1. Software Overview & Scope

The **PlaneTracker App** is designed for airports to improve the ability to track aircraft arrivals and departures, as well as monitor emergency situations.

It is an edge-based ACAP (Axis Camera Application Platform) application that integrates real-time aircraft tracking data (ADS-B) with live video. It transforms a PTZ Axis network camera into an automated spotting tool that can overlay flight information and automatically steer a PTZ (Pan-Tilt-Zoom) camera to follow aircraft.

- **System Purpose:** To provide real-time flight data overlays and automated PTZ tracking of aircraft on a live or recorded video stream including searchable metadata.
- **Operating Environment:** Outdoor-rated Axis PTZ cameras located near flight paths.
- **Key Functionalities:** Integration with ADS-B receivers, dynamic data overlays, aircraft prioritisation, and automated PTZ positioning and focus.

2. System Architecture & Integration

The application is software operating on a network camera. It acts as a data processor that uses external location data to control pan/tilt/zoom and focus of the camera.

Component	Role	Specification
Location Data Source	ADS-B Receiver	External network feed of location data
Location Data Protocol	Mode-S Beast	Configurable IP address and port
Flight Data Source	Flightradar24 or Radarcrape database	External database
Processing Unit	Axis Network Camera (Edge)	ARTPEC-7/8/9

PTZ Control	Internal camera API/SDK	High-precision absolute positioning
Graphics Overlay Engine	Internal camera API/SDK	Dynamic SVG/PNG rendering
Audio	ATC radio receiver	External network feed of audio data

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3. Functional Requirements

3.1 Location Data Acquisition

- **Receiver integration:** The app shall connect to a local or remote ADS-B receiver via an IP address and port.
- **Database integration:** The app shall have the ability to connect to a database for additional information about the aircrafts, including flight number, origin, destination, call sign and file photo.
- **Geofencing:** Users shall define a "Detection Zone" (defined by radius and altitude) to ignore aircraft outside the area of interest.

3.2 Automated Tracking

- **Calculation Engine:** The app shall convert coordinates of aircraft and camera coordinates into pan/tilt angles and zoom/focus value using spherical trigonometry. The tracking engine shall be independent from the visual contact with the aircraft i.e. when the aircraft is obscured by clouds, dust, another aircraft or object, or at night.
- **Smoothing:** The software shall implement a smoothing algorithm to prevent "jittery" movement caused by low-frequency ADS-B updates (typically 1-2Hz).
- **Homing:** The camera shall return to a "Home position" when no aircraft are detected within the defined parameters, or follow a preset “Guard tour”
- **Prioritisation**: Users shall define prioritisation rules based on ICAO, blacklist, whitelist, detection zone, direction, speed, altitude, aircraft type and takeoff or landing if the required data is available. Aircrafts sending distress squawk codes shall automatically be granted highest priority.
- **Sun avoidance:** The app shall automatically avoid damage to the camera chip possibly caused by pointing the PTZ positioning directly into the sun with high focus and open aperture.

3.3 Audio

- The app shall support
    - ATC radio
    - Audio captured by an external microphone
    - Multiple audio sources simultaneously embedded to the video stream

3.4 Dynamic Overlay

- Overlay must include following metadata: ICAO, Altitude (ft/m), Speed (kts/kph), Distance from the camera (ft/m)

3.5 VMS compatibility

- The app shall have the ability to embed metadata to the video feed for video management systems of major vendors e.g. Axis, Genetec.
- The output video stream shall be compatible with video management systems of major vendors
- (when applicable) Genetic plugin - operation of the app shall be supported by accompanying dedicated plugin for Genetec VMS, certified by Genetec.

3.6 Configuration

- Configuration shall be available in a web based user interface
- Configuration shall be stored in a secured file stored directly in network camera and be available for manual backup and restore
- Configuration UI shall include map tiles
- User interface shall include dashboard including following items
    - Live view of the output video stream
    - Map with location and current heading and field of view of the camera
    - Location of planes available for tracking with the plane being currently tracked highlighted with different aircraft categories distinguished by different icons
    - Information panel about aircraft currently tracked
    - Tools for manual tracking of aircrafts
- Following parameters shall be configurable
    - At least 12 zones with different tracking priorities defined by polygon
    - Whitelist - list of relevant planes to be tracked
    - Blacklist - list of planes to be ignored by tracking algorithm
    - Maximal tracking distance
    - Overlay size and position
    - Zoom level - target size of the aircraft in the scene
    - PTZ Guard tour to be used when there are no planes to track

4. Software Logic & State Machine

The app operates on a high-speed polling loop to ensure tracking remains accurate relative to the aircraft's ground speed.

- **Scan State:** The app listens to the ADS-B feed for any aircraft entering the "Detection Zone."
- **Lock State:** Once a target is identified and chosen for tracking, the app calculates the vector and sends the first movement command.
- **Track State:** Continuous loop:
    1. Receive new GPS packet.
    2. Calculate predicted position based on current velocity.
    3. Update PTZ coordinates (Pan, Tilt, Zoom) and Focus value.
- **Lost/Timeout State:** If data is lost for > 5 seconds, the app stops tracking to avoid "searching" empty sky.

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5. Network & Security

- **Local Traffic:** Communication between the ADS-B receiver and camera should ideally occur on a dedicated VLAN to minimize latency.
- **Authentication:** Access to the configuration UI shall be protected by the camera's admin credentials via HTTPS.
- **Offline operation**: Tracking functionality must be assured even without internet connectivity, including for extended periods of time.

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6. Testing & Validation Criteria

- **Stability Test:** 168 hours of continuous operation
- **Accuracy Test:** At a distance of 1 km, the aircraft must remain within the video frame during a fly-by.
- **Latency Test:** The delay between an ADS-B packet arrival and the start of a PTZ movement shall be < 200 ms.
- **Capacity Test:** The app must be able to parse a feed containing up to **100 concurrent aircraft** without crashing, even if only one is being tracked.