PRESS RELEASE

SAMSON – Towards the orchard of the future through digitalization, practical technologies and automated tools

New results from the SAMSON project lead practically and data-supported to the goal to relieve work processes through digitalization, artificial intelligence (AI) and automation, to use resources more efficiently as well as to make fruit growing more resilient to climatic and economic challenges in order to optimize the quality and quantity of yields in the long term.

The SAMSON project – "Smart automation systems and services for fruit growing on the Lower Elbe" – funded by the German Federal Ministry of Agriculture, Food and Regional Identity (BMLEH) and now extended until December 2027, is characterized by the fact that dialogue and professional as well as practical exchange with apple growers from the Altes Land region has been an essential part of the research and development work (R&D work) right from the start. In close cooperation with the Fruit Advisory Service of the Altes Land e.V. (OVR), Jork, the project partners Fraunhofer IFAM, Stade, HAW Hamburg, hochschule 21, Buxtehude, and the TU Hamburg are working together with practitioners to develop sustainable solutions for the cultivation practice of the future and to exchange constructive ideas in regular forums. The additional project period will serve to validate the R&D results achieved to date: the systematic analysis and processing of the data collected will then make it possible to provide practical decision-making aids for fruit growers. In addition, field and technical days as well as a regional conference will be held to further intensify the transfer of knowledge into practice.

Besides the first results from field trials, the focus will be on the latest R&D results on practical technologies and automated tools "to touch", which will support fruit farms in their transformation to a future-oriented business – resource-saving, data-based and future-proof: from data acquisition through flowering strength regulation, yield forecasting, localization and prediction of diseases and pests, mobile robots as well as frost protection and irrigation up to the digital farm management system via app including digital fruit tree twins.

Sensorbox – Basic data acquisition for other SAMSON technologies

At the beginning of the project, Fraunhofer IFAM in Stade developed the so-called "sensor box" (Figure 1). It contains a LiDAR, an IMU sensor, stereo cameras and a precise GNSS system to capture image and sensor data. It can be easily attached to the tractor using the standardized three-point mount and is carried along during regular drives through the orchard,

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enabling automatic data collection during all work throughout the year without additional effort for the orchardist. While driving through the rows of trees, the camera systems record several images of each individual tree from different perspectives and simultaneously save the precise GPS coordinates. These allow not only rows of trees but also individual trees, fruits and blossoms to be precisely recorded from different angles during the usual work tours. The image and sensor data obtained in this way form the basis for the digital mapping of the rows of trees and individual trees in their seasonal stages of development.

Data- and AI-based automated blossom vigor detection and adaptive thinning to increase yield and reduce alternance

Excessive fruit set in orchards leads to smaller, lower quality fruit and weak flower set the following year, known as "alternance" (Figure 2). To counteract this, the fruit set of high-flowering fruit tree varieties is already specifically reduced by thinning out at flowering time. However, individual tree-specific thinning at flowering or at the young fruit stage has so far been labor-intensive and can only be applied precisely to each individual tree to a very limited extent.

A new joint approach as part of the SAMSOM project now combines the automated acquisition of flowering intensity with a coordinated, individual tree-specific thinning. For this purpose, image data is recorded with the sensor box and then the flowering intensity of each individual tree is evaluated using an AI-supported model. This model uses a well-established flowering intensity bonitation scale (1-9), which takes into account the relationship between leaf buds and flower buds, and enables the creation of application maps for targeted treatment, i.e. tree-specific blossom thinning. Application maps are digital maps on which the necessary treatment intensity is defined for each tree at a precise location. They can be read by GPS-controlled plant protection devices.

First results of the OVR, Jork, for the digital flowering vigor assessment on the 'Elstar' variety in spring 2025 show good correlation between the automatic data-based rating and the manual scoring. The newly developed system is very promising, especially as it also takes physiologically relevant characteristics – such as the leaf to flower bud ratio – into account. However, there is currently still a need for improvement in the detection of very strong flowering strengths (stages 7-9).

Based on application maps from 2024, the first thinning trial on weakly flowering trees indicates a potential for increasing yields. Further research is needed to determine whether this can also effectively break alternance.

More accurate harvest forecasts through fruit detection and fruit size measurement using sensor box and AI

In the SAMSON project, new innovative methods from the TU Hamburg for digital fruit detection and fruit size measurement form the basis for increasing the accuracy of harvest forecasts. The focus here is on counting the fruits and determining the fruit sizes at certain points in the growth cycle, as these parameters have a significant influence on the quality of the forecast.

By combining stereo images, GNSS data and an AI for visual motion detection, it is possible, for example, to assign unique GNSS coordinates to the apples detected in the image. This means that apples can be clearly assigned to the correct tree – even if the rows of trees are photographed from different angles – and double counting on the outward and return journey can be avoided. Dedicated object recognition models reliably identify the individual visible apples in the image. In addition, tracking algorithms ensure that each recognized apple retains its digital ID in successive images and is continuously tracked – also in case of short-term covering by leaves.

According to initial results, the resulting counting accuracy of the AI for fruit detection is around 80 percent compared to manual apple counting per tree. The size determination of the fruit is based on the pixel-precise segmentation of the apple contour in combination with depth information: initial measurements show slight deviations in the millimeter range for the diameter.

This data is used as the basis for more precise harvest forecasts, which will be further optimized using the many years of experience of fruit-growing consultants.

Data- and AI-based detection and localization of fungal diseases and pests

Using the camera systems integrated in the sensor box, GPS data and specially trained AI algorithms, it is possible to detect and localize typical disease patterns for fruit cultivation, such as fungal diseases or pest infestations, in high resolution. This data-based monitoring enables fruit growers not only to intervene in the fruit tree population at an early stage, but also to apply pesticides in a targeted and precise manner.

HAW Hamburg has succeeded in using a basic AI for visual motion detection and a 3D reconstruction to create both the position and orientation of the camera as well as a 3D model of the environment that can be captured by the sensor box. This allows the positions of various tree features, such as fungal diseases and pest infestations, to be localized using GPS coordinates and assigned to the individual tree.

Until now, the AI for disease detection has been working based on an elaborately created data set – consisting of high-resolution smartphone macro images to validate whether image-based disease detection is possible – with good results (Figure 3).

The next step is to create a new data set with images from the sensor box. This is necessary because the camera images from the sensor box are very different from the images from the smartphone camera: the diseases only make up a small part of the overall image from the perspective of the sensor box, making it more difficult for the AI to localize the disease in the image.

An AI for detecting harmful influences is able to recognize for example fruit tree cancer, apple scab, mildew as well as infestation by aphids in high resolution and assign them to the corresponding position.

Prediction model for pest pressure – example green food bug

The green food bug is damaging increasingly pome and soft fruit. It causes deformation and necrosis on young shoots and fruit, which can lead to considerable losses in yield and quality. As it lives in a hidden manner, the infestation is often only visible late in the crop, often too late for efficient countermeasures.

HAW Hamburg has developed a data-based forecasting model for the early detection of pest infestations in fruit growing. The aim is to plan plant protection measures more precisely, timelier and with fewer resources as well as to use them more efficiently. Using the example of the green food bug, the model shows how weather data, location information and field data can be usefully combined to identify the risk of damaging events at an early stage.

Among other things, weather data such as temperature trends, precipitation, humidity and other microclimatic influences that control the development of the pest are taken into account. Site-specific factors in and around the orchard that can affect population dynamics are also considered. Field data is based on monitoring information collected on site, such as observations, visual bonitures, development stages of the crop, typical damage patterns and historical infestation data of the respective orchard. The combination of these data types creates individual risk profiles for individual plots or entire orchards.

The underlying data platform has a modular structure and is prepared for productive use via a web interface. It provides access to risk characteristics, time series and warnings. Furthermore, operational monitoring data can also be entered in the future, further improving the forecast for the respective fruit farm. The modular architecture of the platform enables future expansion to include other crops and pathogens.

In addition, documentable decision-making bases are created for the fruit farm, which can be used in consulting discussions, for example. The system is to be expanded to include further data and harmful organisms in the future. Prospectively, it is also possible to integrate the system into federated data rooms in fruit growing or horticulture. These allow a decentralized and secure exchange between farms, consulting, research or authorities without losing data sovereignty. In practice, this means extended access to regional information sources and improved monitoring through data aggregation across several fruit farms.

AurOrA – Autonomous mobile robot all-rounder for the orchard

The autonomous mobile robot "AurOrA" ("Autonomer Obstplantagenhelfer Altes Land") from hochschule 21 in Buxtehude is a modular platform that has been specially developed for daily work in modern orchards. In the current SAMSON project, a completely new AurOrA platform was designed and built to better meet practical requirements. A fundamentally new kinematic model was developed for this purpose. AurOrA supports fruit growers in several time-consuming and physically demanding tasks, such as:

- **Transporting the sensor box**: AurOrA can also move the sensor box through the orchard using a specially developed three-point mount. This enables recurring data collection to be carried out fully autonomously.
- **Weed control between and around trees:** Unwanted weeds deprive young trees of water and nutrients, but also provide shelter for mice and other rodents, which nibble on sensitive roots and can cause growth or even total damage. AurOrA removes weeds fully automatically, helping to reduce plant stress (Figure 4).
- **Targeted irrigation of young trees:** Newly planted young trees require a precise and individual water supply. The robot can target each tree and irrigate it as required.
- **Transporting apple boxes:** During the harvest, AurOrA transports heavy fruit boxes quickly and safely through the orchard. This saves valuable working time.

The focus of the development is on the navigation system, which enables reliable autonomous movement between the narrow rows of the plantation. AurOrA moves safely under real weather as well as soil conditions and interacts precisely with the mounted modules. A key feature is that AurOrA not only serves as an equipment carrier, but also actively communicates with the respective tools. This makes all work more efficient, precise and resource-saving.

A new, enhanced version of AurOrA has been built based on the experience gained with the previous robot system. This new platform is more stable, but at the same time around 25 percent lighter – an advantage that helps to protect the soil on sensitive orchards.

Digital frost warning sensors and irrigation control

As part of the SAMSON project, Fraunhofer IFAM in Stade carried out a comprehensive comparative study in which modern commercial IoT-based frost warning systems and a system developed by Fraunhofer IFAM were compared with the established Esteburg frost warning system. Alongside measurement accuracy, the focus was also on aspects such as data update rate, warning methods and the technological basis of data transmission.

Of particular interest are the advantages and disadvantages of different radio technologies such as LoRaWAN (Long Range Wide Area Network), mobile communications and other Low Power Wide Area Networks (LPWAN). The study shows that the high energy efficiency, low operating costs and good range coverage of LoRaWAN make it a promising approach for decentralized use in the Altes Land fruit-growing region – especially with a small topography and limited mobile phone coverage.

Furthermore, the first field tests with LoRaWAN-based pressure monitoring sensors for controlling frost protection irrigation pumps will be carried out soon. A system for the remote activation of LoRaWAN devices is also under development, which will enable the automated remote start of frost protection irrigation lines.

The aim is to use these technologies to achieve a more precise, faster and automated response to frost events in the orchards, thus minimizing harvest losses and significantly reducing water consumption by controlling frost protection irrigation according to demand.

SAMSON app – Digital farm management system with individual tree data

In addition to the innovative technology modules described for recording precise, cultivation-relevant data on the cultivation areas using the sensor box, the SAMSON app developed by Fraunhofer IFAM in Stade enables the data generated in the orchard to be implemented in such a way that a digital twin of each individual fruit tree is created (Figure 5 and 6). The intuitive app offers the option of importing not only existing rows of fruit trees, but also each individual tree as an independent instance by importing geo-information or entering these using digital tools via satellite maps. Even at the planning stage, it is possible to lay out areas before the actual planting and configure the ideal row and plant spacing.

The sensor and camera-based data records are assigned to each individual tree via synchronous geo-based localization, so that the data master is enriched and individual information such as blossom intensity, number of fruits or fruit size can be derived.

The example of the 2025 apple blossom illustrates the precise allocation of data and the derivation of cultivation-relevant information for each individual tree: The images from spring are analyzed in terms of blossom intensity and the blossom intensity is assigned to each individual tree. Based on this, the fruit growers are able to generate tree-specific application maps that only take into account those trees that are above a certain threshold in terms of blossom intensity. The digital farm management system supports this and offers the user the opportunity to visualize the analysis, randomly check the assessments in the field and thin out the blossoms accordingly.

Extensive case distinctions show prototypically how, for example, it is possible to identify the trees that had a high blossom intensity in 2025 and a low one in 2024. On the one hand, this can be used to derive tree-specific recommendations for action in practice, and on the other hand, it offers researchers the opportunity to get to the bottom of the correlation between alternating blossom intensity.

Interaction with the digital twin also represents further high innovation potential for both fruit growers and research institutions. Not only can application maps be generated, but large-scale variety, fertilization and cutting studies can also be managed and correlations between data sets or derived information can be investigated. Thanks to the modular software architecture, it is possible to call up the individual tree data directly in the field via mobile devices (e.g. cell phone or tablet) and compare it with the real apple tree, but is also available web-based in the office for the derivation of application maps or analyses.

It is also possible to record individual measurement data in the field using mobile devices such as measuring sticks. Using the interactive interface of the app, users can then, for example, manually assign the blossom intensity to each individual tree – as an alternative to sensory recording using the sensor box – which can be used as an evaluation parameter on the one hand, but also offers researchers a platform for digital experimentation on the other. Practically, the fruit grower is also able to use the app to make GPS-supported, tree-specific notes of other anomalies or comments. The stored information is then available for further purposes.

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- **Fruit Advisory Service of the Altes Land e.V.; OVR, Jork**
  - www.esteburg.de/startplatt/mid_39245.html

Further Information

- Project website: https://samson-projekt.de/
- Instagram @samson_projekt
- Video: https://s.fhg.de/bb4F

Photos

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Figure 1 l Caption

The tractor-mounted sensor box is equipped with precise sensors and camera systems. During normal journeys through the orchard, it records the individual data tree by tree (© Project SAMSON).

Figure 2 I Caption
The alternance phenomenon illustrated on the "Red Prince" apple variety. Left: Three trees during flowering in 2023 – tree 2 (center) has almost no blossoms, tree 1 (left) and tree 3 (right) carry a lot of blossoms. Right: The same three trees during flowering in 2024 – tree 2 (center) is extremely rich in blossoms, trees 1 (left) and 3 (right) have almost no blossoms (© Project SAMSON).

Figure 3 I Caption
Challenges in fruit tree cancer detection with AI. An AI model recognizes the fruit tree cancer site on a high-resolution smartphone macro image (© Project SAMSON).

Figure 4 l Caption
A further development of AurOrA enables targeted reduction of weeds between the fruit trees using a string trimmer (© Project SAMSON).

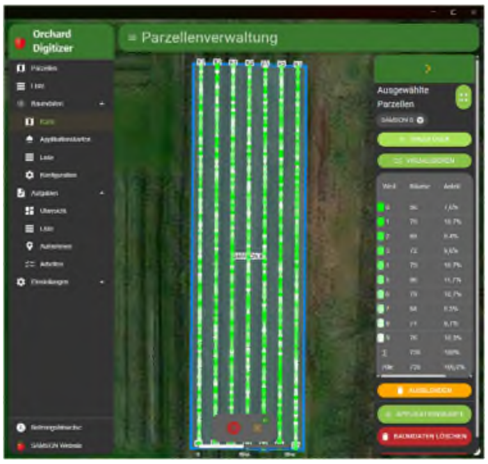

Figure 5 l Caption
Insight into the "OrchardDigitizer" app. Left: Navigation menu. Center: Representation of the SAMSON B area with individual tree positions and color-coded flowering intensity (green = no flowers, white = many flowers). Right: Detailed view with number and percentage distribution of flowering intensities on the area (© Project SAMSON).

Figure 6 I Caption
Digital twin of a tree. Selecting a tree on the map (blue dot) opens the detail menu (example: tree no. 16 in row 1). In the "history" view, all digitally recorded measured values (e.g. flowering intensity, number of apples) are displayed in chronological order. The "details" view contains master data such as planting date, variety and species. In the "images" view, the historical images are stored for the respective measurement dates (© Project SAMSON).

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