# Intellectual Property Register

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| PROJECT TITLE | VespAI / VespAlert |
| PROJECT LEAD | Juliet L. Osborne |
| PARTNERS / SUBCONTRACTORS | States of Jersey Department of Infrastructure, Housing and Environment / Jersey Asian Hornet Group (JAHG) |

# PART 1: BACKGROUND IP

## Pre-existing / Background IP to be used in the project (including; patents, Un-patented inventions and Know-how, methodologies, processes, software, models, copyright, genes, formulations, data, thesis, reports, plant varieties, designs,)

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| **ID** | **Date**  (Date in which details initially listed and / modified in register) | **Description of IP** | **Originator Organisation(s)**  (the organisation or organisations that created the IP) | **Originator**  **Person(s)**  (the person or persons who created the IP) | **Type of IP**  (know-how, patent, software, data etc..) | **Intended purpose and value of the IP that is provided** | **Any restrictions on use** (e.g being used in another project, existing licence conditions, restrictions on publication) |
| B1 | 02/08/2022 | Original design concept/sketch for an automated Asian hornet bait station (March 2018).  Key elements:   * Avoid by-catch by using open dish with food bait/attractant. * Cheap motion-activated camera. * Includes a rain-cover. * Dish provides simple 2-D photo arena. * Simple background filling whole viewing field; avoid periphery triggering camera. * Combined with image-recognition software, to select & only retain images of Asian hornets. * Potentially using Arduino / Raspberry Pi electronics linked with phone camera. * Send an SMS alert when Asian hornet detected.   Concept arose during Q&A/discussion/brain-storming with **Angleo Spencer-Smith**, after PJK presented on Asian hornets to West Cornwall BKA on 20/03/2018. (see details below Table) | U. Exeter | PJK | Know-how |  | No |
| B2 |  | Prototype bait station with image capture | U. Exeter | PJK & TOW | Know-how |  | No |
| B3 | 04/08/22 | The image database: >1TB of video data and 2647 selected frames of insects visiting the system in Jersey, Portugal, and the UK, providing a comprehensive training and validation dataset for specifically identifying *Vespa velutina* and *Vespa crabro*. | U. Exeter | PJK & TOW | Data/ Know-how |  | No |
| B4 | 04/08/22 | Annotated image database for training & validation: Manual polygon annotation of the image database outlined in ‘B3’, to produce >1700 labelled cases of *V. velutina* and *V. crabro* in COCO format. | U. Exeter | TOW | Data/ Know-how |  | No |
| B5 | 30/08/22 | Image augmentation process used to expand the data set as well as anticipate scenarios unseen in the training dataset, a bespoke augmentation procedure is applied to the datasets referenced above. Including but not limited to:   * Mosaic combinations of training data. * Copy-paste augmentation (requiring polygonal labelling; see B4). * Colour, hue, orientation, and contrast, etc. | U. Exeter | AC | Know-how |  | No |
| B6 | 30/08/22 | Algorithm: AI code developed in PyTorch utilising YOLOv5 object detection. YOLOv5 is licenced under a GNU General Public Licence v3.0 and can be found here: <https://github.com/ultralytics/yolov5/blob/master/LICENSE> | U. Exeter | AC | Data/ Know-how/ Software |  | No |
| B7 | 30/08/22 | Algorithm optimisation: Optimisation of the detection algorithm to run on a Raspberry Pi, specifically utilising YOLOv5 and other motion detection techniques, including ViBE monitoring. | U. Exeter | AC | Data/ Know-how/ Software |  | No |
| B8 | 23-26/08/22 | Hardware design to combine AI with bait station prototype for automated monitor field evaluation. | U. Exeter | PK, JO, TOW, AC | Know-how |  | No |
| B9 | 04/08/22 | Idea to use an LED to indicate a positive alert on a monitor, thus delivering a cheaper basic monitor without the need for Wi-Fi, SMS, or Bluetooth. | U. Exeter | PK | Know-how |  | No |
| B10 | 04/08/22 | Explainability through Layer-wise relevance propagation. A reverse propagation algorithm applied to the AI hornet classifier to reveal the relevance of each pixel in making classification decisions. This lead the design process once such relevance maps were studied. | U. Exeter | AC | Software |  | No |

# PART 2: FOREGROUND IP

## Arising / Foreground IP (and results) to be used in the project (including; patents, Un-patented inventions and Know-how, methodologies, processes, software, models, copyright, genes, formulations, data, thesis, reports, plant varieties, designs,)

## Research Councils and other funding bodies expect academics to capture the output of research. If ideas with commercial potential have emerged as a result of your research you can register them with our IP and Commercialisation team via this secure online form:

# [INNOVATION DISCLOSSURE](https://www.exeter.ac.uk/researchtoolkit/partnershipsandcontracts/innovationdisclosureform/) - university form to register the general Innovation

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| F1 |  |  |  |  |  |  |  |
| F2 |  |  |  |  |  |  |  |
| F3 |  |  |  |  |  |  |  |
| F4 |  |  |  |  |  |  |  |
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| F7 |  |  |  |  |  |  |  |
| F8 |  |  |  |  |  |  |  |

# PART 3: THIRD PARTY IP

## Any Third Party Intellectual Property owned or controlled by an organisation or person not included as an official partners or sub- contractor to be used in or relied upon within the project or any subsequent commercialisation (including; patents, Un-patented inventions and Know-how, methodologies, processes, software, models, copyright, genes, formulations, data, thesis, reports, plant varieties, designs,)

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| **ID** | **Date**  (Date in which details initially listed and / modified in register) | **Description of IP** | **Originator Organisation(s)**  (the organisation or organisations that created the IP) | **Originator**  **Person(s)**  (the person or persons who created the IP) | **Type of IP**  (know-how, patent, software, data etc..) | **Intended purpose and value of the IP that is provided** | **Any restrictions on use** (e.g being used in another project, existing licence conditions, restrictions on publication) |
| T1 |  | PLAINSIGHT software for image annotation (however there are many alternatives if this becomes a limiting factor) | PLAINSIGHT | Carlos Anchia, Elizabeth Spears, Logan Spears | Software |  | No |
| T2 |  | AI modelmodel architecture: YOLOYOLO family | Joseph Redmon | Joseph Redmon | Software |  | No |
| T3 |  | Machine learning framework: PyTorchPyTorch | Meta AI | Adam Paszke, Sam Gross, Soumith Chintala, Gregory Chanan | Software |  | No |
| T4 |  | Hardware: Raspberry Pi components | Raspberry Pi Foundation | David Braben, Jack Lang, Pete Lomas, Alan Mycroft, Robert Mullins, Eben Upton | Hardware |  | No |
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**Protection measures for knowhow:**

1. Encryption of all code on development platform – HGitHub (currently set to ‘private’).
2. Encryption of all images on development platform –– GitHub (currently set to ‘private’).).
3. Encryption of all code and images on all sample/ prototype devices and separation from generated data.
4. Encryption of all code and image databases on production devises and storage in secure area away from generated and user-accessible data.
5. Secure storage in the university of all development code, databases, flow charts and design details on a limited access ODOneDrivefolder and locally on encryptedindividual team member laptops.
6. Limited sharing of specific details by team members, including development processes, design philosophy, and hardware specifications.

**Users with access to the knowhow:**

1. Limited to the following only – no general
   1. Juliet L. Osborne (JLO)
   2. Peter J. Kennedy (PJK)
   3. Thomas O’Shea-Wheller (TOW)
   4. Andrew Corbett (AC)
   5. Mario Recker (MR)
   6. Limited research group access to general information for research purposes and specific enquiries for collaboration?

* Some of the VespAI data (including training images/video) are retained on the Osborne Bee GroupGroup OneDrive / SharePointSharePoint, accessible to others within Juliet’s research group;
* All videos collected to-date are kept on the VespAI Google drive; video data is retained in folders referring to the person who collected the videos for us, using equipment we provided;
* An external drive has a local back-up of all videos.

**Evidence / Correspondence re. B1 Original design concept (2018)**

Email (27/03/2018): **PJK to Alex Huke**, exploring whether AgriTech would fund a project developing an Asian hornet monitor.  
“I have been mulling over ideas on how to develop a monitoring tool for Asian hornets with little consequence for our native insect fauna (i.e. avoiding the massive problem of by-catch in current non-selective traps).  
Others are far better suited to explore possibilities for developing a selective trap around use of a pheromone lure (a fair amount of work with only limited success so far; none with imminent potential to be realised). Arnia are building on their hive monitoring technology by developing an add-on capable of detecting the sound of Asian hornets hawking – a clear benefit for their existing clients but a very costly option for those who don’t have Arnia’s hive monitoring technology. And this technology cannot be deployed away from an apiary, or be used in areas of poor mobile coverage (e.g. I have none in my apiary).  
Instead, I have been dwelling for a while on a simpler approach of cheap motion activated cameras set above open dishes with attractants. The dishes provide a simple 2-dimensional plane and could be set to occupy the whole viewing field, avoiding issues of objects in the periphery triggering the camera. Musing about this with **Angelo Spencer-Smith** (a West Cornwall beekeeper, Parish councillor for St Erth, and director of Maverick Ventures UK Ltd), we thought that combining this approach with image recognition software to evaluate captured images and only keep those of insects that incorporate key characteristics of Asian hornets would show promise. Such battery-powered monitoring traps could be deployed anywhere and provide much better coverage when trying to provide early alerts to the presence and activity of Asian hornets.  
Is AgriTech still looking for projects to fund? Do you know of any Cornwall-based technology companies that may be interested? HandyKam springs to mind but I think they are more of a distributor. Tumbling Dice (e.g. their Rana system: <http://www.tumblingdice.co.uk/rana/detecting-pollinators>) could be a useful contact but are Newcastle based. What are your initial thoughts?”  
Alex responds wondering if there might be an opportunity within Environmental Growth for Business to trial something. Recently recruited Kyle Roskilly to EG4B project to develop environmental sensor network

Email (27/03/2018): **PJK** t**o Matt Witt & Lucy Hawkes**, tapping into their expertise on bio-logging (e.g. 2013 JISC Summer of Student Innovation [BioAcorn](https://webarchive.nationalarchives.gov.uk/ukgwa/20140702145247/http:/www.jisc.ac.uk/research/projects/bioacorn) project ([YouTube pitch](https://www.youtube.com/watch?v=OJ1a3sqR8CA)), getting students to build simple, cheap environmental monitors using Arduino / Raspberry Pi based electronics).  
“I have an idea for a monitoring/alert tool for the Asian hornet. At the moment, most countries are relying on monitoring traps (one-way traps with attractant) to provide an early alert of Asian hornet activity in an area. These are non-selective and have a huge issue of insect by-catch. To mitigate for this, UK advice is to check traps daily and release everything when no Asian hornets have been caught. In reality, I am unsure how diligent people are or will remain with this process.  
A better approach would be to use a bait station where hornets (and others insects) are attracted to a location but are not held, but instead their image is stored. I was thinking along the lines of a cheap motion-activated camera set immediately above a feeding dish (perhaps incorporated into a rain shield), providing a two dimensional plane to optimise image-taking and occupying the whole field of view to minimise peripheral movement activating the camera. If this could be combined with image recognition software that was programmed to recognise and only retain those images meeting the key criteria for an Asian hornet (size, shape, colouration), it could be left in remote locations with images checked on a weekly/fortnightly basis (or could be linked with an SMS alert … although this would add to the cost).  
Would you have any ideas of a company that might be interested in developing something like this?  Even better if it was a Cornish or south-west based company.”  
Matt suggested a French company ([www.wipsea.com](http://www.wipsea.com)) that use image analysis by deep learning to sort wildlife/satellite imagery may be able to help (Gwénaël Duclos from WIPSEA has visited CLES Cornwall on 04/10/2017). Suggestion not followed up.

Call (28/03/2018): **Angelo Spencer-Smith to PJK**, sharing link to [www.TrapView.com](http://www.TrapView.com) website. This is the website of a Slovenian company (EFOS) that uses AI and camera + pheromone/attractant(?) traps to monitor for specific crop pests (mainly moths; not vespids) and provide forecasts to inform targeted pest control measures.  
Contacted TrapView on 08/06/2018 to enquire about the price for a standard automated pest monitoring unit (I confirmed the insects of interest were approx. 25mm with distinctive colour patterns).  
Boštjan Božič **(**Sales and Marketing) responded indicating list price for standard trap is € 700 (includes support services and access to TrapView app for 1st year; thereafter support services/access fee is € 100 / year / trap. Pheromones are not included and would need to be sourced locally.

Email (03/05/2018; **PJK to Martin Stevens & Jolyon Troscianko**, enquiring about cost-effective camera to incorporate into a bio-logging bait trap.

07/06/2018) “I am currently working on projects linked with the non-native invasive predator: the Asian hornet, that is generating substantial concern amongst insect and pollinator conservationists as well as beekeeping organisations. It has spread rapidly across France since its arrival in or before 2004, and has crossed into northern Spain, northern Portugal, northern Italy, Belgium, south-west Germany, and has been’ knocking on our own door’ lately. Key to initiating eradication and containment initiatives are determining its presence. The latter is largely achieved by public-awareness campaigns but also the use of one-way traps. Sadly the latter can have a significant impact on non-target (bycatch) insect fauna, so there is a real need to develop a more selective or less damaging monitoring system.  
For the latter I have been developing ideas for a camera-based system set over a bait station and recording visitation (but not collecting or catching) by insects. Linked with image-recognition software, this may provide an effective means for recording the presence of Asian hornets in an area.  
But cost for the camera system would be a critical point influencing to what extent this could be rolled out at a sensible scale. Are there cheap camera systems, potentially suited to motion-activation, out there that might suit?”  
Jolyon responds (08/06/2018) suggesting combining simple robotics, like Arduinos, with cheap smart phone. Potentially include sensors for size & weight, or analyse wing-beat frequency, take photo, etc. Estimates this might be possible for ~£100. If it didn’t include camera but relied on other sensors, might be possible for ~£30. Jolyon suggests a barcode scanner (or simple low-power sensor reading light/dark patterns) might be able to distinguish e.g. V. crrabro and V. velutina.

Email (08/06/2018): **PJK to Martin Stevens & Jolyon Troscianko**, sharing sketch of PJK’s design for a camera-based Asian hornet monitor. Emphasise that the camera should ideally cost < £50 to be utilised in meaningful numbers.

Email (12/12/2018): **From Angelo Spencer-Smith to PJK**, expanding on his ideas for an Asian hornet “smart trap”. He is considering adapting existing low cost bait stations/traps to become smart traps, enabling them to identify Asian hornets when visited, send an alert via SMS/email, and closing the trap (… though remaining open for non-selected species). The trapped Asian hornet could then be tagged with RFIS and tracked; this part optional. Angelo just shared the concept but not how this would be achieved. Looking for my thoughts on a joint ESI/company bid for AgriTech Catalyst funding.  
Shortly afterwards ((2012/2018), Angelo shares he had approached Nigel Semmence with the idea; Nigel enthusiastic.

Email (25/01/2019): **PJK to Nigel Semmence (in confidence)**, clarifying that Angelo and I have slightly different ideas that share a common interest: improve early detection of Asian hornets. Emphasise the difference between (1) smart bait station, and (2) smart trap, i.e. whether Asian hornet is retained. Specifically ask, to help guide early development, what price Nigel would be willing to pay for an Asian hornet smart trap or monitor. No reply.

Email (14/05/2019): **PJK to Andrew Cowley**, capturing a discussion about developing a concept and potential prototype.  
“The Asian hornet is an invasive non-native predator that is spreading across Europe and is reported to have devastating effects on honeybees and other pollinators. In those area where it is well established, eradication is no longer a possibility and management is the best that can be hoped for. But the UK (& some other countries) are only just being exposed to Asian hornets. Finding those that are present as quickly as possible and locating their nests is the only real answer to prevent their establishment. At the moment, the authorities are reliant on beekeepers and the public reporting sightings of these invaders but this is very hit and miss. There is also a network of traps managed by volunteers but these are non-selective and risk damaging our native insect fauna if the traps aren’t managed properly. And now to the monitoring device …  
Better than a trap would be to use a bait station that does not entrap an insect attracted to the bait but takes its photograph. A good quality photograph of an Asian hornet is all the authorities need to roll out their contingency plan and activate their workforce to locate hornets at a location. An appropriate bait is placed in an open dish and a camera is positioned above it. The whole field of view can be the dish avoiding moving vegetation at the edge of a shot triggering the camera. An opaque [PJK meant translucent] domed shelter can be positioned over the camera and dish ensuring diffuse lighting and avoiding rain diluting the bait, but access maintained through open sides. Insects (flies, wasps, bees, hornets) would be attracted and photographed. The photograph could be triggered by the motion of arrival or maybe heat from the flight muscles; ideally both via motion activated near-IR camera. Once feeding, the insects remain quite still so a series of triggered photos is likely to produce a good shot. In the long run, I would be interested in image analysis software that would trawl through the photographs and discard all that do not have key characteristics of an Asian hornet. Even better is it then sends out an SMS alerting an individual to which trap has been triggered by a likely suspect …. but this would follow much later after the concept has been demonstrated.  
Would really appreciate your help with developing the concept and potential prototype for this.”  
Andrew suggests logging a SID call to enable him to work on this.  
SID call logged by PJK (001934420 – Hornet monitoring using Pi camera). Log of previous logged enquiries shows “Awaiting first response from analyst, IT Research – Penryn team”.

PK Presentation: “**VespAlert monitor History Jan 2022.pptx**” documenting interactions with Sam Day, Bob Hogge and U. Kent.

Mario to add:

* Dates and interaction with U. Kent for Masters student project – and location of thesis

Email JLO: 26/11/21: Full proposal to IDSAI for Research Award to develop VespAlert and VespAI.

**Add evidence for “know-how” in B2 to B8 if relevant** – or at least where procedures/evidence can be found.

**Evidence / Correspondence re. B3 image database**

**Email (03/11/2021) PK to TOW**

‘Hi Thomas, I have put the images/videos I have taken so far on the Osborne Bee Group share-point under AsianHornets/Data/Bait Station/Raw videos. These unedited. I am taking some more today with DragonTouch now corrected to 1080p. I’ll also place some (dead) Asian hornets on the feeding mat. Quick question: I cannot find a feature on the Dragon Touch for time-lapse. There is loop recording but this is continuous recording where you elect to save only the previous 5/10/15 minutes on the press of the trigger. If you don’t press the trigger, it overwrites the previous 5/10/15 minutes with a new 5/10/15 minute recording presumably at infinitum. Resolution of still images seems better than video (although more data in video) but without time-lapse, still images are more point & shoot than a monitoring option. Still getting my head around the Video0 Motion-Activated camera. Need to find quick way to support it and make it weather-proof …. owing to autumnal weather patterns. Aiming to get a setup fixed by end of this week to get items sent/ordered for Alastair (Jersey) and Sandra (Galicia). Can you already check on availability and delivery times? Cheers, Pete’

**Evidence / Correspondence re. B4 Annotated image database for training & validation**

**Email (01/03/2022) TOW to AC**

‘Dear Andy, I have now uploaded the files to the folder 'Take 2' in each of the desired formats, with the annotations randomly split 80:10:10 for training, testing, and validation, respectively. I have also created separate folders for frames annotated by myself and Pete. I'll continue with the full video uploads in the meantime. Best wishes, Thomas’

**Evidence / Correspondence re. B5 Image augmentation used to supplement training data**

**Email (30/07/2022) AC to All**

‘Hi all, Thanks Thomas for sending me another 560 labelled images from the ‘insect pollutants’ (ip) category. I’ve retrained the models and performed some analysis on both. The analysis is all performed on \*test\* data never before seen by the machine. However, in many cases the test data is very similar to the training data due to the small number of individuals we have on record. (The good results at least prove our augmentation is working across new frames.)’

**Evidence / Correspondence re. B5 Algorithm: AI code developed using the YOLO family of models, on PyTorch framework**

**Email (24/03/2022) JO to AC**

‘HI Andy, Sorry I missed the meeting yesterday. Thomas shared your slides with me – which looks like fantastic progress! How exciting..although I understand it might be due to lack of variability in our dataset! But great start indeed….I have never seen graphs like that with the lines round the boundaries… 98% success Non-scientifically speaking ….I love the collation of images on slide 12. It would fit into one of our “Creative Exchange” galleries! Its very striking and Andy Warhol. Don’t worry – I won’t share it for now. But in future, when all this is done – we might find an artistic use for it Look forward to the next catch up Juliet’

* Capture of training images (both initial ones by me and then those captured with JAHG help).