Design - Automated Cargo UAV

Automated unmanned flight transport of goods has great business potential, will solve congestion and emission challenges and prevents excessive use of land. Key for this segment is automated, as operation and FPV mode won't scale.

Outcome of constraints

The constraints given by the brief results in the following overall outcome

- Business model and human factors considerations require automated flight, just tracked by a supervisory console and interacted for incidents.
  - Smart contracting, including bookings of corridors and insurance, needs to be part of the solution.
- Flight corridors deliver verified data for flight paths, constraints and exit points. Explored, documented and maintained ahead of operating flights.
- Foundation for automated flight is a rigid body, simple to foresee and tolerant and all intelligence and learning in SW. No calibration apart from rotors, easy to assemble and to fix.
- Even though the plane might be load from bottom, ergonomically preference is Top load. The container used contributes to the static rigidity of the body and includes a strain gages based weight indication.

- Longitudinal changes of CoG via the payload will be balanced dynamically like for critical constellations by the rear vertical fans.
- A Service module carries LiPos and a USB stick with SW updates and mission information, as there are path, weather information etc.
- Considerable energy consumption by vertical fans only start and landing, apart low balancing effort.
- Parameters for wing design are based on cruising conditions. Winglets reduce drag and support a relatively short wing span.

Administration and operation

- Repetitive procedures, operation and monitoring are automated. In flight there's not planned human interaction, just visualization to track and notification of incidents and authorization requests.
- Administration and supervision facilities allow for personell to deliver the service:
  - Mobile app for local setup and and handover of responsibility for the payload.
  - A supervisory console to tract and react on incidents.
  - Part of the administration is contracting, insurance and reservations.
- Load control of the container allows to limits breaking-up of starts.
- Next to operation and administration the SW will gather data to improve SW and for incremental business.

Structure

- Rigid frame with no movable parts like flaps or rudder. All controls by fans. Rigidity based on central plate, which is also base to assembly all components. Container is part of static structure, supporting rigidity.
- The body basically consists of the central plate, the wings, the empennage, and a shell covering the body. Fixation for the payload and Service module is also via the plate. Payload might be introduced from the top or the bottom.
- Loads for thrust are introduced via wings and the empennage.
- The structure allows for customization of wings, rotors and engines.
- V-wings form stabilizes cruising flight around longitude, limiting energy consumption.
- Winglets allows to save energy as well and to keep wings short.

Assembly

- Central plate connecting structure and components. 3 connectors and cable bundles to fans. Electronics and sensors fixed on the plate, easy accessible from the top.
- Parts and one shell to build the plane. No component more than 2m.
- Except for new rotors no calibration efforts.
- No sensitive components like flaps and rudders to damage.
- Selftest of active components before each start.

Flight mechanics

- Overall structure corresponds to a less dynamic, kind of sluggish behavior and passiv/active tolerance to flight incidents.
- For start and landing basically flight characteristic of an quadrocopter plus balance by horizontal fans. Big fans allow to limit noise. Considerable energy consumption by vertical fans only in this phase, just balancing while cruising.
- Transition to horizontal flight with decoupled vertical and horizontal thrust. A critical phase for tilt and other concepts, which is under full control by this plane.
- As there's vertical start and landing, the wing layout and profile selection corresponds to the cruising speed. Which results, supported by winglets, in less wing span and a more narrow structure.
- As weight and longitudinal position of CoG varies, active balancing according to sensors by rear fans.
- Movements controlled by horizontal and vertical rotors
  - Vertical rotors to start, land and reach cruising level.
  - Horizontal rotors for thrust and control.
  - All fans for movements around axes and cornering.
  - No positioning of fans necessary.

Telematics

- Stereo-Camera for monitoring of flight direction and to measure distance to potential obstacles. Potential bottom camera for point landing(like amazon). Capacity and intelligence for pattern recognition processing.
- Monitoring and ruling to follow corridor, as specific in the information and mission control loaded from the Service module. Not as precise as with autonomous car and with bigger „lanes“, but following the same logic and covering 3 dimensions.
- Transponder tracking will allow mapping in the supervision console. Sensors for pressure, GPS, temperature and compass including Gyro allow for automated navigation.
- Low speed communication allows for tracking and to communicated notifications for incidents. For given communication the plane may ask for authorization. If unconnected defined recovery procedures will be followed.
- Information base gained will become part of the operational excellence.

Simplicity

- Rigid body concept simple to design, calculate and produce. Layout focused on optimum support for cruise position reached with fans. Exceptions handled via fans.
- Passive tolerant body simple to steer and control. No interference with physical (rudder, flaps) controls.

- No servos, only rotary movements. No calibration except for new rotors necessary.
- All intelligence in SW, making use of existing and special developed modules. Maintenance mainly in SW.
- Making use of likely advances in battery, sw, processing and automated mind intelligence resulting of other automated solutions.

Safety

- All moving parts are covered.
- Weight will be controlled via an instrumented container before loading in the plane.
- Active balancing allow for variation in payload and dynamic adaptation of cruise balance.
- Active parts are always on, failure will result in direct awareness. Active parts are also less prone to failure because of temperature. Modern BL engines are robust with rain.
- Control procedures allow the recovery of single engine failures and direction controls.
- Obstacles in flight direction will be detected by the stereo camera in front. UAV will come to a stop and hoover waiting for remote commands. If unconnected the UAV will land at the next exit point defined.
- Failure not to be recovered will result in a controlled UAV crash with limited arrival every via build in parachute.