Drone Safety and Regulations

Unit 5

Drone Technology (DI05000081)

Gujarat Technological University

Academic Year 2024–25

Learning Goal

Build the judgement to fly safely, comply with Indian regulations, and integrate airspace awareness into every mission.

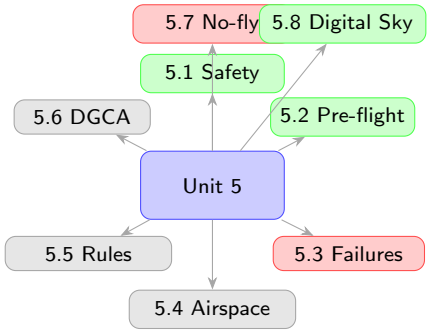
Eight Topics

Safety, checklists, failures, airspace, rules, DGCA, no-fly zones, Digital Sky.

Unit Overview: Why Safety and Regulations Matter

Why this unit matters

- Investigation trends for small UAS repeatedly show that **human factors, checklist failures, and poor judgement** dominate accident causes.
- **Propeller strike, falling drone impact, and battery fire** are the most common injury and property-damage mechanisms.
- **Privacy incidents** arise when drones hover above houses, campuses, roads, or events without a clear operational need.
- **Airspace incidents** include airport sightings, near-misses with helicopters, and unauthorised flights in restricted zones.



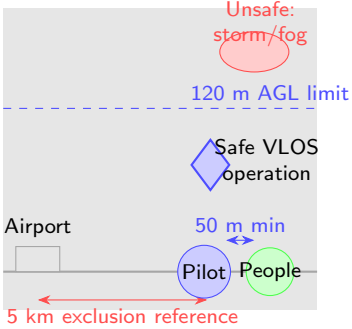
Safety message

Safe + legal + documented is the minimum acceptable standard for a professional drone mission.

5.1 Drone Safety Guidelines

Core operating rules

- Maintain **visual line of sight (VLOS)** at all times.
- Stay at or below **120 m AGL** unless specifically authorised.
- Keep at least **5 km from an airport perimeter** unless the airspace map and ATC process permit otherwise.
- Keep at least **50 m from uninvolved people**, vehicles, and buildings.
- Do not fly in **rain, thunderstorms, strong wind, dense fog, or poor light**.
- Configure **home point, RTH altitude, failsafe action, and low-battery thresholds** before launch.



Operational Safety Principles

Risk thinking used in professional operations

- **SORA concept**: identify the mission, the location, nearby people, airspace users, aircraft performance, and mitigation measures before flying.
- **ALARP principle**: reduce risk "as low as reasonably practicable" rather than merely "probably okay".
- **Ground risk**: impact, propeller injury, privacy intrusion, or damage to cars, buildings, crops, or power lines.
- **Air risk**: conflict with helicopters, low-flying aircraft, other drones, or emergency responders.

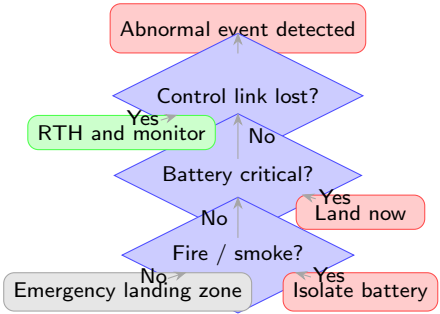
Risk level vs mitigation

Level	Typical mission	Mitigation needed
Low	Empty field, daylight, VLOS	Basic checklist, spotter optional, capped altitude
Medium	Near buildings, modest traffic	Site survey, cordon, spotter, RTH check, briefing
High	Urban, near roads or sensitive	Formal approval, detailed

Emergency Procedures

Immediate actions

- **Signal loss**: allow configured RTH to activate; regain control only if link returns and the situation is safer.
- **Low battery**: stop mission tasks, descend early, land immediately; never "stretch" the pack.
- **Motor or prop failure**: reduce forward speed, aim for open ground, and prepare an emergency landing.
- **Flyaway**: trigger failsafe or kill throttle if the aircraft is leaving safe containment and cannot be recovered safely.
- **Fire or smoke**: land at once, isolate battery,



Weather and Environmental Hazards

Hazards to evaluate

- **Wind**: consumer drones are comfortable only around **Beaufort 3** (about 15 km/h); professional platforms may tolerate **Beaufort 5** (about 30 km/h) with margin.
- **Rain and moisture**: consumer drones are usually not waterproof; IP rating indicates how well a platform resists dust and water.
- **Fog and haze**: reduced visibility damages VLOS and weakens pilot orientation.
- **Temperature**: cold weather reduces Li-Po voltage under load; very hot weather raises battery and ESC stress.
- **Electromagnetic interference**: towers,

Go / No-Go weather table

Weather	Decision	Comment
Wind < 15 km/h	Go	Normal consumer operation
15–30 km/h	Caution	Only trained crew / suitable platform
Rain / drizzle	No-Go	Water ingress and visibility risk
Fog / smoke	No-Go	VLOS degraded

5.2 Pre-flight Checklist

Pilot IMSAFE check

IMSAFE Check

- **I** - Illness: physical fit
- **M** - Medication: no drugs
- **S** - Stress: workload managed
- **A** - Alcohol: zero tolerance
- **F** - Fatigue: sleep & hydration
- **E** - Emotion: calm, alert

12-point drone systems checklist

- ☐ Propellers secure, clean, no cracks
- ☐ Battery charged, seated, no swelling
- ☐ GPS lock obtained
- ☐ RTH altitude set above obstacles
- ☐ RC transmitter bound and healthy
- ☐ NOTAM / permission checked
- ☐ Area clear of people and obstacles
- ☐ Weather and visibility acceptable
- ☐ Home point recorded correctly
- ☐ Failsafe action confirmed
- ☐ Compass status normal / calibrated
- ☐ Visual check of all arms and motors

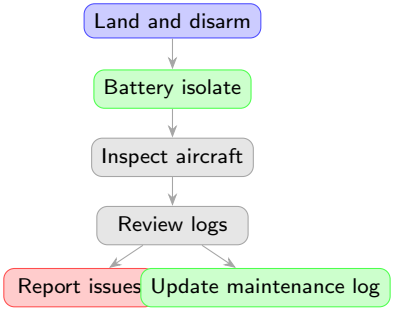
Launch discipline

Final verbal call

Post-flight Procedures

After landing

- Remove the battery and allow it to cool; store or discharge to about **3.8 V per cell** for long life.
- Review mission data: flight time, max altitude, max distance, warnings, GPS quality, and any failsafe events.
- Inspect frame, props, motors, landing gear, camera, and connectors for fresh damage.
- Report incidents, lost-link events, or hard landings according to organisation and DGCA rules.
- Update the **maintenance log**: battery cycles, prop replacement, repairs, firmware issues.



5.3 Common Drone Failures

Failure – symptom – cause – fix

Failure	Symptom	Likely cause	Fix
Motor failure	Sudden yaw / fall	Burnt winding, loose wire	Replace motor, inspect ESC
ESC failure	One arm dead or desync	Overheat, solder fault	Replace ESC, check current draw
Prop damage	Vibration, poor lift	Chips, imbalance, loose hub	Replace prop set
Battery failure	Voltage sag, short flight	Old pack, cold pack, puffing	Retire pack, warm and balance-charge
GPS glitch	Position jump, drift	Weak satellite geometry, multipath	Wait for better fix, relocate
Compass error	Toilet-bowl motion, yaw drift	Magnetic interference	Recalibrate away from metal
FC crash / reboot	Freeze, random reset	Brownout, firmware issue	Check power rail, logs, firmware
RC signal loss	Failsafe, delayed response	Obstruction, antenna orientation	Reposition pilot, inspect antennas
Gimbal failure	Tilt shake, horizon skew	Ribbon damage, overload	Recalibrate or repair gimbal
Flyaway	Ignores pilot intent	Bad compass, GPS / mode	Trigger failsafe, investigate logs

First troubleshooting priorities

1. Make the site safe.
2. Disconnect battery.
3. Preserve logs.
4. Check power train.
5. Verify sensors.

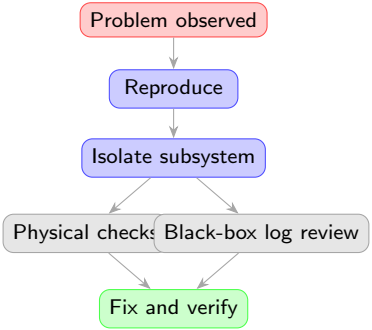
Pattern recognition

Random faults are rare; many "mystery" incidents reduce to power, vibration, compass, or human setup error.

Troubleshooting Methodology

Systematic approach

1. **Reproduce**: understand when the fault appears — arming, hover, climb, RTH, or payload use.
2. **Isolate**: separate power, propulsion, sensor, radio, and software possibilities.
3. **Fix**: change one thing at a time so the cause remains traceable.
4. **Verify**: bench test first, then controlled hover, then full mission profile.



Useful diagnostics

Mission Planner / GCS log review, vibration plots, motor temperature by touchless check, compass

Crash Investigation

Li-Po and wreckage safety

- Check the battery for **swelling, puncture, leakage, or heat**.
- Do **not transport or recharge** a damaged Li-Po; isolate it in a fire-safe area.
- Remove props before handling motors, gimbal, or broken arms.

Evidence to collect

- Photos of impact site, aircraft orientation, damage pattern, and nearby obstacles.
- Flight log download before powering the aircraft again if possible.

Reporting threshold

Report to DGCA / authorities when an accident causes **injury** or significant property loss, especially damage above **Rs.1 lakh**. Local police or site authorities may also require immediate notice.

Root-cause method

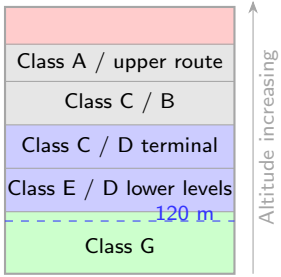
Ask: what failed, why it failed, why protection did not stop it, and what changes prevent recurrence. Distinguish **trigger** from **systemic cause**.

Typical chain

5.4 Airspace Structure

ICAO airspace classes and flight rules

Cls	Who flies	Control	Meaning for drone pilot
A	IFR only	High	Airline / high-level route structure; drones not relevant operationally
B	IFR + VFR	Very high	Busy terminal airspace; drone access tightly controlled
C	IFR + VFR	High	Controlled traffic with separation service
D	IFR + VFR	Moderate	Control zones near many airports
E	IFR + VFR	Partial	Controlled for IFR; VFR enters with fewer services
F	Advisory	Limited	Rarely used; advisory structure
G	IFR + VFR	Open	Most small-drone operations occur here below 120 m



Key terms

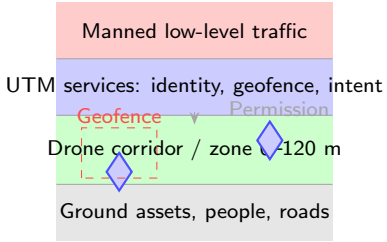
Low-level Airspace and UTM Concepts

Drone operating layer

- Most routine drone activity occurs in the **0–120 m AGL** layer.
- Traffic is dense, local, and close to people, roads, trees, and wires.
- BVLOS operations are harder because the pilot loses direct visual separation and must depend on systems and procedures.

UTM / U-space ideas

- **UTM** (UAS Traffic Management) coordinates drone identity, airspace, flight intent, and deconfliction.

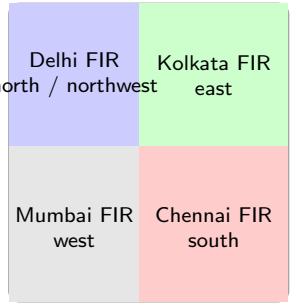


Indian Airspace Structure for Drone Pilots

Operational awareness in India

- India is managed through major **Flight Information Regions (FIRs)**: **Delhi, Mumbai, Kolkata, and Chennai**.
- The **Airports Authority of India (AAI)** manages aeronautical information, many NOTAM services, and infrastructure support for civil aviation.
- Near airports or controlled areas, drone operators may need coordination through **Digital Sky, airport processes, or ATC-linked procedures**.
- **NOTAMs** warn about temporary hazards, VIP movement, airshows, military activity, or emergency restrictions.
- **VFR charts** such as WAC / TAC help pilots

Simplified conceptual map



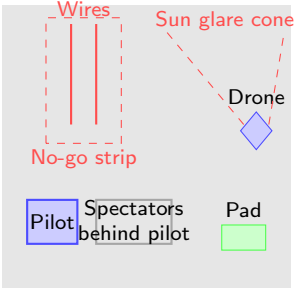
Before airport-area flight

Know the nearest aerodrome, runway orientation, traffic pattern, and the communication / permission path.

Safe Flying Practices

Site selection checklist

- Open area with clear takeoff and landing surface.
- No overhead wires, cranes, trees, or reflective glass directly on the route.
- Firm ground for takeoff pad; avoid dust, loose sand, or standing water.
- Bystanders kept behind the pilot and outside the rotor disc plane.



Crew and visual safety

- Give a short **safety briefing** before launch.
- Use a clear **handover procedure** if control

5.5 India Drone Regulations History

Evolution of the legal framework

- **Before 2018**: no mature public framework; most civilian flights required special permission and many operators considered routine flying effectively banned.
- **2018 DGCA CAR**: first structured regime, but it was compliance-heavy and document-intensive.
- **2021 Drone Rules**: simplified forms, reduced approvals, clearer classifications, and stronger digital workflows.
- **2022 amendments**: wider use of the Drone Airspace Map, approved lists, and market clean-up for legal import / sale.

Exam takeaway

2021 is the major simplification milestone; remember how it reduced process complexity.

Drone Rules 2021: Key Provisions

Drone categories

Class	Weight	Typical use
Nano	Up to 250 g	Learning, indoor, very light hobby tasks
Micro	Above 250 g to 2 kg	Camera, survey, inspection, basic commercial work
Small	Above 2 kg to 25 kg	Mapping, delivery trials, agriculture, industrial work
Medium	Above 25 kg to 150 kg	Heavy payload, special enterprise tasks
Large	Above 150 kg	Special aviation-grade platforms

Remember these rule points

No routine permission for **Nano** up to 400 ft in uncontrolled airspace; **UIN** generally applies from Micro and above; **RPC** is mandatory for more demanding categories and operations; **type certification** is expected for legal market entry; imports require

Operational meaning

- Lighter class usually means simpler compliance.
- Sensitive location can still make a small drone high-risk.
- Certification and registration link the aircraft to the legal operator.
- Weight class is only one part of risk; **where** and **how** you fly matter equally.

Use class + airspace + purpose

Always evaluate a mission through all three lenses, not by weight alone.

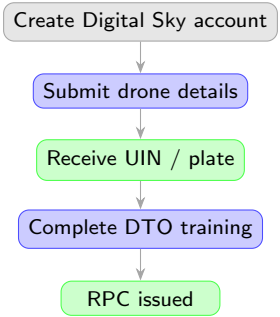
Registration and Certificates

UIN: Unique Identification Number

- Required for **Micro and above** in routine regulated operations.
- Applied through the **Digital Sky** portal with owner, aircraft, and compliance details.
- The UIN or identification plate must be affixed visibly on the drone body.

RPC: Remote Pilot Certificate

- Eligibility commonly includes **18+ years**, educational baseline, and suitable **Class 2 medical** fitness.
- Training is completed at a **DGCA-authorised DTO**.



Documents typically needed

Identity, ownership proof, model details, serial number, training records, and fitness evidence.

UAOP / Operational Authorisation

What the syllabus means by UAOP

- Historically, **UAOP (UA Operator Permit)** referred to authorisation for certain commercial or non-basic operations.
- In current practice, many approvals are handled through **Digital Sky and mission-specific authorisation workflows** rather than older paper terminology.
- For exam language, remember UAOP as the permit concept associated with **commercial / higher-risk operations using Small and above drones**.

Documents and renewal

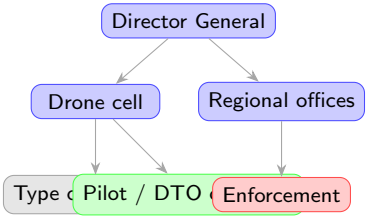
Which permit for which operation?

Operation	Typical need	Example
Nano in green zone	Minimal / local rules	Practice flight
Micro survey	UIN + pilot competence	Real-estate capture
Small commercial job	UIN + RPC + authorisation	Mapping contract
Yellow / red zone mission	Mission permission	Airport-adjacent inspection
Govt. security	Exemption path	Police surveil-

5.6 DGCA Roles in Depth

What DGCA does

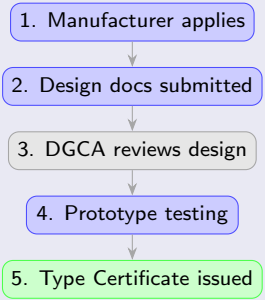
- Headquartered in **New Delhi** with regional and field offices supporting civil aviation oversight.
- Led by the **Director General of Civil Aviation**.
- Issues rules, circulars, approvals, and oversight relating to drones, pilots, operators, and training organisations.
- Maintains the compliance framework for **type certification, registration, pilot training, and enforcement**.



Enforcement powers

Type Certification Process

Typical process flow



Why it matters

Certification helps ensure the market is traceable, supportable, and linked to approved hardware and

Certified vs non-certified market view

Compliant side	**Risky side**
Approved mapping / agri models on current list	Grey-import model with no valid local approval
Mavic-class enterprise drone *if listed through authorised channel*	Consumer drone sold without legal market traceability
Manual,	No clear

Penalties and Enforcement

Legal exposure for unsafe or illegal flight

Violation	Possible action	Severity
Prohibited / red zone flight	Fine up to **Rs.1 lakh** and imprisonment up to **2 years** under applicable law and schedules	High
Causing injury or damage	IPC / local police action plus DGCA enforcement	High
NPNT bypass or fake permission	Seizure, cancellation, prosecution	High
No	Suspension,	Medium

Illustrative enforcement cases

- Drone filmed near an airport approach path: aircraft seized, pilot questioned, flight records checked.
- Event overflight without permission: local police stop the operation and organisers face action.
- Unauthorised social-media stunt in restricted area: FIR plus regulator scrutiny.

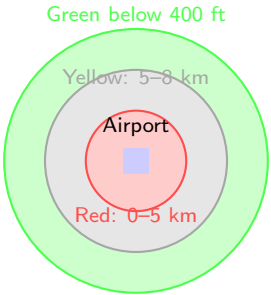
Practical lesson

Digital evidence is easy to preserve: timestamps, GPS tracks, video metadata,

5.7 No-fly Zones: Red, Yellow, Green

Classification and meaning

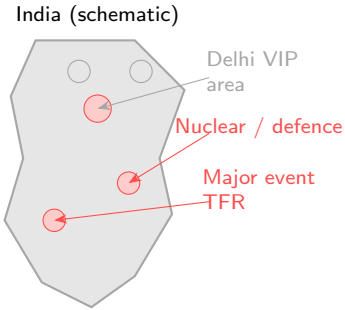
Zone	Distance / height	Meaning
Red	0–5 km from airport perimeter; also defence, nuclear, VIP, etc.	No routine flight; only specific approval / authority
Yellow	5–8 km from airport and other controlled	Flight only through permission workflow



Special Restricted Areas

Areas needing extra caution or prohibition

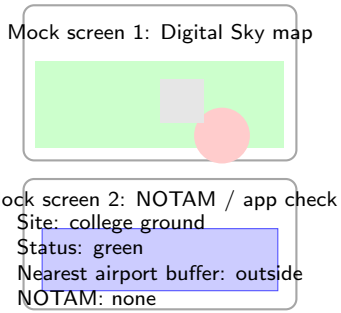
- **Nuclear power plants**: often treated with about a **5 km** security buffer.
- **Border areas**: additional security restrictions and buffer policies may apply.
- **Military stations, ammunition depots, and defence labs**: highly sensitive; avoid unless specifically authorised.
- **Vijay Chowk, Rashtrapati Bhavan, Parliament precincts, and VIP venues**: tightly restricted.
- **Major events**: cricket matches, public rallies, state visits, and disaster zones may trigger temporary restrictions.



How to Check Airspace Before Flying

Step-by-step procedure

1. Open the **Digital Sky airspace map** and search the site.
2. Check colour code, nearby airports, and any mission approval requirement.
3. Review **AAI NOTAM** sources for temporary restrictions.
4. Cross-check with local tools such as **DroneAcharya** or **AirMeet** style awareness apps if available.
5. Record the result in your flight log: date, map screenshot reference, and permission status.
6. Re-check just before launch if the mission is



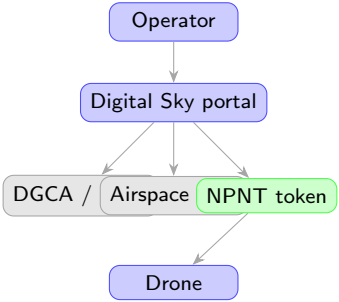
What to save

Map view, permission reference, time checked, and any ATC / authority contact notes.

5.8 Digital Sky Platform

Main functions

- Drone registration portal for owner and aircraft details.
- Pilot licensing and credential workflows.
- Flight permission request system for yellow / restricted cases.
- Interactive airspace map using red, yellow, and green coding.
- NPNT support by issuing a permission token to compatible aircraft.



Operational value

Digital Sky creates a single digital trail linking

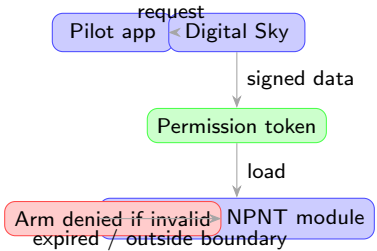
NPNT: No Permission, No Takeoff

Technology concept

- Before arming, an NPNT-capable drone checks whether it has a valid mission permission from the authorised server.
- The permission token behaves like a signed digital pass and can include **drone UIN, pilot RPC, time window, and GPS boundary**.
- If the token is expired, missing, or outside the allowed polygon, arming should be denied or the mission should be blocked.

Why NPNT matters

It converts regulation into machine-enforced behaviour, reducing dependence on honesty alone.



Token contents

UIN, RPC, mission date, start-end time, altitude cap, approved polygon, and signature.

Summary and Course Conclusion

Unit 5 key points

Safety starts with judgement, checklists, and airspace awareness. Indian compliance requires understanding DGCA, permissions, no-fly zones, Digital Sky, and NPNT.

Complete course in one table

Unit	Theme	Core learning
1	Introduction	Drone basics, applications, classifications, history
2	Components	Frame, motor, ESC, propeller, battery, FC, sensors
3	Flight dynamics	Forces, stability, control axes, manoeuvres
4	Communication	RC link, telemetry, GCS, frequency bands, navigation
5	Safety & rules	Safe operation, airspace, DGCA, no-fly zones, Digital Sky

Professional mindset

Career paths and resources

Careers: pilot, manufacturer, payload integrator, regulator / compliance analyst, agriculture specialist, mapping engineer, app developer.

Resources: DGCA website, Digital Sky portal, ArduPilot / PX4 docs, AAI NOTAM services, training organisation manuals.

Eight final review questions

1. Why is VLOS essential?
2. State the 120 m AGL rule.
3. What does IMSAFE mean?
4. Give four common drone failures.
5. Differentiate Class G and controlled airspace.
6. Explain red, yellow, and green zones.
7. What is the role of DGCA and Digital Sky?
8. How does NPNT prevent unauthorised takeoff?