

The AUTOPIC Project – Objectives & Outcomes

Institution of Agricultural Engineers - Landwards Conference 16-11-2016

Ag Eng Innovation: Concepts to Cash

Turning ideas into profit: the engineers' survival guide

Harper Adams University

Partners



Harper Adams
University

Harper Adams University was responsible for the autonomous vehicle, systems integration and vision and information processing.



NPL was responsible for fruit and ripeness sensing, fruit grading and visual recognition of fruit.



Shadow Robot Company provided the robotic arm, the picking head and the systems for punnet filling and much vision work



BerryWorld was the project's link to the real world of fruit production and delivery to your supermarket.



Telemetry Associates Limited managed and disseminated the project and directed the overall progress of the project



Outline

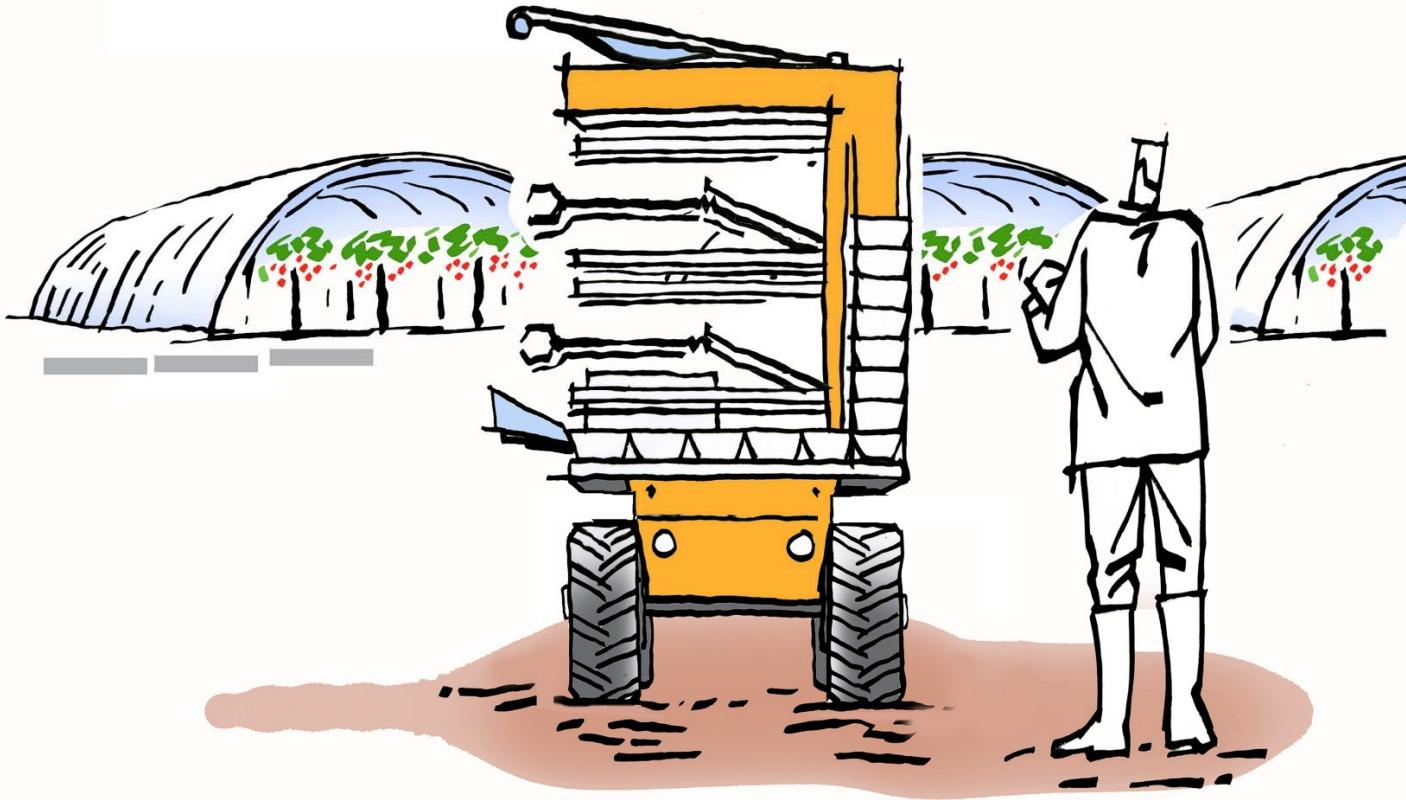
- 24 month project to create a system able to pick strawberries in polytunnels autonomously.
- The project delivered a robotic arm with picking head capable of identifying and picking strawberries in poly tunnels.
- The robot was mounted on an autonomous vehicle.
- The objective was to make the system cost competitive with the ever decreasing supply of manual labour.
- This presentation looks at the project achievements.

AUTOPIC Aspiration

AUTOPIC

the use of robotic technology
for soft fruit picking

Our aspiration was a
complete system



Challenges - Humans

1. They are rather good at picking strawberries
 - So AUTOPIG needed to pick strawberries at least as efficiently as humans.
 - A strawberry picked every 3 seconds
 - Find every strawberry even those behind leaves and in clusters
 - Handle them very carefully with no bruising or damage
 - Put them in a punnet
 - Put the punnet in a tray
 - Put the tray on a trolley
 - All day long.

So why start the project?

- Reliable labour to pick strawberries and other soft fruit were likely to become increasingly scarce.
- The Seasonal Agriculture Workers Scheme (SAWS) which guaranteed 22,500 workers from EU accession states had been withdrawn.
- The potential exists for robotic and autonomous systems to replace this labour, but only if:
 - The costs are comparable or better than existing labour can deliver.
 - Which meant the AUTOPIG system had to pick fruit as fast, more efficiently, more carefully and with less damage than human workers.



Technical Challenges

1. The system had to be able to find strawberries growing on trays in a polytunnel
2. It had to find and identify strawberries that are ripe
3. It had to work out exactly where they are
4. It had to reach out with its robotic arm and grip the strawberry and sever its stem without damaging the berry in any way
5. It had to place the strawberry into a punnet
6. And it had to do it all in around 3 seconds per berry picked.

More Technical Challenges

7. We envisaged a robotic arm mounted on an autonomous vehicle that would move very slowly along the stands of strawberries
8. The AV could be no wider than the gaps between the rows in the polytunnel
9. The AV had to carry replacement punnets and trays and manage punnet filling and trays once they were full
10. The AV had to navigate through the polytunnel and not cause any damage
11. The system had to identify the fruit to be picked using optics, sensors and pattern recognition to identify ripe, Class 1 fruit, ignore unripe fruit and dispose of anything else.

Even more Technical Challenges

- 12. The AUTOPIG system had to be safe and recognise obstacles or people in its path and stop
- 13. It had to be reliable and ultimately be capable of working 24/7 and able to work irrespective of ambient light
- 14. Replacement parts had be easy to fit and cheap.
- 15. All its systems needed to work together as one overall system.

This is the target

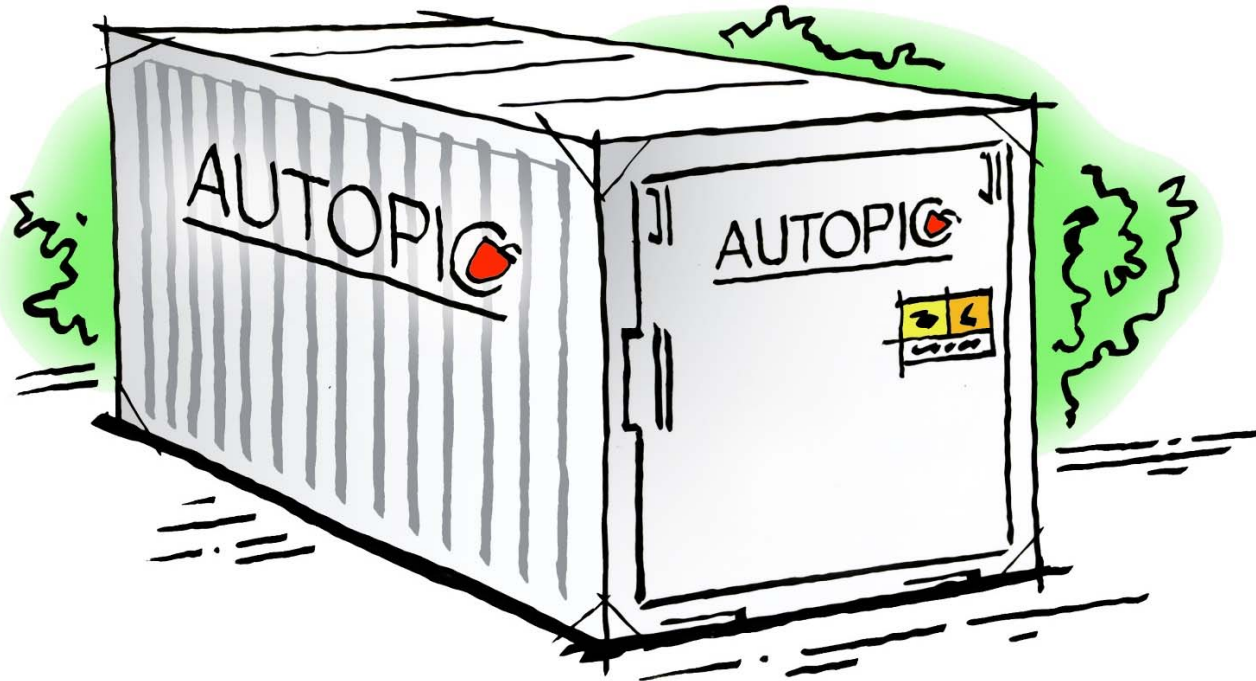


Imagine a day in the life of an AUTOPIC



the use of robotic technology
for soft fruit picking

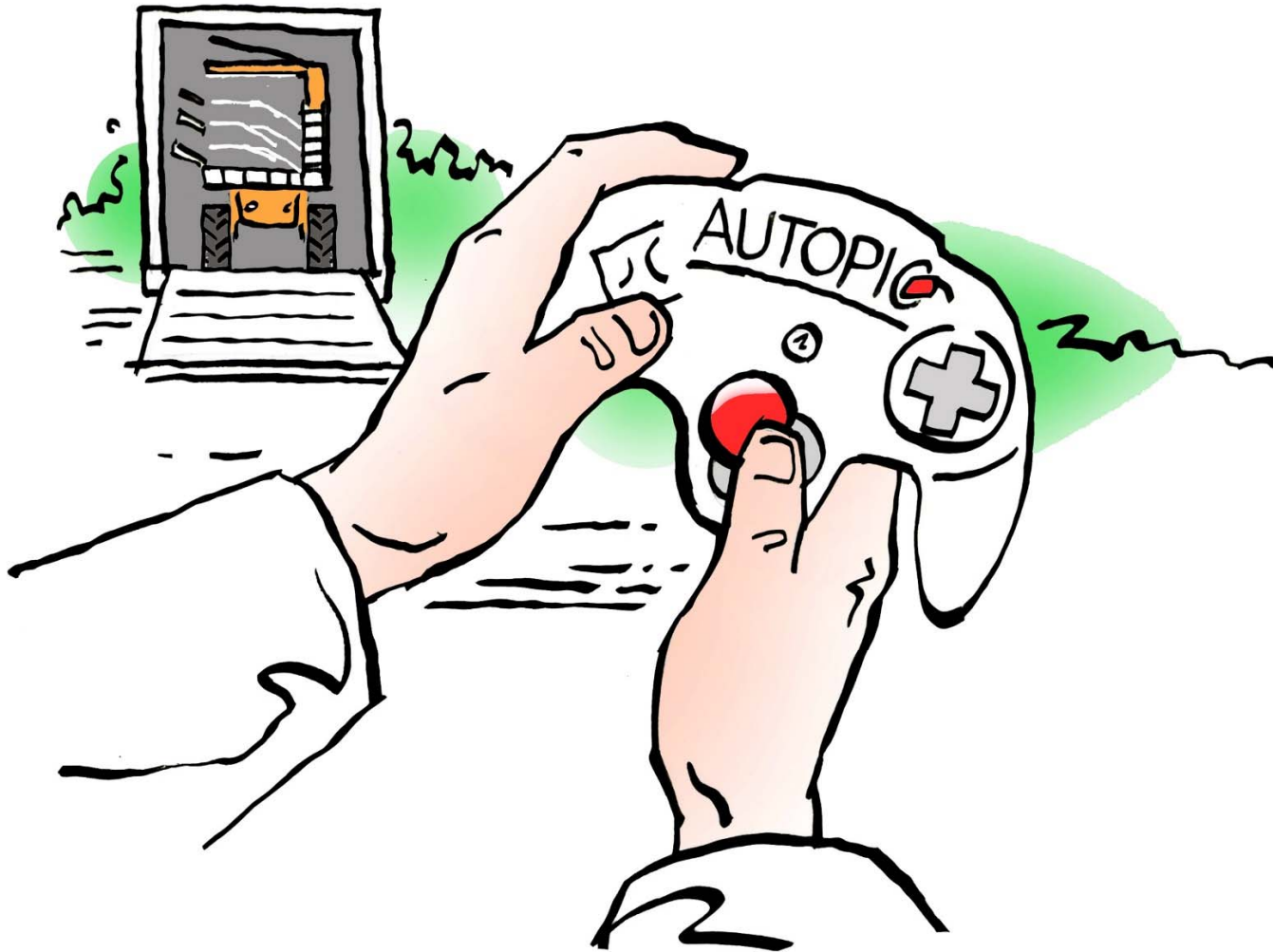
1. AUTOPIC is kept overnight in a container.



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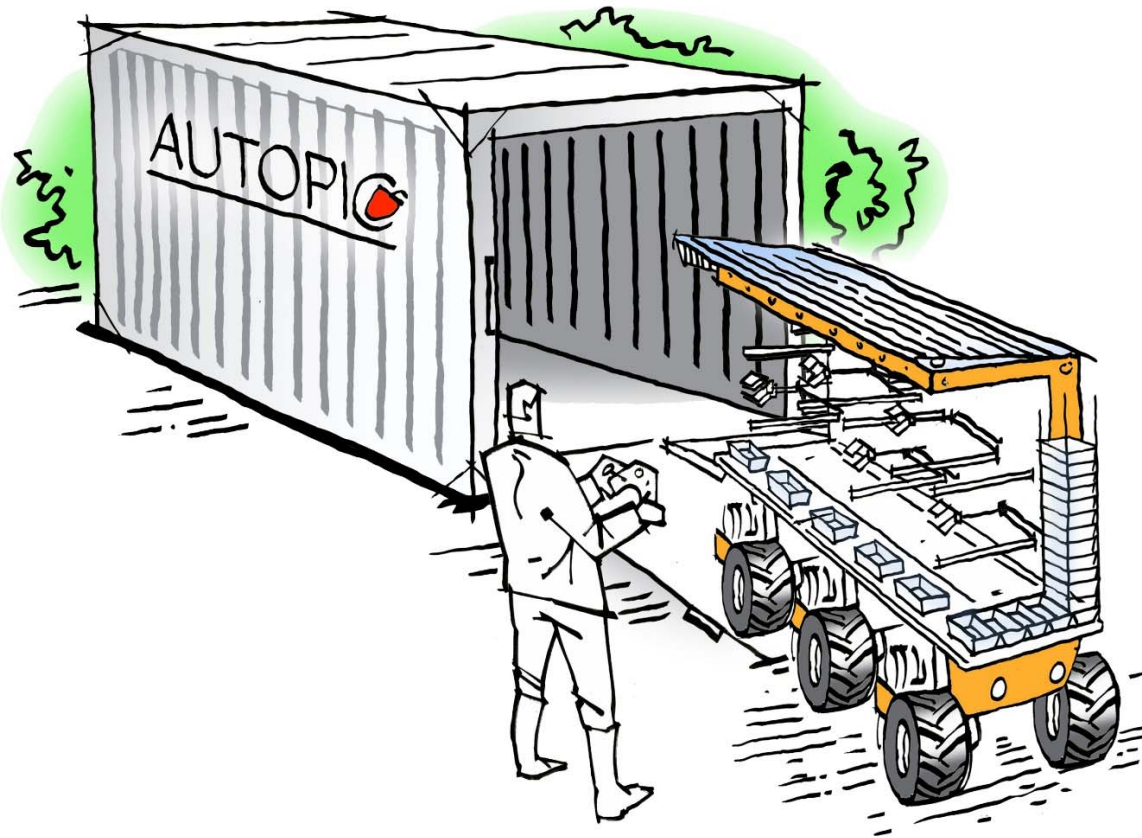
2. At first light or 04.00 the container is opened and an employee using a hand held joystick controller, starts it up and drives the AUTOPIC out.



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So how did we do?

- It's not easy.
- We found that stereo cameras worked but have limited application
- Much effort went into “point cloud” techniques
- For size, shape and orientation we tried “convoluted neural networks”
- We can find and pick strawberries in the lab if they are single hanging down
- We cannot deal with occlusion
- We cannot deal with clusters
- But we know how this can be done and what additional research is needed



What else

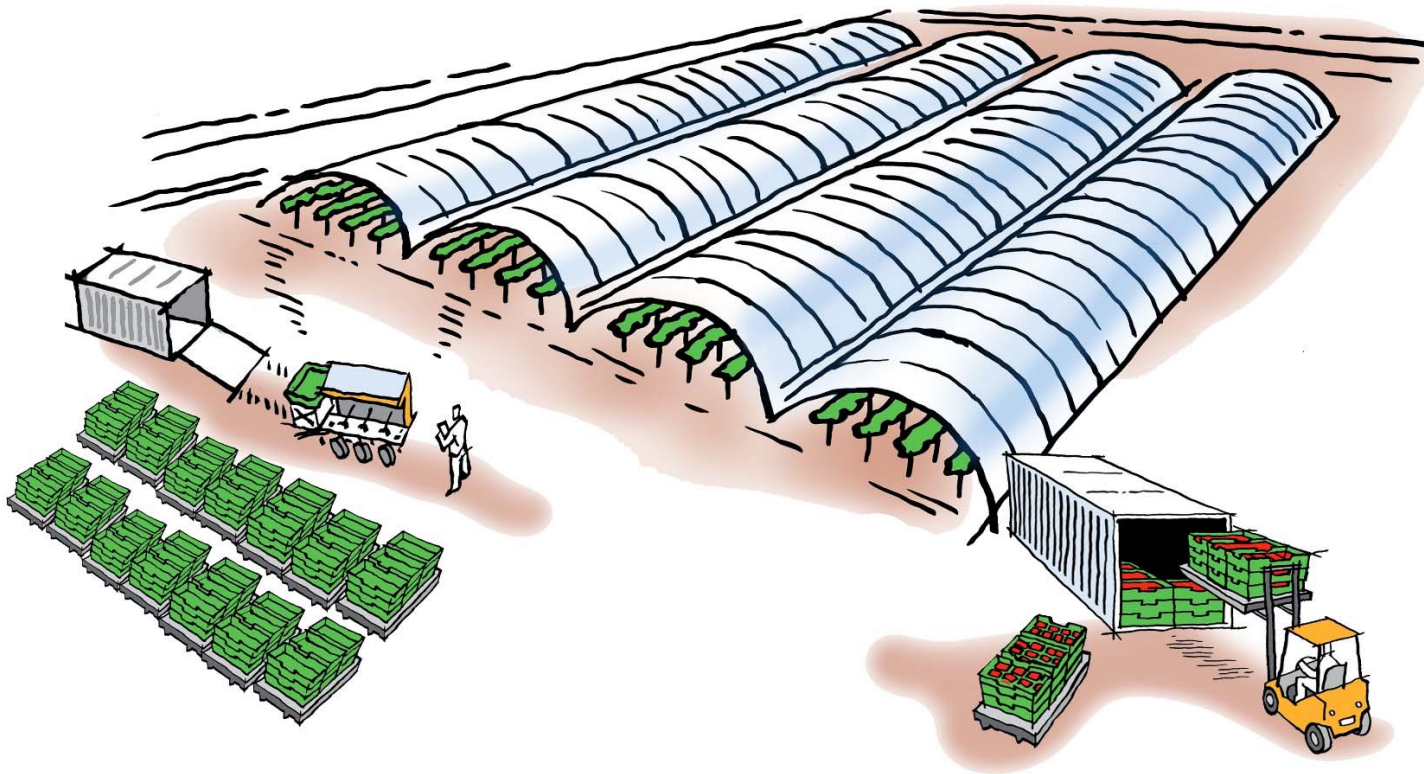
- We converted a vehicle to carry the robot and this is now capable of working in poly tunnels autonomously
- We have a robot solution that is quick and accurate
- We have a picking head that holds the fruit and cuts the peduncle
- We don't have an "agriculture hardened" robot or picking head
- The robot is too big to go through some rows in typical poly tunnels
- The picking head only picks berries that hang down.
- But in laboratory conditions we can pick a berry every 3 seconds.



Imagine a day in the life of an AUTOPIC

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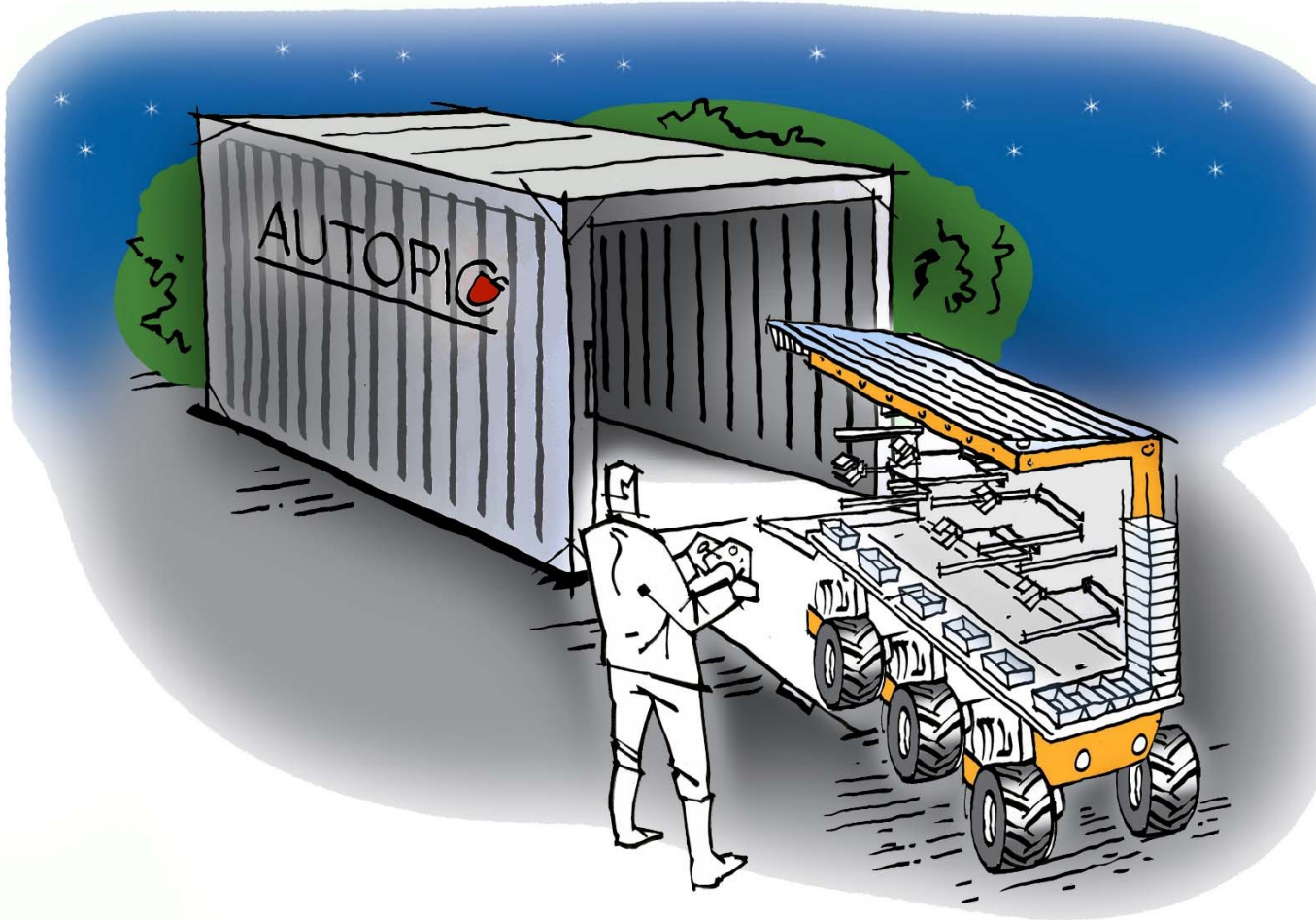
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21. At around 00.00 (midnight) it will stop work, undergo its daily service routine and (employee) will reverse into its container. Ready for the next day's work. Or it may simply carry on working, in which case the wording becomes "on Sunday at midnight ready for the next week's work".



What next

- We need to make the vision systems much better at finding all the berries
 - This implies multiple stereo cameras to build up a complete picture
 - Multiple stereo cameras implies some quite advanced mathematics
- We need to be able to focus on each berry we find and:
 - Evaluate its ripeness so we only pick perfectly ripe berries
 - Make sure the berry is not damaged, diseased, infected or infested
- Then we need to sequence our picking so that we pick the berries in an order that avoids touching other berries
- A nice to have is for the last few berries for a punnet to make an exact weight for that punnet. Eg. exactly 400 gms



What next

- We need to redesign the robotics and picking head
 - The robotics mechanisms must be smaller so we can mount multiple robots
 - The picking head needs enhancement so it can sever the berry's stem in whatever orientation it is. (more degrees of freedom)
 - The redesign must be for continuous agricultural conditions
- Ultimately, we will need a purpose made autonomous vehicle
 - Narrow enough to negotiate all the rows in polytunnels
 - Low and stable deck
 - Able to run at least 4 hours before refuelling



Market

- Using human pickers the cost per punnet picked is about 25 pence
- Human pickers cost around £10/hour and pick about 25kg of berries (one berry every 4 seconds)
- An AUTOPIG robotic picker with 2 robots could pick around 25kg of berries per hour but can work for twice as long every day. So could replace 2 humans
- Brexit and the falling £ puts at risk the 65,000 migrant population working in soft fruit (about half on strawberries) because the UK is now less attractive.
- Our estimate is that some 1,500 AUTOPIGs would be needed to replace some 60% of the human labour picking strawberries



Market - 2

- The UK strawberry market is about 1/10 of the European market
- The European Market is about 1/10 of the world market
- This indicates a large potential market.
- We would like to take AUTOPIG forward and engage with this market.
- But we need to do some more research and development before we reach minimum viable product status and commercial funding
- With this we could have products in the field in 2019
- Talk to us if you can help us take this project forward. (NDA required).



Conclusion

- The project has reached a stage where its potential can be shown
- Many issues remain before significant funding can be attracted
- Proof the AUTOPIG concept is feasible
- Validated market need for vehicle at right price / performance
- Question of what we do next and how it can be funded.
- Ambition is perfect grade 1 strawberries from “plant to plate” untouched by human hand.





Questions