radar sensor Light bulb icon
53	Removing dirt			Single Rotor		Ultrasonic sensors
54	Cleaning of machines with pressure		 	Multi Rotor		Camera sensor Ultrasonic sensors Radar sensor Light bulb icon
55	Cleaning out beddings		 	Multi Rotor		Camera sensor Ultrasonic sensors Radar sensor Light bulb icon
56	Watching plants characteristics		 	Multi Rotor		Optical sensors Mass flow sensors

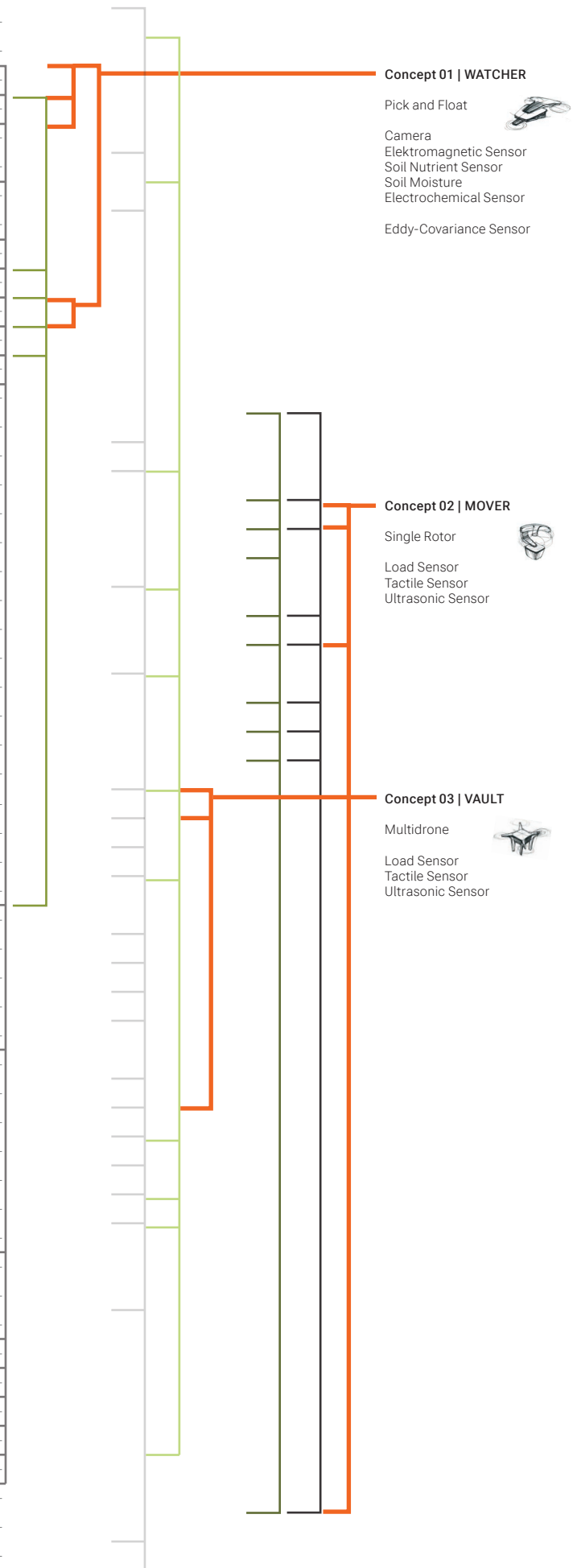
- Rotor + Fixed Wing
- Multi Rotor
- Single Rotor
- Fixed Wing

		 Sensors	Drone Type	Frequency
01	Looking at straw pattern and straw distribution	   	Multi Rotor	
02	Safe field work		Multi Rotor	
03	Monitoring hazardous materials (e.g. wastewater)	     	Rotor + Fixed	
04	Water quality monitoring	PH Sensor, COD Sensor	Fixed Wing	
05	Road traffic monitoring	 	Rotor + Fixed	
06	Planting in between plants	RGB, Multispectral	Multi Rotor	
07	Forest mapping		Multi Rotor	
08	Weed removal	RGB, Multispektral	Multi Rotor	
09	Watching the field for obstacles	    	Lift & Cruise	
10	Watching livestock in the shed	  	Fixed Wing	
11	Watching livestock on open fields	  	Fixed Wing	
12	Watching multiple fields		Fixed Wing	
13	Watching multiple machines mechanical aspects		Fixed Wing	
14	Watching road entries		Rotor + Fixed	
15	Moving bales	Load sensors	Single Rotor	
16	Sensor Deployment in high or inaccessible areas		Multi Rotor	
17	Wasp prevention via Cellulose		Multi Rotor	
18	Moving fertile earth	Load Sensor, Tactile Sensor	Single Rotor	
19	Transporting fertilizer	Load Sensor, Tactile Sensor	Single Rotor	
20	Moving implements	Load Sensor, Tactile Sensor	Single Rotor	
21	Herdng livestock	  	Multi Rotor	
22	Moving implements around on the field	Load Sensor, Tactile Sensor	Single Rotor	
23	Moving fooder around	Load Sensor, Tactile Sensor	Single Rotor	
24	Grabbing of multiple dirt samples	Tactile Sensor	Multi Rotor	
25	Moving away obstacles	Load Sensor, Tactile Sensor	Single Rotor	
26	Moving After Sales Items	Load Sensor, Tactile Sensor	Single Rotor	
27	Moving bedding	Load Sensor, Tactile Sensor	Single Rotor	
28	Delivering After Sales Items	Load Sensor, Tactile Sensor	Multi Rotor	
29	Carrying the equipment of one specific person	Load Sensor, Tactile Sensor	Single Rotor	
30	Fire scene assessment		Rotor + Fixed	
31	Construction sides status	 	Multi Rotor	
32	Inspection of Air Area like Overhead Power Lines		Fixed Wing	
33	Making weather predictions	Optical	Multi Rotor	
34	Checking on water supplies	PH Sensor, COD Sensor	Multi Rotor	
35	Adding communication points for a network		Multi Rotor	
36	Fire extinguishing	Thermal, Gas, Optical	Rotor + Fixed	
37	Charging other electronic components	Tactile Sensor	Multi Rotor	
38	Adding sensors temporarily to a systems	Tactile Sensor	Multi Rotor	
39	Adding personal objects	Load Sensor, Tactile Sensor	Multi Rotor	
40	Recognition of garbage	 	Multi Rotor	
41	Disaster alert	    	Rotor + Fixed	
42	Documentation of property damage	  	Multi Rotor	
43	Identification of weed nests	 	Multi Rotor	
44	Temperature mapping		Rotor + Fixed	
45	Detection of drying stress	  	Rotor + Fixed	
46	Wildlife detection	  	Multi Rotor	
47	Marking work place hazards	 	Multi Rotor	
48	Marking different heights	 	Multi Rotor	
49	Marking boundaries to work		Multi Rotor	
50	Marking spots in fields		Multi Rotor	
51	Marking machine damage		Multi Rotor	
52	Marking dirt on machines	   	Multi Rotor	
53	Removing dirt		Single Rotor	
54	Cleaning of machines with pressure	   	Multi Rotor	
55	Cleaning out beddings	   	Multi Rotor	
56	Watching plants characteristics	 	Multi Rotor	

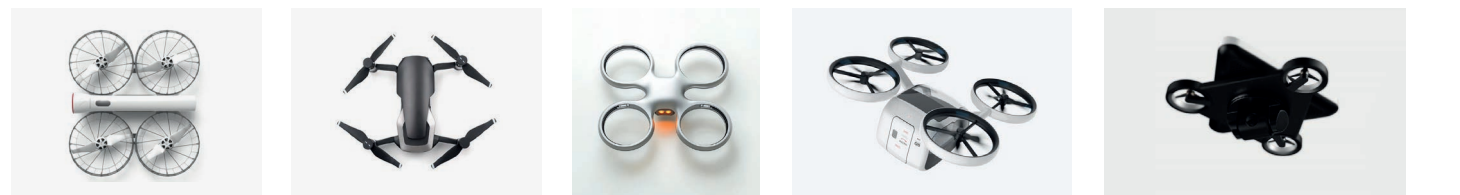




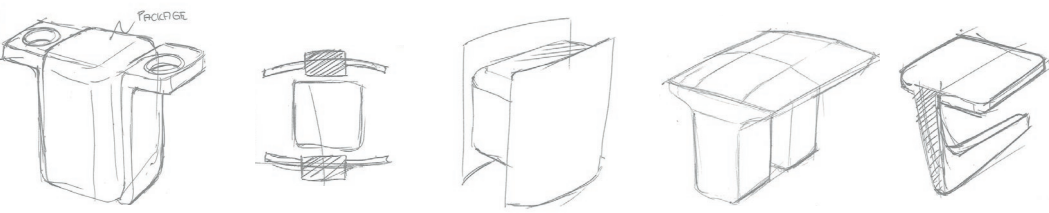
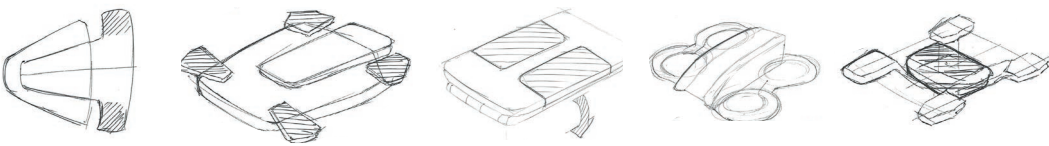
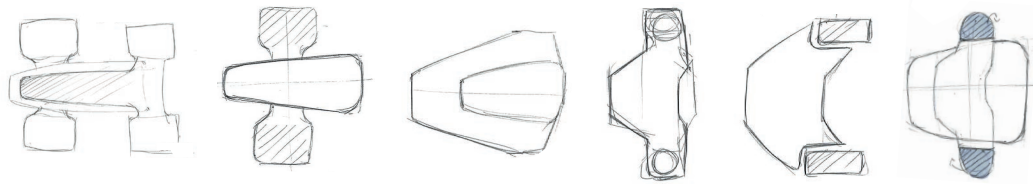
	 Drone Type	Frequency
01	Multi Rotor	
02	Multi Rotor	
03	Rotor + Fixed	
04	Fixed Wing	
05	Rotor + Fixed	
06	Multi Rotor	
07	Multi Rotor	
08	Multi Rotor	
09	Lift & Cruise	
10	Fixed Wing	
11	Fixed Wing	
12	Fixed Wing	
13	Fixed Wing	
14	Rotor + Fixed	
15	Single Rotor	
16	Multi Rotor	
17	Multi Rotor	
18	Single Rotor	
19	Single Rotor	
20	Single Rotor	
21	Multi Rotor	
22	Single Rotor	
23	Single Rotor	
24	Multi Rotor	
25	Single Rotor	
26	Single Rotor	
27	Single Rotor	
28	Multi Rotor	
29	Single Rotor	
30	Rotor + Fixed	
31	Multi Rotor	
32	Fixed Wing	
33	Multi Rotor	
34	Multi Rotor	
35	Multi Rotor	
36	Rotor + Fixed	
37	Multi Rotor	
38	Multi Rotor	
39	Multi Rotor	
40	Multi Rotor	
41	Rotor + Fixed	
42	Multi Rotor	
43	Multi Rotor	
44	Rotor + Fixed	
45	Rotor + Fixed	
46	Multi Rotor	
47	Multi Rotor	
48	Multi Rotor	
49	Multi Rotor	
50	Multi Rotor	
51	Multi Rotor	
52	Multi Rotor	
53	Single Rotor	
54	Multi Rotor	
55	Multi Rotor	
56	Multi Rotor	

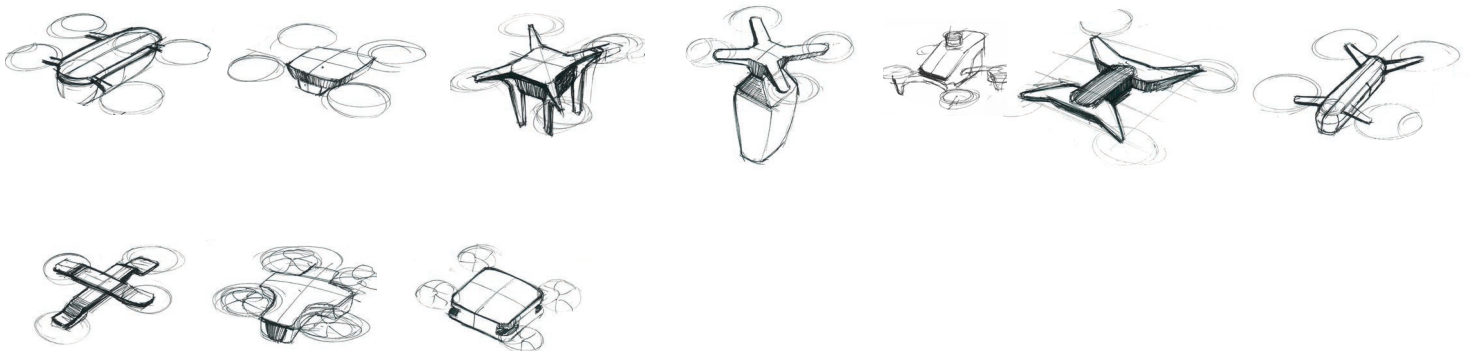
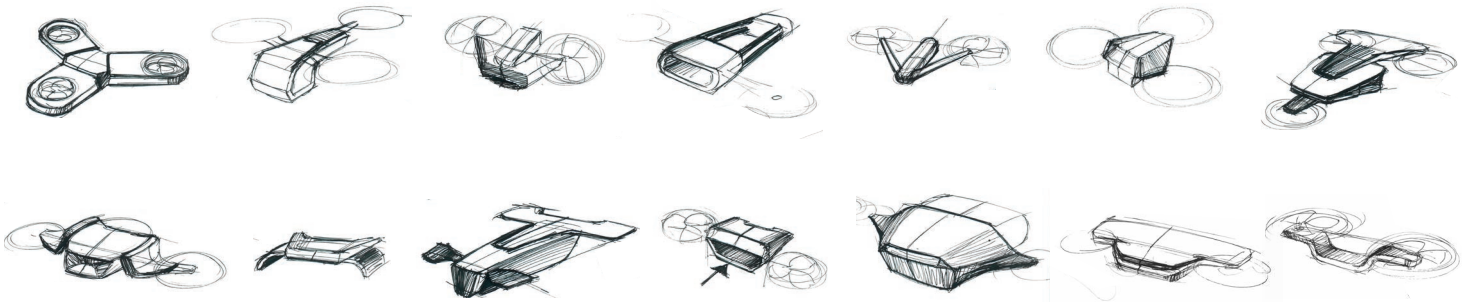
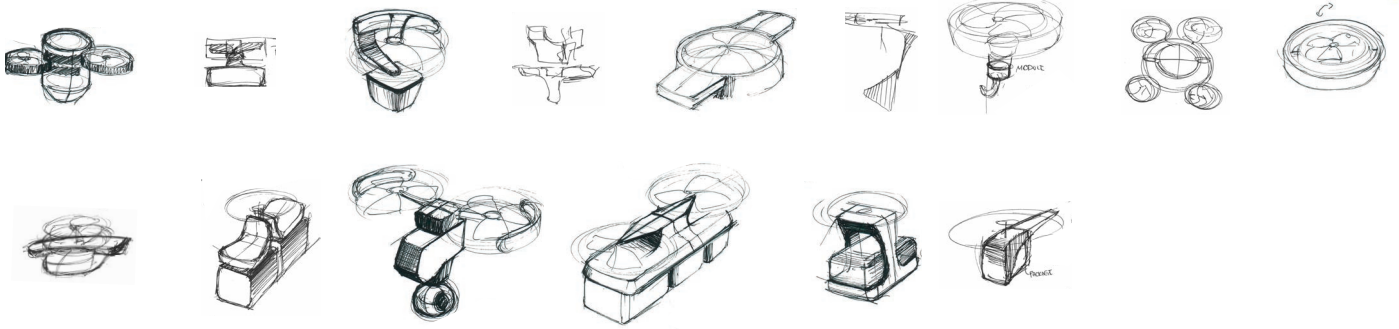


K. Drone Architectures



L. Form sketches





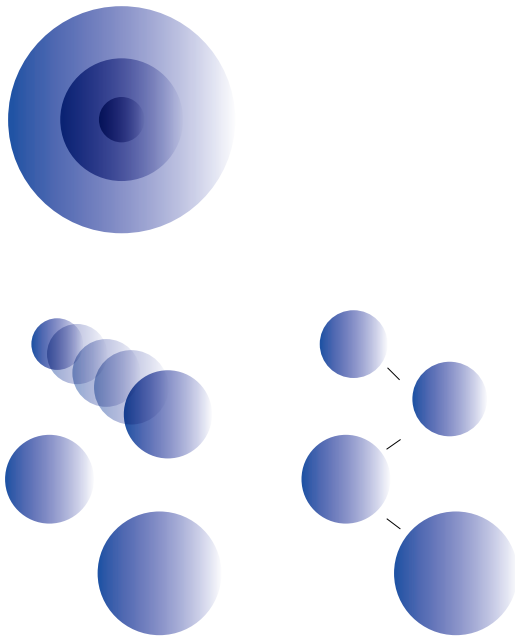
N. Expert Concept Interviews



Name	Role and Topic	Date	What does that mean for drones?
01	Hendrik Flessner Sales Promoter combined Harvester	05.09	<p>Farmers show strong interest in stock management and fawn rescue use cases. Detecting points of interest like waterholes or stones is also appealing, especially for autonomous systems.</p> <p>Integrating drone data into CLAAS Connect aligns with CLAAS's digital strategy. Collaborating with Bayer avoids redundant development and strengthens the business case.</p> <p>While algorithms are essential for data interpretation, partnerships make development more feasible. Some regulatory barriers remain, especially for integrating drones into combine harvester workflows</p> <p>Drones are on the radar of CLAAS.</p>
02	Felix Gieseke Technology Scouting	08.09	
03	Martin Leinecker Group Strategy	12.09	

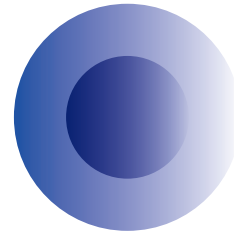


01. CLAAS. Sales promotion combine Harvester.



Small tools are always in the cab in the storage rooms
 Sees it for after sales items and special tools-> ‚Interessante Sache‘
 Accidents and maintainace does not happen at the field entry
 5kg-> more could lead to the transport of plant protection products + seeds
 -> at the end of the day there is always missing a bag
 -> annoying to send someone to the storage again
 good opportunity on normal work
 kitchen could send the lunch to them and keep it warm
 Interesting for sales partners
 Could be transported from pick Up and own operation location
 Servicability of CLAAS is a huge selling and value point for them
 As a sales prompoter you need less material, but I do have small tools with me
 Good if the machine does not have to stop
 Interesting in terms of productifity for bigger farms
 Filter and Fluids are interesting
 Can come multiple times right?
 Could also be like a drone chain, so multiple drones
 Can you define the touch down and start time for me?
 Not bad!
 Calculation with 10.000- 10. Years usage- 100 a year- 20h at a rate of 40/50 euros
 How often do you drive yor pickup outinto the field ?
 Nice to have tools for adjusting things
 Drive & Engine Parts
 Service costs are basically in the price
 Tennis ball effect-
 Going over trees and obstacles
 Zukauf gut vorstellbar
 Service developement and item providing
 tennis ball effect
 beginning small end expanding the portfolio is possible
 Story fist with the new tractors where we also weant to include service of trainings
 Spidewrweb for different clients- could push the tractor

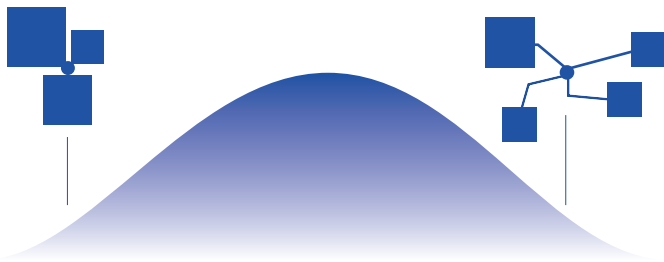
02. CLAAS. Sales promotion combine Harvester.



Interesting perspective
 for the agronomic environemnet
 looks promising so far
 CLAAS does not see themself as a Sensor manufacturing company
 what can wee add as functions beyond sensors ?
 Add on for existing drone-> What can we do with that?
 Broad thought
 Important for me are the scenario images- an listing what different scenarios can be fulfilled
 Conservative calculation of driving hours
 Could you include all the other use cases
 Perception Sensors- Jannick Kredenius
 10-20h potential
 BAstian Rohrmann-Automation and Autonomy; Field Scanner + Lidar, Sensorik on Roofs
 Use case listing
 Drone model
 Promising in general



03. CLAAS. Group Strategy.



earnings before interest, taxes, depreciation could be considered for a more detailed cost analysis

you can not fully understand the scenarios in one grasp right now- make an image for each scenario

Realistically the median earnings could be lower

you mentioned a median- but the extremes would be interesting as well

You have to describe the median drive number more clearly- what vehicles and which scenario

You could play with different assumptions

Ktbl for an economic analysis

Down time

Ganz spannend- quite interesting

Where is it placed on the machine itself

Why not supplier parts?

Smaller tools that a person has forgotten

There is a social component to going to the driver himself- Acknowledging that helps your concept

How does the interaction look on the field- Taking down and reaching something

O. Product Pitch



Modern agriculture demands efficient logistics that **reduce downtime and support both machinery and staff**. The CLAAS Cargo Drone is a modular aerial transport system designed to optimize the movement of tools, spare parts, and personal packages across the field.

Fitted to the realities of seasonal work, staff coordination, and technical maintenance, it ensures that **resources reach the right place at the right time**.

Value for Agriculture

By integrating an aerial logistics solution into the CLAAS ecosystem, farms can **reduce machine downtime**, improve staff efficiency, and support flexible, responsive workflows. The Cargo Drone brings automation to **small-scale logistics** in agriculture, providing value in everyday operations.

Core Functionality

The drone operates as a flexible link between the coordinator vehicle, field machines, and farm staff. Personal and technical packages can be loaded centrally and distributed directly to machines or user cabins. Through its clamp mechanism and axis element, the drone can secure, release, and store a variety of items reliably. This reduces the need for manual transport and ensures quick response during **peak workloads**.

Example Cargo

After-sales drop	parts box (1.0), docs (0.1), compact driver (0.3)	1.4 kg
Technician light kit	tablet (0.9), tool roll (0.8), PPE (0.3), powerbank (0.3)	2.3 kg
Tech kit + personal add-ons	bundle B + jacket (0.6)	2.9 kg
Personal carry	lunch + bottle (0.7), jacket (0.6), small pouch (0.2)	1.5 kg
Heavy service kit	small laptop (1.3), full tool roll (1.2), water (0.5)	3 kg

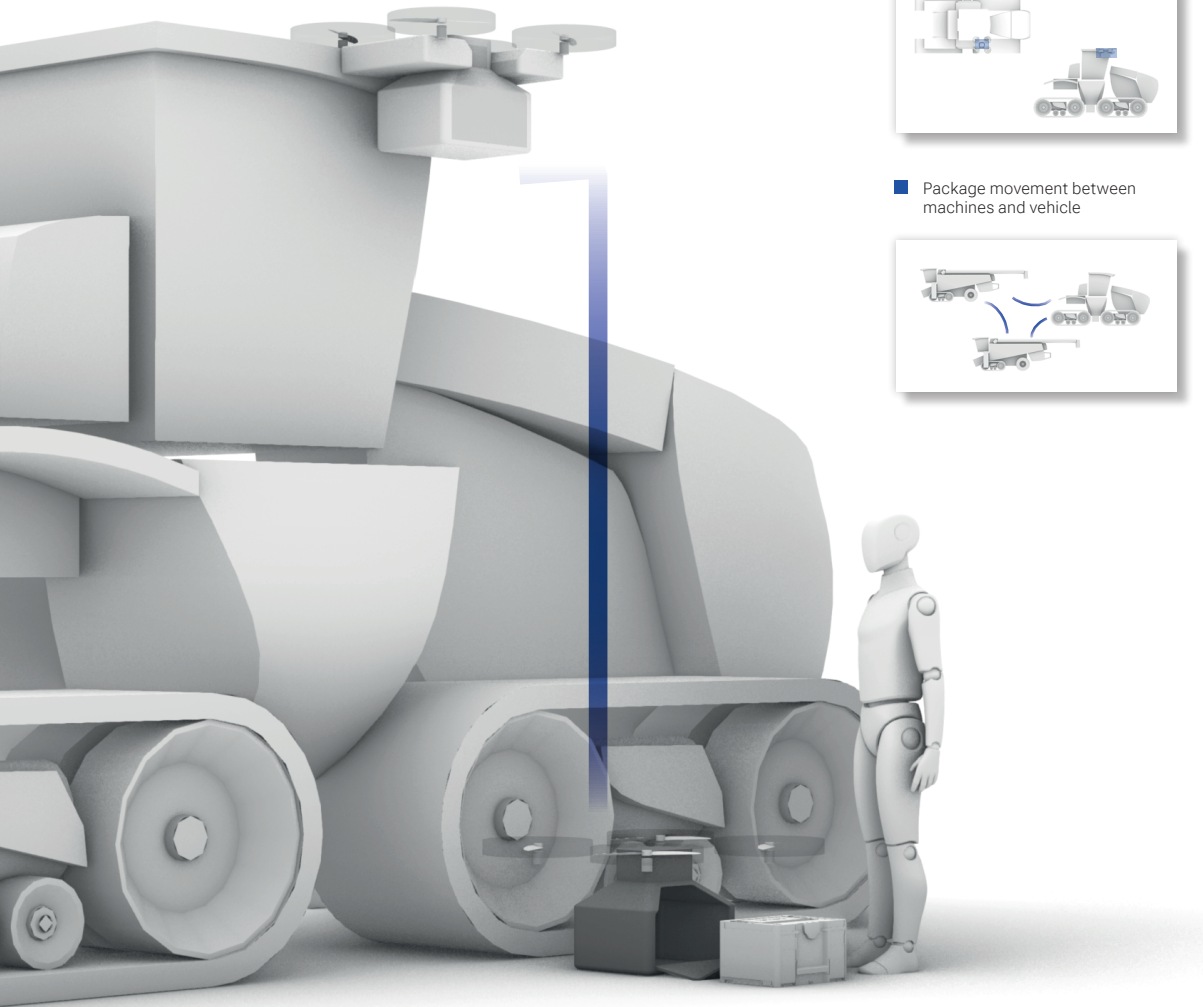
based on DJI M400

1h
Flighttime

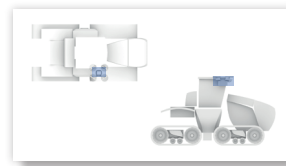
6kg
Payload

10.000 €
Cost

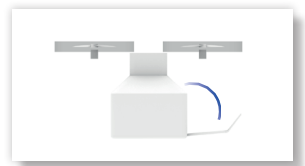
20km
Distance



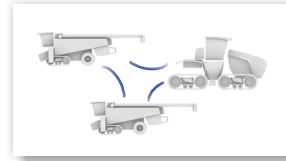
Item drop off on machine itself



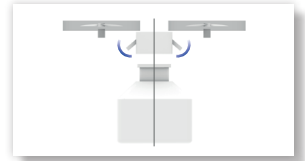
Storage of items



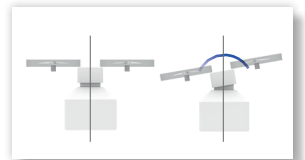
Package movement between machines and vehicle



Clamp opening



Axis element



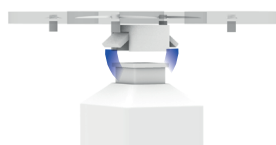
Personal Packages are loaded on coordinator vehicle



Charging
Charging cargo modules on different vehicles besides the fields



Starting
Controlling if cargo is secured correctly



Hovering
Moving from field borders to a machine



Landing
Landing in module attached to user cabine for access



P. User Concept Interviews



	Number	Description	Date
Lukas	02	contractor	18.09



01. Lukas. Contractor.

After Sales is very dependent on the machine_> there is a lot of machine specific things

Schwader

After Sales Items could be sth
Electronic Safety components, Sensors

Filter is something that will be needed less frequent- there has to be a lot wrong beforehand

Sensors have to be changed a few times-> I know how to do it after a few times, but others would still need instructions

Sensors themselves are plug and play-Distance has to be right

Hydraulik tubes are important-Sometimes there are tree branches in the way

Screws and split screws-could be ripped away

Tools are usually predetermined in each cabin
changing operators in cabins leads to confusion and untidy cabin interior - no overview of the items that are actually there

good if you are more far away, for longer drives or on the road in general

Food gets delivered by the farmer 80 percent of the time in the evening at least

over the day, usually bring own food- morning into the supermarket

Becomes generally less when it is bigger operations.

We usually do not do big repairs on the field

Has to be driven to the field by the farmer themselves who owns the machine

Exchange between each other interesting if the vehicles work asymmetric

Medicine, Lighter, Drink
I usually carry a backpack with me with drink, sun glasses and short trousers

App makes sense for the interaction: takes time to come so it would be interesting to see in between

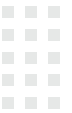
maybe in the cabin inside digital system

In the farm items are usually sorted by machine, in smaller farms it is less organized

It's difficult to grasp it becoming reality at the moment: i am also astonished right now when there is a pizza delivery robot

-> has to work

Q. System overview



1	Vertical Rail	+ Vertical Rail	- Defined stacking order
2	Stacking System	+ Modular through attachment points on package	- Defined stacking order
3	Vertical Shelve	+ Vertical Shelve	- Defined stacking order
4	Horizontal Shelve	+ Undefined stacking order	- Additional weight through shelve
5	Internal Push and Release System	+ Internal Push and Release System Form closure possible	- ///
6	External Push and Release System	+ External Push and Release System	- No centred point of gravity Spacial limitations vertically
7	Elektromagnetic System	+ No external mechanics necessary	- More complex Locking mechanism

R. Form Moodboard



LIGHT
Aerodynamic Appearance



STATIC
Structural Integrity

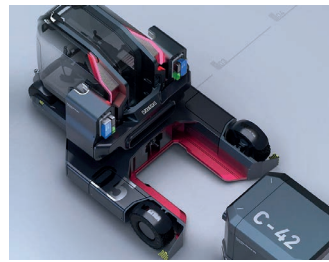


TECHNOID
Emphasizing function

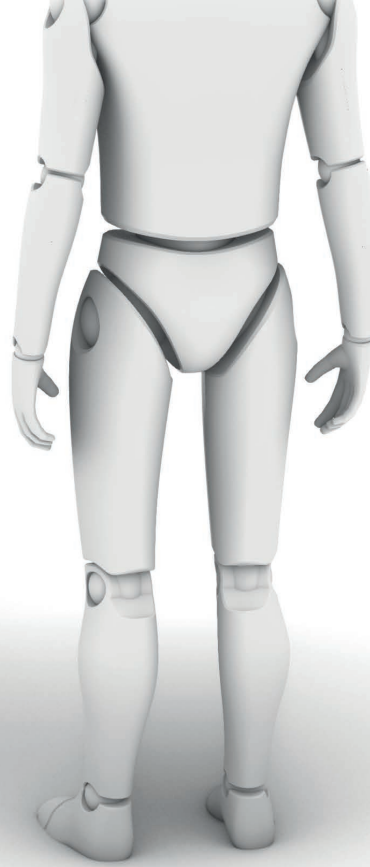
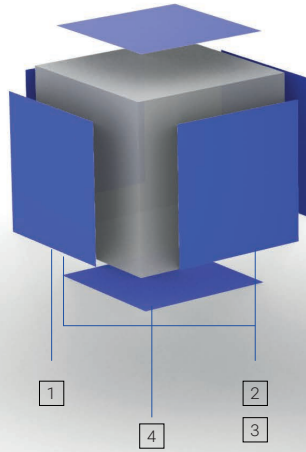


MODULAR
Adding forms

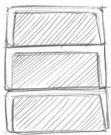
S. Cargo Moodboard



T. Packaging overview



1

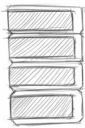


Vertical Rail

+ Access while stacked

- Limited volume access

2



Stacking System

+ Big opening surface
Stacking possible

Sideways access

- No Roof access

3



Vertical Shelf

+ Vertical Shelf

- Mechanical component
No roof access

4



Horizontal Shelf

+ Bottom acces for roof
Big surface opening

- Weight has to be held by user when
dismounting
No stacking and immediate access

U. Van Westendorp-Questionnaire



Transport Drohne für die Landwirtschaft

Guten Tag!

In dieser Umfrage möchten wir Ihnen ein Drohnenkonzept vorstellen, welches die Arbeit auf dem Hof erleichtert.

Die Umfrage dauert etwa fünf Minuten und ist Teil einer Abschlussarbeit in Zusammenarbeit mit der Firma CLAAS.

Nicht freigegeben

* Gibt eine erforderliche Frage an

Transport-Drohne für den Landwirtschaftsbetrieb

1h
Flighttime
6kg

Die CLAAS Drohne ist eine Transportdrohne, die auf dem Hof oder auf dem Feld Ersatzteile, Werkzeuge oder persönliche Gegenstände liefert. Sie hilft Wege zu sparen und Zeitverluste zu vermeiden, zum Beispiel wenn während der Ernte ein Werkzeug oder Ersatzteil fehlt.

Je nach Bedarf kann sie mit unterschiedlichen Boxen oder Halterungen ausgestattet werden, um verschiedene Güter zu transportieren.

...mögliche transportierbare Produkte

- After Sales Leistung: Ersatzteile (z.B. Sommeröl), Komplexarbeiten (z.B.)
- Technischer Support: Feld (z.B. Workshop/PSA, PSA-Öl, Problemfeld)
- Technik für eigenbetriebliche Zwecke: Pflanz (z.B. Lande) (z.B.)
- Personlicher Transport: Aufgassen + Geräte (z.B. Mähre (z.B.), Mähre (z.B.))
- Unternehmensbedarf: Koffer (z.B.), Transportbehälter (z.B., Wasser (z.B.))

...Wege im Betrieb

...Zeitersparnis

Wende	Zeit (min)				Einsparung (min)	Einsparung (%)
	vorher	jetzt	jetzt (mit Drohne)	jetzt (mit Drohne)		
Innenhalb des Hofgeländes	0,8min	1,4min	0,8min	0,6min	30%	3,5%
Strecke vom Hofgelände	2,5min	4,3min	2,5min	1,8min	25%	7,5%
Feldrand zur Maschine	0,8min	0,7min	0,4min	0,3min	60%	3,0%
Hofgelände zur Maschine	2,9min	5,0min	2,9min	2,1min	40%	14%
After Sales zum Hofgelände	35min	65min	35min	30min	20%	8,3%
After Sales zur Maschine	37min	65min	38min	27min	60%	27%
Maschine zu Maschine	1,8min	3,1min	1,8min	1,3min	30%	6,5%

Van-Westendorp-Methode

Bei welchem Preis würden Sie denken, dass der CLAAS Drohne **zu billig** ist, um zuverlässig zu sein?

- Unter 3.000€
- 3.000€ bis 6.000€
- 6.000€ bis 9.000€
- 9.000€ bis 12.000€
- 12.000€ bis 15.000€
- 15.000€ bis 18.000€
- Über 18.000€
- Sonstiges:

Bei welchem Preis wäre die CLAAS Drohne ein **gutes Angebot**?

- Unter 3.000€
- 3.000€ bis 6.000€
- 6.000€ bis 9.000€
- 9.000€ bis 12.000€
- 12.000€ bis 15.000€
- 15.000€ bis 18.000€
- Über 18.000€
- Sonstiges:

Bei welchem Preis würden Sie sagen, die CLAAS Drohne ist **zu teuer**, aber noch **akzeptabel**?

- Unter 3.000€
- 3.000€ bis 6.000€
- 6.000€ bis 9.000€
- 9.000€ bis 12.000€
- 12.000€ bis 15.000€
- 15.000€ bis 18.000€
- Über 18.000€
- Sonstiges:

Bei welchem Preis wäre die CLAAS Drohne **zu teuer**, um in **Betracht** zu kommen?

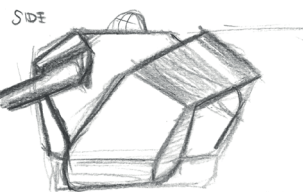
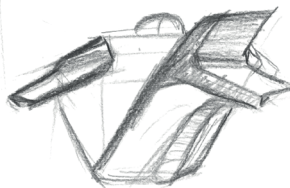
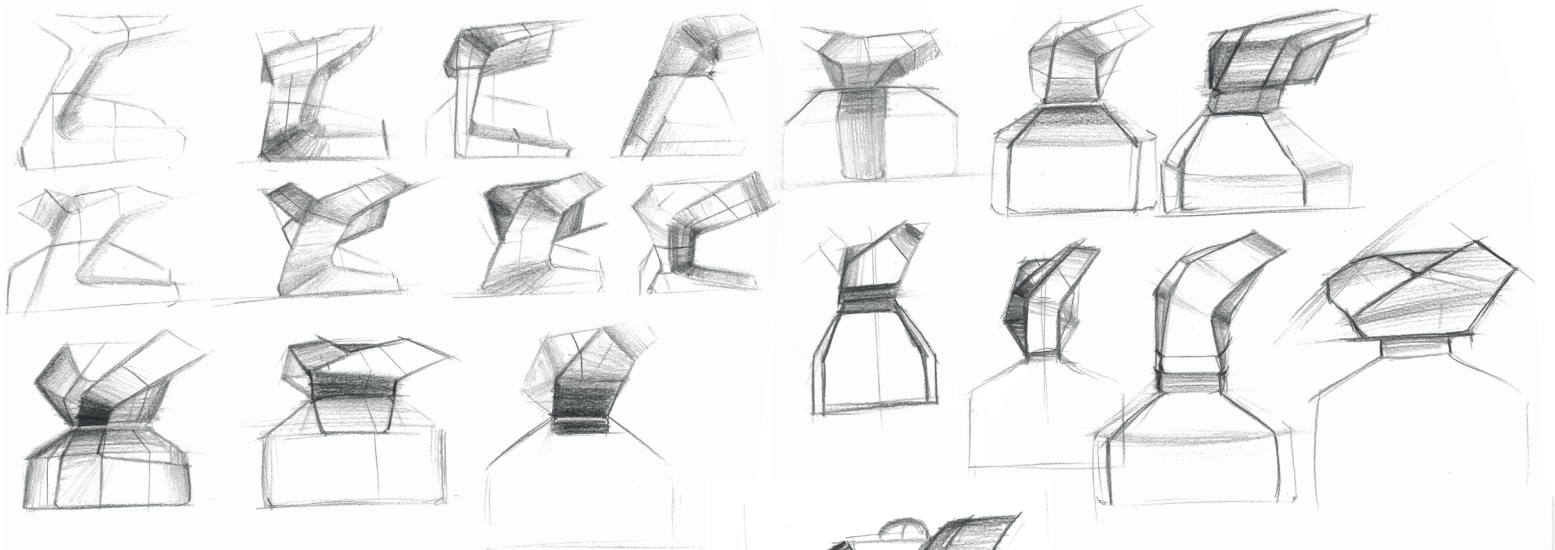
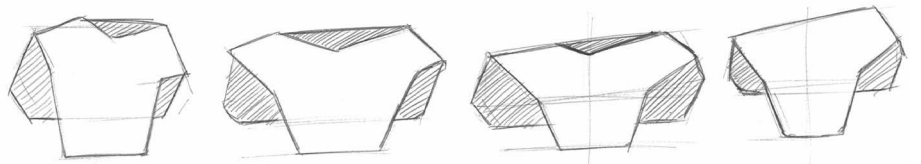
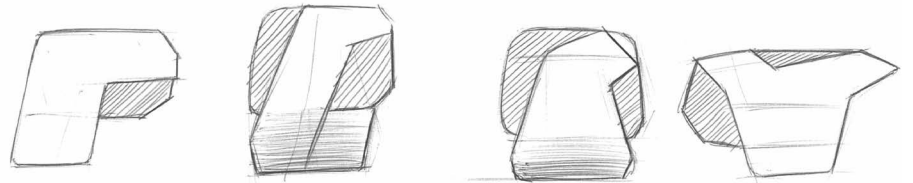
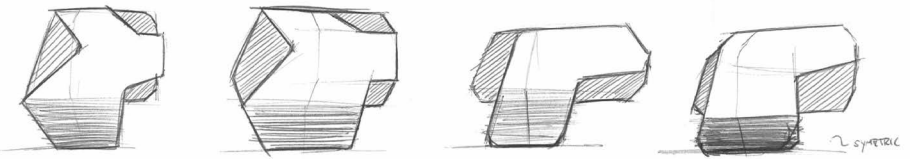
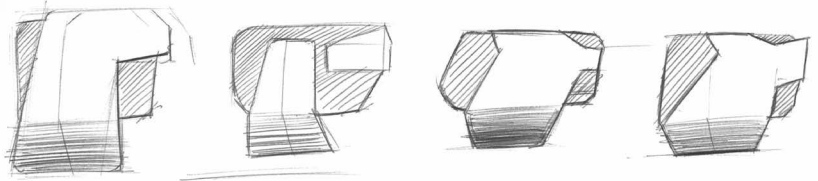
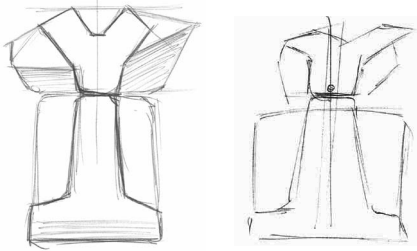
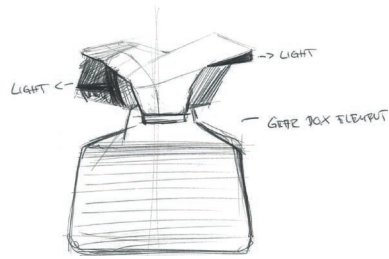
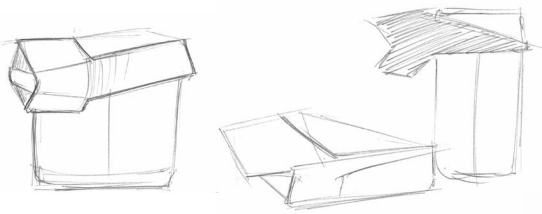
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- Über 18.000€
- Sonstiges:

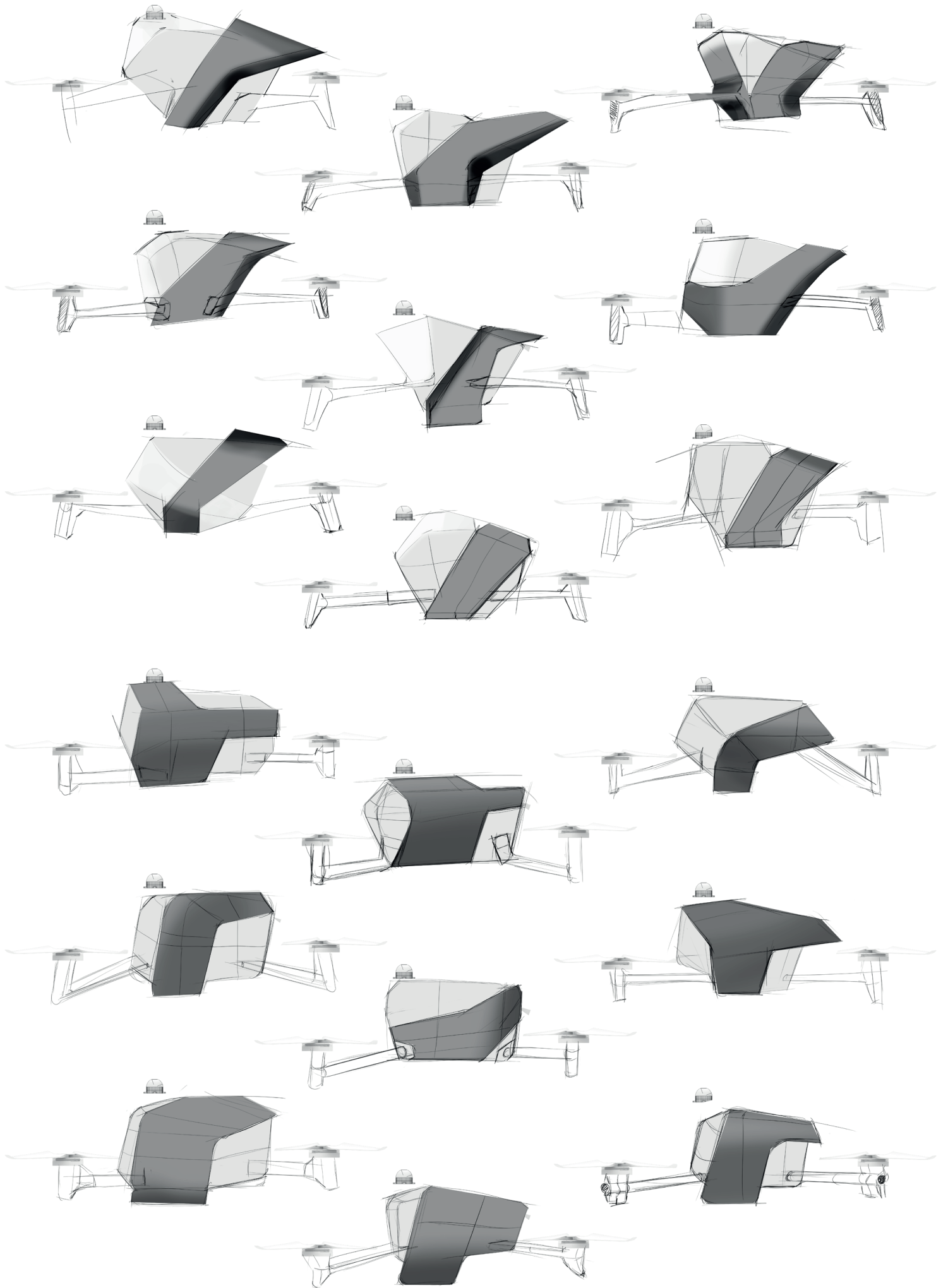
Platz für Kommentare

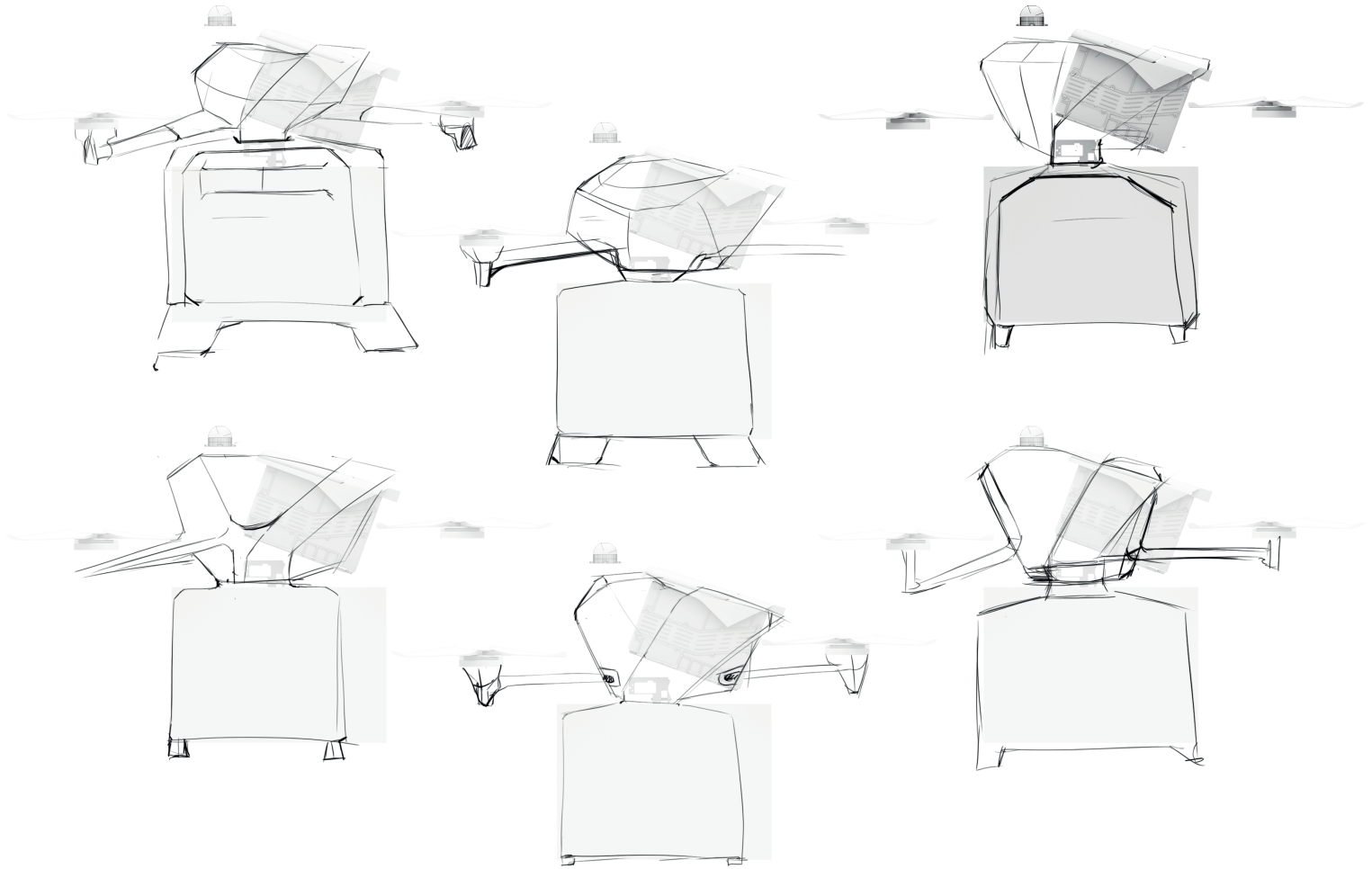
Meine Antwort

Vielen Dank, dass Sie an dieser Umfrage teilgenommen haben! Wenn Sie noch Anmerkungen oder Ideen haben, freue ich mich über einen Kommentar

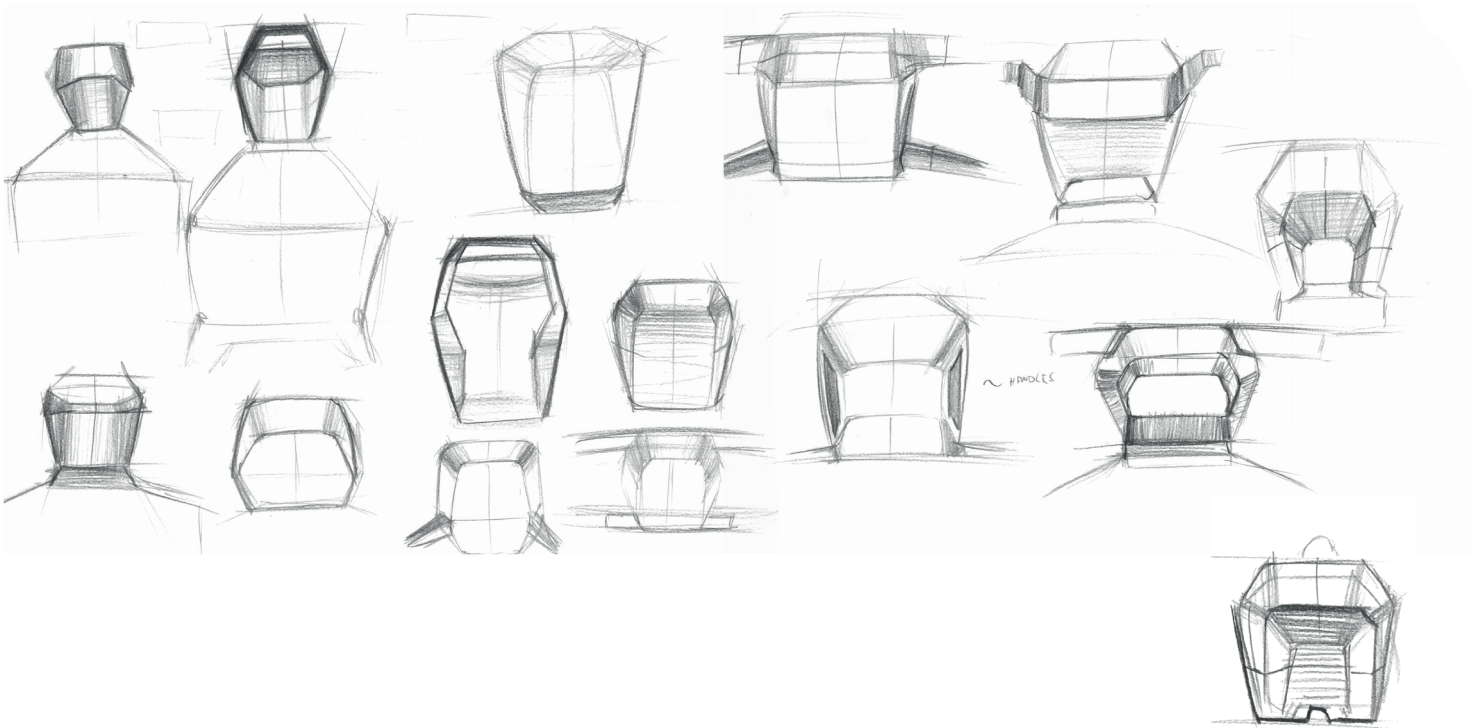
V. Sketches side view

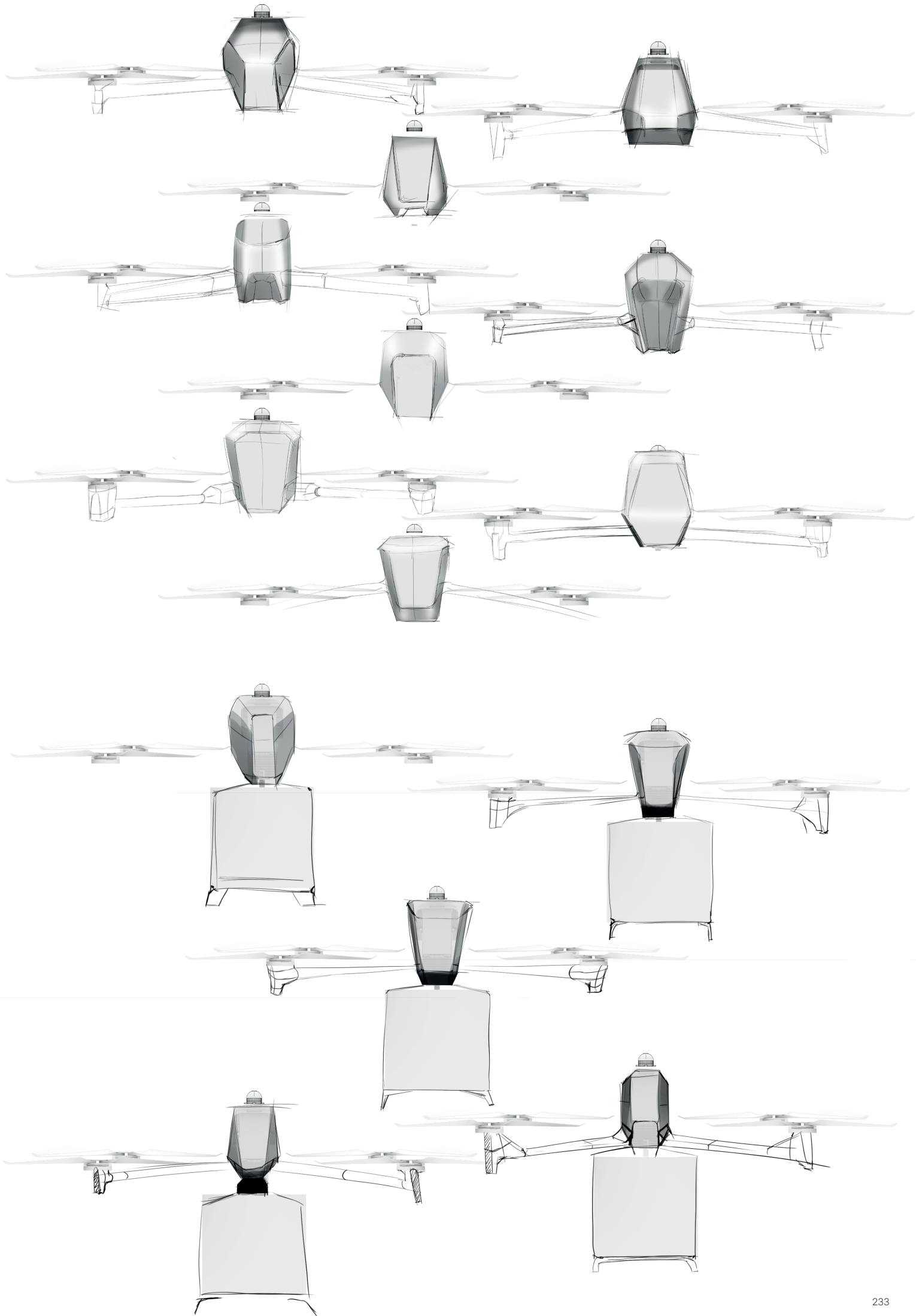


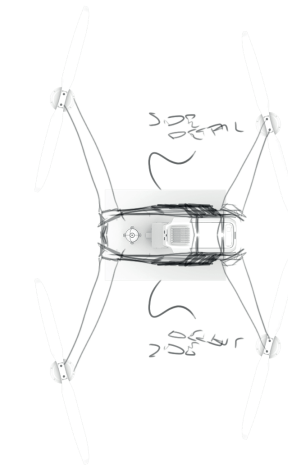
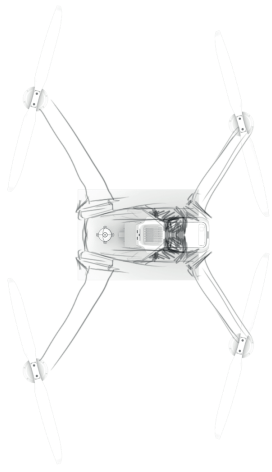
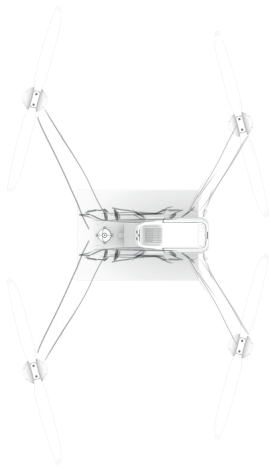
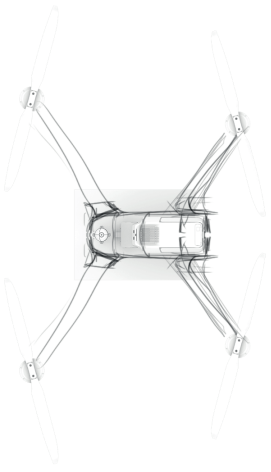
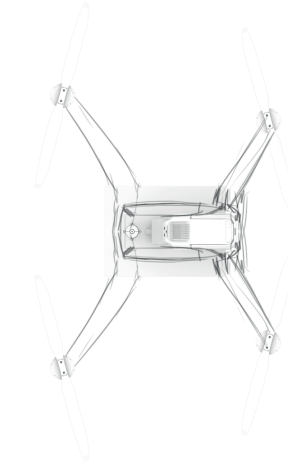
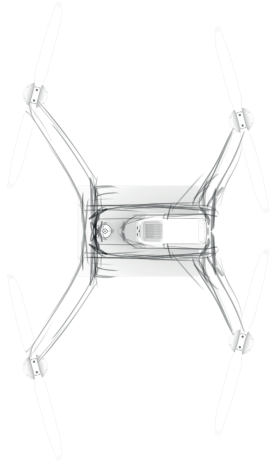
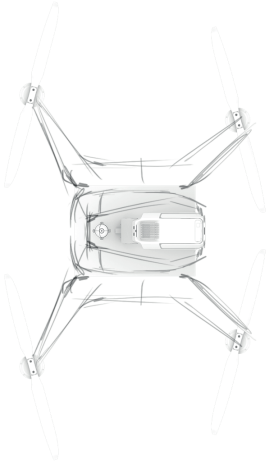
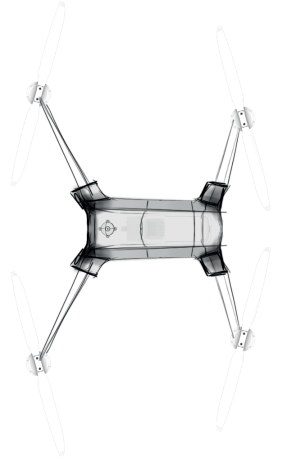
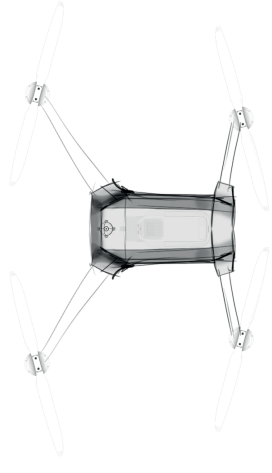
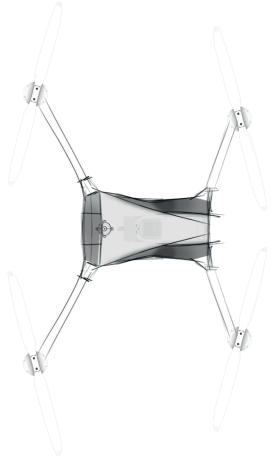
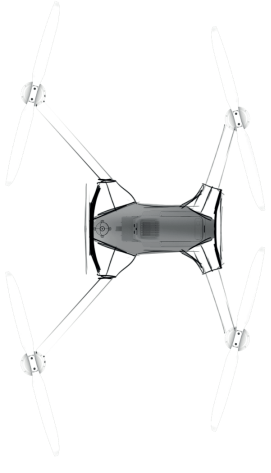
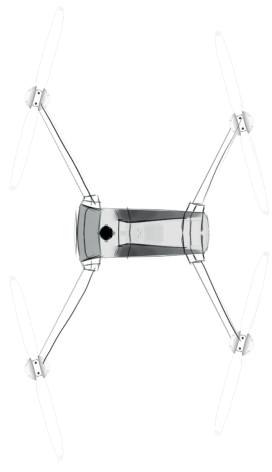
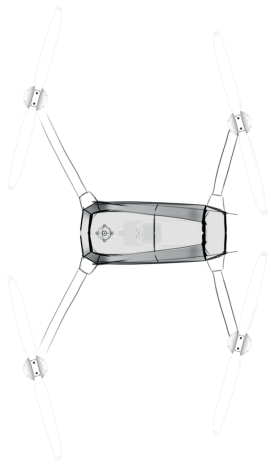
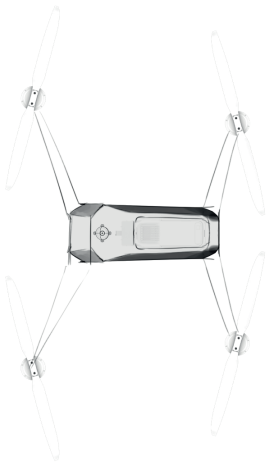




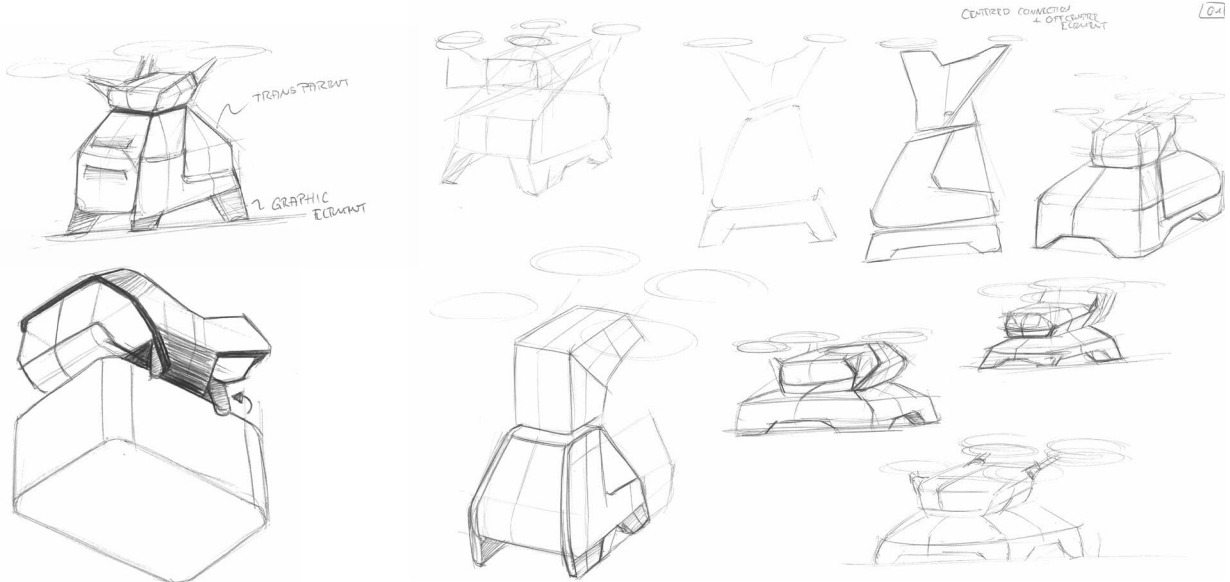
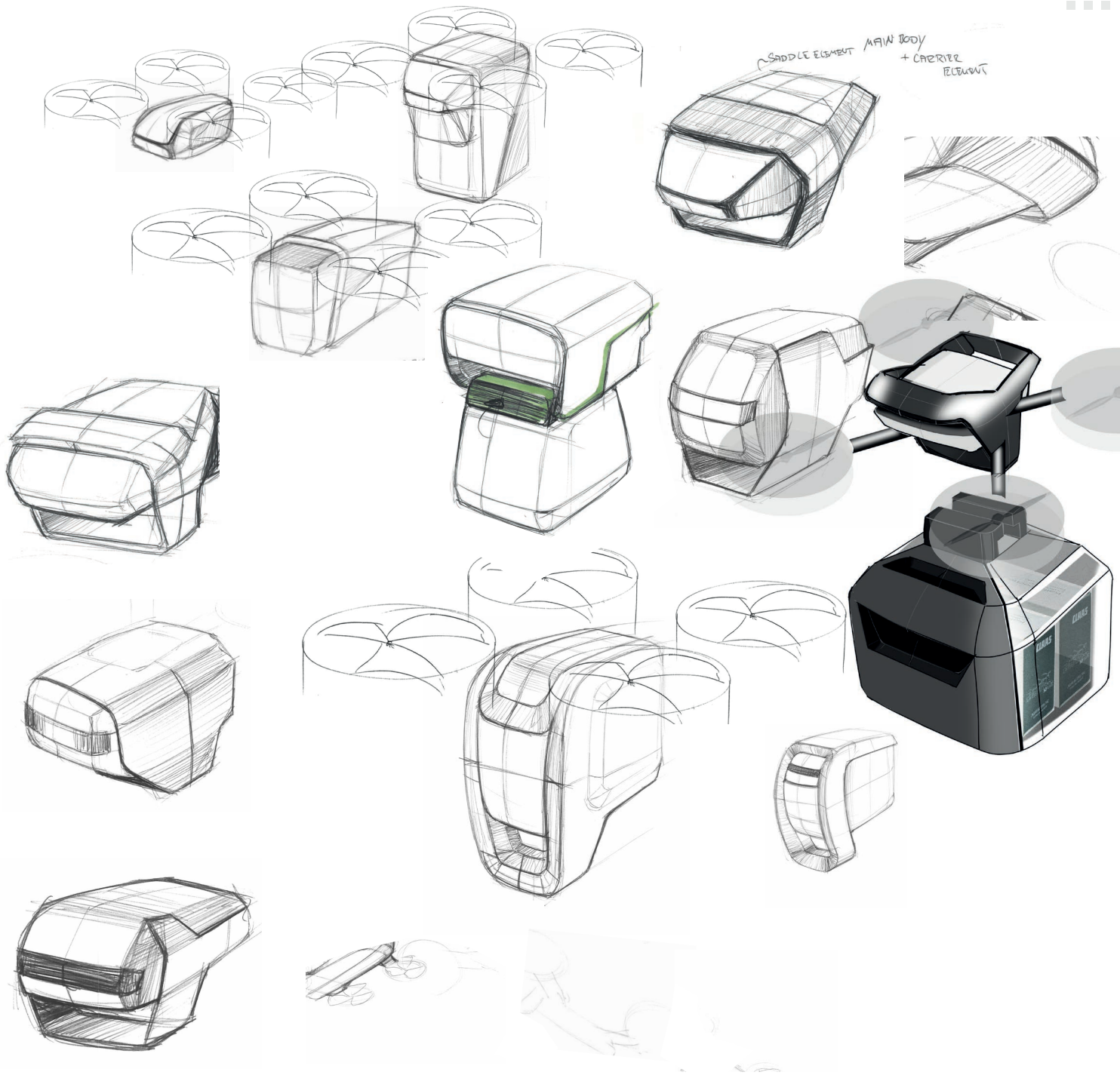
W. Sketches front view







X. Sketches iso view



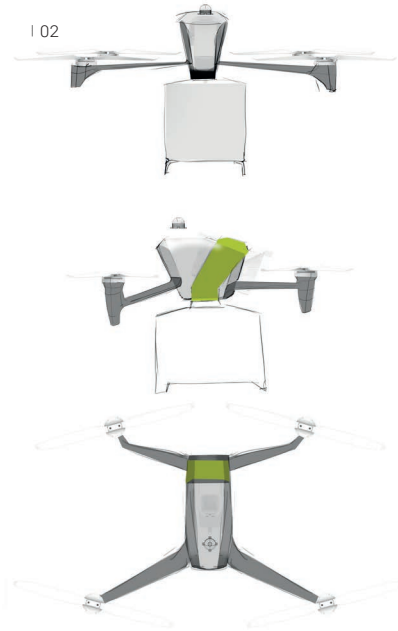
Y. Sketches views



I 01



I 02



I 03



I 04



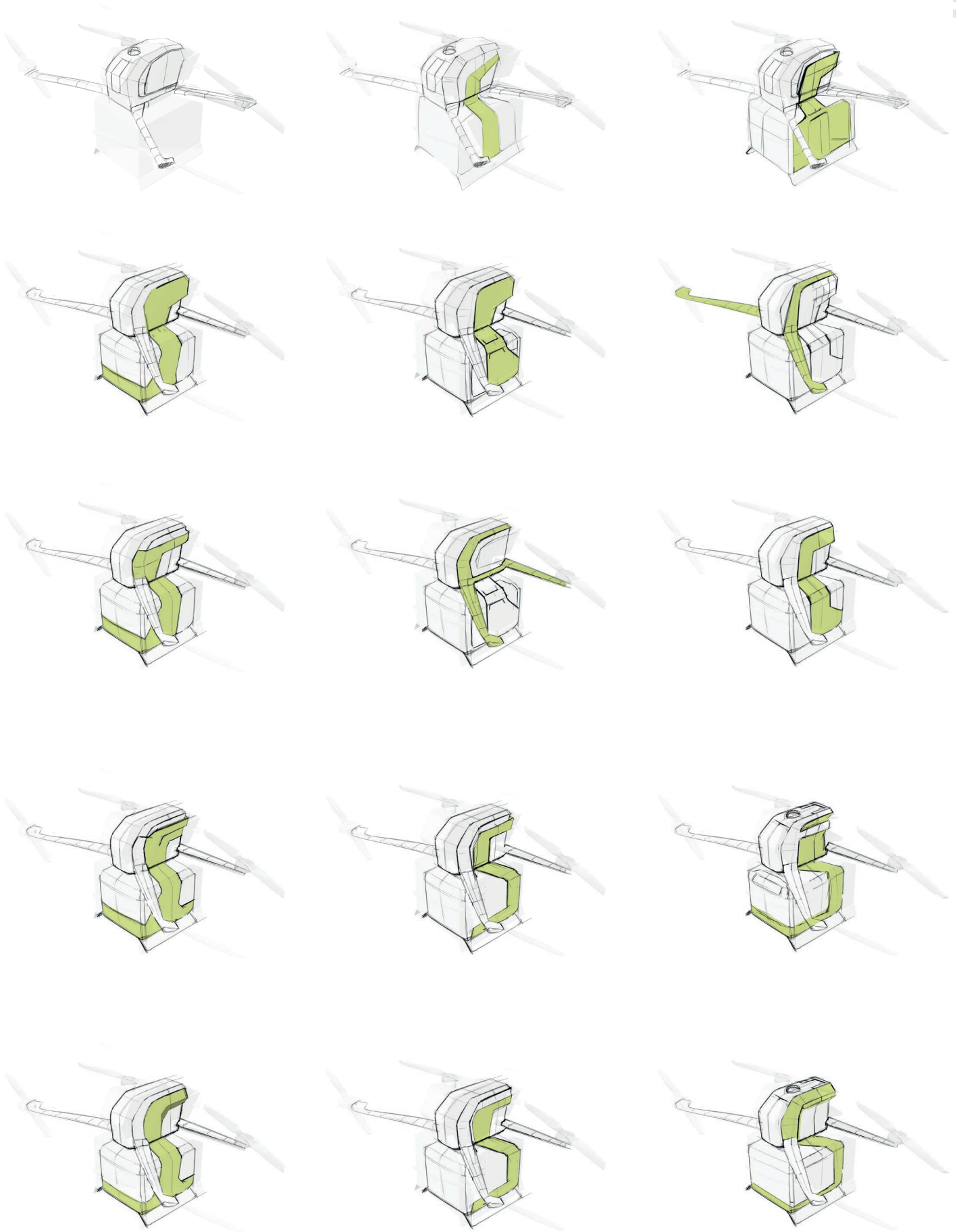
I 05

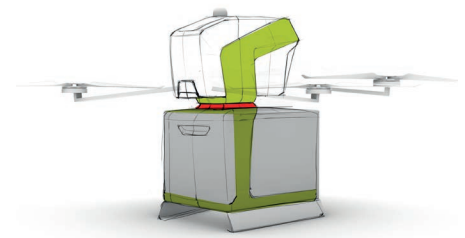
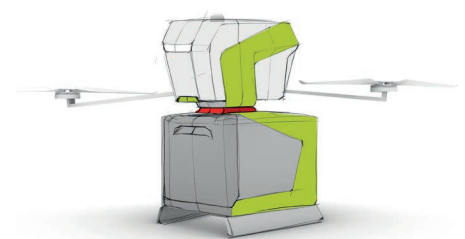
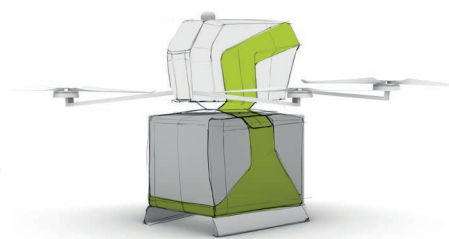
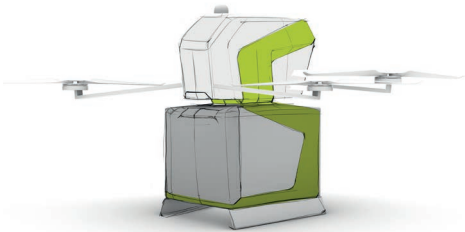
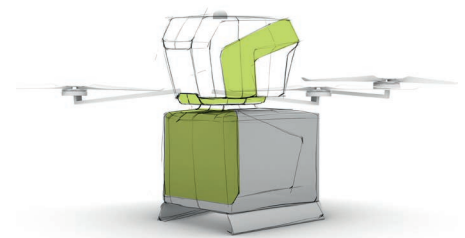
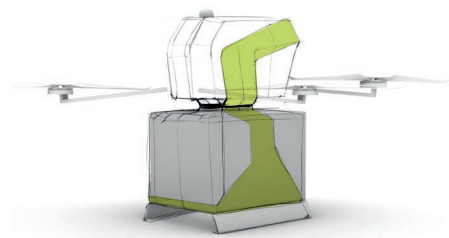
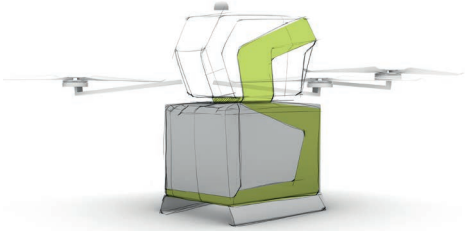


I 06



Z. Sketches views





AA. Attachment research



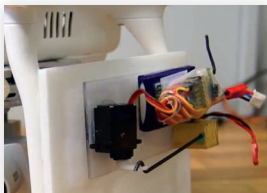
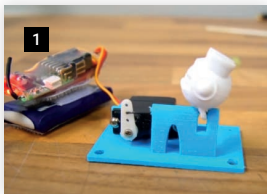
Include semi automatic an automatic systems

	Parallel-jaw clamp (2-jaw)	Two flat jaws close in parallel via lead screw, rack-and-pinion, or linkage.	Simple, predictable force, easy pads.	Needs alignment; can bruise surfaces; heavy if high force.
	3-jaw self-centering chuck	Scroll plate drives 3 jaws radially to center and clamp.	Auto-centers; high holding power.	Complex, heavy; not great for flats.
	Collet / Expanding mandrel	Split sleeve expands against inner bore via taper screw.	Very secure; concentric; compact.	Needs a good internal feature; limited stroke.
	Wedge clamp (self-locking)	Wedge ramps convert small motion to high normal force; self-locks if $\tan \alpha < \mu$.	High force, passive lock, compact.	Sensitive to surface finish; can jam with dirt.
	Cam clamp (eccentric)	Eccentric cam rotates to squeeze part with over-center lock.	Fast; minimal actuation.	Small stroke; local point load; can back-drive if not over-center.
	Over-center toggle clamp	Linkage snaps past dead-center to lock with high force.	Very secure; visual lock state.	Limited tolerance to misalignment; needs rigid mounts.
	Screw clamp (lead/ball screw)	Screw drives jaw(s); friction holds position.	Precise, cheap, robust.	Slow; can vibrate loose without lock.
	Scissor (pantograph) gripper	Linkage expands/closes symmetrically with one DOF.	Large stroke; simple actuation.	Force falls at extremes; can rack if off-center.
	Underactuated adaptive fingers	Tendon/linkage lets fingers wrap and conform; one actuator.	Good tolerance, gentle; light.	Lower peak force; repeatability varies; needs good pad friction.
	Multi-tine grapple	3-5 curved tines close around bulk.	Tolerates shape variance; high capture.	Bulky; can snag; point loads damage.
	Clamshell bucket	Two shells scoop and close.	Contains spill; easy release.	Heavy; hinge wear; needs clearance under load.
	Hook + safety latch (carabiner style)	Hook engages ring/handle; spring latch prevents slip-out.	Very fast; gravity-friendly pickup.	Requires compatible feature; side-load risk.
	Automatic J-hook/gravity latch	Hook engages under edge; gravity or ramp trips latch closed.	Passive, quick, low-power.	Needs precise lip; accidental unlatch possible.
	Clevis + removable pin (shackle)	U-shackle around lug; secure with pin.	Extremely reliable; standard parts.	Manual pin insertion; not great for aerial quick-release.
	Ball-lock quick-release pin	Spring-loaded balls expand to lock in a through-hole.	Fast, secure, light.	Needs aligned through-hole; contamination can jam.
	Bayonet / quarter-turn lock	Insert male studs into keyholes, rotate 90° to lock under flanges.	Very fast; positive lock; low stroke.	Needs precise interface; wear on cams.
	ISO-style twist-lock (mini)	Rotating head expands under a standardized recess.	Known, robust, tolerant to load.	Requires matched geometry; heavier than clamps.
	Ratchet strap / cinch band	Wrap webbing or band; ratchet to tension.	Huge compliance; cheap; light hardware.	Slow cycle; pendulum risk in aerial lift; can creep.
	Net capture + drawstring	Enclose with net; cinch mouth closed.	Captures many items at once; light.	Risk of tangling; slower precise release.
	Parrot-beak drum gripper	Cammed jaw catches drum rim; weight locks it tighter.	Auto-locking under load; single-point pickup.	Needs rim; off-axis loads can slip.
	Fork tines / pocket engagement	Insert forks into pockets; lift.	High payload; simple; low actuation.	Needs pallet/pockets; poor for aerial use.
	Snap-fit/detent latch	Springy tab snaps over rib; pry or cam to release.	One-part simplicity; quick.	Wear/fatigue; low load unless reinforced.

AB. Charging stations

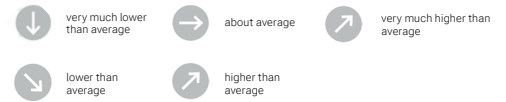


- 1** Tesla charging port
- 2** Parachute activation system
- 3** Ship attachment sytem
- 4** Industrial lifter
- 5** Logistic system
- 6** Logistic robot

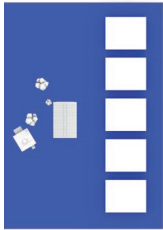


	modules	Payload per module	Weight of module	possible number of modules	overall payload	overall weight	efficiency
1	DS3235 Servo (35 kg)	2.5 kg	-60 g	2	6 kg	120 g	50 : 1
2	STServo 35 kg Drop Kit (RCDrone)	8 kg	-80 g	1	6 kg	80 g	75 : 1
3	DJI M4T Drop Kit (Dual, ≤25 W)	3 kg	75 g	2	6 kg	150 g	40 : 1
4	DJI M4T Dropper (≤3 W)	2 kg	50 g	3	6 kg	150 g	40 : 1

AC. Models



Model 1- Small farm private

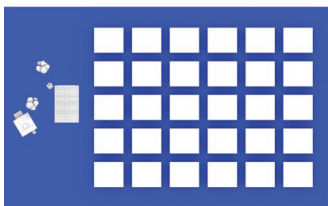


distances		number of trips per field	
Farm area	100	Within farm premise	350
Number of fields	5	Daily way from farm premise	250
Mean field distance	1.3 km	Field edge to machine	600
Dealer to farm	18 km	Farm premise to machine	400
Field corner to machine	0.25 km	After Sales to farm premise	20
farm to field	1.34 km	After Sales to Machine	60
dealer to farm	18 km	Machine to Machine	300

- > 55 years
- 200 ha
- Mixed farming

Cautious Traditionalist

Model 2- Average Farm

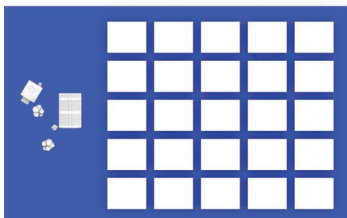


distances		number of trips per field	
Farm area	300	Within farm premise	350
Number of fields	30	Daily way from farm premise	250
Mean field distance	2.5 km	Field edge to machine	600
Dealer to farm	15 km	Farm premise to machine	400
Field corner to machine	0.2 km	After Sales to farm premise	20
farm to field	2.5 km	After Sales to Machine	60
dealer to farm	15 km	Machine to Machine	300

- 18-44 Years
- 500+ ha
- Arable farming contractor

Experienced operator

Model 3- Big farm organization



distances		number of trips per field	
Farm area	500	Within farm premise	350
Number of fields	25	Daily way from farm premise	250
Mean field distance	3.0 km	Field edge to machine	600
Dealer to farm	18 km	Farm premise to machine	400
Field corner to machine	0.25 km	After Sales to farm premise	20
farm to field	3.0 km	After Sales to Machine	60
dealer to farm	18 km	Machine to Machine	300

- < 65 years
- 200 ha
- Forage farming

Optimistic Pioneer

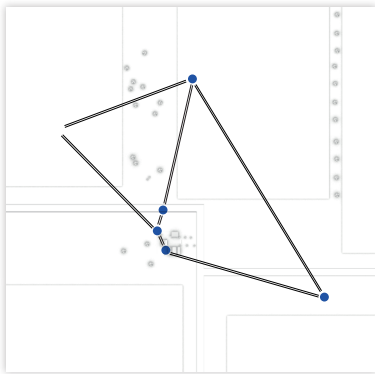
Model 2 (500 ha): distances increase roughly +20 %.

Model 3 (100 ha): distances decrease by ~40 %.

Internal field distances scale with $\sqrt{\text{area}}$ — typical for spatial spread models in rural GIS data.



Model 1- Small farm private



distances

Farm area	100
Number of fields	5
Mean field distance	1.3 km
Dealer to farm	18 km
Field corner to machine	0.25 km
farm to field	1.34 km
dealer to farm	18 km

number of trips per field

	per field	per farm
Within farm premise	12	60
Daily way from farm premise	9	45
Field edge to machine	20	100
Farm premise to machine	13	65
After Sales to farm premise	1	5
After Sales to Machine	2	10
Machine to Machine	10	50

> 55 years

200 ha

Mixed farming

Cautious Traditionalist



per field

	distance	time without drone	time with drone	time saved per trip	trips per year	time saved per year
01	0,36 km	0,6 min	0,36 min	0,26 min	12	3,12 min
02	1,12 km	1,92 min	1,12 min	0,8 min	9	7,2 min
03	0,18 km	0,31 min	0,18 min	0,13 min	20	2,6 min
04	1,30 km	2,23 min	1,30 min	0,93 min	13	12 min
05	35 km	60,00 min	35,00 min	25 min	1	25 min
06	36 km	61,71 min	36,00 min	26 min	2	51 min
07	0,8km	1,37 min	0,80 min	0,6 min	10	5,7 min



per farm

trips per year time saved per year

01	60	15,6 min
02	45	36 min
03	100	13 min
04	65	60,45 min
05	5	125 min
06	10	260 min
07	50	30 min

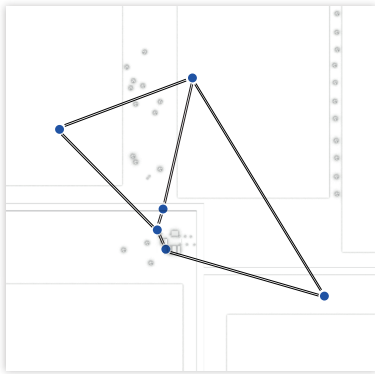
low= 0,5x
base= 1x
high= 2x

scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	30	1,56 min	7,8 min	6,50 €
	12	60	3,12 min	15,6 min	13,00 €
	24	120	6,24 min	31,2 min	26,00 €
02	5	25	4 min	20 min	16,67 €
	9	45	7,2 min	36 min	30,00 €
	18	90	14,4 min	72 min	60,00 €
03	10	50	1,3 min	6,5 min	5,42 €
	20	100	2,6 min	13 min	10,83 €
	40	200	5,2 min	26 min	21,67 €
04	7	35	6,51 min	32,55 min	27,13 €
	13	65	12,09 min	60,45 min	50,38 €
	27	135	25,11 min	125,55 min	104,63 €
05	0	0	0 min	0 min	0 €
06	1	5	25 min	125 min	104 €
	2	10	50 min	250 min	208 €
07	1	5	26 min	130 min	108 €
	2	10	52 min	260 min	216 €
07	4	20	104 min	520 min	433 €
	5	25	5 min	15 min	12,50 €
	10	50	6 min	30 min	25,00 €
07	20	100	12 min	60 min	50,00 €

Fig.187 Saved time per field with different assumed occurrences



Model 2- Average Farm



		per field	per farm
distances	Farm area		300
	Number of fields		30
	Mean field distance		2.5 km
	Dealer to farm		15 km
	Field corner to machine		0,2 km
	farm to field		2,5 km
	dealer to farm		15 km
number of trips per field	Within farm premise	12	350
	Daily way from farm premise	9	250
	Field edge to machine	20	600
	Farm premise to machine	13	400
	After Sales to farm premise	1	30
	After Sales to Machine	2	60
	Machine to Machine	10	300

18-44 Years

500+ ha

Self Propelled forgrager

Arable Framing Contractor

Experienced operator

per field

	distance	time without drone	time with drone	time saved per trip	number of trips per year	hours saved per year
01	0.2 km	0.21 min	0.12 min	0.9 min	12	10.8 min
02	2.5 km	4.17 min	2.30 min	1.47 min	9	13.23 min
03	0.2 km	0.21 min	0.12 min	0.9 min	20	18 min
04	2.7 km	4.38 min	2.42 min	1.56 min	13	20.28 min
05	15 km	25.43 min	15.00 min	10.43 min	1	10.43 min
06	17.7 km	30.21 min	17.42 min	12.39 min	2	25 min
07	3.6 km	6.10 min	3.36 min	2.34 min	10	23.4 min

per farm

(30 fields)

per farm

trips per year
time saved per year

01	350	5.40 h
02	250	6.62 h
03	600	9.00 h
04	400	10.14 h
05	30	5.22 h
06	60	12.50 h
07	300	11.70 h

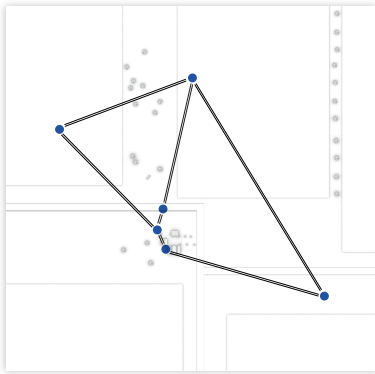
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base= 1x
high= 2x

scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	175	0.09 h	2.63 h	131.50 €
	12	350	0.18 h	5.25 h	262.50 €
	24	700	0.36 h	10.50 h	525.00 €
02	4	125	5.88 h	3.06 h	153.00 €
	8	250	0.196 h	6.13 h	306.50 €
	17	500	0.4 h	12.25 h	612.50 €
03	10	300	0.15 h	4.50 h	225.00 €
	20	600	0.30 h	9.00 h	450.00 €
	40	1200	0.60 h	18.00 h	900.00 €
04	7	200	0.18 h	5.20 h	260.00 €
	13	400	0.34 h	10.40 h	520.00 €
	27	800	0.70 h	20.80 h	1040 €
05	0	10	0 h	1.74 h	87.00 €
	1	20	0.17 h	3.48 h	174.00 €
	2	40	0.35 h	6.95 h	347.50 €
06	1	30	0.21 h	6.19 h	309.50 €
	2	60	0.41 h	12.38 h	619.00 €
	4	120	0.83 h	24.76 h	1238.00 €
07	5	150	0.20 h	6.10 h	305.00 €
	10	300	0.41 h	12.15 h	607.50 €
	20	600	0.81 h	24.3 h	1215.00 €

Fig.188 Saved time per field with different assumed occurrences



Model 3- Big farm organization with external help



		per field	per farm
distances	Farm area		500
	Number of fields		25
	Mean field distance		3.0 km
	Dealer to farm		18 km
	Field corner to machine		0.25 km
	farm to field		3.0 km
	dealer to farm		18 km
number of trips per field	Within farm premise	12	300
	Daily way from farm premise	9	225
	Field edge to machine	20	500
	Farm premise to machine	13	325
	After Sales to farm premise	1	25
	After Sales to Machine	2	50
	Machine to Machine	10	250

- < 65 years
- 200 ha
- Forage farming

Optimistic Pioneer

per field

	distance	time without drone	time with drone	time saved per trip	number of trips per year	hours saved per year
01	0.5 km	0.86 min	0.5 min	0.36 min	12	4.32 min
02	3.00 km	5.14 min	3.00 min	2.14 min	9	19.26 min
03	0.25 km	0.43 min	0.25 min	0.18 min	20	3.60 min
04	3.00 km	5.14 min	3.00 min	2.14 min	13	27.82 min
05	18.00 km	30.86 min	18.00 min	12.86 min	1	12.86 min
06	21.00 km	36.00 min	21.00 min	15.00 min	2	30.00 min
07	0.25 km	0.43 min	0.25 min	0.18 min	10	1.80 min

per farm

(25 fields)

per farm

trips per year time saved per year

01	300	1.8 h
02	225	9.04 h
03	500	1.5 h
04	325	11.6 h
05	25	5.35 h
06	50	12.5 h
07	250	0.75 h

- low= 0,5x
- base= 1x
- high= 2x

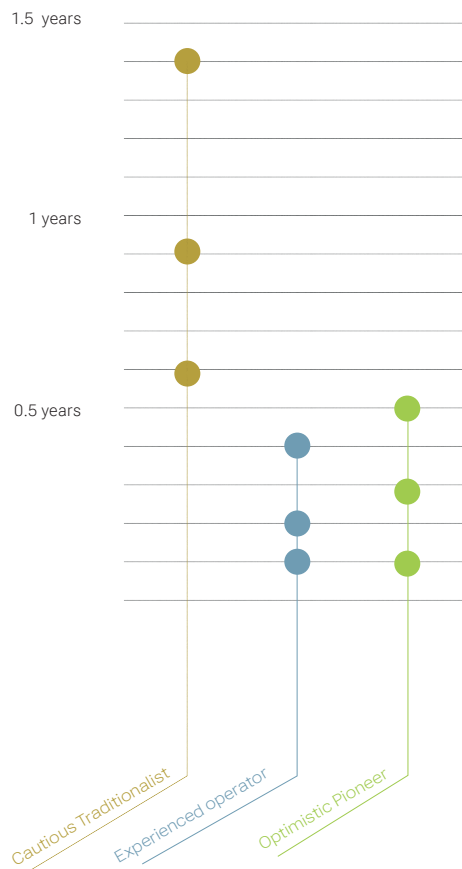
scenario	trips per field	trips per farm	saved time per field	saved time per farm	saved salary
01	6	150	0.04 h	0.9 h	45 €
	12	300	0.07 h	1.8 h	90 €
	24	600	0.14 h	3.6 h	180 €
02	4	112.5	0.143 h	4.01 h	200.5 €
	8	450	0.29 h	16.05 h	803 €
	17	225	0.61 h	8.03 h	402 €
03	10	250	0.03 h	0.75 h	38 €
	20	500	0.06 h	1.5 h	75 €
	40	1000	0.12 h	3 h	150 €
04	7	162.5	0.25 h	5.8 h	290 €
	13	325	0.46 h	11.59 h	580 €
	27	675	0.96 h	24.08 h	1204 €
05	0	0	0 h	0 h	0 €
	1	25	0.214 h	5.4 h	270 €
	2	50	0.43 h	10.72 h	536 €
06	1	25	0.25 h	6.25 h	313 €
	2	50	0.5 h	12.5 h	625 €
	4	100	1 h	25 h	1250 €
07	5	125	0.02 h	0.38 h	19 €
	10	250	0.03 h	0.75 h	37.5 €
	20	500	0.06 h	1.5 h	75 €

Fig.189 Saved time per field with different assumed occurrences

AD. Break-Even with Vehicle



scenario	fixed costs car	variable costs car	investment	fixed costs drone	variable costs drone	investment	Break -Even point
● 167.5	5.000 €	5.360 €	20.000 €	1380 €	2.395 €	11115 €	1.4 years
335		10.720 €			4790 €		0.9 years
670		21.440 €			9580 €		0.6 years
● 995		31.840 €			14370 €		0.4 years
1990		63.680 €			28.750 €		0.2 years
3980		127.360 €			57486 €		0.1 years
● 837.5		26.760 €			11975 €		0.5 years
1675		53.600 €			23950 €		0.3 years
3350		107.200 €			47905 €		0.1 years



AE. Draft Views for Visualisation

