Design and Fabrication of a Long Endurance DEP Aircraft using Battery Power Source / Fuel Cell Tech

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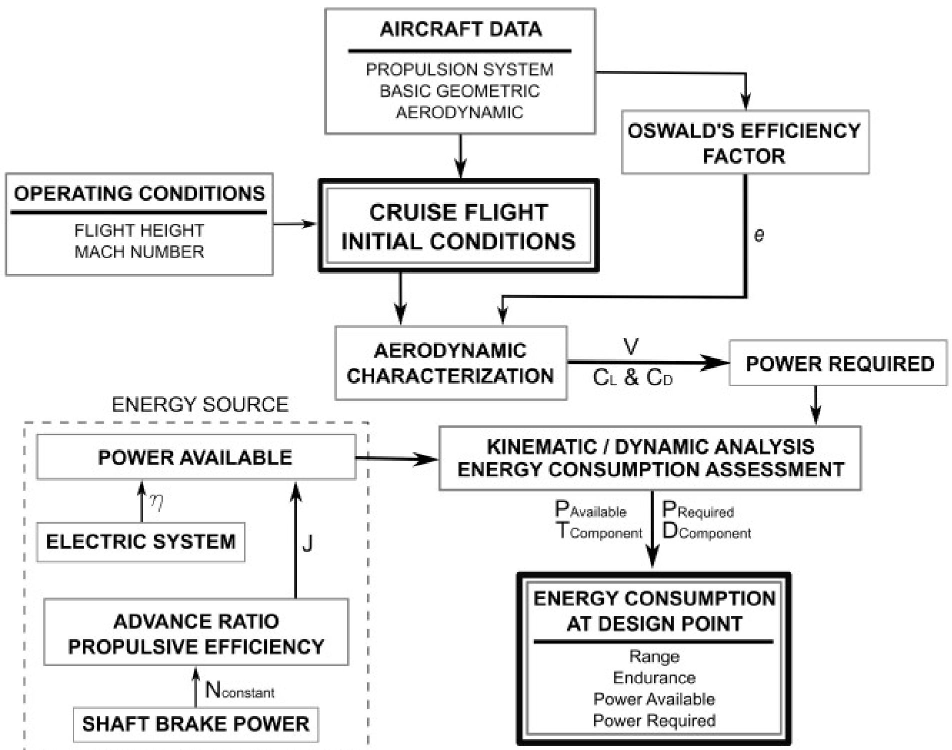
Target: Long endurance: 3 - 4 hours of flight using batteries/ Fuel Cell
Use: Smart agriculture, aerial surveillance

Process flow chart of the general drone aerostructural assessment



Conceptual Design Phase

This is the early stage where broad design choices are made.

A. Mission Requirements

- Define purpose: passenger transport, cargo, military, surveillance, etc.
- Payload, range, speed, altitude, field performance.
- Operational environment (e.g., civil airports, carrier operations, rough fields).

B. Initial Configuration

- Select configuration: wing placement, tail type, fuselage shape.
- Choose engine type: turbofan, turboprop, piston, electric, etc.
- Estimate weight and size.
- Use empirical formulas or software (e.g., NASA's OpenVSP) to get initial shapes.

C. Performance Estimation

- Use handbook methods or MATLAB/Python tools to estimate:
  - Lift-to-drag ratio (L/D)
  - Thrust-to-weight ratio (T/W)
  - Wing loading (W/S)
- Constraint analysis: Draw matching graphs to determine design point.

D. Feasibility Studies

- Trade studies for design alternatives.
- Cost vs. performance vs. manufacturability.
- Initial compliance with aviation regulations (FAA/EASA).

🛠️ 2. Preliminary Design Phase

Detailed analysis of selected configuration.

A. Aerodynamic Design

- Airfoil selection for wings/tails.
- 3D wing design (span, sweep, dihedral, twist).
- High-lift devices: flaps, slats.
- Computational Fluid Dynamics (CFD) simulations.

B. Weight Estimation

- Detailed breakdown:
  - Structure
  - Propulsion
  - Avionics
  - Payload
  - Fuel
- Center of Gravity (CG) range analysis.

C. Propulsion Integration

- Engine performance modeling (e.g., thrust lapse rate).
- Inlet and nozzle design.
- Fuel system planning.

D. Structural Design

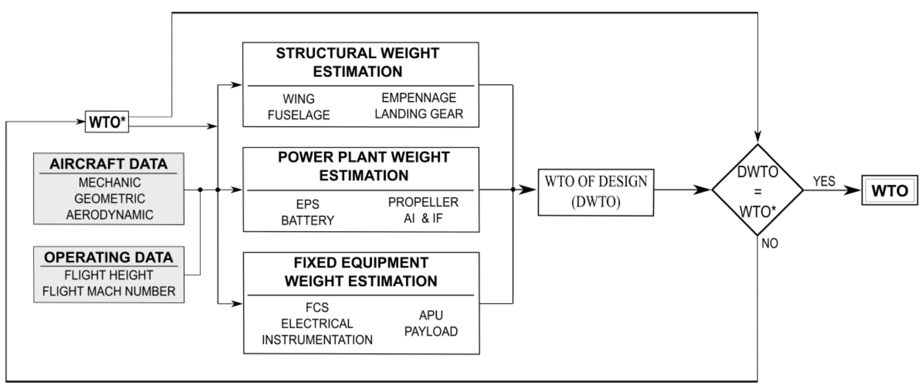
- Material selection (aluminum, composites, titanium).
- Load paths and stress analysis (e.g., using Finite Element Method - FEM).
- Design of fuselage frames, stringers, wing spars, and ribs.

E. Stability and Control

- Static and dynamic stability.
- Control surface sizing.
- Longitudinal, lateral, and directional handling qualities.

F. Systems Layout

- Avionics placement.
- Electrical and hydraulic systems.
- Landing gear configuration and retraction mechanism.



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3. Detailed Design Phase

Transition from concept to manufacturable parts.

A. CAD Modeling

- Full 3D solid modeling (e.g., CATIA, Siemens NX, SolidWorks).
- Detailed geometry for all parts and assemblies.

- Interference and tolerance checks.

B. System Integration

- Wire harness routing.
- Integration of sensors, actuators, and software.
- Redundancy and fault tolerance analysis.

C. Manufacturing Planning

- Material procurement.
- Tooling and jig design.
- Assembly procedures.

D. Documentation

- Engineering drawings.
- Bill of Materials (BOM).
- Maintenance and operation manuals.

🧪 4. Testing and Validation

A. Ground Testing

- Structural tests: static, fatigue, crashworthiness.
- Systems checks: hydraulics, avionics, landing gear.
- Engine run-up tests.

B. Wind Tunnel Testing

- Low- and high-speed tests of scale models.
- Validation of CFD results.

C. Flight Testing

- Envelope expansion: handling at various speeds/altitudes.
- Performance and stability verification.
- Certification testing (FAA Part 23/25, MIL-SPECs, etc.).

🏁 5. Certification & Production

A. Certification

- Regulatory compliance (e.g., FARs, CS-25).
- Design data approval.
- Environmental certification (noise, emissions).

B. Production Readiness

- Supply chain alignment.
- Quality assurance setup.
- Final assembly line layout.

C. Support Planning

- Training materials for pilots and maintenance.
- Spare parts logistics.
- In-service support documentation.

📈 6. Post-Production & Upgrades

- Operational feedback and incident analysis.
- Mid-life upgrades: avionics, engines, interiors.
- Variant design: stretched versions, cargo models, etc.

1. Conceptual Design Phase – Common Problems

Area	Problem	Explanation
Requirements	**Unclear or changing requirements**	Stakeholders (military, airline, etc.) may modify specs mid-process, impacting the entire design.
Configuration	**Overly ambitious design**	Choosing novel or unproven layouts (e.g., blended wing body) can increase complexity and risk.
Sizing	**Incorrect weight or thrust estimates**	Early estimations based on assumptions can lead to underpowered or overweight aircraft.
Trade Studies	**Inadequate trade-off analysis**	Failing to explore enough alternatives can lock the project into a suboptimal path.
Regulations	**Neglecting early regulatory input**	Not accounting for certification requirements (e.g., FAR 25) can lead to major redesigns later.

🛠️ 2. Preliminary Design Phase – Common Problems

Area	Problem	Explanation
Aerodynamics	**CFD results that contradict wind tunnel data**	CFD is sensitive to mesh and turbulence models, which can lead to misleading results.
Structural Design	**Weight growth**	Structural reinforcements add weight, which snowballs across the design (e.g., more lift → larger wings → more weight).
Propulsion	**Engine-airframe integration issues**	Engine placement can affect aerodynamics, noise, and maintenance access.
Stability & Control	**Poor dynamic stability**	Improper tail sizing or CG location can result in oscillatory or unstable flight characteristics.
Systems Layout	**Space conflicts**	Subsystems may compete for space or interfere with structural members, especially in tightly packed designs.

Area	Problem	Explanation
Human Factors	**Neglecting cockpit ergonomics**	Early designs sometimes miss pilot visibility, reachability, or workload issues.

🧪 3. Detailed Design Phase – Common Problems

Area	Problem	Explanation
CAD Models	**Integration mismatches**	Subsystems designed by different teams might not fit together due to tolerance or miscommunication.
Systems Integration	**Wiring & plumbing clashes**	Routing electrical, hydraulic, and fuel lines through confined spaces is prone to errors.
Manufacturing	**Designs that are hard to build**	Sharp corners, complex curves, or non-standard materials increase tooling complexity and cost.
Documentation	**Incomplete or inconsistent drawings**	Errors in BOMs or drawings lead to rework and delays on the shop floor.
Supply Chain	**Unavailable or long-lead parts**	Relying on rare materials or components not in production can cause critical path delays.

🧪 4. Testing and Validation – Common Problems

Area	Problem	Explanation
Ground Tests	**Test article failures**	Components may fail under static or fatigue loads due to overlooked stress concentrations.
Wind Tunnel	**Scale model issues**	Scaling laws (Reynolds number, Mach number) may not represent full-scale behavior well.
Flight Test	**Unexpected behavior**	Aircraft may display flutter, control reversal, or handling problems not predicted in simulations.
Certification	**Noncompliance with regulations**	Overlooking specific certification rules can require costly retrofits or testing redo.

Area	Problem	Explanation
Safety	**Inadequate fail-safes**	Failure to simulate critical failures (engine-out, fire) can reveal last-minute safety gaps.

🏁 5. Certification & Production – Common Problems

Area	Problem	Explanation
Certification	**Lack of documentation or traceability**	Authorities require detailed compliance documentation and testing traceability.
Quality Control	**Manufacturing defects**	Inconsistent workmanship or inadequate quality checks can lead to rejected parts or field failures.
Production Readiness	**Inadequate tooling or automation**	Production bottlenecks arise if manufacturing was not considered early in design.
Cost Overruns	**Design creep**	Added features, systems, or performance targets inflate costs late in the process.

📈 6. Post-Production – Common Problems

Area	Problem	Explanation
In-Service Support	**Poor maintainability**	Difficult access to components, unclear maintenance manuals increase operating costs.
Upgrades	**Integration of new tech**	Adding newer avionics or engines might not be compatible with original design.
Feedback Loop	**Slow response to field issues**	Delayed or ineffective product support damages reputation and trust.
