Garuda Plex

Getting started with

GARUDA PLEX DEVELOPER PROGRAMME

by

Garuda Robotics

AUTHOR Ong Jiin Joo
CTO & co-founder
Garuda Robotics

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For more information
Sales: sales@garuda.io
Technical Support: support@garuda.io

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Welcome Message

In the summer of 2014, when Amazon.com first started marketing drone deliveries, the founding team of Garuda Robotics set off to chart out where the drone industry is heading. We anticipated that commercial use cases would take no shorter than a decade to realise their returns, and it would be our strategy to build a platform for the proliferation of diverse ideas, opinions, or approaches to drone operations, while being carried out in the safest, most reliable, and most globally distributed fashion.

This platform first needed a “killer app”. After a decade of building these apps, from the original Garuda Plex, to a series of vertically focused applications such as TowerSight, Plex Pilot, Plex Horizon, Plantation 4.0, Facilities 4.0, and MyDroneFleets, as well as end-to-end Unmanned Aircraft Systems (UAS) such as Garuda DragonFly, Garuda Responder, SafeDistance, Tenera, OVERWATCH and CraneTrackers, we are now ready to place the platform bearing the same name as our original killer app, in the hands of innovators like you.

Designed to be vehicle agnostic from day one, we envision our industry’s future as one that is not dominated by a single manufacturer, where checks and audits of all drone operations can be made at every level, and where new intelligence and capabilities can be plugged in easily, all while ensuring that the safety of the aircraft and the public it overflies remain a top priority.

At every stage, we will do our utmost to guide you in ensuring that your investments are protected from the dangers of bleeding-edge software. The last thing we want is for your latest LLM experiments to send your drone to its doom. However, this will require a partnership with you - specifically with your qualified pilots who will be playing the part of the last line of defence, as a failsafe for your UAS.

We wish you all the best in your pursuit of advanced use cases to realise the value of your unmanned aerial and ground vehicles.

Yours sincerely,

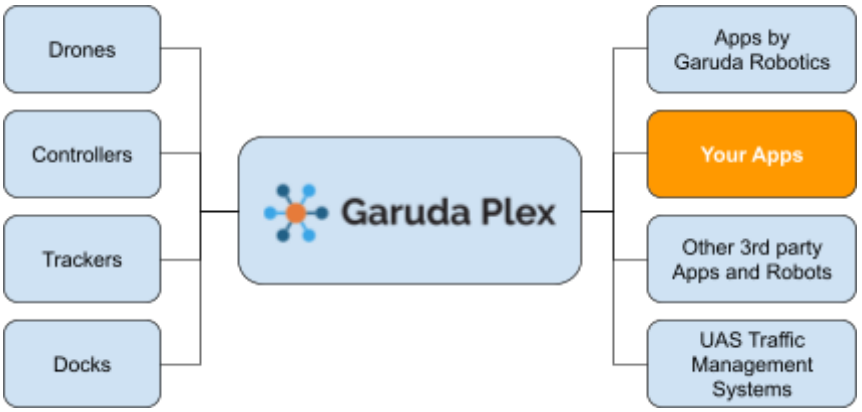
Ong Jiin Joo
CTO & Co-founder
Garuda Robotics

1. About Garuda Plex

1.1. What is Garuda Plex

Garuda Plex is Garuda Robotics' open platform for innovation. It combines the best Ops Tech capabilities with an easy to use C2 for extracting value from your unmanned vehicle.

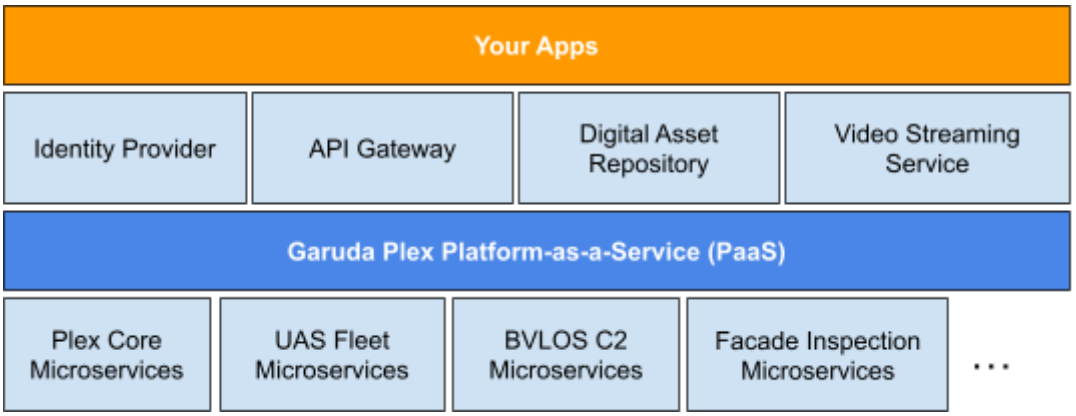
The platform's vision is to enable cloud connected aerial robots to carry out auditable, reliable, and complex tasks that have predictable, intelligent, and beneficial outcomes.



1.2. Where is Garuda Plex

If you're on our Individual plan, you will be interacting with the following main URLs

1. identity.garuda.io — OAuth 2.0 / OIDC Identity Provider (IdP)
2. api.mydronefleets.com — API Gateway
3. media.mydronefleets.com — (For select customers only) Digital Asset Repository
4. stream.mydronefleets.com — (For select customers only) Video Streaming Service



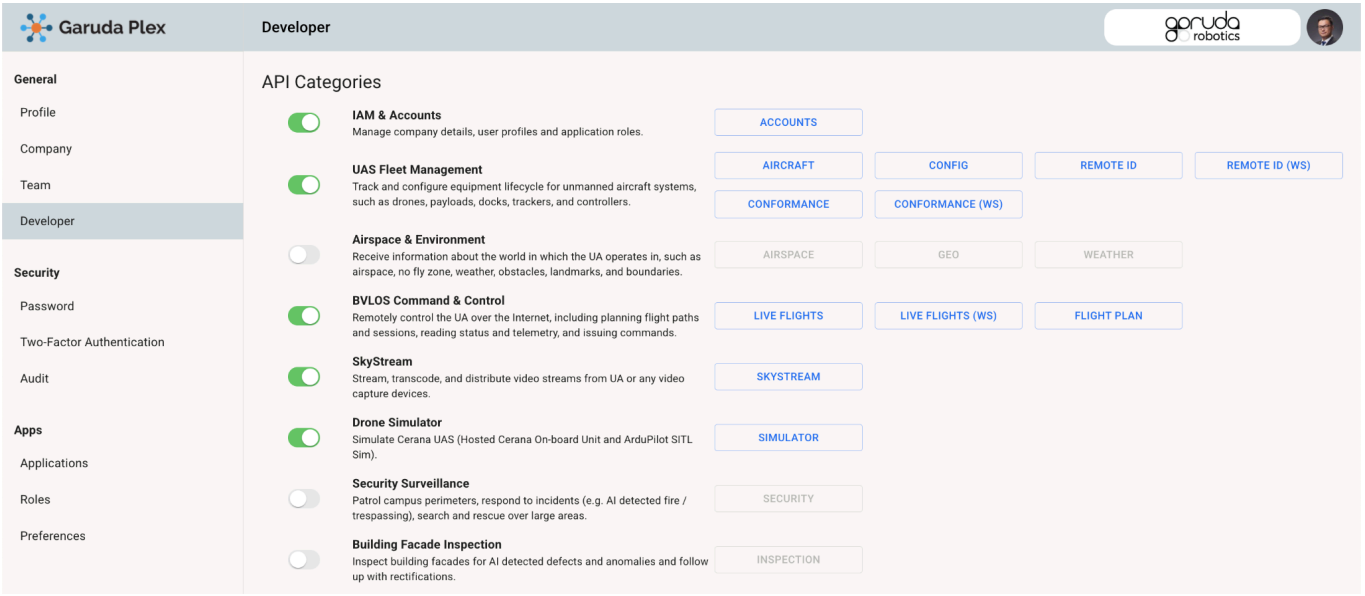
If you're on our enterprise plan, we will be sending out dedicated endpoints for integration.

We also have on-premise solutions, where such APIs are hosted in your private cloud, private cellular network, mobile edge compute VMs, and other secured networks.

1.3. Enrolling in Garuda Plex Developer Programme

To check if you have been provisioned a developer account,

1. Visit accounts.garuda.io
2. Click on **Developer**
3. If you can view the portal and see at least one API Category enabled, then you have access to the Developer Programme



If you do not see this screen, try logging out and logging in again, or contact our technical support. If you would like to enrol, please contact our sales representative.

Continue to set up:

4. Add developer credentials (an OAuth 2.0 Client) for users to connect to your application.
5. A **Client ID** and a **Client Secret** will be created for each user. Client Secrets are only visible to the user themselves (e.g. if you add yourself then you will have access to your client secret).

You now have the necessary credentials to interact with our APIs. You can revoke your API access. Your company administrator can revoke any user's API access. Garuda Robotics also reserves the right to suspend the access if any mis-use has been detected.

See **Appendix A** for further suggestions on Cyber Security between your apps and the Garuda Plex.

1.4. Developer Programme Subscription and Terms

Our programme is offered under a SaaS License. See garuda.io/terms for more information regarding the terms of use.

The duration of the licence is usually one year and is renewable. We offer both opt-in and opt-out arrangements. Speak to our sales representatives for more information about payment methods.

Important: By using this service, you understand and agree that at all times a suitably qualified individual must be assigned as the legally responsible pilot-in-command (LRPIC) / driver-in-command (LRDIC) of any vehicle controlled by the API. This applies whether or not the equipment is involved in a flight, and whether any flight is conducted within or beyond visual line of sight (VLOS / BVLOS).

The LRPIC is ultimately responsible for ensuring the safety of any operations involving such equipment, and must, among other things, ensure that all relevant permits are obtained from the authorities, that appropriate testing is carried out prior to any operation, that appropriate risk management has been conducted, and that appropriately trained personnel are involved in all phases of each operation.

Even when an operation is fully automated such that human involvement is theoretically not required, an LRPIC must be appointed. The LRPIC's identity must be submitted via the API as precondition for commencing operations. By submitting the LRPIC's identity through the API, you are declaring that the operation complies with all relevant laws and will be safely conducted.

Garuda Robotics will merely effect your instructions as conveyed by the API. You, and the LRPIC/LRDIC, are solely responsible for determining the safety and suitability of any API operation. Garuda Robotics assumes no responsibility whatsoever for reviewing or monitoring any API activity. Garuda Robotics assumes no responsibility for determining if you, or the LRPIC, are complying with any applicable laws regarding your activities.

You agree to indemnify Garuda Robotics and our officers, agents, employees, partners, and licensors from any claim, demand, loss or damages, including reasonable attorney fees, arising out of or related to your use of or reliance upon this service.

2. Key Concepts

2.1. Use Cases

The Garuda Plex APIs are designed to support a variety of commercial drone operations, such as

1. Drone inspection / census
2. Drone surveillance / patrol
3. Drone mapping / photogrammetry
4. Drone reconnaissance / search & rescue
5. Drone spraying / spreading (agriculture)
6. Drone delivery / transportation
7. Ground Vehicle surveillance / patrol

2.2. Systems / Subsystems / Components

Drones are often supplied as part of a system, with other equipment. These include:

1. Controllers (or Transmitters, RC)
2. Landing / charging stations (which we will refer to as Docks in this document)
3. Additional transmitting devices such as Trackers and associated base stations
4. Specialised payloads: multispectral cameras / thermal cameras / LiDAR sensors, to mechanical winches, thickness gauges, flash lights, speakers etc.

Vehicles are similarly supplied as part of a system with other equipment. Payloads might not be inter-changable due to its physical constraints, but components like trackers would work the same way.

2.3. Robot Operations

Garuda Plex provides a means to programmatically describe and manipulate your UAV or UGV to achieve all of the above use cases. It does so by providing a set of common building blocks that can be adapted to various drone models or vehicle models.

To unify all robot operations regardless of drone models or vehicle models, a set of common language and definition must first be established.

2.3.1. Single Flight Model

To begin, consider a single drone performing a single flight. All such flights consist of these 3 stages:

		
Pre-Flight	During Flight (Flying)	Post-Flight

Each flight consist of

1. One drone
2. One or more pilots
3. Zero or one dock
4. Zero or one controller
5. Zero or more payloads
6. Zero or more trackers
7. Zero or more geofences

And more (see developer docs for full model description)

The flight is further broken down into specific Flight States, which forms a Finite State Machine, as follows:

	Pre-Flight	**During Flight**	**Post-Flight**	**Unknown**
Drone Flight States	INIT RTF	LAUNCH HOVER MISSION MOVING BACKTRACK LANDING	OG ENDED	EMERGENCY
Dock States	NOT_READY DOCKED	LEAVING AWAY ARRIVING	DOCKED	

You can programmatically use these states as events in your system to drive certain behaviour, with the caveat that not all drone manufacturers support all the states in this design.

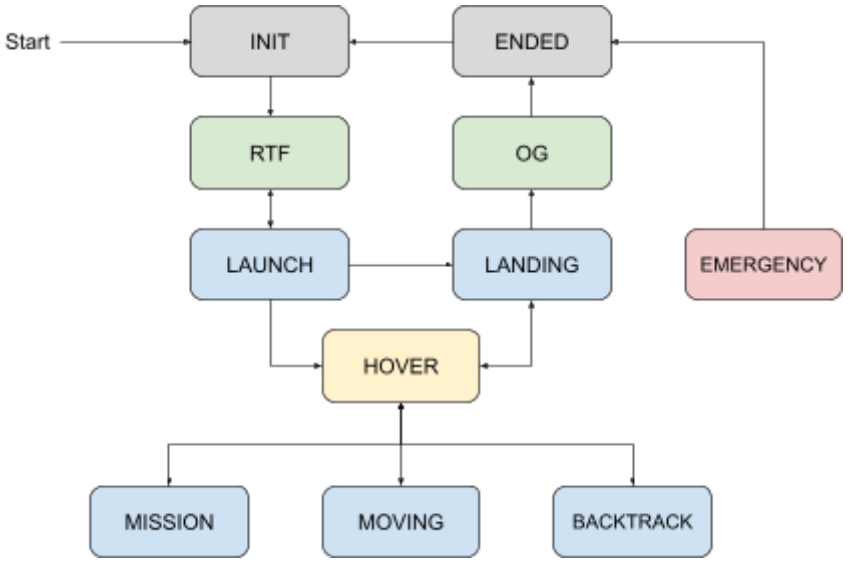


Figure: Drone States

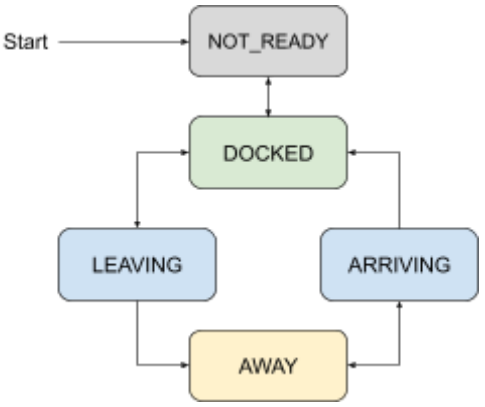


Figure: Dock States

Cerana UAS is the preferred aerial platform that supports most of Garuda Plex's features. The current list of supported aircrafts include

1. Cerana ONE Pro
2. Cerana 5
3. Cerana X8
4. Aria 400
5. DJI Mini 3
6. DJI M30 / M30T (optionally with DJI Dock 1)
7. DJI M3D / M3TD (optionally with DJI Dock 2)
8. DJI M4D / M4TD (optionally with DJI Dock 3)

Similarly, consider a single vehicle making a single trip. All such trips consist of these 3 stages:

		
Pre-Trip	During Trip (Travelling)	Post-Trip

Each trip consist of

1. One vehicle
2. One or more drivers
3. Zero or one controller
4. Zero or more payloads
5. Zero or more trackers
6. Zero or more zones (with speed limits)

And more (see developer docs for full model description)

The trip is further broken down into specific Flight States, which forms a Finite State Machine, as follows:

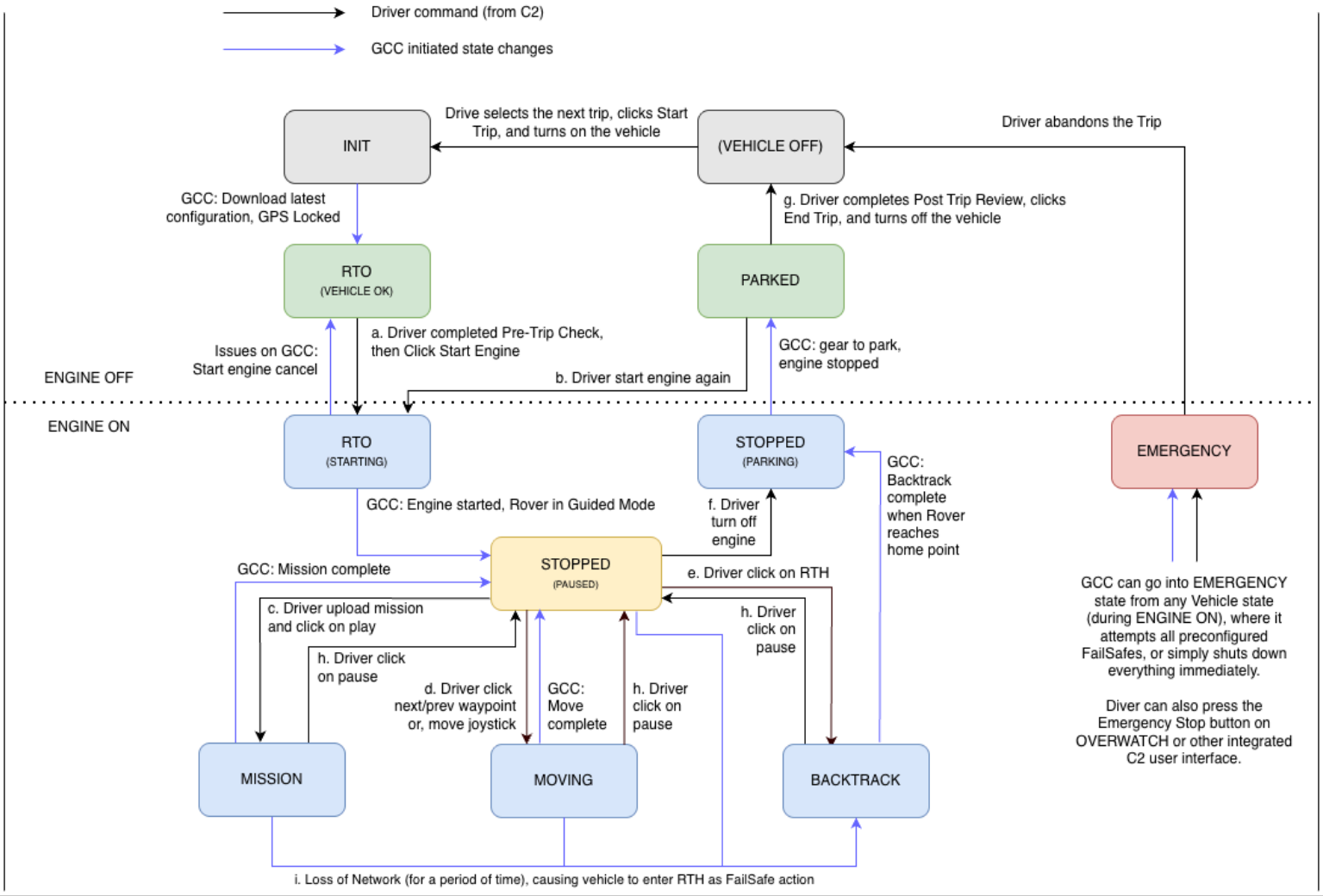
	Pre-Flight	**During Flight**	**Post-Flight**	**Unknown**
Vehicle States	INIT RTO	STOPPED MISSION MOVING BACKTRACK	PARKED	EMERGENCY

You can programmatically use these states as events in your system to drive certain behaviour, with the caveat that not all vehicle manufacturers support all the states in this design.

The current list of supported vehicles include

1. C.max BirdyBot

Figure: Vehicle States



2.3.2. UAS Management

All operations consist of one or more of the above drone flights or vehicle trips. In Garuda Plex, each physical device / subsystem is virtually represented in the following abstract concepts:

 Drones / UAV	 Trackers	 Payloads
 Docks	 Controllers	 Batteries
 Vehicles / UGV		

Collectively, these equipment form the Unmanned Aircraft System (UAS) or Unmanned Ground System (UGS). As the number of equipment grows, they can be collectively seen as a Drone Fleet (multiple UAVs). or Vehicle Fleet (multiple UGVs).

The various interacting subsystems of the UAS/UGS can utilise the following services endpoints:

1. Flight
    a. As described in the previous chapter, is a record of every single take off to landing of a drone
    b. It is the right place to archive the flight log from the system if available
2. Trip
    a. As described in the previous chapter, is a record of every single arm and disarm of a vehicle
    b. It is the right place to archive the trip log from the system if available

3. Config
    a. More specifically Onboard Config, is a record of every single configuration ever deployed to the drone / vehicle
    b. Once the config is deployed, it gets “locked”, i.e. no further changes are possible. This versioning approach allows us to trace which configuration was used in a previous flight / trip.
4. LiveFlights
    a. An extension of the drone’s / vehicle’s native GCS system to control the drone / vehicle over the Internet
    b. Often referred to as Drone / Vehicle / Robot C2 (Command and Control)
    c. See later section on BVLOS Operations to learn more
5. Maintenance
    a. In between operations, drones / vehicles need to be serviced and maintained, to ensure they are in tip top condition.
    b. Garuda Plex allows you to capture such maintenance records, which will inform the operations team on the readiness of the drone / vehicle for the next operation.

Garuda Plex maintains a common list of well known Equipment Models (all of Garuda Robotics UAVs / UGVs, and several popular ones in the Enterprise space). If you find that your drone model or vehicle model is not included, you can send us the specification sheet to be included.

2.3.3. Operating in a Physical World

Robots operate in the real world, and the real world is messy. To aid the navigation of the robot, operators will need to plan their flights or trips carefully, including setting up automation based on well known navigational aids. Garuda Plex provides a growing set of supplementary data that can be referenced:

Base Street Map Tiles (Singapore only) Source: SLA OneMap	Base Street Map Tiles (Global) Sources: OpenStreetMap (OSM) Google Street Map	Base Satellite Map Tiles (Global) Source: Google Satellite Maps
National Airspace (Singapore only) No Fly Zones, UA Flying Areas Source: SLA OneMap	Rain Map (Singapore only) 5-min Live Rain Cover Source: NEA / WSS	Maritime Vessels (Singapore only) 3-min Live Vessel Position Source: MPA Maritime Data Hub
Base 3D Map Tiles (Singapore only)	Base 3D Map Tiles (Global)	

Source: SLA OneMap 3D	Source: Google 3D Maps	

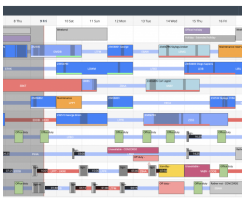
Data sources currently on the roadmap include global weather forecast and global ADS-B from manned aircraft. We welcome suggestions to data sources necessary for your drone operations.

A growing number of these are extensible with your own dataset:

1. Private Airspace
    a. A privately declared 4D volume (space and time) that can be used either as a geofence for a flight, a keep out zone for drone operations, or something informational that is space and time specific.
    b. Examples: Predesignated take off landing zones, obstacles for flight planning, national temporary flight restrictions that weren't picked up from national sources.
2. Private Base Map (coming soon)
    a. A pre-tiled map data source that can override parts of the existing base map that's outdated.
3. Places
    a. A point based location used to mark out key considerations on the map.

2.3.4. Flight Planning and Airspace Management

With the above contextual information about the real world, you can also use our services for flight planning. There are 3 main concepts:

 Flight Reservation Zone Book an area to fly	 Flight Plan Plan a route to fly	 Flight Session Schedule a time to fly

1. Flight Reservation Zone (FRZ)
    a. Otherwise known as Operational Intent Volume (OIV) by some regulators
    b. Used to declare that operation will be happening within this area
    c. Often needed when integrated with upstream UTM systems to seek approvals
    d. Does not necessarily mean you have exclusive use of the airspace, unless it is enforced in a privately managed airspace
    e. Once given the permission to use this airspace, the FRZ's 4D boundary acts as the default geofence (i.e. its boundary gets copied into the Flight record as a geofence).

   f. Is probably sufficient if the flight will be carried out manually.
2. Flight Plan
   a. Otherwise known as a Mission by some GCS
   b. Usually used to set the drone for a waypoint mission based on real world coordinates
   c. Does not necessarily mean autonomous flight - might be just a guide and/or used to create a tighter cylindrical geofence for strategic collision avoidance systems (predict if any two drones might occupy the same airspace in the future), or tactical collision avoidance systems (declared as a 4D geofence within that space / time)
   d. Can be directly sent to the drone for selected drones as autonomous missions. Currently we support the following file formats:
      i. QGC WPL 110
      ii. DJI WPML
   e. Roadmap: KMZ download
3. Flight Session
   a. Otherwise known as a Flight Window
   b. Pre-binds and pre-authorise flights for a given time window, based on specified drone, pilots, flight plans etc.
   c. For docking systems, you are also able to plan automated takeoff time. Supported dock models currently is limited to DJI Dock 1 and Dock 2

The equivalent for UGVs is coming soon.

2.3.5. Integrating into National Airspace Systems

Garuda Plex had a 10 year head start from regulators trying to put in place a digital airspace management system for drones, and at this current time of writing, we are still in the process of demonstrating systems integration to airspace regulators.

Adapters to aspiring national airspace systems that we have previously enabled includes

1. CAAS Centralised Flight Management System (CFMS)
2. OneSky
3. AirMap (now defunct)

While the APIs published in this document are sufficient to build an adapter to national airspace systems, we invite you to have a deeper conversation with us on how to achieve a smoother integration experience in your jurisdiction.

Singapore developers can refer to **Appendix B** for a step by step summary on how to integrate with CFMS via API.

<table>
<tr>
<td> 
Network Remote ID Tracker

Cellularly connected tracks</td>
<td> 
Broadcast Remote ID Tracker

Localised broadcast tracks</td>
<td rowspan="2"> 
Construction Crane Tracker

Cellularly connected tracks for ground obstructions</td>
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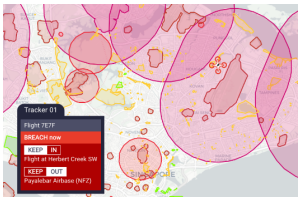
<td> 
Conformance Monitoring

Highlight airspace violations</td>
<td></td>
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</table>

1. Network Remote ID (NetRID) Tracks
    a. Data sources
        i. MyDroneFleets Tracker G1 (CFMS Trackers)
        ii. MyDroneFleets Tracker G2
        iii. API submitted tracks (by developers like you)
    b. Global reach
        i. Privacy depends on implementation details (private APN vs public Internet)
        ii. Strong authentication from the track provider (e.g. OAuth2)
2. Broadcast Remote ID (B-RID) Tracks
    a. Data source: Any integrated B-RID receiver
    b. Local reach
        i. No privacy, anyone with B-RID listener can detect
        ii. Weak authentication from track provider
3. Construction Crane Tracks
    a. Data source: Construction Crane Trackers
    b. Limited to construction companies, global reach
        i. Regulators can have combined view of contractors under their purview
        ii. Privacy / Authentication similar to NetRID Trackers
        iii. RTK base station for < 10cm accuracy
4. Conformance Monitoring
    a. Default conformance is to ensure all drones / trackers do not violate national laws, e.g. KEEP OUT from aerodromes or restricted areas.
    b. Additional airspace can be added to ensure all drones / trackers KEEP OUT of private airspace.

c. Flight geofences, if known, are monitored for KEEP IN conformance.
    i. Same goes for Crane Trackers
d. Violation is issued in real time and will only stop when the drone / tracker is conforming again. There are 2 types of violation
    i. A BREACH is issued when the drone / tracker has exceeded the boundary.
    ii. A WARNING is issued when the drone / tracker is approaching (within 50m distance) from the boundary.

2.4. BVLOS Operations

The most important concept that Garuda Plex is designed around (that might not be enforced by some other platforms), is this: a Drone in Flight must ALWAYS have a Pilot.

The pilot is, legally speaking, the most important person for the flight. Although most BVLOS systems being built will be autonomous in nature, the pilot will always have control over the aircraft during the flight, and can override the autonomy of the drone. The pilot is required to comply with all legal requirements for drone operations in the country where the drone is operating.

For example, in Singapore, the pilot must have an Unmanned Aircraft Pilot's Licence (UAPL) for the specific class of aircraft that will be flown. Additionally, if the pilot does not have visual line of sight of the drone during operations, the pilot must apply for BVLOS Operator and Activity Permit prior to flying. Check with your local regulator to learn more about what is required for BVLOS operations in your jurisdiction.

Note: While the same concepts are enforced for UGVs (a Vehicle on a Trip must always have a Driver), there are no / less legal basis for this at the moment. Garuda Plex currently does not cover AVs that move on the road, which is governed differently in most countries.

To maximise the situational awareness of the aircraft during flight / vehicle during trip, we recommend that you

1. Take full advantage of all available sensor information (see Drone Telemetry / Vehicle Telemetry) as well as video streams (see SkyStream) to help the BVLOS Pilot feel more confident of the flight / trip

2. Build apps that always require the Pilot / Driver to pay attention to the flights / trips - avoid setting it and forget it type concepts of operations unless safety can be assured.

3. Remind the Pilot or Driver of their responsibilities as a BVLOS operator, even after achieving your local BVLOS regime's requirements.

Drone Telemetry Real time information from Drone	Vehicle Telemetry Real time info from Vehicle	Payload Telemetry Real time info from Payload
Warnings Telemetry System alerts from any Device	ML Telemetry Real time detections from Machine Learning Algorithms	Crane Telemetry Real time information from Construction Site Cranes

Drone Command Issue Command to drone	Vehicle Command Issue Command to Vehicle	Payload Command Issue Command to payload
Drone Simulator Hosted Ardupilot SITL	Media Media (Image / Video / File) Asset Management	SkyStream Video Streaming Engine

2.5. User Authentication & App Roles

To be a robot operator (i.e. Pilot or Driver), one must first be a User, which in turn belongs to a Company. At this current time, Users on Garuda Plex can only belong to one Company. The Developer Programme is tied to the Company in the system.

To manage your user profile	accounts.garuda.io/general/profile
To manage your company profile	accounts.garuda.io/general/company
To enumerate your company's users	accounts.garuda.io/general/team
To access your company's developer programme details	accounts.garuda.io/general/developer
To see your company's subscribed applications	accounts.garuda.io/apps/all
To adjust your user's roles in each applications	accounts.garuda.io/apps/roles

A User is subsequently given roles in the system. Roles are App specific, thus we will be using the phrase App Role to refer to these user roles. The following are pre-defined, default, permanent App Roles:

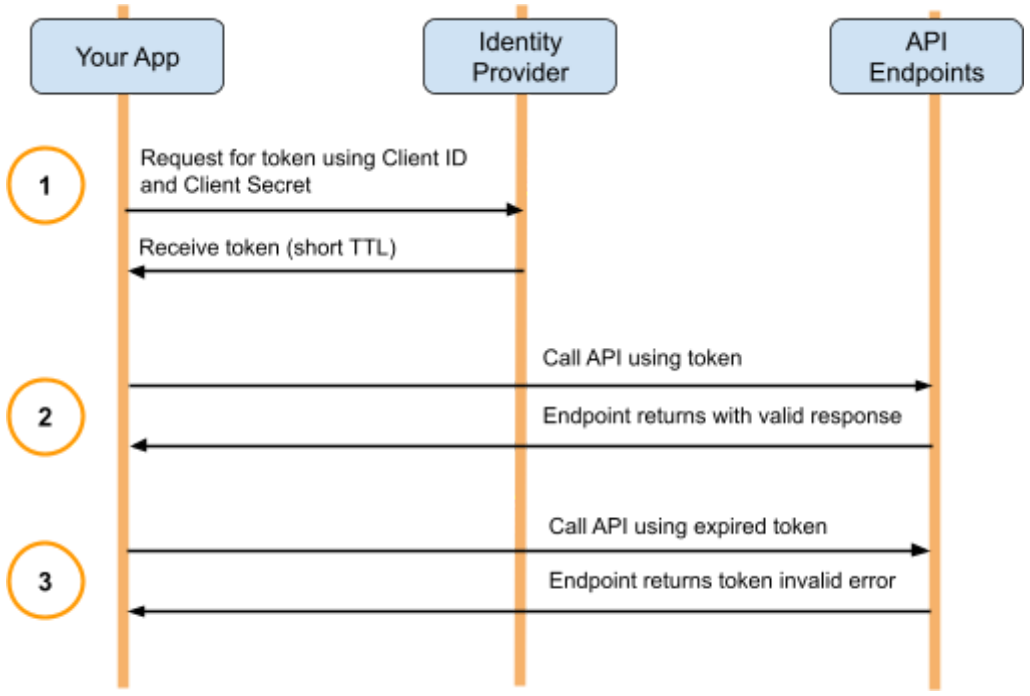
Application	Role	Description
Garuda Plex	User	Normal user on the Garuda Plex platform.
Garuda Plex	Admin	Company administrator, needed for managing users in the same company.
Garuda Plex	Super Admin	Administrator of companies. Only applicable to on-premise systems. Contact Technical Support for more details.
MyDroneFleets	Pilot	Person who is in control of the drone using a transmitter and visual line of sight of the drone.

Application	Role	Description
MyDroneFleets	Spotter	Person who is keeping their eyes on the drone while it is being flown.
MyDroneFleets	Engineer / Technician	Person who is responsible for preventive and corrective maintenance of the drone system.
MyDroneFleets	Ground Control System Operator	Person who is in control of the drone using a GCS application (within or beyond visual line of sight).
MyDroneFleets	Accountable Manager	Person responsible for the operations of the entire drone fleet, or admin assistants to such a command post.
MyDroneFleets	Safety Officer	Person responsible for the safety and risk management of the drone operation.
MyDroneFleets	Trainer / Instructor	Person responsible for training all personnel involved in drone operations and using MyDroneFleets.
Plex Horizon	UAS Operations Lead	Executive Officer and Leader of the UAS Operations.
Plex Horizon	UA Pilot (Primary)	Main pilot of a BVLOS aircraft.
Plex Horizon	UA Pilot (Secondary)	Secondary pilot of a BVLOS aircraft.
Plex Horizon	Ground Equipment Operator	On-site pilot who assists BVLOS pilot with UA and other ground equipment.
Plex Horizon	Ground Safety Officer	On-site officer who ensures the safety of uninvolved persons.
Plex Horizon	UA Recovery Officer	Leader of emergency response for BVLOS operations.
Plex Horizon	UA Recovery Responder	Mobile force who recovers BVLOS aircraft in the event of an emergency landing.
Plex Horizon	Engineering On-Call	Engineers who provide 24/7 monitoring and troubleshooting of connected systems.
Plex Horizon	Responsible Personnel	Overall in-charge of the organisation sponsoring the drone operations.
Plex Horizon	Map Maintenance Specialist	Specialist who provides maps for BVLOS operations.
Facilities 4.0	Facility Manager	Manager of the facility who schedules inspections and approves the work done by the Vendors.
Facilities 4.0	Other Facilities Management User	Uninvolved facility managers and stakeholders requiring only read-only access.

Application	Role	Description
Facilities 4.0	Drone Service Provider Pilot	Pilots who are authorised to fly drones, plan inspection missions, and upload images.
Facilities 4.0	Other Drone Service Provider Users	Data processing staff who are responsible for image upload, annotation, and AI model maintenance.
Facilities 4.0	Professional Facility Inspector with Competent Person Qualifications	Inspector with qualifications to sign off on documents for regulatory submission.
Facilities 4.0	Professional Facility Inspector	Facade inspectors and other facility contractor staff.

2.5.1. API Authentication

Normally, app users can access the platform by logging into any existing application (via identity.garuda.io). However, for programmatic access, you will be interacting via OAuth2.0 Client Credential Grant Flow.



Only Company Administrators can enrol users in the company as developers.

Company Administrators can also revoke any developer's token.

If the user is no longer required to be a developer, Company Administrators should remove their developer credentials.

If the user is no longer with the company, by removing the user will also result in the removal of the developer credentials.

2.6. Glossary

Here are high level meanings of each entity in our system.

Entity	Meaning	API
App Roles	App specific Role for Users	IAM & Accounts
User	Any person using the system. Must have a unique email.	
Company	Any organisation, in which User can belong to.	
Subscription	Company's valid Subscription to an App allows it Users to interact with the said App	
Developer	Company with access to at least one of the API categories	

Pilot	Any User with the following App Roles
	`Plex Horizon :: UAS Operations Lead`
	`Plex Horizon :: UA Pilot (Primary)`
	`Plex Horizon :: UA Pilot (Secondary)`
		UAS Fleet Management (Crew)

Driver	[TBD]	
Provider	Organisations that manufactures or sells drones and any related accessories	UAS Fleet Management (Equipment)
Drone Model	Manufacturer assigned aerial robot model with specs	
Drones	Any kind of unmanned aircraft (rotocrafts, fixed wing, etc.) with a unique serial number	
Vehicle Model	Manufacturer assigned ground robot model with specs	
Vehicle	Any kind of unmanned ground vehicle (wheeled, legged, etc.) with a unique serial number	
Controller	The device used to operate the Drone / Vehicle by the Pilot / Driver	
Payload Model	Manufacturer assigned payload model with specs	
Payload	The attachment to the Drone / Vehicle to provide it specialised capability (mostly various types of cameras)	
Tracker Model	Manufacturer assigned tracker model with specs	

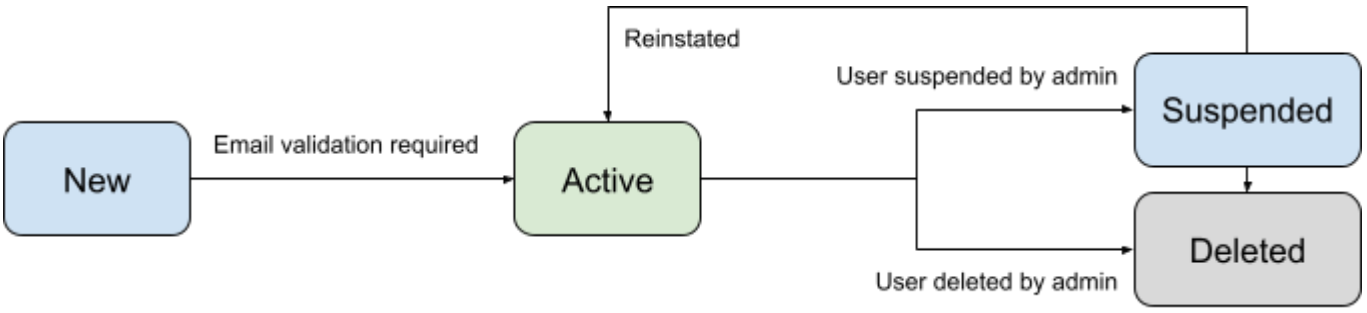
Entity	Meaning	API
Tracker	The attachment to the Drone / Vehicle to provide an independent source of Electronic Conspicuity	
Dock Model	Manufacturer assigned model with specs	
Dock	The device used to house the Drone / Vehicle when it's not in flight. Possibly also the drone's or vehicle's power charging station.	
Subsystem	Part of the drone (e.g. Flight Controller / Microcontroller, Companion Computer, Battery Management Subsystem, etc.)	UAS Fleet Management (Configuration)
Component	Specific instance of Subsystem with unique serial number	
Config	Configuration loaded onto the subsystem for a given flight	
Flight	The end-to-end historic record of how a flight was planned, flown, and ended.	UAS Fleet Management (Flight Records)
Flight Log	Manufacturer generated drone system log, usually attached to the Flight	
Trip	The end-to-end historic record of how a trip was planned, travelled, and ended.	UAS Fleet Management (Trip Records)
Trip Log	Manufacturer generated vehicle system log, usually attached to the Trip	
GeoJSON	A subset of the full RFC 7946 definition, specifically, only the `geometry` part of the definition.	All APIs
NFZ	No Fly Zones, including Aerodromes, Permanent or Temporary Restricted Areas, and other special areas designated by the government	Airspace & Environment
FRZ	Flight Reservation Zones, also called Operational Intent Volume, which is an area Pilots seek permission to fly in.	
Places	Any landmarks on the ground	
Weather	Weather forecast of the area	
Flight Plan	The path a drone will be taking. At its simplest form, a flight Plan is a line string with a single takeoff and a single landing, with waypoints in between.	BVLOS Command & Control (Flight Planning)
Flight Session	A future planned flight with known Pilot, Drone, Flight Plan, and Expected Take Off Date / Time	

Entity	Meaning	API
Flight Status	The current status of an ongoing flight, including the exact Pilot in command, and the Flight State of the Aircraft	BVLOS Command & Control (Controls)
Drone Telemetry	The sensor and system readouts from all subsystems of the drone, including Controller Telemetry, if available	
Vehicle Telemetry	The sensor and system readouts from all subsystems of the vehicle, including Controller Telemetry, if available	
Payload Telemetry	The sensor and system readouts from the payload (e.g. active lens, catch release mechanism status)	
Tracker Telemetry	The sensor and system readouts from the drone tracker (e.g. position, altitude)	
Crane Tracker Telemetry	The sensor and system readouts from the crane tracker (e.g. position, altitude) or base station	
Dock Telemetry	The sensor and system readouts from the dock (e.g. weather, aircraft presence)	
ML Telemetry	The detection annotations from Machine Learning algorithms in structured data format	
Drone Command	The command given to the drone (e.g. take off, navigate to waypoint, etc.). The command can originate from a Pilot or an approved programmatic source that is monitored by a Pilot (LRPIC).	
Vehicle Command	The command given to the vehicle (e.g. start engine, navigate to waypoint, etc.).	
Payload Command	The command given to the payload (e.g. zoom in, pitch down)	
Dock Command	The command given to the Dock (e.g. open, close)	
Video Stream	The live video feed from the drone, distributed via the video streaming server	SkyStream
SITL	Software In The Loop, i.e. no physical drones are required to try out APIs	Drone Simulator
Facilities	A physical property under a Facility Management company's care to ensure its safety and suitability for continued use.	Building Facade Inspection Ops

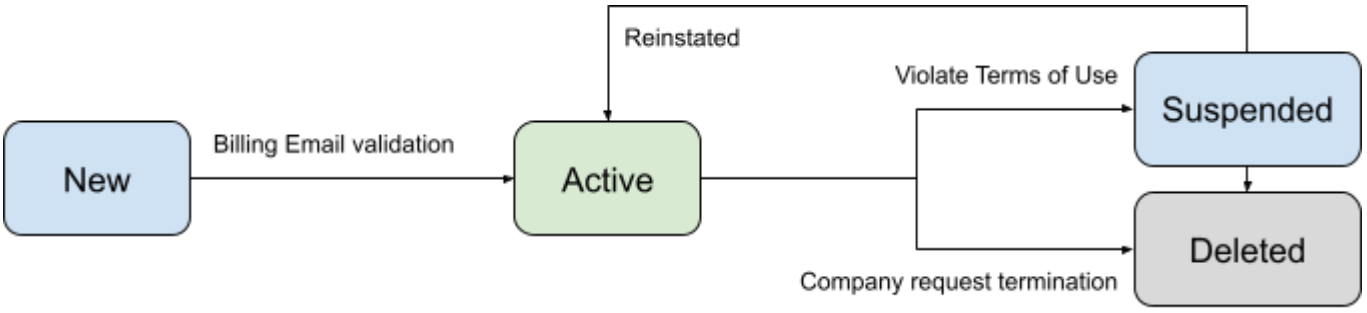
Entity	Meaning	API
Inspection	Goal oriented inspection assignment to be carried out on the facility's facade, such as visual or tactile inspection	
Defect	A detection / annotation within an image which is unexpected and might need to be rectified	
Event	Detection of intruders, trespassers, fire, anomalies, or any point of interest to be actioned on	Security Surveillance Ops
Mission	Responding to an Incident, searching and rescuing survivors from an emergency	Search And Rescue Ops
Task	Goal oriented task assignments to be carried out in the plantation, such as Mapping and Spraying	Palm Plantation Spraying
Estate	Geospatial boundaries of a part of the plantation under a single management and work process	
Annotations	Geospatial markings specific to Palm Plantations, such as palm tree centres, rivers, roads, and anomalies	
Media	Underlying Object Storage representation of Images, Videos, PDFs, Flight Logs, Maps, and other Files or File Collection	Media Asset
Map Tiles	Base map over the area of operations, either via public source like OSM Map, or self created	

2.7. State Transition Diagrams

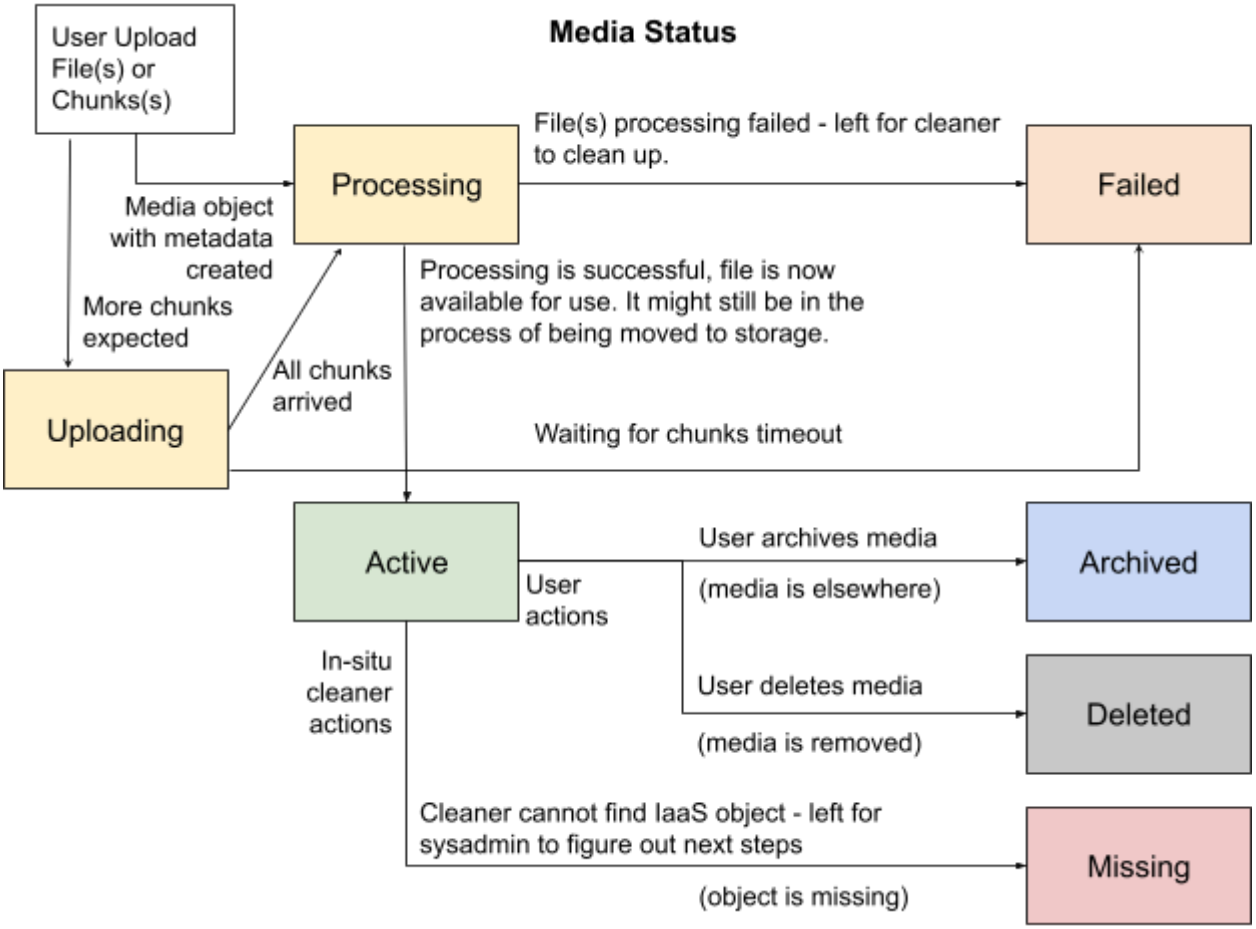
2.7.1. User



2.7.2. Company



2.7.3. Media



3. APIs

3.1. About Garuda Plex APIs

You can see the list of allowable APIs for your company here: accounts.garuda.io/general/developer. For each allowable APIs, you will see a link to the actual endpoints hosted api-docs.mydronefleets.com.

You can manually disable certain allowable APIs by category. However, if you would like to access other non-allowable APIs, you will need to contact technical support to learn more.

If you have an on-prem edition of the system, we will send you alternative URLs to access this information. Keep in mind that on-prem editions are often stable but behind the latest APIs published on api-docs.mydronefleets.com.

Currently, only the latest version of each API is available. APIs are versioned using semver semantics, i.e.

- Version numbers starts with the letter `v` followed by 3 numbers in MAJOR.MINOR.PATCH format (e.g. `v1.2.5`)
- We increment the MAJOR version when the API is incompatible with the previous version
- We increment the MINOR version when new functionality is added, but all existing functionalities are backward compatible manner
- We increment the PATCH version for all other reasons, including making backward compatible bug fixes, or adding clarification to documentation.

At the time of writing, we have yet to increment any API's major version. If there's a major version increment, we will publish a migration guide, and share the deprecation schedule. There is always only one major version of each API running (i.e. the latest minor / patch).

3.2. API Types

We have 3 types of interfaces:

1. REST APIs
2. Web Socket APIs
3. Video Streaming APIs

3.2.1. REST APIs

RESTful web API is the most common API type, and is performed over HTTPS.

You must include the provided JWT as a HTTP Authorization header as a Bearer token.

```
curl -i \
     -H 'Content-Type: application/json' \
     -H 'Authorization: Bearer {token}' \
     https://api.mydronefleets.com/aircraft/drones/555
```

You can check whether a service is available by accessing the sanity REST endpoint

```
curl https://api.mydronefleets.com/accounts/sanity
```

If you get the following response, it means the service is ready to accept requests

```
{"status":"success","data":{"message":"This service is running"}}
```

3.2.2. Web Socket APIs

WebSocket APIs are utilized to enable real-time, bidirectional communication between clients and the server. These APIs serve two primary purposes:

- Server-Initiated Data Push: Delivering updates or new information from the server to the client after an initial HTTP GET request.
- Persistent Subscriptions: Maintaining a continuous connection to publish and subscribe to data streams without the overhead of repeated HTTP requests.

All WebSocket connections are established over **WebSocket Secure (WSS)**, which is WebSocket communication encrypted using **TLS/SSL**.

WebSocket URL Convention

All WebSocket endpoints are consistently prefixed with `/live`, distinguishing them from standard HTTP API routes. For example:
`wss://api.mydronefleets.com/live/...`

Connection Keep-Alive

To prevent idle WebSocket connections from being closed by intermediaries (e.g., proxies, load balancers), clients should send a **ping frame** or a custom keep-alive message **at least once every 5 seconds**.

Example Using `wscat`

The following example demonstrates how to connect to a WebSocket endpoint using the `wscat` CLI tool:

```
wscat -c 'wss://api.mydronefleets.com/live/airspace/nfzs/?access_token={token}'
```

Important Notes:

- The `access_token` must be passed as a query parameter, since the WebSocket protocol does not support HTTP headers (such as `Authorization`) after the initial handshake.
- The URL path to Websocket APIs must be terminated with a trailing slash (/) **before** the query string question mark (?) begins.

3.2.3. Video Streaming APIs

RTMP is the easiest way to integrate with our APIs to get video streaming working but will not be able to work out of the box on Web Browsers. You can use FFPlay, VLC Player, or any software that supports RTMP to subscribe to the video, or integrate it with your VMS such as Milestone XProtect or .

Refer to Video Streaming Endpoints to get the streaming link for a given drone and a given payload camera.

We support WebRTC via a custom setup protocol for browser live streaming use in our application front ends and may expose these endpoints to developers in the near future.

For mobile devices or other devices that have limited bandwidth, we also support HLS, which is an adaptive bitrate streaming, as well as downsizing the video (e.g. to 480p) to better utilise the available network resources.

3.3. API Categories

There are 10 groups of APIs published. Only enabled API Categories can be seen on your developer portal. You can disable any provisioned API categories if necessary to reduce the risk of making unwanted calls.

API Category	Purpose	Default Access
IAM & Accounts	Manage company details, user profiles and application roles.	Available to all developers
UAS Fleet Management	Track and configure equipment lifecycle for unmanned aircraft systems or unmanned ground systems, such as drones, vehicles, payloads, docks, trackers, and controllers.	Available to all developers
Airspace & Environment	Receive information about the world in which the UA operates in, such as airspace, no fly zone, weather, obstacles, landmarks, and boundaries.	Available to all developers on a needs basis. Public data sources depend on the country's government making it available.
BVLOS Command & Control	Remotely control the UAV / UGV over the Internet, including planning flight paths and sessions, reading status and telemetry, and issuing commands.	Available only to Cerana UAS customers Note: Integration with your preferred drone models / vehicle models can be provided. Contact our sales representatives to learn more.
SkyStream	Stream, transcode, and distribute video streams from UA or any video capture devices.	Available only to Cerana UAS customers
Drone Simulator	Simulate Cerana UAS (Hosted Cerana On-board Unit and ArduPilot SITL Sim).	Available only to Cerana UAS customers
Security Surveillance	Patrol campus perimeters, respond to incidents (e.g. AI detected fire / trespassing), search and rescue over large areas.	Available on a case by case basis, based on project needs
Search and Rescue	Activate a fleet of drones to look for survivors during a calamity	Available on a case by case basis, based on project needs
Building Facade Inspection	Inspect building facades for AI detected defects and anomalies and follow up with rectifications.	Available on a case by case basis, based on project needs
Palm Plantation Spraying	Map and spot spray insecticides on AI detected trees in oil palm estates.	Available on a case by case basis, based on project needs

API Category	Purpose	Default Access
Media Asset	Store and retrieve UA related images, videos, documents, while masking away AI detected personally identifiable info (eg. face, car plate).	Available on a case by case basis, based on project needs

3.4. API Authentication

Step 1: To get an access token (or simply "token"), you will need to authenticate by submitting your Client ID and Client Secret string via a `POST` call to this token endpoint: `https://identity.garuda.io/token`.

The following is an example on how to request for a token:

```
curl -X POST \
     -H 'Content-Type: application/x-www-form-urlencoded' \
     -d
'grant_type=client_credentials&client_secret={client_secret}&client_id={client_id}&resource=urn:wl:jwt' \
     https://identity.garuda.io/token
```

Your Client ID and Client Secret can be found in your Developer Page and each access token obtained via the token endpoint will last for 3 days.

Step 2: You can now access any of the endpoints using the token.

Step 3: If you receive an error that the token has expired, repeat Step 1. Alternatively, you can also obtain a fresh token before the expiry of the current token by repeating Step 1.

Important: Each of these tokens represents the specific User's identity. Do not mix them up!

You should not place the Client ID and Secret into frontend code that will be executed on your user's client device. Only the token should be used for the interaction.

—

That's it, head over to accounts.garuda.io/general/developer to set up your credentials and continue reading the specific API documentations.

Appendix A: Cyber Security

A.1. Network Policies

If your company has strict firewall policies, you will need to whitelist the above URLs for outgoing traffic to be able to access the system.

The following are the ports you will need to whitelist

API Category	General Hostname	Ports
Media Asset	media.mydronefleets.com	443
SkyStream	stream.mydronefleets.com	443, 1935, 8443
Drone Simulator	simulator.mydronefleets.com	5760, 5763, 5766, 5769, 5772
All other API categories	api.mydronefleets.com	443
Identity Provider	identity.garuda.io	443

A.2. Secrets Management

OAuth 2.0 Client ID and Client Secret works as a pair to generate opaque tokens that access our services. We recommend that you architect your system as such

1. As part of your enrollment process, store the generated Client ID and Client Secret in a secure database only accessible to the user.

2. When your user login to your app successfully, from your backend application, fetch a fresh token from `identity.garuda.io/token` and pass it back to the front end application to be used.

3. You can store the token if you would like it to persist (e.g. if you're building a web application, you might want to keep the token in `localstorage`, which is only accessible by your app). It will expire in 3 days or less.

4. Never send the Client ID and Client Secret to your front end code, where malicious users could view the source and obtain them to generate tokens.

5. If you suspect your account has been compromised, please immediately login and revoke the Client Secret on https://account.garuda.io/general/developer. This will also revoke all prevailing tokens. We would appreciate it if you would also report such events to us at support@garuda.io.

A.3. Cyber Incident Response

Garuda Plex is manned by a global team of engineers. We operate a 24/7 cyber security watchdog and monitor our traffic for anomalies. You will also notice that our traffic goes through Cloudflare, whom we use as our globally distributed firewall.

If we suspect that your account is compromised, we will initiate the following steps

1. Investigate the issue
2. If the issue is network related, to resolve the issue with Cloudflare (e.g. DDoS attacks)
3. If the issue is traced to application misuse, to suspend the API categories (e.g. secret leaks)
4. If the issue is traced to malicious use, to suspend the Developer Programme enrolment

To better coordinate the recovery effort from the above, we will require that you share with us a point of contact for emergency matters. This could be your devops team lead, or 24/7 operations centre hotline, whatever fits your context.

Appendix B: CFMS Integration

Are you a Singapore-based operator? Are you tired of mounting a tracker for every operation? Are you flying using an advanced GCS that allows for programmatic access to the cloud? We can be your telemetry broker to CFMS to stay compliant with CAAS CFMS regulations.

B.1. Pre-requisites

To utilise this facility,

1. You UAS must be able to connect to the Internet at all times during operation
2. You are technically capable of extracting the telemetry data from your UAS (via GCS or other means)
3. You are technically capable of passing on the telemetry data to a WebSocket service

By utilising this service, you agree to indemnify and hold harmless Garuda Robotics for any and all claims, damages, or liabilities arising out of or effort to forward your telemetry data to CFMS.

B.2. Getting Started

The following is a one-time effort

No.	Step	Remarks
1	Sign up for the Developer Programme	Ensure you're given access to the **UAS Fleet Management** API category by your account manager.
2	Visit https://accounts.garuda.io/general/developer to consult the following APIs 1. **Aircraft** documentation (page title Aircraft Service) 2. **Remote ID (WS)** documentation (page title: MyDroneFleets RID Async API)	Use Aircraft Service to 1. Create a Drone / Drone Model 2. Create a Flight which contains CFMS Flight ID Use MyDroneFleets Remote ID Service to 1. Send telemetry data from your UA through Garuda Plex to CFMS
3	Upgrade your GCS to allow pilots to pass information from FlyItSafe mobile app Test and deploy it to your pilots	Minimum feature set: 1. key in CFMS Flight IDs 2. Start Flight 3. Stop Flight

B.3. Tips for developers

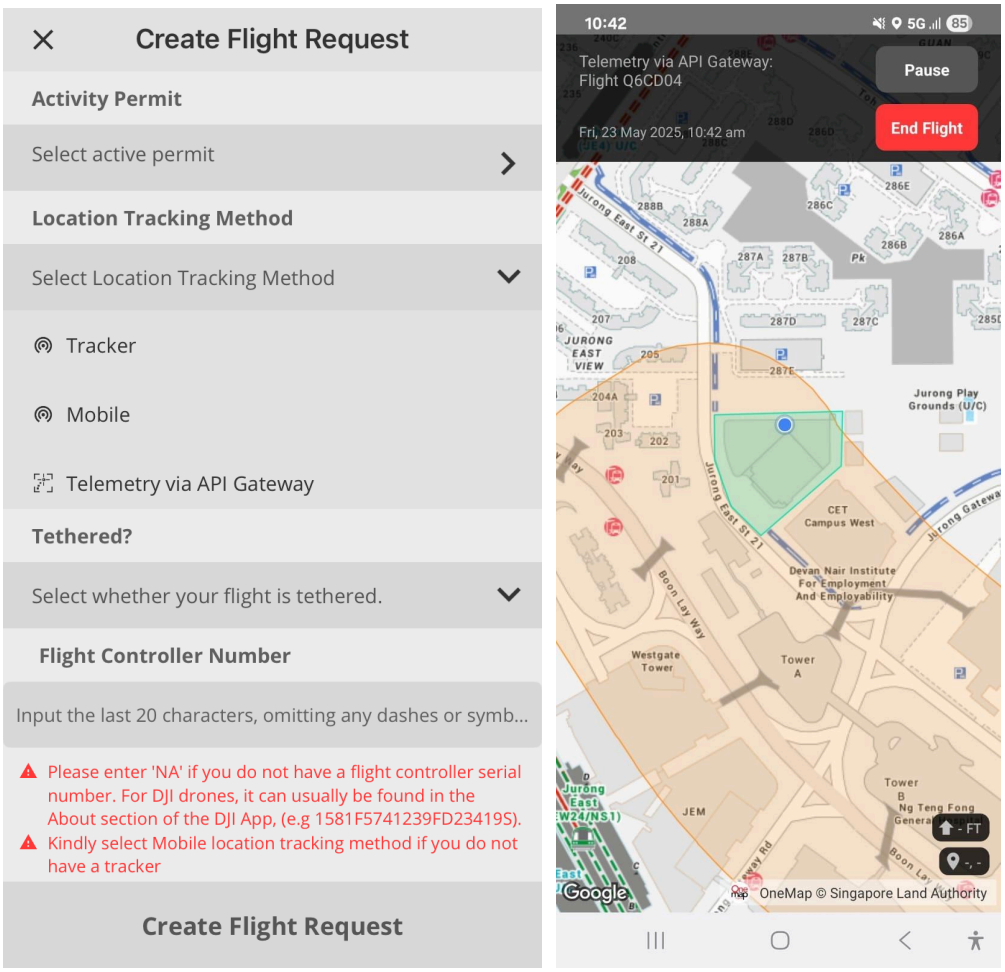
No.	Tip	Remarks
1	Create one Drone (unique `drone_id`) for each physical Aircraft you have. Note: if you're building a tracker instead, you should create a unique `tracker_id` instead. Trackers can be mounted onto drones in the `Flight` object (see tip #3).	
2	For sending Remote ID message via the API from your aircraft 1. Set the `ua_telem_type` to `"aircraft"` 2. Set the `ua_id` to the `drone_id` from tip #1 above Note: if you're building a tracker instead, you should set `ua_telem_type` to `"tracker"`, and set the `ua_id` to the `tracker_id` instead.	
3	If you are using our LiveFlights API to control your aircraft, please ensure the following steps For each flight: 1. Create a Flight for your drone and the pilot 2. Make sure the `permits[0].authority` is set to `"SG-CAAS"` 3. Make sure the `permits[0].ref` is set to `"CFMS-Flight-ID_xxxxxx"` (case sensitive), where xxxxxx is the 6 characters from the FlyItSafe app 4. Switch the status from `preflight` to `flying` using the PATCH endpoint. This will start the telemetry transmission to CFMS 5. Switch the status from `flying` to `postflight` using the PATCH endpoint. This will stop the telemetry transmission to CFMS	Every flight should start in a `preflight` state. You will likely need to build 3 UI for your pilots to (1) copy the 6 characters CFMS Flight ID over each time before they fly, (2) start a flight, and (3) stop a flight Of all the Flights associated with a specific Drone ID, only one of them can be set to `flying` at any time. This ensures the right permit is sent among other things.

No.	Tip	Remarks
4	Double check your UAS's altitude read out for HAE. Do not send AGL!	Avoid correcting for sea levels (i.e. AMSL) and report the HAE value you typically get from your GNSS, which is what CFMS expects currently.
5	Try to provide all fields, including deprecated ones.	We currently insert default values for non-compulsory fields, which might not best represent the state of your aircraft to CFMS.

B.4. Day to day operations

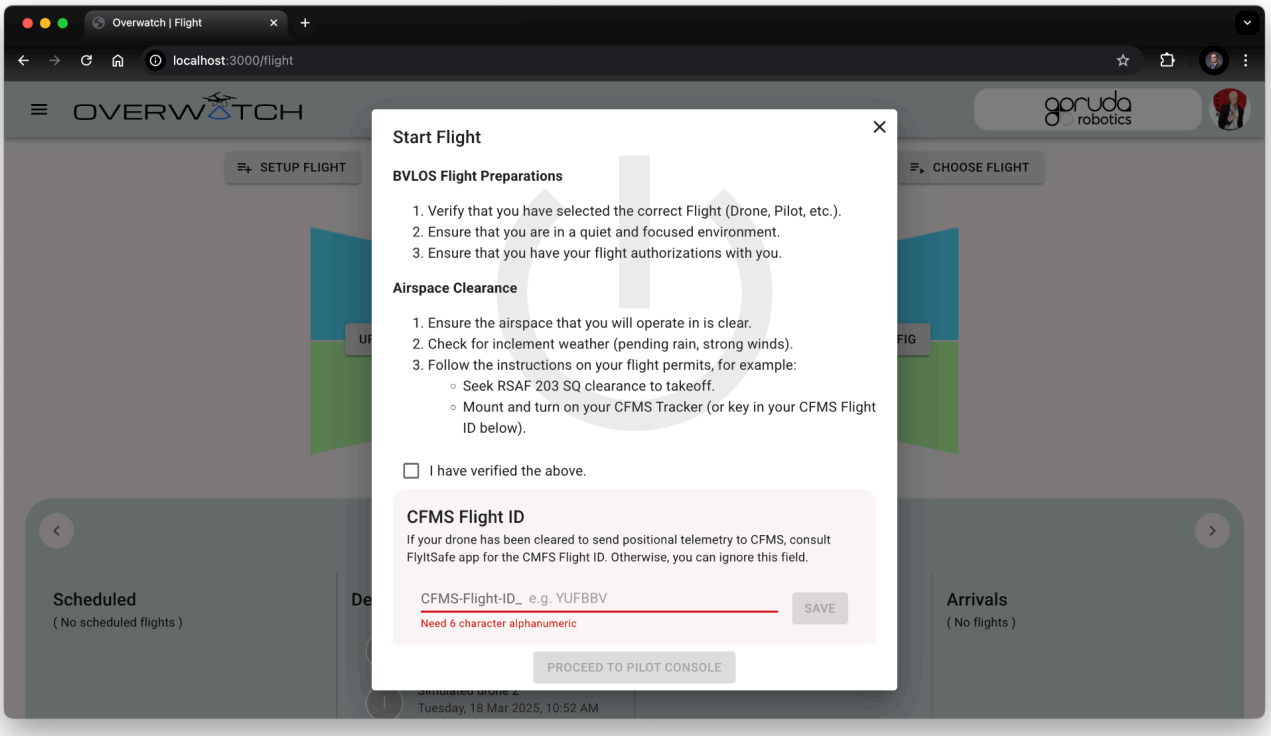
Once your system is fully developed, your pilots can expect to do the following

1. Login to FlyItSafe with your CorpPass
2. Click New for Flight Requests
3. Fill in the blanks as usual, except for **Location Tracking Method**, choose **Telemetry via API Gateway**.



4. Once your flight is approved, copy and paste the CFMS Flight ID into your own GCS system. In the example above, it is Q6CD04.

   Here's an example from Garuda Robotics OVERWATCH:



5. Click Start Flight on your GCS to start the telemetry transmission
6. Fly
7. Click Stop Flight on your GCS to stop the telemetry transmission