# Autonodyne Blog – 26 Oct 2019

Autonomy is sometimes a difficult thing to define. There is a long-term model that may eventually eliminate all human involvement, but, for the foreseeable future, we believe a supervisory human role will be essential. We subscribe to the school of thought as described in Dave Mindel's *Our Robots, Ourselves* that involves the human and machine working together trading control and shifting levels of automation to suit the situation at hand. At certain times, in certain places, the vehicle is very autonomous and in others, it takes more human involvement. We want to put the human in a supervisory role that commands high-level behaviors and use rich sensor and algorithmically enhanced models of the environment to move across the spectrum of automation moment by moment, driving in and out of clouds of autonomy and risk.

We think it makes sense to make great use of agent technology in appropriate places such as calculating and suggesting re-routing options, looking up and suggesting procedures, drawing upon a database of past events to offer situationally appropriate suggestions, and off-loading high human workload, but highly deterministic tasks.

The table below identifies some high-level autonomy behavior functionality and the non-defense commercial applications as well as the proposed adaptation for military application/use case.

| **Autonomy Behavior** | **Brief Description** | **Non-defense Commercial Use Case** | **Potential Defense Use Case(s)** |
|---|---|---|---|
| Fly Over That | Waypoint Navigation – this command instructs the vehicle to proceed directly to the designated waypoint. | **Basic navigation** of any autonomous vehicle. | **Basic navigation** of any autonomous vehicle. |
| Loiter or Hold Over There | Commands a vehicle to perform a loiter (e.g. circular, figure-8, racetrack, etc) at the designated location with default/designated parameters (e.g. altitude, leg length, direction of turn, etc). | **Basic navigation** of any autonomous vehicle. | **Basic navigation** of any autonomous vehicle. |
| Follow Him | Keeps a defined X-Y-Z offset from the designated "lead" vehicle. | Grouping multiple vehicles for navigation/transit | Grouping multiple vehicles for navigation/transit |
| Hold Current | Holds the current (at time of command) vehicle speed, heading, altitude indefinitely. | Place the vehicle in "pause" mode – especially useful for fixed wing vehicles | Place the vehicle in "pause" mode – especially useful for fixed wing vehicles |
| Hold Commanded | Holds a commanded vehicle speed, heading, altitude indefinitely. | Basic navigation when no specific destination is defined. | Basic navigation when no specific destination is defined. |
| Light It Up | A form of sensor-based navigation for vehicles that are equipped with sensors that are optimized for certain conditions (e.g. detection of a specific type | ISR workload reduction | ISR workload reduction |

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| | of RF emitter), when a sensor gets "a hit", the vehicle will automatically reposition itself to achieve the ideal geometry that assists the sensor for precisely determining the location of the item of interest. | | |
| RTB | Return to Base (RTB) creates a specific 3D profile to return the vehicle to the designated recovery location. | | |
| Deliver | Auto compute a path for delivery of vehicle or supplies. Execute that path, perform precision landing, and release the payload.<br><br>Equally applicable to sUAS carrying <10lb payloads as with partner company Elroy Air carrying packages >300 lbs. | **Autonomous drone package delivery** is tops on this behavior use case. The Amazon, FedEx, UPS, DHL, US Postal Service, etc industry is racing to bring this to everyday life now, not to mention the food delivery industry.<br><br>The capability was demonstrated to Sprint and Amazon during a 11 Sep 2019 IoT demonstration in Peachtree Georgia. | Autonomous cargo delivery. Autonomous resupply. Autonomous cargo removal.<br><br>All use cases reduce personnel exposure, reduce personnel footprint/manning, increase ops tempo.<br><br>If used extensively, also generates field service history for the technology and vehicle reliability. |
| Perch | Principally intended for sUAS to direct it to a perch location and observe. | Law enforcement can use this behavior to send temporary surveillance, monitoring, sensing vehicles to a dynamic area of interest. This behavior enables **"Protection As A Service (PAAS)"** where pop-up monitoring is desired (e.g. outdoor concert venues, social unrest protests, etc). | Discrete, rapid and mobile ability to position on a ledge or look around a corner or any one of a number of tactical observation uses. |
| Lasso | When selected, this allows n-entities to be instantly grouped into a formation/swarm. Handles alignment and deconfliction. | **Post natural disaster search and recovery** scenarios are increasingly making use of UAS platforms for assessment. To date, those involve multiple, uncoordinated, | Group, ungroup, and regroup a set of airborne assets to give the entire set, or subsets specific commands. |

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| | We suggested this behavior to our SOCOM customers in the spring of 2017. | UAS platforms. With this behavioral command, all individual UAS platforms that are participatory in the tactical network can be easily grouped and team commands issued. | Equally as useful in special operations involving a few sUAS as it with larger, higher platforms.<br><br>A Gremlins scenario seems to be well suited to use this behavior. |
| Funnel | Considered a standing lasso that funnels/necks down to a point of singularity. Once vehicles have been directed into the funnel, sequencing and deconfliction is automatically handled, even for heterogeneous vehicles down to singularity (typically a landing area). | **Urban Air Mobility (UAM)** or "Air Uber" operations are expected to bring multitudes of airframes into and out of the same general airspace (e.g. vertiports) resulting in dangerous congestion in the terminal area. This behavior allows for orderly alignment no matter what the inbound heading, altitude and airspeed were. | Deconfliction and coordination when integrating manned and unmanned assets coming/going from the same forward operating location (FOL).<br><br>Enables manned-unmanned teaming to operate from the same facility. |
| Stage | In this task, a staging area is defined by a swoop of your fingers or mouse. Any vehicle directed into the staging area will remain in the staging loiter until commanded out of it, or the fuel/energy state requires departure. Sequencing and deconfliction is handled by the task. | **Urban Air Mobility (UAM)** or "Air Uber" operations are expected to bring multitudes of airframes into and out of the same general airspace (e.g. vertiports) resulting in dangerous congestion in the terminal area. This behavior allows for orderly staging before funneling into the landing area, much like commercial aircraft in holding patterns waiting for their time to penetrate poor weather conditions – you can park the aircraft in a safe spot and not worry about them until it's time to bring down. | Deconfliction and coordination when integrating manned and unmanned assets coming/going from the same forward operating location prior to commencing the final approach to the landing area.<br><br>Enables manned-unmanned teaming to operate from the same facility. |

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| Sentinel | When an external sensor or on-board monitor sensor trip-wire is activated, the vehicle(s) launches and provides perimeter defense/monitoring capability.<br><br>Until the virtual trip-wire is triggered, the UAS is on the ground in watching/listening mode, almost indefinitely. | Our current use case is in **wild fire fighting scenarios**: One or more Sentinel systems are poised atop the lookout watch towers in the Sierras. If there are more than one, they are networked together and sharing info. And in the CalFire scenario, we should know what the tinder level is of the ground, the outside humidity, and where there are thunderstorm/lightning activity areas. We can predict where hotspots may occur and if we sense one, the Sentinel trip wire is activated, one or more birds launch to go have a closer look and conclude, "yup, it's a hotspot, send in the fire fighting resources", or "nope, it's just a family having a campfire cookout".<br><br>We can use computer vision landing methodology to recover back to the watchtower when the flight is complete. | Airfield or high-value asset perimeter defense.<br><br>Ground, or near ground-based ISR. |
| Envelop | When selected and a Point of Interest (POI) identified, all available assets take up observation positions around the POI. If 3 vehicles, they take a 120 degree spread offset a distance (say 100') away from the POI. If 36 vehicles, they take a 10 degree spread. | **Law enforcement** can use this behavior to send temporary surveillance, monitoring, sensing vehicles to a dynamic area of interest. This behavior enables multi-angle surveillance in a pop-up environment for maximum situational awareness. | Simultaneous, multi-axis surveillance of a point of interest.<br><br>May be used to determine targeting, observe the attack, and conduct battle damage assessment post strike. |

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| Rejoin | In this behavior, the software is constantly computing an optimal rejoin path to a moving (ground or air) target.<br><br>Depending on the availability of on-board sensors, this takes into account obstacles/obstructions that appear. | Our principal use case is in **autonomous drone package delivery** dispensed from, and recovering to, a moving delivery van. | Recovery of an airborne asset that was used during convoy escort that needs a recharge, battery replacement or refueling.<br><br>Autonomous resupply to a moving recipient.<br><br>Autonomous rejoin to an airborne refueling platform. |
| Point At That | Air vehicle flies directly at airborne point of interest designed by the master at optimum cruise parameters unless otherwise specified. Think pure pursuit. | No current commercial or civil use cases in-play or being pursued. | Counter UAS operations.<br><br>Threat deterrent operations. |
| Stare At That | The air vehicle flies a path that keeps the sensor aligned on the POI. | **Long-term persistent surveillance by law enforcement or environmental monitoring** - this behavior optimizes the path to keep the on-board sensor(s) in the desired field of view/regard. | Long-term persistent surveillance (e.g. MQ-9)<br><br>Targeting, both Air-to-Air and Air-to-Ground.<br><br>Detect & Avoid "Padlocking". |
| Marsupial | At least one vehicle carries at least one other vehicle on its back and releases and recovers that vehicle in a force multiplier fashion. The marsupial behavior can be ground-air vehicles or air-air vehicles. Our typical use is to have a ground rover launch and airborne UAS after driving to a specific spot in a form of unmanned-unmanned collaborative autonomy. | **Post natural disaster search and rescue** – post Haitian earthquake or Florida hurricane in which a ground rover hits an unpassable obstacle and it autonomously launches an airborne asset to finish the SAR mission. | Drivable docking stations that can both transport and charge a sUAS until needed.<br><br>The pure airborne variant has the larger UAS releasing a smaller UAS(s) in a host of missions and use cases. |
| Follow Me | Principally intended for sUAS and overwatch mode. The sUAS will follow a designated POI at a specified X/Y/Z offset. | **First responder overwatch** – the drone becomes a personal eye-in-the-sky. When integrated with Edgybees technology, the On-scene Commander and/or | JTAC overwatch.<br><br>JTAC load lightening – still bring the airborne platform to battle with you but it |

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| | | Operations Center can monitor the location and status of all first responders. | flies itself instead of being hand-carried.<br><br>Convoy overwatch.<br><br>USAF first responder overwatch. |
| Greased Pig | If a vehicle becomes aware of an incoming threat, it will take evasive action. | No current commercial or civil use cases in-play or being pursued. | sUAS counter-counter maneuever. |
| Learner / Sharer | Principally useful in swarm/hive operations when a few scouts are sent out to survey the area or map an area, return to the swarm/hive (or just communicate back) and share what was learned. | **Post natural disaster search and rescue** – in areas of unknown obstructions, or threats (e.g. unsound structural integrity), the scout UAS maps the area of interest then communicates back a COP for the remaining UAS to divine their own gameplan and execute without having to all expend their on-board energy reserves. It also provides enough information to the On-scene Commander to formulate a gameplan in which to best utilize his/her assets. | JTAC target area mapping/awareness.<br><br>Roaming airborne "motorcycle gangs" for offensive and defensive uses.<br><br>Airborne collaborative reconnaissance. |
| Surveil | This task will intelligently divide the selected geographic area into the most appropriate surveillance patterns based on the vehicles tasked, their fuel/energy states, and the sensors they have onboard. | **Mountain Search and Rescue** – a number of UAS platforms can be automatically divided up to perform the SAR in remote territory. | Airborne ISR with one or more airborne assets.<br><br>Combat Search and Rescue.<br><br>Battle damage assessments. |
| Path Plan / "5Ds" | This task autonomously computes a path around any known or sensed obstacles and continuously computes an optimal path.<br><br>Works in real-time and in 3D. Uses spline interpolation to more accurately calculate optimal maneuvers and paths that reflect | **Autonomous drone package delivery or Urban Air Mobility** – this behavior can update the path in real-time when obstacles pop up, | Autonomous cargo delivery.<br><br>Autonomous path planning for all manned and unmanned airborne assets – applies to both pre-mission |

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| | real-world vehicle turning dynamics.<br><br>Takes cost functions into account to assist in the "dodge, duck, dive, dart, and dodge" behaviors for obstacle avoidance. | | planning/rehearsal and real-time mission execution. |
| Comm Relay | This behavior places the vehicle into an appropriate loiter or path to serve as a communications relay. It automatically computes the appropriate position and altitude to maintain line-of-sight comm connections. | **Long-term persistent surveillance by law enforcement or environmental monitoring (and virtually all other use cases when terrain or range are a factor)** – this takes a standard loiter and automatically takes terrain and range into account to automatically determine where and how high to place the loiter to ensure comm links are established and maintained. | Applies to virtually all operations and use cases where terrain or obstacles or distances restrict communications but have an uncontested enough airborne environment that is permissive enough to allow an airborne comm relay. |
| Track | This uses either the inherent target track capability of the vehicle under control (e.g. Raytheon Coyote) or uses own on-board image processing/identification/tracking capability. | **Law enforcement surveillance of a moving POI** – we are partnered with Persistent Surveillance Systems who are using a similar capability over cities such as Baltimore and St Louis. | Tracking items of interest for surveillance, or if warranted, strike operations.<br><br>Naturally makes use of 3rd party tracking technology such as what Progeny can provide (we are partnering with Progeny already). |
| Strike | This behavior orchestrates a kinetic strike - think loitering munition. | No current commercial or civil use cases in-play or being pursued. | All scenarios that involve the use of loitering munitions. |
| Target Grid | This behavior generates Cat 1 target grid coordinates for designated POIs. | No current commercial or civil use cases in-play or being pursued. | Aiding the JTAC task of computing actionable and accurate Cat 1 target grids. |

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| OCA | This behavior informs the vehicle to perform the offensive counter air role. | No current commercial or civil use cases in-play or being pursued. | Autonomous unmanned fighter use in manned-unmanned offensive scenarios.<br><br>Ability to conduct offensive counter-air operations without risking blue-force life.<br><br>Force-multiplier during near-peer engagements. |
| DCA | This behavior informs the vehicle to perform the defensive counter air role. | No current commercial or civil use cases in-play or being pursued. | Autonomous unmanned fighter use in manned-unmanned defensive scenarios.<br><br>Ability to conduct defensive counter-air operations without risking blue-force life.<br><br>Force-multiplier during near-peer engagements. |
| Decoy | This behavior intentionally maneuvers vehicles in a pattern or manner that would be distracting to an observer or allows it to be mistaken for a different platform or role. | No current commercial or civil use cases in-play or being pursued. | Force multiplier during offensive and defensive air operations<br><br>Disruptive to adversarial defensive attempts. |
| Defend | Similar to DCA, this behavior defends “the queen”. | No current commercial or civil use cases in-play or being pursued. | Airfield perimeter defense.<br><br>Convoy escort.<br><br>Airborne transport effort.<br><br>Combat Search and Rescue operations. |
| Sacrifice | This behavior will use pure pursuit to intentionally generate a sacrificial path to impact the | No current commercial or civil use cases in-play or being pursue. | Airfield perimeter defense.<br><br>Convoy escort. |

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| | designated item or vehicle of interest. | | Airborne transport effort.<br><br>Combat Search and Rescue operations.<br><br>Counter UAS. |
| Morphing Swarm | The behavior changes the relative positioning of a swarm of UAS to deal with known/sensed geographic or volumetric constraints and/or reductions or increases in the number of swarm members. | **Post natural disaster search and rescue** – in areas of heavy urban destruction (e.g. severe earthquake or hurricane), when a group of UAS are working in concert at defined X/Y/Z offsets from each other and need to "neck down" to squeeze through small openings. | Post natural disaster Search and Rescue.<br><br>Post adversarial strike Search and Rescue.<br><br>Offensive swarming strike operations.<br><br>ISR in urban environments. |
| Refuel | When commanded (may need to designate the vehicle from which the fuel will be dispensed), the system will drive the selected vehicle(s) to attempt a rejoin on the providing vehicle and connect for fuel. | **Persistent surveillance for law enforcement, natural disaster operations, and environmental monitoring** – we are currently developing this capability with a partner company in Ohio where we intend to demonstrate the impact on long-duration surveillance UAS platforms. | All persistent airborne ISR scenarios.<br><br>Range extension.<br><br>Force multiplier for most classic Air Force aerial operations. |
| Mimic Me | Air vehicle mimics the master actions in pitch, roll, course, and speed. | **Alternative swarm control method** – in this case we are only directly controlling a single master UAS and all other swarm members mimic that master's behavior like a flock. | Simplistic swarm operations.<br><br>"Drag-along" manned-unmanned teaming operations.<br><br>Unmanned air transport. |
| Observe | This behavior trains the sensors on a designated point or area of interest and maintain that observation state for as long as feasible. | **Long-term persistent surveillance by law enforcement or environmental monitoring** - this behavior optimizes the | Airborne ISR with one or more airborne assets.<br><br>Combat Search and Rescue. |

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| | | path to keep the on-board sensor(s) in the desired field of view/regard. | Battle damage assessments. |
| Monitor | Slightly different than Observe or Surveil. This one is more public acceptance friendly. | **Public Safety** where the public gets a little spooked about being "spied upon". This behavior is monitoring vehicular or pedestrian traffic. Not that it's identifying specific vehicles or people but instead, it's a data input source to do something special or send additional resources to congested chokepoints. | |
| Document | This behavior command documents an accident or crime scene. Again, it's attempting to address public policy concerns where the autonomous vehicles are not being used to "spy on" the public. Here, it's an aid to post-mishap investigation efforts.<br><br>For example, the vehicles when told to "document" a POI, will fly a specific pattern around the POI and automatically start any recording devices. Whatever the typical crime scene documentation/evidence collection behaviors are should be represented here. | **Law Enforcement** is documenting an accident scene or crime scene. | |