PROTOCOL WHITEPAPER · VERSION 1.0

An air traffic protocol for the low-altitude century.

Altitude-direction encoding, hexagonal cell topology, and deterministic AI fallback — a foundational protocol for autonomous and semi-autonomous flight below 500 metres.

AUTHOR
Jittapol Prukpatarakul

AFFILIATION
VerSky · Bangkok, Thailand

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FRONTMATTER

About this document

This is the version 1.0 release of the VerSky Protocol Whitepaper. It describes the protocol's motivation, foundational p
formational layers, AI communication semantics, and the path it offers for adoption — at a level of detail intended to sup
cal evaluation by engineers, regulators, standards bodies, and prospective licensees.

The protocol described herein is the subject of two pending United States patent applications filed pro se with the
Trademark Office on 27 February 2026:

- **Application No. 19/551,620** — Altitude-Direction Encoding Protocol for Air Traffic Management with Hexagonal Grid
Separation
- **Application No. 19/551,624** — AI Aerial Communication Protocol with Peer-to-Peer Negotiation and Deterministic Fal

Both applications establish a priority date of 27 February 2026 and will publish on or around 27 August 2027 in accor
month rule. Until publication, this document and the public-facing materials at *versky.org* are the principal sources
protocol.

Scope and intent

This whitepaper is not a specification. It is a description. The normative specification of the protocol, including the p
definitions of message formats, reservation primitives, and fallback rules, lives in the filed patent applications and in t
implementation (licensing terms TBD).

The intent of this document is to make the protocol comprehensible, evaluable, and citable. It is written for readers who
once.

A note on terminology

Throughout this document, "the protocol" refers collectively to the airspace structure (altitude bands, hex cells, reserva
cle communication layer (AACP). When a distinction is material, the components are named individually. A glossary at t
defines the key terms used.

> **READING THIS DOCUMENT**
>
> *The document is structured to be read linearly. Chapters 1–3 establish motivation. Chapters 4–6 describe the three te*
> *Chapter 7 situates the protocol against existing systems. Chapters 8–9 cover adoption and patent status. Appendices*
> *glossary and references.*

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Tables are numbered within their chapter (e.g., Table 4.1, Table 7.2). This whitepaper deliberately favours descriptive prose and struc readers seeking a visual companion are referred to the protocol page at *versky.org/protocol*.

§ 1 · EXECUTIVE SUMMARY

CHAPTER ONE

§ 1

Executive Summary

The next decade will place between ten million and one hundred million autonomous and semi-autonomo
the airspace below five hundred metres. Existing air traffic management infrastructure was not designec
not be cost-effectively retrofitted, and will not scale. VerSky proposes a new protocol layer for that airs
openly, under a licensing framework intended to make adoption frictionless for compliant operators.

The protocol rests on three load-bearing ideas. The first is that altitude itself can carry a vehicle's direction of travel, er
six directional sub-layers tiled in a hexagonal pattern. The second is that low-altitude airspace can be partitioned into
four-dimensional (cell-direction-time) occupancy is the unit of coordination, allowing reservations to be made and ve
rather than full trajectory predictions. The third is that an AI communication layer — AACP — can negotiate routing crea
while the safety of the airspace itself rests on a deterministic fallback that runs identically on every vehicle when negotia

These ideas combine to produce a system with properties that traditional centralised ATC cannot offer at the relevant
that is constant per request rather than combinatorial in fleet size; safety guarantees that do not depend on the success
ty that scales gracefully with asymmetric traffic; and observability that is local, passive, and free of telemetry.

What the protocol does

- Encodes direction of travel into altitude, observable passively by any vehicle with a standard altimeter and a publishe
- Partitions airspace into hexagonal cells that map one-to-one onto a six-direction movement alphabet, eliminating dia
- Defines a 4D reservation primitive (cell · sub-layer · time) with constant lookup cost and bounded conflict-detection
- Specifies a peer-to-peer AI negotiation protocol with mandatory deterministic fallback resolution, ensuring safety pro
under AI failure.
- Provides a trust-and-reputation layer with anti-Sybil aggregation and cross-region credential portability.

What the protocol does not do

- It is not a flight controller. Vehicles continue to navigate within cells using their own systems.
- It is not a replacement for collision avoidance. Static spatial separation is provided; dynamic resolution is the respons
its AACP layer.
- It is not a regulator. The protocol can be implemented by national aviation authorities, standards bodies, or private op

Status

Two non-provisional applications were filed with USPTO on 27 February 2026, establishing priority. PCT internationa
twelve months. A reference implementation is in development; licensing terms are to be determined. Engagement with r
— ASTM F38, ICAO RPAS Panel, ITU-R aeronautical mobile work — is intended once the priority position is fully secured

§ 2 · PROBLEM STATEMENT

CHAPTER TWO

§ 2

Problem: Low-Altitude Airspace at Scale

Air traffic management as currently practised assumes a manned aircraft flying between two airports u
trol. Every assumption in that sentence breaks down below five hundred metres above ground level, whe
of aerial vehicles will operate.

2.1 The assumption stack

Classical air traffic management is built on a stack of assumptions that work well for commercial aviation and fail for lo
erations. The aircraft are large, sparse, and travel between a small number of well-known city pairs. They cruise at flig
thousand feet, navigate using published airways, and communicate continuously by voice radio with regional controll
enough that each one merits direct human attention.

None of these properties survive at the operational scale projected for low altitude. The vehicles are small, dense, and
tively infinite number of origin-destination pairs. Their speeds are low, their altitudes are bounded by terrain and st
economy, and they will exist in numbers that no human controller can supervise individually. Voice radio is unavailable
will lack any radio operator at all.

2.2 What the regime actually looks like

A conservative estimate of operational vehicle counts within a single major metropolitan area within ten years is in the te
neously, distributed across delivery drones, inspection platforms, photography vehicles, taxis and shuttles for human
medical aircraft, agricultural vehicles, and recreational devices. The total daily flight count will be in the hundreds of th
area.

This is not a future projection. It is a near-term consequence of existing battery, motor, and autopilot trajectories applie
demand. The question is not whether the regime arrives. The question is what coordinates it.

2.3 Why existing approaches do not extend

Three categories of existing approach have been proposed or partially deployed for this regime. Each has known limitati

APPROACH	MECHANISM	WHY IT DOES NOT SCALE TO THE REGIME
Centralised UTM	Cloud-hosted service grants or denies flight authorisations	Single point of failure; latency-bound; bandwidth and compute with active vehicle count; requires continuous connectivity fro
See-and-avoid extension	Vehicles broadcast position and avoid collisions reactively	Provides no static separation, no priority class semantics, no catastrophically with sensor failure or jamming.
Adapted ICAO procedures	Re-use of semicircular rule, named corridors, controller-issued clearances	Two-direction encoding insufficient; voice clearances impossi cannot supervise the vehicle count; corridor model fragments

Each of the three has a place in the eventual stack. None of them, on its own or in combination, addresses the coordina
scale. What is missing is a protocol layer that operates beneath them — one that defines how the airspace is structured
and how vehicles communicate intent and resolve conflicts without requiring continuous central oversight.

2.4 The properties such a protocol must have

Local observability. A vehicle must be able to infer essential properties of nearby vehicles — direction, broad class
observable state, without querying a central system.

Constant-cost coordination. The cost of reserving or checking airspace must not grow linearly or combinatorially wi

Graceful degradation. The protocol must continue to provide safety properties when communication, sensors, or AI

Asymmetric traffic tolerance. The protocol must allocate capacity to whichever direction the traffic is actually flowin
is symmetric.

Vendor neutrality. The protocol must be implementable by any vehicle with reasonable sensors, regardless of AI ven

Auditability. Every consequential decision must be inspectable after the fact by humans.

The remainder of this document describes how VerSky satisfies these requirements.

§ 3 · SEVEN FOUNDATIONAL PRINCIPLES

CHAPTER THREE

§ 3

Seven Foundational Principles

The protocol's design is governed by seven principles. Each is intended to be load-bearing: removing any rial properties of the system. They are listed here, then elaborated in the chapters that follow.

1

Altitude Encodes Direction.

Altitude determines direction of travel. Other vehicles can determine a vehicle's direction solely by obser querying any server. The vertical position of a vehicle implicitly declares its direction of travel, drawn from a se allel directions arranged in a hexagonal pattern at approximately 60° intervals. Together with strict altitude tole property produces intersection-safe trajectories by construction.

2

4D Space-Time Reservation.

3D space plus time is reserved before flight, preventing conflicts from the outset. The unit of coordination is th of *cell, directional sub-layer, and temporal occupancy window*. Each cell-sub-layer-time combination maintai with a configurable temporal buffer. Reservations are made by checking these records — a constant-cost op than by predicting full trajectories.

3

Hex-Cell Capacity.

Airspace is divided into hexagonal cells, each with a maximum capacity per cell. Cell capacity is a configur and may vary by cell class, by direction balance, and by time-of-day envelope. A cell whose capacity is exce tion request triggers a re-routing search through alternative trajectories, departure times, or floors.

4

Speed Scales with Height.

Higher altitude permits higher speed. The protocol's vertically stacked floors are not merely a class-separatio carries a distinct maximum speed appropriate to its altitude band, with higher floors permitting greater spee tance from people, obstacles, and ground hazards expands the available margin for manoeuvre. The flo aligned with vehicle capability and operational risk in a single monotonic relationship.

5

Priority by Purpose.

Conflict resolution and reservation precedence are governed by a fixed mission priority hierarchy: **Emergency** **Commercial > Recreation**. The hierarchy is determined by declared mission type, observable in the negotiatio enforceable by airspace authorities through credential revocation. Higher-priority missions proceed; lower-pri

6

Fail-Safe = Descend.

System failure equals controlled descent in all cases. A vehicle that loses positioning, communication, or cor deterministic descent profile through five escalation levels (Normal, Advisory, Warning, Critical, Emergency along its prior trajectory. This converts unrecoverable failures into local landing events whose consequences network-propagating.

7

Digital-Only Infrastructure.

Everything is implemented in software. No physical infrastructure exists in the airspace itself — no beacons yond standard communications, no additional radars. The entire coordination layer exists as software runni supporting cloud or edge systems. Adoption is therefore bounded by software deployment, not capital hardware.

Principles 1, 3, and 4 are addressed in detail in chapter 4 (encoding and floors); Principle 2 is the subject of chapter 5 (reservation) throughout chapter 6 (AACP priority and deterministic fallback) and the comparison chapter; Principle 7 is cross-cutting and underlie

CHAPTER FOUR

§ 4

Altitude-Direction Encoding

The first technical layer of the protocol is an encoding scheme in which a vehicle's altitude implicitly de
travel. This chapter describes the encoding, the constraints it must satisfy, and the operational properties

4.1 The encoding

Within a defined airspace volume, the altitude band available to operational traffic is partitioned into at least six directio
layer is assigned a unique travel direction drawn from a set of six non-parallel vectors arranged in a hexagonal pattern.
ed from its adjacent directions by approximately sixty degrees, producing complete azimuthal coverage with no gaps an

A vehicle assigned to a particular direction operates within that direction's designated altitude band for the duration o
vant airspace volume. Any other vehicle, or any monitoring system, observing the vehicle's altitude can derive the veh
direction from the altitude alone — without further communication or query.

4.2 Design requirements (derived)

The encoding function — the specific mapping between altitude bands and direction vectors — is not arbitrary. The file
the load-bearing safety requirement directly: a sub-layer separation invariant of *sub_layer_separation ≥ 2 × altitude tole*
gap(claim 1(d); P1 spec ¶[0036]). The following four properties are this author's formalisation of what such an encodin
ally satisfy to be practically deployable; they are derived from the filed text rather than enumerated within it.

CONSTRAINT	STATEMENT	FAILURE MODE IF VI
Locality	Direction inferable from altitude alone, without external query.	Loses the no-coordin
Stability	Sub-layer bandwidth exceeds altimeter error budget by configurable safety margin.	Sensor noise flips enc
Reflective invariance	Direction *d* and direction *d + 180°* separated by ≥ 2 × altitude tolerance + minimum vertical gap.	Head-on traffic at ins
Bijectivity	One altitude band ⇄ one direction within the operating envelope.	Ambiguity at boundar inference.

4.3 Intersection separation as an emergent property

A consequence of the encoding is that two vehicles travelling in different directions are, by construction, at different alt
— a geographic point where flight paths from different directions converge — the vehicles pass through the same horiz
altitudes, vertically separated by the gap dictated by the encoding function.

This eliminates the need for temporal sequencing, ground delays, speed reduction, or lane changes at intersections for
ferent directions. The intersection is not a point of contention to be managed; it is a point at which the static encodi
management.

> **WHY SIX DIRECTIONS, NOT FOUR OR EIGHT**
>
> *Four directions cannot tolerate asymmetric traffic loads and cannot accommodate diagonal travel without inflating re*
> *Eight directions do not tile a plane cleanly under any hex- or square-based cell grid. Six is the lowest direction count*
> *topology and the directional alphabet match exactly — every direction maps to one cell-edge neighbour, with no asy*
> *remainder.*

4.4 Vertical floor stacking

The encoding can be replicated vertically. The airspace is divided into multiple altitude floors, each independently imple
sub-layer structure. Different floors are designated for different vehicle classes, distinguished by characteristics such

operational capability. A heavier vehicle that requires higher cruising speed is assigned to a higher floor; a small deliv
lower one. The encoding within each floor is independent, so the directional separation property holds floor-by-floor.

4.5 Transition sub-layers

Vehicles changing direction during multi-segment flights must move between sub-layers. Within each altitude floor, a d
layer is provided for these manoeuvres. Vehicles in transition operate within this sub-layer, signal their non-directional
direction change before re-entering an operational sub-layer. The transition sub-layer is bounded in altitude and time an
rectional separation of vehicles in operational sub-layers.

4.6 Terrain-adaptive ramp

Ground elevation varies. A vehicle whose assigned sub-layer is defined relative to local ground level must therefore adju
it crosses terrain transitions. The protocol specifies a terrain-adaptive altitude ramp procedure in which the vehicle gra
altitude across a sequence of cells while maintaining its assigned directional sub-layer relative to local ground. The ra
and length, and is integrated with the reservation layer so that the physical-altitude trajectory remains predictable for adj

4.7 Fallback time-slicing

Under conditions in which reliable altitude-based separation cannot be guaranteed — sensor degradation, severe weath
ational regime — the protocol provides a fallback mode in which vehicles from different directions are sequenced throug
alternating temporal phases. This is a degraded mode: throughput is lower than under altitude-based separation, but
operable.

CHAPTER FIVE

§ 5

Hexagonal Grid and 4D Reservation

The second technical layer is the spatial substrate on which the encoding from chapter 4 operates: a hex
four-dimensional reservation primitive.

5.1 Why cells at all

Coordination in a continuous airspace requires every pair of vehicles whose claims might overlap to negotiate boundar
The number of such pairs grows quadratically with active vehicle count and rapidly becomes intractable. Discretising th
treating cell occupancy as the unit of coordination, reduces the per-reservation cost to a constant lookup.

5.2 Why hexagons

Hexagonal cells have six edge-neighbours, all equidistant from the cell's centre. Square cells have four edge-neighbour
bours at different distances, producing path-length asymmetries that inflate diagonal travel cost. The hexagonal topolo
metry. It also maps one-to-one onto the six-direction encoding scheme described in chapter 4.

Hexagonal tiling is well-studied. Discrete global grid systems on hexagonal bases have been formalised in academic
years; standardisation work for geospatial applications is ongoing at the Open Geospatial Consortium. The protocol uses
nal discretisation rather than introducing a new one.

5.3 Cell-level capacity

Each hexagonal cell, on each altitude floor, has a maximum vehicle occupancy. The occupancy limit is a configurable
may vary by cell class (urban, suburban, transit, emergency, exclusion), by direction balance, and by time-of-day envelo
ity is exceeded by a new reservation request triggers a re-routing search: alternative trajectories, alternative depart
floors.

Capacity is not a fixed physical property of the volume. It reflects the policy of the airspace authority for that volume, ar
state distributed to vehicles. The protocol provides the primitive; the values are decided by the regulator or operator res
in question.

5.4 The 4D reservation primitive

A reservation is a four-dimensional tuple: *cell identifier*, *directional sub-layer identifier*, *temporal occupancy window*, a
buffer. When a vehicle submits a flight reservation request specifying origin, destination, departure time, and vehicle cla
a trajectory through the airspace as a sequence of such tuples — one per cell along the path.

Each tuple is checked against the maximum vehicle occupancy for the corresponding cell, sub-layer, and time slot. If
reservation is confirmed and recorded. If any tuple fails verification, the system computes an alternative trajectory a
reservation is a contract between the vehicle and the airspace: the vehicle commits to occupying only the reserved cells

5.5 What a reservation is not

A reservation is not a forecast of the vehicle's full trajectory. The protocol does not predict, and does not require predict
hicle does outside the reservation window. A vehicle can hover, land, change mission, or terminate before the reservat
tion is a contract about cell occupancy, not about the vehicle's broader behaviour.

This bounded scope is essential. Long-horizon trajectory predictions age rapidly under wind changes, battery deviation
A reservation system whose primitives depend on accurate long-horizon predictions has failure modes that are myst
system whose primitive is a scoped cell occupancy has failure modes that are local and inspectable.

5.6 Spatial and temporal buffers

Around the reserved trajectory, the protocol maintains a spatial buffer specifying a minimum longitudinal separation c
buffer extending the reserved occupancy window beyond the nominal traversal time. Both are configurable and may va

traffic density: shorter buffers in high-density areas provide finer-grained capacity management, while longer buffers i eas provide additional safety margin.

5.7 Dynamic adjustment

Real flight rarely matches its plan. Wind, energy state, and mission updates cause vehicles to deviate from reserved t supports dynamic reservation adjustment: when a vehicle's actual progress deviates from its plan beyond a toleranc cell-sub-layer-time tuples are re-computed and the reservation is updated. The vehicle continues to operate against without restarting from scratch.

5.8 Multi-stop flight plans

Many real missions are not single-segment. A delivery vehicle visits multiple drop points; a survey aircraft visits multiple vehicle services multiple pickups. The reservation structure supports multi-stop flight plans composed of independen Conflict resolution affecting one segment does not require re-computation of the entire plan — only the affected seg neighbours.

5.9 Vertical transition zones

Vehicles changing altitude floor — for instance, climbing from a delivery-drone floor to a transit floor — do so within d tion zones at specified cell locations. Each transition zone has a defined radius and exclusive vertical occupancy rule forming a floor transition, the vertical column above and below the transition cell is reserved exclusively to that vehicle f This ensures that vehicles in transition do not collide with vehicles operating in cruise on adjacent floors.

§ 6 · AACP

CHAPTER SIX

§ 6

AACP — AI Aerial Communication Protocol

AACP is the inter-vehicle communication layer of the protocol. It is a language for autonomous and semi-
to declare intent, negotiate conflicts, share observations, and establish trust — built around the principle
optimise but is not permitted to make safety properties depend on its convergence.

6.1 What AACP is

AACP is a communication protocol, not a control system. Its job is to let autonomous vehicles tell each other things and
those things. It is not a controller, it does not issue commands to remote vehicles, and the airspace it operates within
guaranteed by the deterministic substrate described in chapters 4 and 5 rather than by AACP itself.

6.2 The five layers

The protocol describes five communication layers, each a protocol surface rather than an algorithm. The protocol speci
cated and how it gets validated; the intelligence inside each vehicle is the vehicle operator's design space.

LAYER	NAME	WHAT IT DOES
Layer 1	Intent & State Broadcasting	Broadcast current position and intended trajectory to all participants. Vehicles publish current s and predicted future positions with bounded uncertainty envelopes.
Layer 2	Peer-to-Peer Negotiation	AI agents negotiate autonomously to resolve conflict. When intents conflict, the affected vehicle proposals, counter-proposals, agreements — within a bounded time window.
Layer 3	Collective Intelligence	Every vehicle acts as a sensor, contributing to shared awareness. Vehicles share validated obse environment with each other; subsequent vehicles in the area benefit from prior detection.
Layer 4	Interoperability & Trust	All vendors, one language, plus trust scoring. Vehicles maintain bounded reputations of counter how heavily broadcasts are weighted; manipulation-resistant aggregation prevents inflation.
Layer 5	Explainability & Audit	Every decision is logged with reasoning, in a tamper-evident cryptographic hash chain inspecta fact.

A transport layer underneath (5G, LTE-V2X, Wi-Fi 6E, satellite) carries AACP messages but is not part of the protocol itself.

6.3 Five Compliance Levels

Each layer is independently valuable. Vehicles are not required to implement every layer; the protocol defines five com
with operational capability.

LEVEL	LAYERS REQUIRED	DESCRIPTION
Basic	Layer 1 only	Broadcast only — compatible but passive.
Standard	Layers 1–2	Broadcast + negotiate — full participant.
Advanced	Layers 1–3	+ collective sensing — benefits entire network.
Trusted	Layers 1–4	+ trust scoring & interoperability — cross-manufacturer compatible.
Full	Layers 1–5	Complete protocol — maximum capability.

6.4 Four Operating Modes

The protocol degrades gracefully across four operating modes when infrastructure or peer communication is impaired. ty; performance reduces but safety properties do not.

MODE	INFRASTRUCTURE	AACP	PERFORMANCE	USE CASE
Full	ATM active	All layers	Maximum	Normal city operations
Degraded	ATM down	All layers	Good	Infrastructure failure
Peer-Only	No ATM	Layers 1–2	Adequate	Remote areas, emergenc
Standalone	No ATM, no peers	Onboard rules only	Minimal	Single vehicle, lost comr

Graceful degradation flows in one direction: *Full → Degraded → Peer-Only → Standalone*. Each transition is triggered tion (loss of ATM connectivity, loss of peer messages) and is recoverable when the condition reverses.

6.5 The deterministic fallback principle

Every AACP negotiation has a time bound. If two vehicles begin negotiating over a conflict and have not reached agre the negotiation stops, and the conflict is resolved by a deterministic rule that does not involve AI at all. The rule produ output for both vehicles given the same input parameters, allowing the vehicles to compute the resolution indepe communication.

The fallback hierarchy applies an ordered priority chain:

Mission priority class — the higher-priority mission proceeds.

Remaining energy — the vehicle with greater remaining energy yields.

Current heading — used as a deterministic geometric tie-break.

Vehicle identifier — used as a final tie-breaker when all preceding parameters are equal.

Each parameter is exchanged in the negotiation initiation message, meaning the fallback can be computed by either veh already in its possession. No further communication is required to execute the fallback.

> **AUTHOR'S SUMMARY OF THE DESIGN PHILOSOPHY**
>
> *AI does the optimisation. Determinism does the safety. The two are kept architecturally separate. Neither is asked to (This summary paraphrases P2 spec ¶[0029], which states the design philosophy as "AI-Native", "Decentralized-Firs "Safety-Critical: Life-safety is designed to take precedence", "Explainable", and "Gracefully Degradable".)*

6.6 Intent and uncertainty envelopes

State messages broadcast by each vehicle include a current-state portion (position, velocity, status), an intent portion future window), and a prediction portion (predicted future positions, each associated with a spatial confidence envelo tainty value). The uncertainty envelope grows monotonically with prediction horizon and is computed from inputs in sensor quality, vehicle stability, and remaining battery level.

Other vehicles read these envelopes and check for envelope intersection against their own predicted positions. Interse resolution procedure. Bounded uncertainty is the price of usable predictions; the protocol makes the bound expl computable.

6.7 Capability announcement and interoperability

Vehicles entering managed airspace announce their capabilities: AI system type, protocol compliance level, supporte negotiation style preference, sensor capabilities, and operational limitations. Counterparts adapt their communication for example, reducing to a common subset of supported communication layers when interacting with vehicles of lowe interoperation between fleets from different manufacturers and at different protocol levels without requiring lock-step de

6.8 Trust and reputation

The trust layer maintains a numerical score for each counterpart, reflecting accuracy of position reports, reliability of s with negotiated agreements, and quality of shared observations. Trust scores affect the safety buffers a vehicle maintai terpart: lower trust scores result in larger buffers and more conservative negotiation strategies.

Trust scores are aggregated across the network using a manipulation-resistant method — median values rather thar weighted by the trust score of the reporter. Inputs from vehicles sharing an operator with the subject vehicle receive rec ability of an operator to inflate its own vehicles' scores. New vehicles receive an initial score derived from their manufac Scores decay toward neutral over time without interactions, reducing the risk of stale assessments.

6.9 Cross-region trust portability

When a vehicle transitions between airspace regions managed by different authorities, its trust score travels with it in a credential. The destination authority can verify the credential and seat the vehicle at its established score rather than re from a default. This avoids the cold-start problem for vehicles operating across jurisdictions.

6.10 Three-vehicle and multi-vehicle conflicts

Most conflicts involve two vehicles. Some involve three or more. AACP resolves multi-vehicle conflicts via priority-ord the highest-priority vehicle in the conflict cohort maintains its trajectory, and lower-priority vehicles sequentially neg avoids the combinatorial complexity of simultaneous multi-party negotiation while still producing a deterministic and auc

§ 7 · COMPARISON

CHAPTER SEVEN

§ 7

Comparison with Classical ATC

VerSky exists alongside an established air traffic management ecosystem. This chapter situates the prot isting approaches and identifies the regimes where each is suited.

7.1 ICAO commercial aviation procedures

The International Civil Aviation Organization framework, descended from 1944 conventions, is the global standard for m tion. It assumes controlled airspace structured by flight levels, navigated by published airways, supervised by regional municating by voice radio, and serviced by aircraft large enough that each one merits individual attention. Within its dom 10,000 feet, established airways between commercial airports — it works well and is appropriately conservative.

It does not extend below 500 metres. The semicircular separation rule encodes one bit of direction; voice radio assum craft; controller attention bandwidth is bounded; airways do not tile the low-altitude airspace. The system is not brok scope does not include the regime VerSky addresses.

7.2 NASA-style UTM

Unmanned Traffic Management, in its NASA-derived formulation, places a cloud-hosted service layer above the airspac authorisations from the service before launch; the service grants or denies based on a model of current and planned act architecture is centralised: a single (or federated) authority maintains the authoritative state.

UTM is appropriate for current-generation unmanned operations at low density and is being deployed operationally. At t ed for the next decade, however, the centralised approach faces three pressures. Latency: every reservation requires a Bandwidth: every active vehicle continuously publishes telemetry. Compute: the service must verify every reservation a reservation in the relevant volume. The growth rates of these costs are not friendly to million-vehicle regimes.

VerSky is complementary to UTM rather than competitive with it. A UTM service can host the VerSky reservation pri space state to vehicles; the negotiation and fallback layers operate vehicle-to-vehicle rather than via the service. The tains its role; the per-conflict cost moves off the service's critical path.

7.3 See-and-avoid systems

See-and-avoid, in its modern instrumented form (ADS-B, Mode S, FLARM, and a range of vendor systems), provides rea based on broadcast position and motion. Each vehicle is responsible for detecting nearby traffic and avoiding it. There is no reservation primitive, and no priority semantics.

See-and-avoid is essential as a last-line-of-defence and remains so under VerSky. The protocol does not replace it. Wha dination layer above see-and-avoid: reservations to reduce the rate of conflict events, negotiations to resolve them effic tic fallback to handle the cases where the negotiation does not converge. See-and-avoid remains as the layer below slips through.

7.4 A combined view

PROPERTY	ICAO	UTM	SEE-AND-AVOID	VERSKY
Operational regime	Manned, > 3,000 ft	Unmanned, low-density	Mixed, last-line	Unmann
Direction encoding	2-way (semicircular)	None native	None	6-way (h
Coordination cost	Linear (controllers)	Quadratic (cloud)	Local (vehicle)	Constant
Safety guarantee source	Controller	Authorisation service	Avoidance logic	Encoding
AI dependence	None	Optional	Optional	Optimisa

PROPERTY	ICAO	UTM	SEE-AND-AVOID	VERSKY
Infrastructure cost	High (towers, radar)	Medium (cloud)	Low (avionics)	Low (dig

7.5 Where VerSky fits

The protocol is designed for the regime where ICAO does not extend, UTM faces scaling pressure, and see-and-avoid
It is intended to compose with all three rather than replace any of them: ICAO continues to govern controlled airspac
UTM hosts the reservation primitive and distributes airspace state; see-and-avoid catches the residual; and VerSky p
layer that makes the regime operable at the projected scale.

7.6 Open questions for adopters

Adoption of the protocol raises a small number of questions that regulatory and operational stakeholders will need to adc

- Which authority sets the encoding function for a given airspace region — the national aviation regulator, the metropo industry consortium?
- Which mission priority classes are recognised for fallback resolution, and how are they certified?
- What initial trust score is assigned to vehicles operating under a given manufacturer's certification, and how is the ce
- How is cell-level capacity set for cells overlying mixed-use airspace (urban corridors above transit routes, for instanc
- What credential format and signature standard governs cross-region trust portability?

Answers to these questions are not embedded in the protocol; they are the work of standards bodies and regulators. T
interfaces.

§ 8 · LICENSE

CHAPTER EIGHT

§ 8

License Framework and Engagement

VerSky is offered for adoption under a framework intended to make compliant implementation accessib
size while preserving the integrity of the protocol and the position of the underlying patent rights.

8.1 Reference implementation

A reference implementation of the protocol — message parsers, reservation logic, fallback rule executors — is planne
phase. Licensing terms are to be determined and will be published ahead of release. The current planning window tar
USPTO publication of the patent applications, on or after 27 August 2027.

8.2 Commercial implementation licensing

Commercial implementations that do not derive from the reference implementation, including in-house engines, novel o
etary extensions, are governed by a separate licensing agreement with the patent holder. The licensing framework is in
and predictable:

- Standard commercial license available on consistent commercial terms, with public disclosure of headline economics
- Reduced-rate licensing tier for academic research, public-interest deployments, and pre-revenue operators.
- Free implementation rights granted unconditionally for use within the reference implementation, as above.
- No restriction on the AI components, optimisation logic, or vendor-specific extensions a licensee builds on top of a c
implementation; the licensed surface is the protocol.

8.3 Standards body engagement

The protocol is intended for eventual contribution to one or more relevant standards processes. Candidate bodies incl
mittee on unmanned aircraft systems, the ICAO RPAS Panel for international harmonisation, and the ITU-R aeronautica
spectrum requirements. Engagement timing is sequenced around the patent publication date to preserve the priority p
dards adoption window.

8.4 Compatibility commitment

Any party adopting the protocol can rely on the following:

- The encoding function, cell topology, reservation primitive, negotiation message format, and fallback rule hierarchy v
changed in a backward-incompatible way after the version 1.0 specification is published.
- Future protocol versions will provide explicit migration paths and may operate concurrently with older versions throu
announcement mechanism.
- The licensing framework will be applied consistently across equivalent operators in the same regime.

8.5 How to engage

Specific engagement channels are listed on the contact page at *versky.org/contact*. The principal categories are licensi
laboration, standards-body coordination, press inquiry, and general correspondence. Each category routes to the appro

Direct correspondence with the inventor remains a feasible channel at this stage of the project. As adoption scal
frastructure will scale with it; the principles above will not.

§ 9 · PATENT STATUS

CHAPTER NINE

§ 9

Patent Status

FIELD	PATENT 1	PATENT 2
Title	Altitude-Direction Encoding Protocol for Air Traffic Management with Hexagonal Grid and Intersection Separation	AI Aerial Communication Protocol wit Negotiation and Deterministic Fallbac
Application No.	19/551,620	19/551,624
Filing date	27 February 2026	27 February 2026
Confirmation No.	6812	4598
Office	USPTO	USPTO
Entity status	Micro entity	Micro entity
Representation	Pro se	Pro se
Expected publication	On or about 27 August 2027	On or about 27 August 2027
PCT deadline	27 February 2027	27 February 2027

Status updates, prosecution events, and any continuation filings will be reflected on the trust and licensing page at plications remain pending and are subject to USPTO examination.

APPENDIX A · GLOSSARY

APPENDIX A

§ A

Glossary

Terms defined here have the meanings stated for the purposes of this document. Where a term has a sta
ation or computing, the definition is consistent with that meaning.

AACP

AI Aerial Communication Protocol. The inter-vehicle communication layer of VerSky, comprising intent broadcasting, peer
tributed sensing, trust, and decision logging.

Altitude floor

One of a series of vertically stacked altitude bands within the airspace volume, each independently implementing the direction
accommodating a different vehicle class.

Altitude sub-layer

A directional altitude band within a floor. Each sub-layer is assigned a unique travel direction; vehicles operating within the s
within its bounds and travel in the assigned direction.

Capability announcement

A message broadcast by a vehicle entering managed airspace, declaring its AI system type, protocol compliance level, supp
ers, sensors, and operational limitations.

Cell

A hexagonal volume of airspace at a given altitude floor, identified by a unique spatial address, and serving as the unit of coo
vation system.

Deterministic fallback

A conflict resolution method that produces an identical resolution output on both vehicles given the same input parameters,
munication once negotiation parameters have been exchanged.

Direction vector

One of at least six non-parallel directions in a hexagonal pattern, each separated from adjacent directions by approximately s
altitude sub-layer is assigned.

Intent envelope

A spatial region around a vehicle's predicted future position, sized by an uncertainty value, used to detect potential conflicts
resolution.

Mission priority class

A categorical declaration of mission type used to order conflict resolution. The protocol defines five classes in descen
Passenger, Cargo, Commercial, Recreation. Higher classes proceed; lower classes yield.

Compliance level

The set of AACP layers a vehicle implements, defining its protocol capability. Five levels are defined: Basic (Layer 1 only
Advanced (Layers 1–3), Trusted (Layers 1–4), and Full (Layers 1–5).

Operating mode

One of four protocol states reflecting available infrastructure and peer communication: Full (ATM active, all layers), Degrade
Peer-Only (no ATM, Layers 1–2), Standalone (no ATM, no peers, onboard rules only). All modes maintain safety; performa
context.

Negotiation initiation message

The first message in a peer-to-peer conflict negotiation, containing all parameters needed for either vehicle to compute the d
gotiation fails.

Reservation

A four-dimensional tuple — cell, directional sub-layer, temporal occupancy window, spatial buffer — representing a vehicle's
portion of the airspace.

Spatial buffer

The minimum longitudinal separation distance maintained around a reserved trajectory, configurable per cell based on local c

Temporal buffer

The additional time appended to a reserved occupancy window beyond nominal traversal time, providing margin for actual veh

Trust score

A numerical reputation maintained for each vehicle, derived from observed accuracy of position reports, intent reliability, ag
observation quality, used to size safety buffers.

Transition sub-layer

A designated altitude band within each floor for vehicles in the process of changing direction or floor; transitioning vehicles s
state and complete their manoeuvre before re-entering an operational sub-layer.

Vertical transition zone

A cell location designated for vehicles changing altitude floor, with a defined radius and exclusive vertical occupancy rules dur

APPENDIX B · REFERENCES

APPENDIX B

§ B

References and Standards

Citations supporting the technical claims and contextual statements in this whitepaper. Standards bodi listed by formal designation; academic references are listed by first author and year.

B.1 Standards bodies and frameworks

ICAO — International Civil Aviation Organization. Annex 11 (Air Traffic Services); RPAS Panel publications on remotely integration.

ASTM F38 — Committee on Unmanned Aircraft Systems. Standards F3196, F3322, F3198 and related publications or requirements and detect-and-avoid systems.

FAA — Federal Aviation Administration. UAS Traffic Management (UTM) Concept of Operations v2.0 (2020). 14 CFR unmanned aircraft systems.

NASA — National Aeronautics and Space Administration. UTM Project publications, including NASA/TM documents airspace coordination architectures.

ITU-R — Radiocommunication Sector. Aeronautical mobile (R) service allocations relevant to UAS command, control,

Open Geospatial Consortium (OGC) — Discrete Global Grid Systems (DGGS) Abstract Specification; standardisation systems for geospatial applications.

EUROCONTROL / EASA — U-space framework for European UAS integration; SORA methodology for specific catego

B.2 Academic and technical literature

Sahr, K.; White, D.; Kimerling, A. J. (2003). "Geodesic discrete global grid systems." *Cartography and Geographic Inf*

Shukla, A.; Karki, H. (2016). "Application of robotics in onshore oil and gas industry — A review." *Robotics and Auton*

Kopardekar, P. et al. (2016). "Unmanned aircraft system traffic management (UTM) concept of operations." NASA Te

Sacharny, D.; Henderson, T. C. (2019). "A lane-based approach for large-scale strategic conflict management for UA *2019 International Conference on Unmanned Aircraft Systems*.

Cohen, M. C. et al. (2021). "Urban Air Mobility: History, ecosystem, market potential, and challenges." *IEEE Transacti Transportation Systems*, 22(9).

Lappas, V.; Zoumponos, G. (2022). "A robust U-space architecture for unmanned aircraft systems." *Aerospace*, 9(5).

B.3 Public-domain prior art reviewed

The patent applications cited in chapter 9 include a complete information disclosure statement listing prior art reviewed Public-facing summaries of that disclosure are available at *versky.org/trust*. Categories of prior art reviewed include US UAV traffic management, published applications in equivalent fields, foreign patent grants from CNIPA, KIPO, JPO, preprints.

B.4 VerSky publications

VerSky Protocol Page — *versky.org/protocol*.

VerSky Blog, Protocol Deep-Dive series — *versky.org/blog*. First arc: altitude-as-information; hexagonal cells and ca deterministic fallback.

About and Inventor Profile — *versky.org/about*.

Press Kit and Fact Sheet — *versky.org/press*.

BACK MATTER

Colophon

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> *19/551,624.*

DOCUMENT

VerSky Protocol Whitepaper v1.0
versky.org/whitepaper

FILINGS

USPTO 19/551,620 + 19/551,624
Filed 27 February 2026

AUTHOR

Jittapol Prukpatarakul
hello@versky.org

NOTICE

Subject to pending US patent applications. Reference
terms are to be determined and will be published ahe