ATMACA

Air Traffic Management
and Communication Over ATN/IPS
Grant n° 101167070

ATMACA Flight Trial: Validating IP-Based Air-Ground Communication in Real Operations

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Concept Leader – Capt.Sergun Özmen, THY

Online, 06.10.2026

SUPPORTED BY sesar JOINT UNDERTAKING

Co-funded by the European Union

ATMACA

WEBINAR PROGRAMME AND SPEAKERS

- Introduction to the ATMACA concept and project



Asst. Prof. Fulya Aybek Cetek

- & Flight trial results



Captain Pilot Sergun Özmen, PhD

- Q&A – 15 min

ATMACA Webinar series;
Webinar 1: 5 February 2026
Webinar 2: 6 October 2026
Webinar 3: on 22 October 2026

Consortium and Partners Roles

ESKİŞEHİR TEKNİK ÜNİVERSİTESİ
ESKİŞEHİR TECHNICAL UNIVERSITY

✓ Project Management, DEC, ATM knowledge

deepblue CONSULTING & RESEARCH

✓ HMI Design and Development

saerco

✓ Integration and Validation

DE MONTFORT UNIVERSITY LEICESTER

✓ Protocol Design, Implementation, and Testing

TURKISH AIRLINES

✓ Protocol Design, Implementation, and Testing

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

ENAC

✓ Concept Design and Definition of Requirements, GRO

POLITÉCNICA | UNIVERSIDAD POLITÉCNICA DE MADRID

✓ Development of ATS

The Challenge That Started ATMACA

Future ATM operations require a communication infrastructure that is more flexible, resilient and IP-native.

THE CHALLENGE

FRAGMENTED COMMUNICATION ENVIRONMENT

Legacy and heterogeneous communication technologies

LIMITED MOBILITY SUPPORT

Need for seamless communication continuity across changing networks and operational domains

INCREASING CONNECTIVITY DEMANDS

Growing number of digital ATM applications and data exchanges

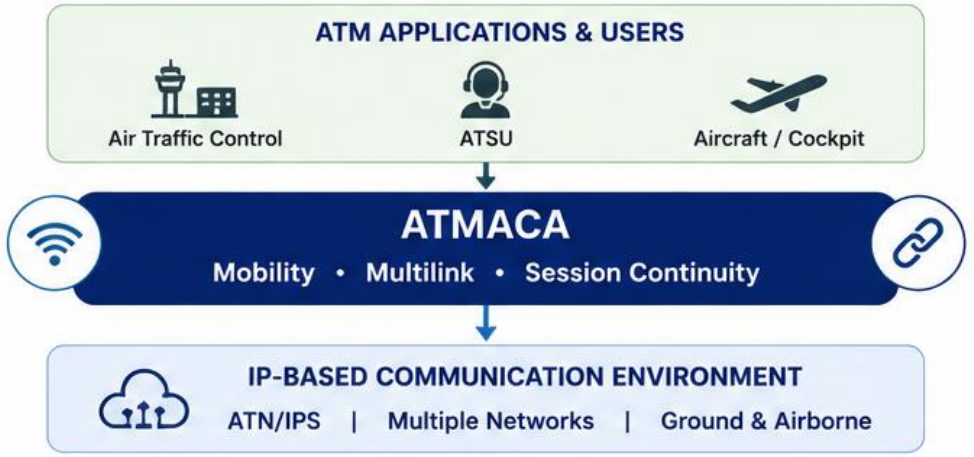
RESILIENCE & AVAILABILITY

Need to exploit multiple communication links without disrupting operational services

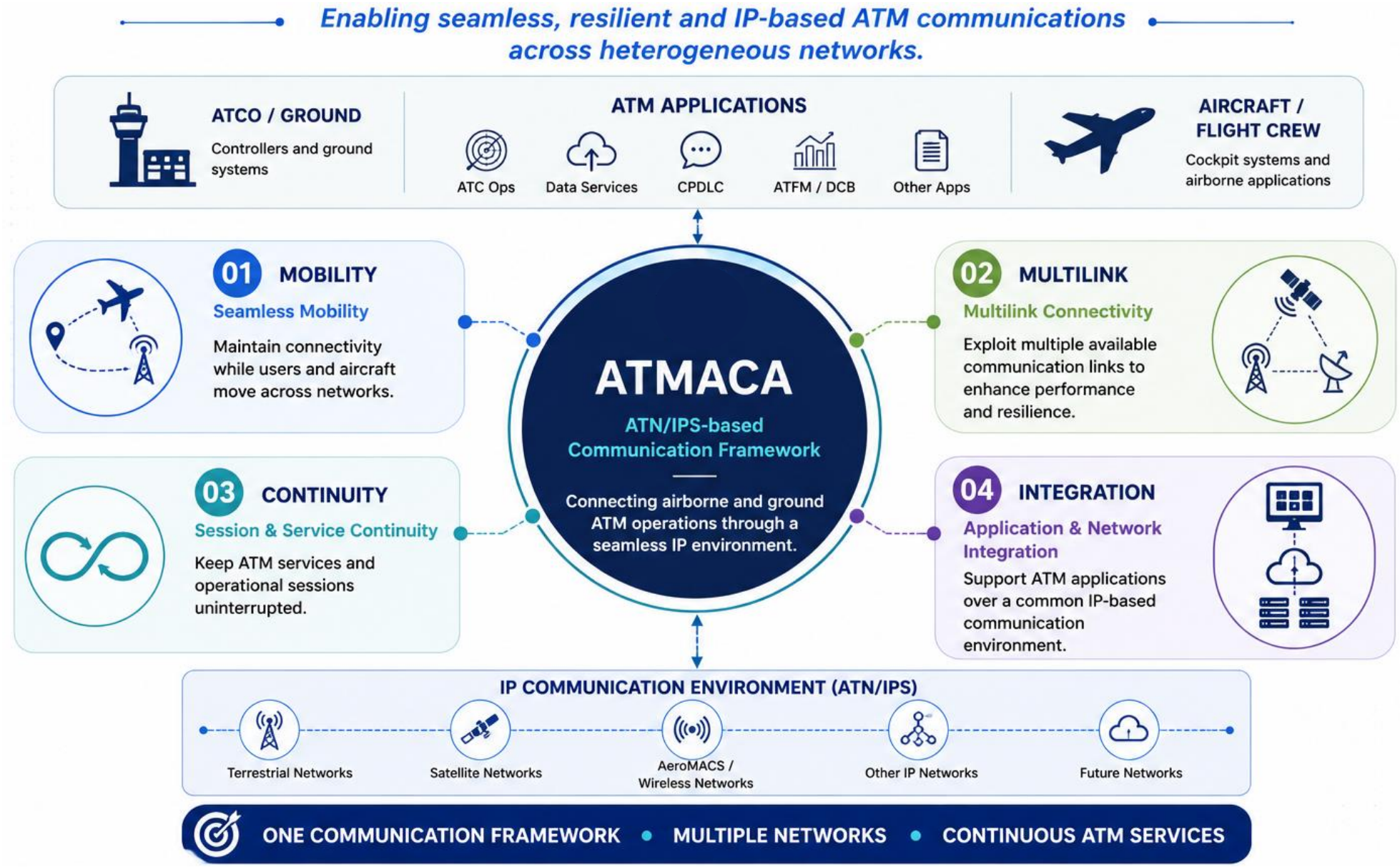
THE ATMACA RESEARCH QUESTION

"Can ATM communications evolve towards an IP-based environment while maintaining seamless service continuity, mobility and multilink resilience?"

ATMACA was designed to explore this question.



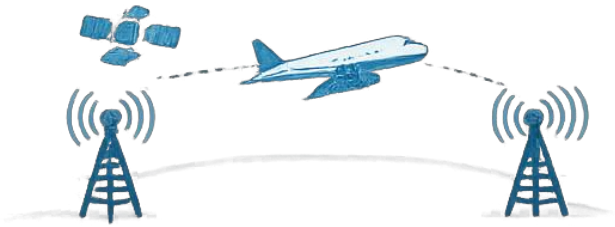
ATMACA Project Journey Overview



Beyond Handover: The Mobility Vision of ATMACA

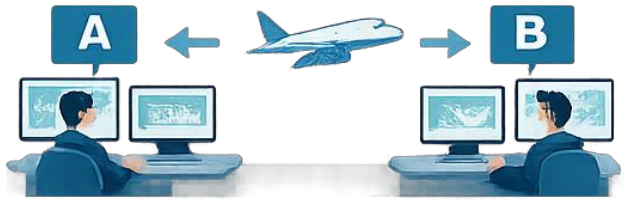
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Terminal mobility: Continuity of an active communication session as the aircraft changes its network attachment.



Terminal Mobility

Session mobility: Continuity of an active communication session as it transfers between ground system endpoints.



Session Mobility

User mobility: Continuity of an active user session as the user moves between workstations or roles.



User Mobility

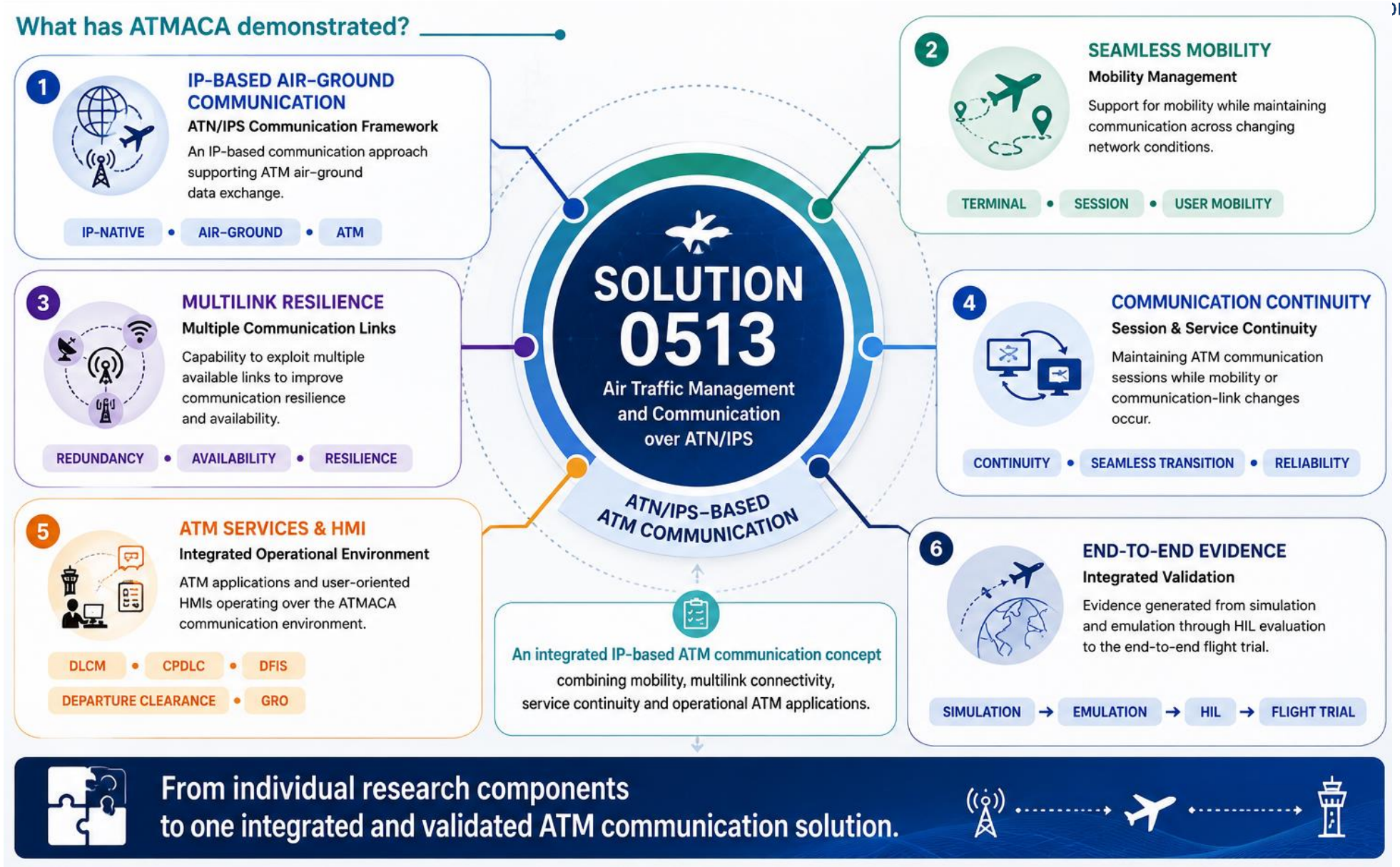
Service mobility: Continuity of an active communication session as the service instance moves to another server or node.



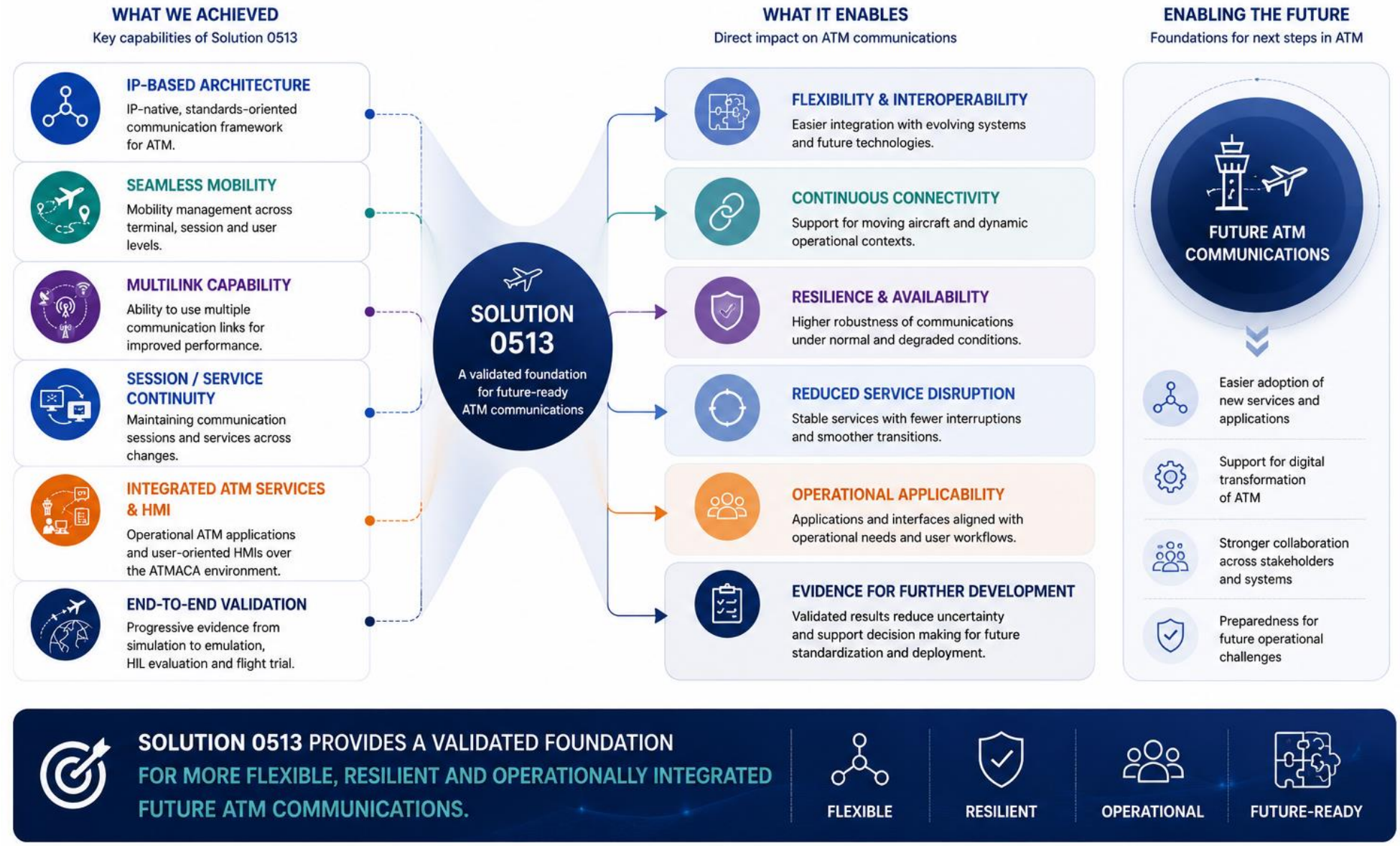
Service Mobility

Final Technical Achievements

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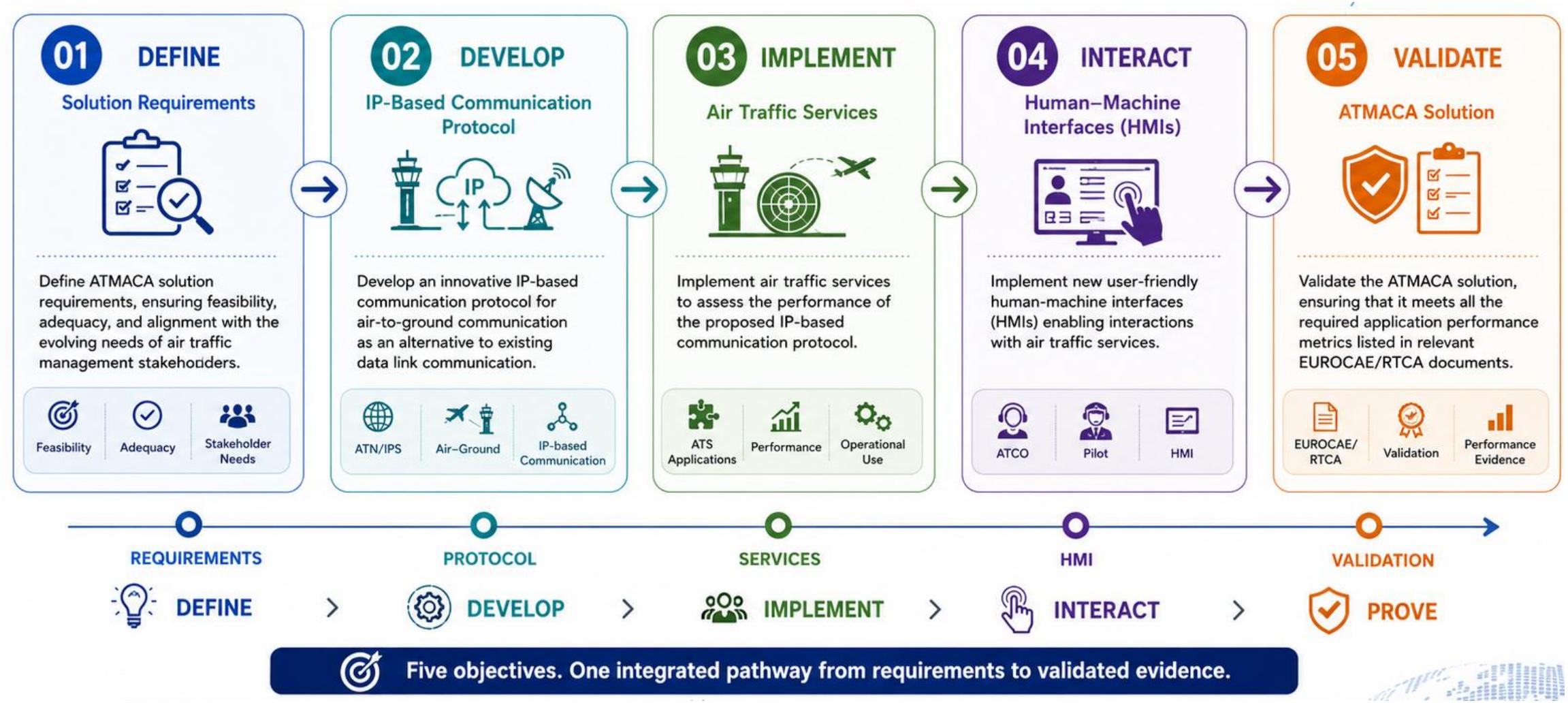


Final Technical Achievements



ATMACA Project Journey Overview

Five objectives shaped the ATMACA journey from requirements to validated evidence.



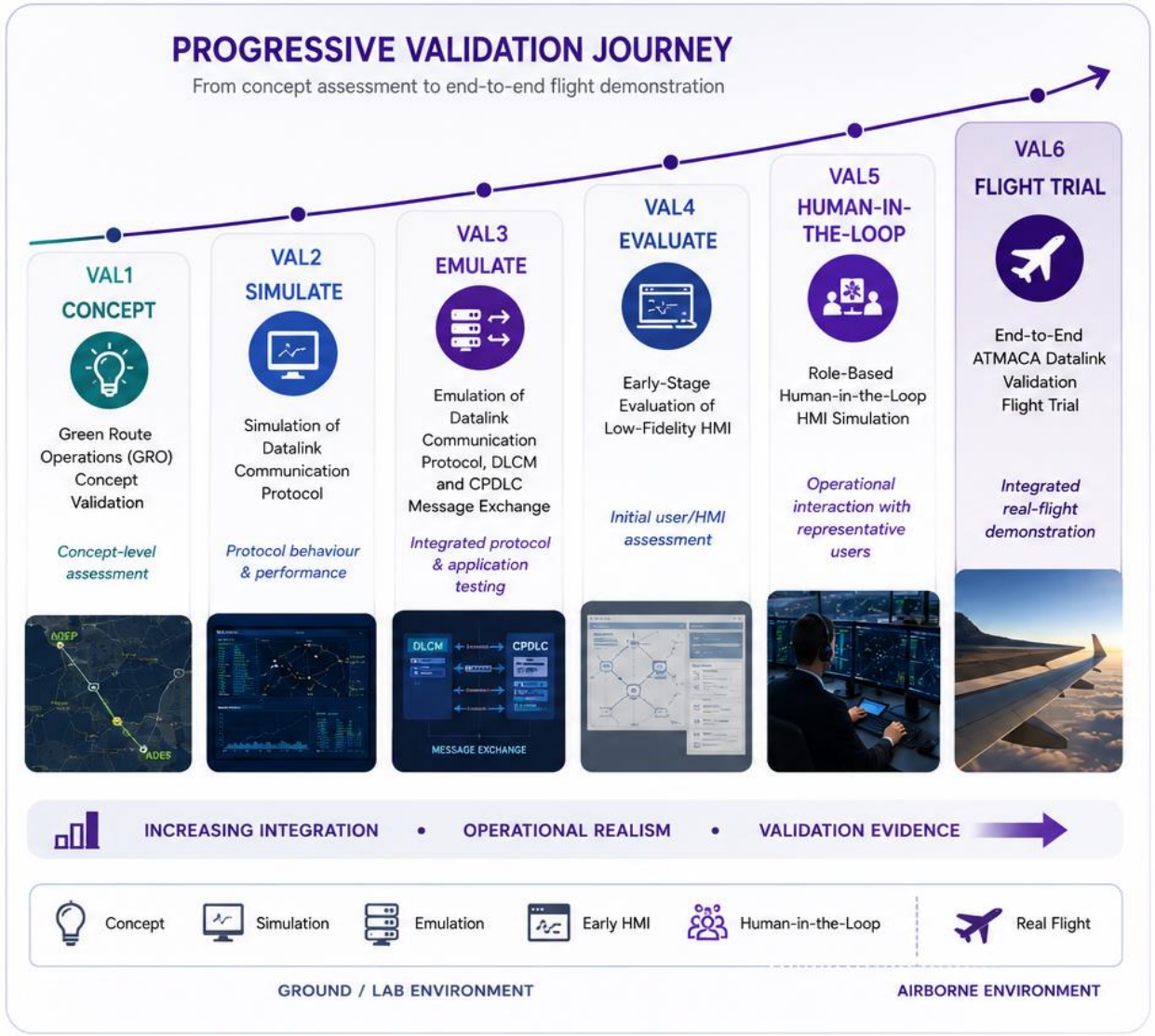
ATMACA Solution Development Path

ATMACA

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01 DEFINE — 02 DEVELOP — 03 ENABLE — 04 INTERACT — 05 INTEGRATE — 06 VALIDATE & DEMONSTRATE

FINAL MATURITY STATUS
TRL 2 ACHIEVED



STEP 06

VALIDATE & DEMONSTRATE

Progressive Validation & Consolidated Evidence

ATMACA followed a progressive validation strategy, moving from concept and protocol assessment towards integrated human-in-the-loop evaluation and, ultimately, an end-to-end flight trial.

VALIDATE
Progressively assess the solution through technical and operational validation activities.

DEMONSTRATE
Demonstrate the integrated ATMACA solution, culminating in the successful flight trial.

CONSOLIDATE
Bring together the validation evidence, results and lessons learned to support the final maturity assessment.

KEY VALIDATION OUTPUTS / DELIVERABLES

D6.1. Exploratory Research Plan (ERP)
D6.2. Exploratory Research Report (ERR)
D6.3. Economic Evaluation (ECO-EVAL)

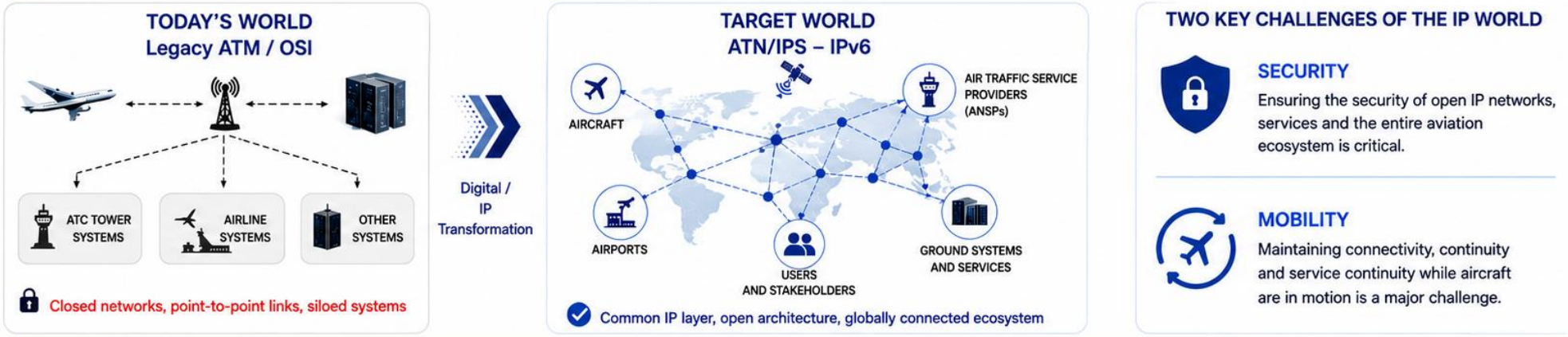
OUTCOME
The six validation activities generated complementary evidence across concept, technology, HMI, operational interaction and end-to-end airborne demonstration.

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Can safety-critical ATM communication remain continuous while an aircraft moves across heterogeneous networks and operational domains?

THE FUTURE OF ATM – IP-BASED TRANSFORMATION AND NEW CHALLENGES

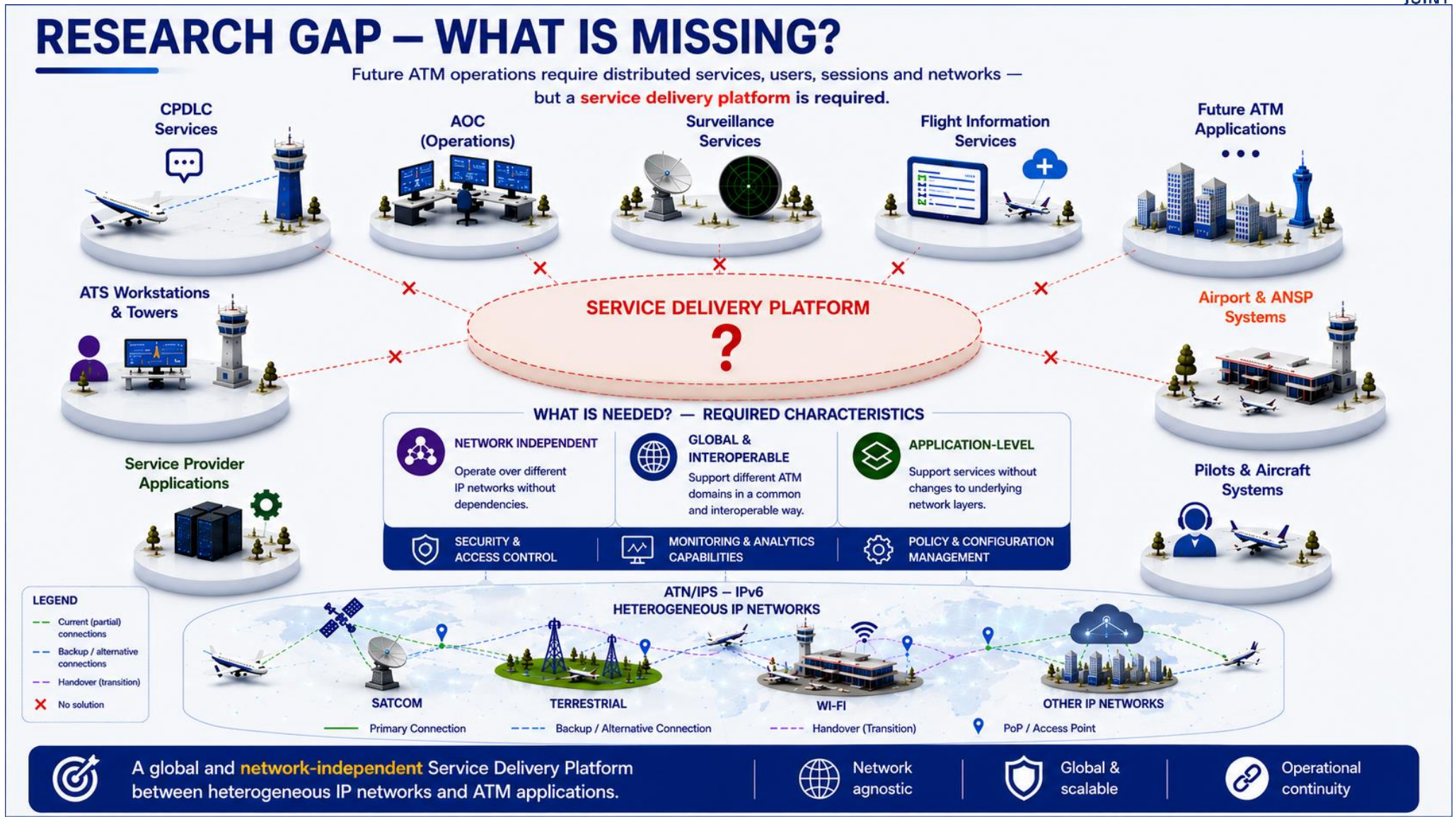
The transition from legacy systems to a global and connected IP-based ATM ecosystem creates new integration, mobility and continuity challenges.







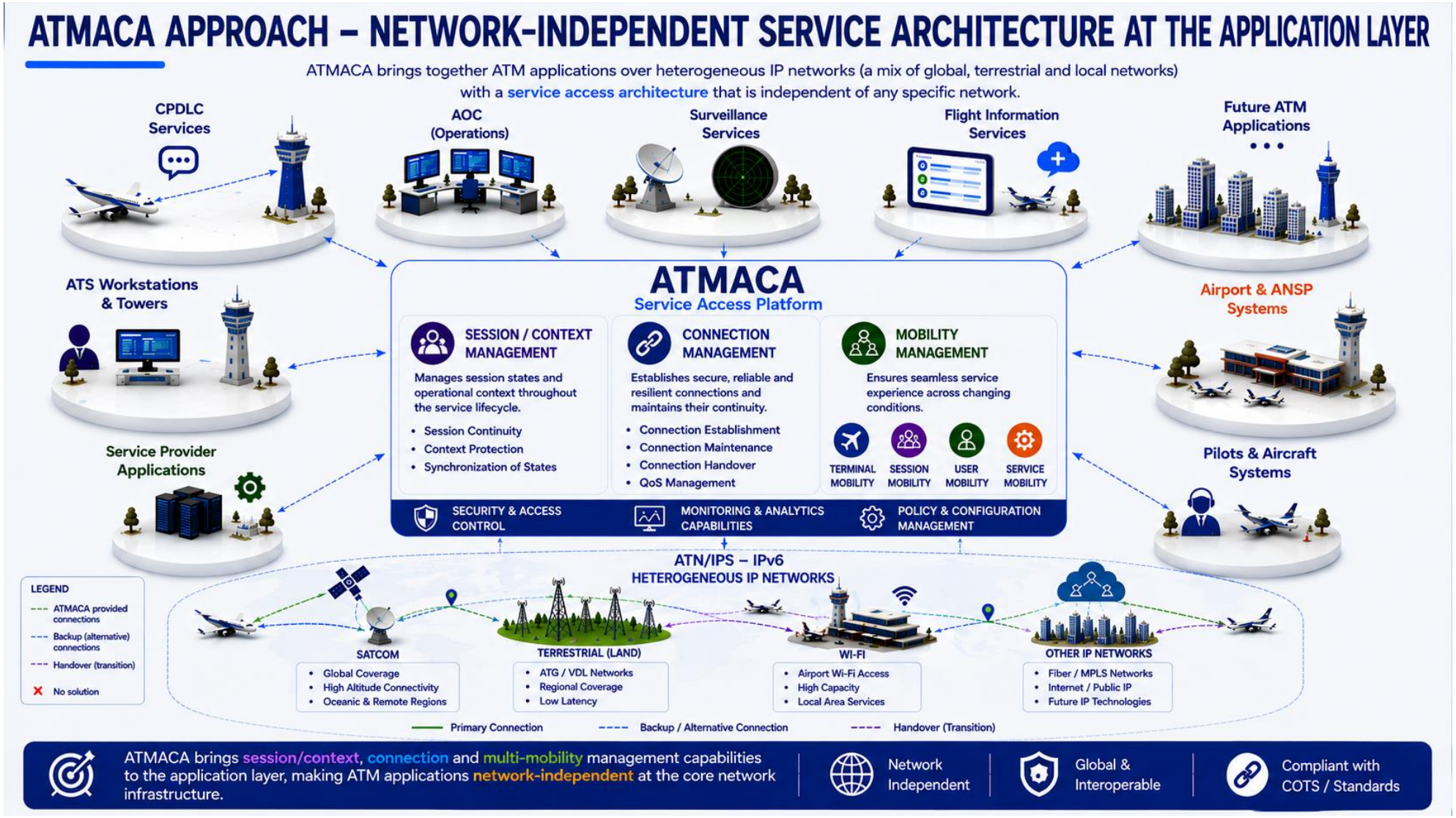
As the aviation world transitions to IP-based environments, the lack of integration, mobility and security across independent ATM service domains threatens operational continuity and the future of the ATM ecosystem.


RESEARCH GAP – WHAT IS MISSING?
Future ATM operations require distributed services, users, sessions and networks —
but a service delivery platform is required.
CPDLC Services
AOC (Operations)
Surveillance Services
Flight Information Services
Future ATM Applications
ATS Workstations & Towers
SERVICE DELIVERY PLATFORM
?
Airport & ANSP Systems
WHAT IS NEEDED? — REQUIRED CHARACTERISTICS
NETWORK INDEPENDENT
Operate over different IP networks without dependencies.
GLOBAL & INTEROPERABLE
Support different ATM domains in a common and interoperable way.
APPLICATION-LEVEL
Support services without changes to underlying network layers.
Service Provider Applications
Pilots & Aircraft Systems
SECURITY & ACCESS CONTROL
MONITORING & ANALYTICS CAPABILITIES
POLICY & CONFIGURATION MANAGEMENT
LEGEND
Current (partial) connections
Backup / alternative connections
Handover (transition)
No solution
ATN/IPS – IPv6
HETEROGENEOUS IP NETWORKS
SATCOM
TERRESTRIAL
WI-FI
OTHER IP NETWORKS
Primary Connection
Backup / Alternative Connection
Handover (Transition)
PoP / Access Point
A global and network-independent Service Delivery Platform between heterogeneous IP networks and ATM applications.
Network agnostic
Global & scalable
Operational continuity

An Integrated Mobility Management Framework for Future Air Traffic Management

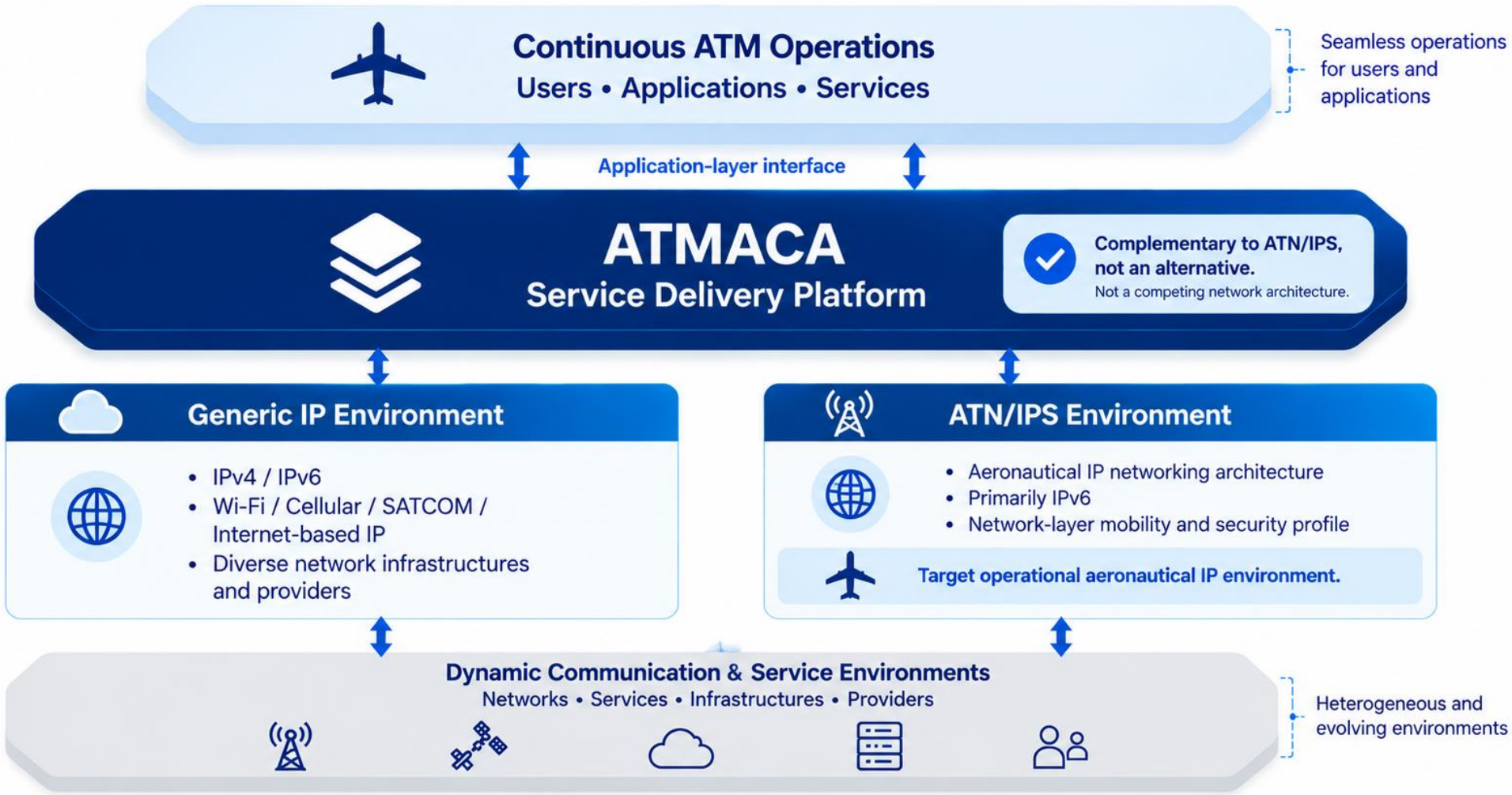
to maintain operational communication continuity across heterogeneous aeronautical communication networks. Rather than focusing solely on network connectivity, the framework preserves communication sessions, operational context, and service availability during mobility events.

ATMACA


ATMACA APPROACH – NETWORK-INDEPENDENT SERVICE ARCHITECTURE AT THE APPLICATION LAYER
ATMACA brings together ATM applications over heterogeneous IP networks (a mix of global, terrestrial and local networks)
with a service access architecture that is independent of any specific network.
CPDLC Services
AOC (Operations)
Surveillance Services
Flight Information Services
Future ATM Applications
ATS Workstations & Towers
Airport & ANSP Systems
Service Provider Applications
Pilots & Aircraft Systems
ATMACA
Service Access Platform
SESSION / CONTEXT MANAGEMENT
Manages session states and operational context throughout the service lifecycle.
Session Continuity
Context Protection
Synchronization of States
CONNECTION MANAGEMENT
Establishes secure, reliable and resilient connections and maintains their continuity.
Connection Establishment
Connection Maintenance
Connection Handover
QoS Management
MOBILITY MANAGEMENT
Ensures seamless service experience across changing conditions.
TERMINAL MOBILITY
SESSION MOBILITY
USER MOBILITY
SERVICE MOBILITY
SECURITY & ACCESS CONTROL
MONITORING & ANALYTICS CAPABILITIES
POLICY & CONFIGURATION MANAGEMENT
ATN/IPS – IPv6
HETEROGENEOUS IP NETWORKS
LEGEND
ATMACA provided connections
Backup (alternative) connections
Handover (transition)
No solution
SATCOM
Global Coverage
High Altitude Connectivity
Oceanic & Remote Regions
TERRESTRIAL (LAND)
ATG / VDL Networks
Regional Coverage
Low Latency
WI-FI
Airport Wi-Fi Access
High Capacity
Local Area Services
OTHER IP NETWORKS
Fiber / MPLS Networks
Internet / Public IP
Future IP Technologies
Primary Connection
Backup / Alternative Connection
Handover (Transition)
ATMACA brings session/context, connection and multi-mobility management capabilities to the application layer, making ATM applications network-independent at the core network infrastructure.
Network Independent
Global & Interoperable
Compliant with COTS / Standards

ATMACA Positioning

ATMACA is a complementary application-layer platform that operates over both Generic IP and ATN/IPS environments.



WHY REAL-FLIGHT VALIDATION?

- Heterogeneous networks create changing connectivity conditions.
- Network connectivity alone does not prove operational continuity.
- Real-flight validation is required to assess session/context continuity under realistic conditions.

The objective is not to validate network connectivity—but to validate operational communication continuity.

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ATMACA VALIDATION — FROM CONCEPT TO REAL OPERATIONS

ATMACA is progressively validated from **model** to **human**, to **real software**, and finally in **real-flight operations.**

1 OMNET++ SIMULATION

Model & Protocol Level



- Hierarchical ATN/IPS environment model (80 aircraft, 3 airports, 3 areas)
- CPDLC over heterogeneous networks (SATCOM, HFDL, Wi-Fi, IP)
- Mobility scenarios & protocol behaviour analysis
- Performance evaluation vs PMIPv6 baseline

OUTPUT

Design validated at model level, expected performance and behaviour obtained.

2 HUMAN-IN-THE-LOOP SIMULATION (HIL)

Operational & Human Interaction Level



- Operational scenarios with pilot & ATCo participants
- Human-system interaction & HMI evaluation
- Operational feasibility assessment
- Workflows, proceduires & roles validated

OUTPUT

Operational concepts and HMI validated with real users.

3 EMULATION

Real Software / Distributed System Level



- Distributed environment with real ATMACA components
- Real software stack & message exchange
- Interoperability testing (ATN/IPS – IPv6)
- Sessions/context, connection & mobility behaviour validation

OUTPUT

Solution validated with real software in a controlled environment.

4 REAL FLIGHT TRIALS

Real Operational Environment



13 & 15 MAY 2026	IST ↔ FCO	Phase 1A / 1B	Sector & inter-area transition exposure
18 MAY 2026	IST → MAD	Phase 2A	Gate-to-gate • Private VPN
18 MAY 2026	MAD → IST	Phase 2B	Gate-to-gate • Public IP

SHADOW OPERATION (NON-INTRUSIVE)

ATMACA messages ran in parallel; operational ATC voice remained authoritative.

OUTPUT

Real-flight validation of end-to-end CPDLC, session/context management and mobility.

Operational validation through real flight trials is essential to assess communication continuity under realistic conditions.

TVAL.06.1

End-to-End ATMACA Datalink Validation Flight Trial

Real-flight proof-of-concept validation of mobility, session/context management and CPDLC performance



TVAL06 – Flight Trial Campaign

Executed in commercial flight conditions under non-intrusive shadow operation

13 & 15 MAY 2026
IST ↔ FCO

Phase 1A / 1B

Sector and inter-area transition exposure

18 MAY 2026
IST → MAD

Phase 2A

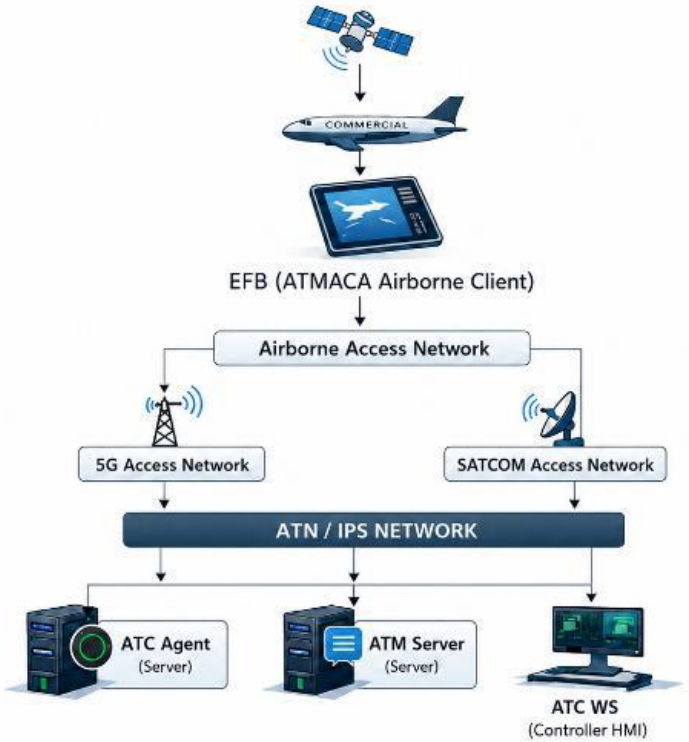
Gate-to-gate • Private VPN

18 MAY 2026
MAD → IST

Phase 2B

Gate-to-gate • Public IP

ACCESS / NETWORK SETUP



Standalone EFB ↔ ATMACA network ↔ ATM Server / ATC Agent ↔ ATC workstation

ATMACA Positioning in the Flight Trial Network Environment

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Positioning of the flight trial environment and future aeronautical deployment

Capability	Generic IP Stack	ATN/IPS	ATMACA
Main role	Generic IP connectivity	Aeronautical IP networking architecture	**Application-layer service delivery**
IP basis	IPv4 / IPv6	Primarily IPv6	**Runs over IPv4 or IPv6**
Mobility	Optional / external mechanisms	MIPv6 / FMIPv6 / PMIPv6 / NEMO (network layer)	**Application-layer mobility**
Continuity target	IP connectivity	IP / network reachability	**Session + context + connection continuity**
Context management	No	No application-context management	**Core capability**
Connection management	Transport / network level	Network-oriented	**Application / service-oriented**
Security	Generic TLS / IPsec etc.	IPsec + IKEv2 profile	Application/service-layer mechanisms; can operate over secured ATN/IPS
Flight trial relevance	Underlying generic IPv4 connectivity used in the trial	Not used for mobility in the trial; intended aeronautical deployment environment	**Mobility and session continuity validated over generic IPv4**

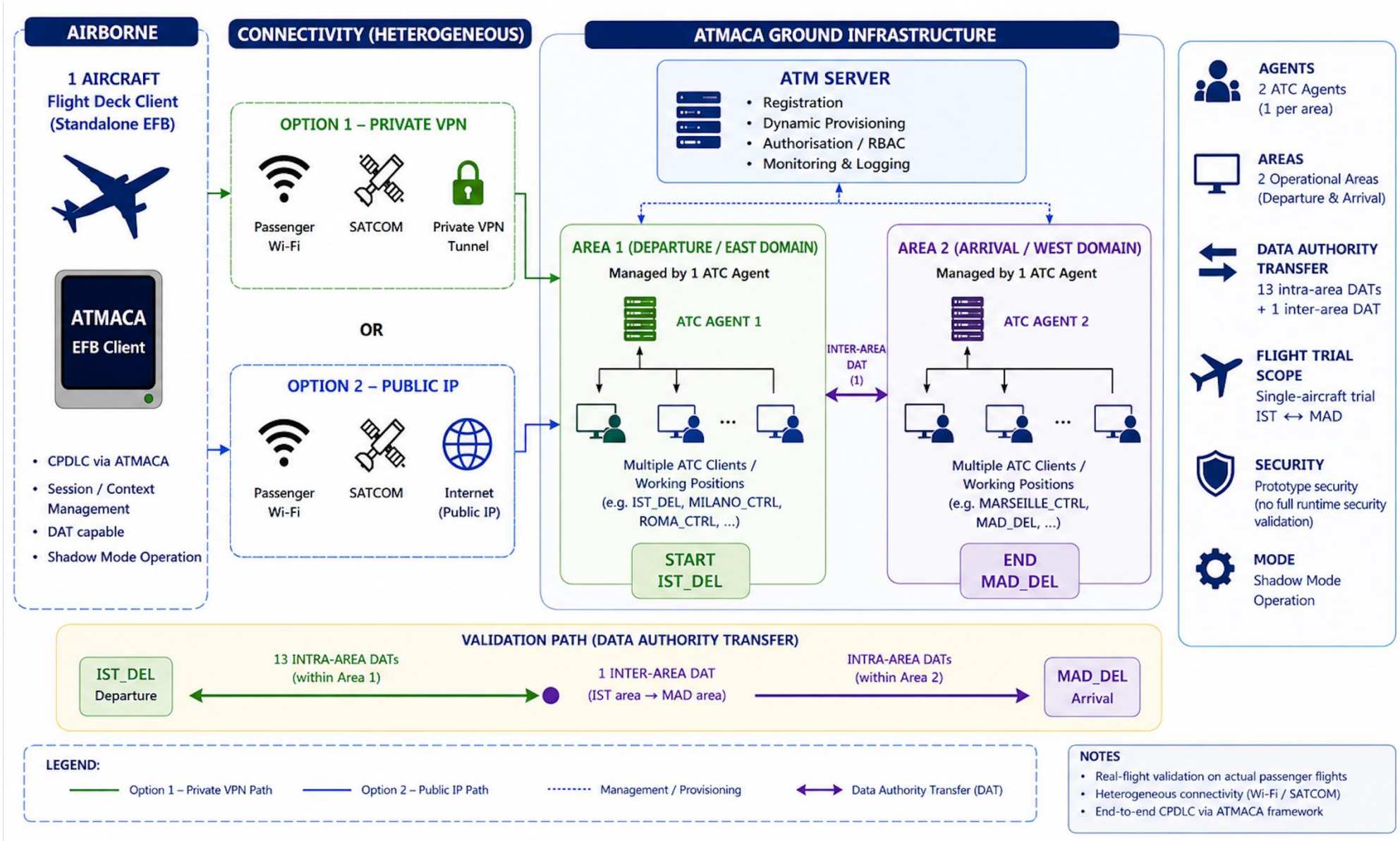
Flight Trial Fact
ATMACA flight trials were conducted over generic IPv4-based connectivity because no ATN/IPS air-ground link was available in the trial environment.

Target Network Environment
ATMACA is network-agnostic, but its intended aeronautical deployment environment is ATN/IPS.

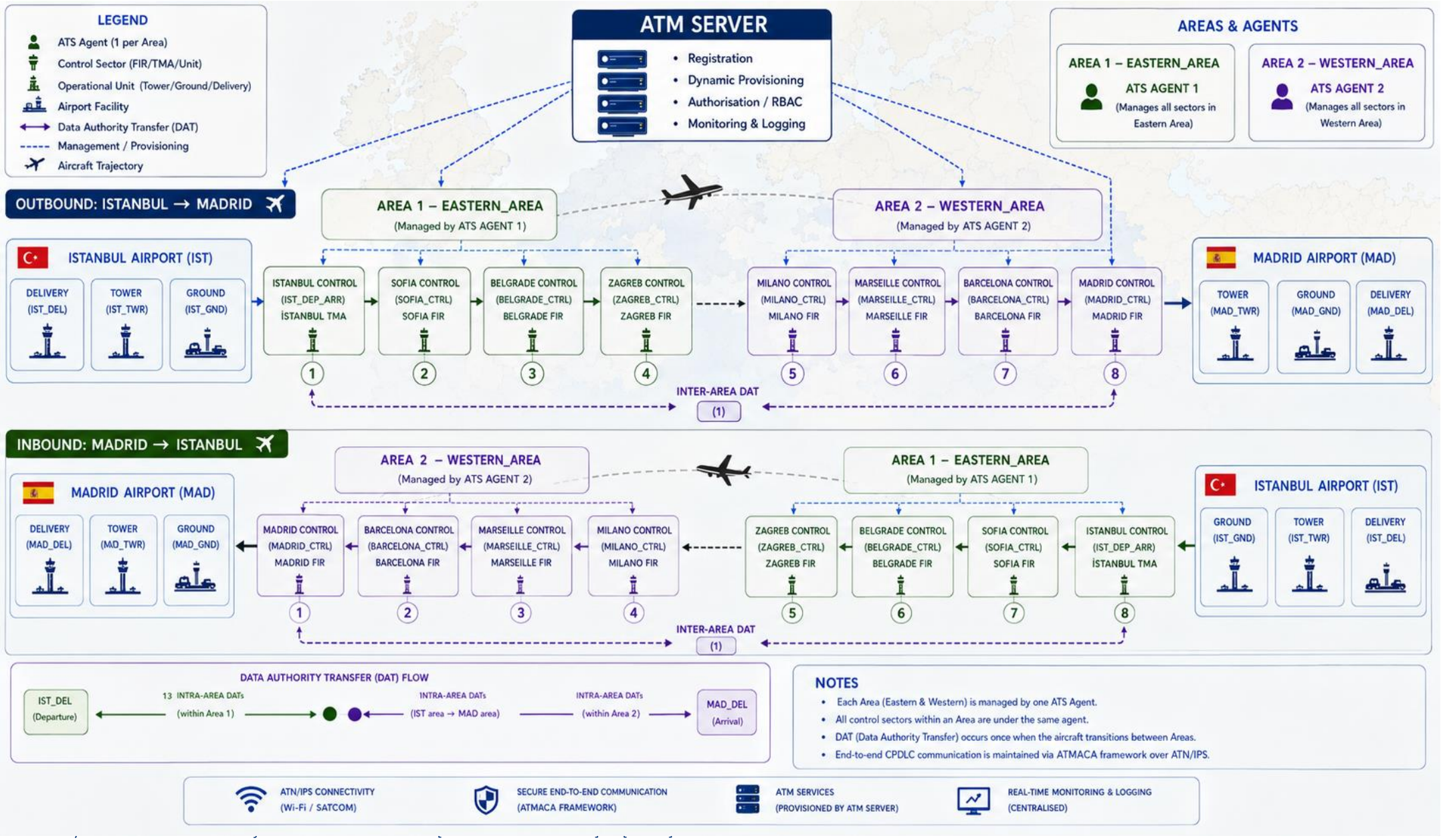
Simulation Benchmark
In simulation studies, ATMACA was compared against PMIPv6-based mobility approaches.

Key Takeaway: The flight trial validated ATMACA application-layer mobility and session continuity over generic IPv4, while ATN/IPS remains the target operational aeronautical IP environment.

TVAL06 – End-to-End ATMACA Flight Trial Architecture



TVAL06 – IST-MAD-IST Flight - ATC Sector/Area Configuration



TVAL06 – Communication Performance

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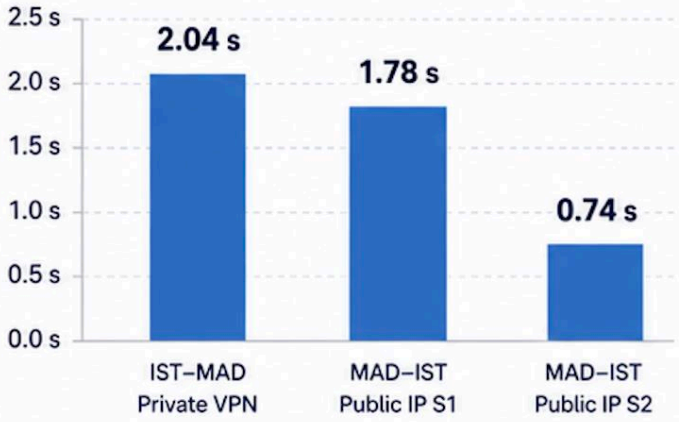
AVAILABILITY
>97%
Service was available for the duration of the trials.

CONTINUITY
>92%
Sessions continued across sector/area transfers.

INTEGRITY
100%
No CPDLC message corruption was observed.

RELIABILITY*
≈87–89%
Under nominal / stable traffic conditions.

AVERAGE CPDLC TRANSACTION TIME
End-to-end transaction time (seconds)



Lower transaction times observed on public IP links, particularly on Public IP S2.

TRANSACTION COMPLETION / RELIABILITY
Successful transaction completion rate

NOMINAL TEST TRAFFIC (STABLE CONDITIONS)
Nominal test configuration
1 CPDLC transaction every 10–15 seconds (stable message rate)

IST–MAD Private VPN	87.16%
MAD–IST Public IP S1	88.55%

Reliability under nominal conditions
≈87–89%

BURST / STRESS CONDITION
Traffic load intentionally increased
1 CPDLC transaction every 3–4 seconds (burst / stress condition)

- Transaction delay increased
- Timeout concentration observed
- Transactions exceeding the configured timeout counted as unsuccessful

MAD–IST Public IP S2	37.59%

TIMEOUT-DRIVEN REDUCTION – NOT MESSAGE LOSS
The 37.59% value reflects transactions not completed within the configured timeout. Messages were not lost; they could still be delivered later.

Reliability / success values are affected by configured CPDLC transaction timeout thresholds.

KEY TAKEAWAY

Under nominal CPDLC traffic (10–15 s), reliability was ≈87–89%.
Under burst traffic (3–4 s), timeout concentration reduced transaction completion to 37.59%, while availability (>97%), continuity (>92%), and integrity (100%) remained high.

TVAL06 – Validation Objectives, Evidence & Assessment

Only validation objectives assessed within TVAL06 are presented.

VO1

Seamless Mobility Management

EVIDENCE

Network transitions + continuity

PARTIALLY OK

WHY PARTIAL?

Short interruptions and timeout concentrations during some transition periods.

VO2

Session / Context Management

EVIDENCE

LOGON + context + CDA + DAT

OK

ASSESSMENT

LOGON/network attachment, session initiation and DAT were exercised with high continuity and availability.

VO3

Robust QoS & Security

EVIDENCE

Delay + availability + continuity + integrity

PARTIALLY OK

WHY PARTIAL?

Timeout sensitivity and delay peaks coincided with burst-based CPDLC traffic; runtime security validation was limited, with identities and roles largely pre-configured.

VO5

HMI Effectiveness

EVIDENCE

EFB + ATC workstation flight feasibility

PARTIALLY OK

WHY PARTIAL?

Basic HMI feasibility was demonstrated in flight; formal pilot/ATCo usability ratings and questionnaire-based assessment were not performed within Exercise #06.

TVAL06 – Evidence Boundaries & Maturity Concerns

SHADOW OPERATION

ATMACA messages ran in parallel; operational ATC voice remained authoritative.

SECURITY

Full runtime security behaviour was not exercised; identities and roles were largely pre-configured.

TIMEOUT SENSITIVITY

Reliability / success values are affected by configured transaction timeout thresholds.

HMI EVIDENCE

Exercise #06 demonstrated flight feasibility, not formal pilot/ATCo HMI effectiveness ratings.

TVAL06 – Overall Conclusion

REAL FLIGHT → HETEROGENEOUS NETWORKS → END-TO-END CPDLC → SESSION CONTINUITY

Exercise #06 demonstrated the real-flight feasibility of the integrated ATMACA datalink framework, providing TRL2 proof-of-concept evidence for end-to-end CPDLC, session/context management and mobility across heterogeneous networks.

Average transaction time	Availability	Continuity	Integrity
< 2.1 s	> 97%	> 92%	100%

TRL2 PROOF-OF-CONCEPT DEMONSTRATED UNDER REAL-FLIGHT CONDITIONS

From successful exploratory research to higher maturity

01 CONSOLIDATE
TRL2 Foundation

- Validated ATN/IPS communication concept
- Integrated protocol, applications & HMIs
- Evidence from six validation exercises
- End-to-end flight trial

02 MATURE
Higher-TRL Development

- Strengthen mobility mechanisms
- Improve multilink robustness & resilience
- Enhance security and system reliability
- Refine HMI and application integration

03 SCALE
Operationally Representative Validation

- Higher traffic and communication loads
- More complex operational scenarios
- Extended airborne/ground integration
- Larger-scale operational trials

04 COLLABORATE
Towards Industrial Research

- Engage ATM and communication industry
- Build on ATMACA results in future R&I
- Explore an Industrial Research pathway
- Prepare the ground for deployment-oriented development

TOWARDS OPERATIONAL DEPLOYMENT

> **ATMACA has established the technical and validation foundation.**
> ***The next challenge is to mature, scale and validate the solution***
> **in increasingly operational environments.**

DISCUSSION
How can Solution 0513 best progress towards higher maturity and future industrial research?

Q&A / Discussion

Your questions and insights are welcome!



ATMACA

Thank you!

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