

# FROM 5G FRONTHAUL TO VIRTUALIZED SATCOM

## DIFI-eCPRI INTERWORKING FOR MULTI-DOMAIN INTEROPERABILITY

A standards-based digital RF gateway concept for terrestrial, non-terrestrial and defense networks  
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# PROPOSED PACKET-BASED DIGITAL RF INTERWORKING

Terrestrial 5G/O-RAN -> DIFI-eCPRI gateway -> virtualized SATCOM, NTN and mission-edge applications

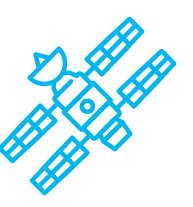
### 1. MOTIVATION

**DIFFERENT DOMAINS. SIMILAR DIGITAL RF PROBLEM.**  
5G/O-RAN and digital SATCOM transport radio information over packet networks, but differ in framing, timing, metadata and context semantics.

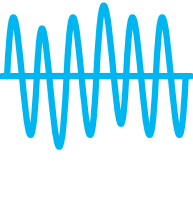
**GOAL**  
Enable an IP-native digital RF fabric spanning:  
**5G / O-RAN · SATCOM · NTN · SDR · MISSION EDGE**  
  
while reusing:  
**COTS COMPUTE · ETHERNET · CLOUD/EDGE INFRASTRUCTURE**

**RESEARCH QUESTION**  
Can a gateway preserve payload, context and timing semantics between eCPRI and DIFI?

### 3. TARGET USE CASES

**DISTRIBUTED GATEWAY**  
Remote RF → centralized / regional virtualized SATCOM

**TACTICAL SDR**  
COTS 5G radios → DIFI-aware mission-edge processing

**SPECTRUM MONITORING**  
Time-synced replay → analytics + anomaly detection

**JOINT COMMS + SENSING**  
Shared transport/compute → controlled sensing experiments

### 5. PLANNED VALIDATION

**DIFI CONFORMANCE**  
Packets · context · stream association

**LOSS + REORDER**  
Tolerance · detection · recovery

**FIRST PROTOTYPE → RECORDED + SYNTHETIC FLOWS → REPRODUCIBLE MEASUREMENTS**

**TIMING ERROR**  
Timestamp · phase-reference error

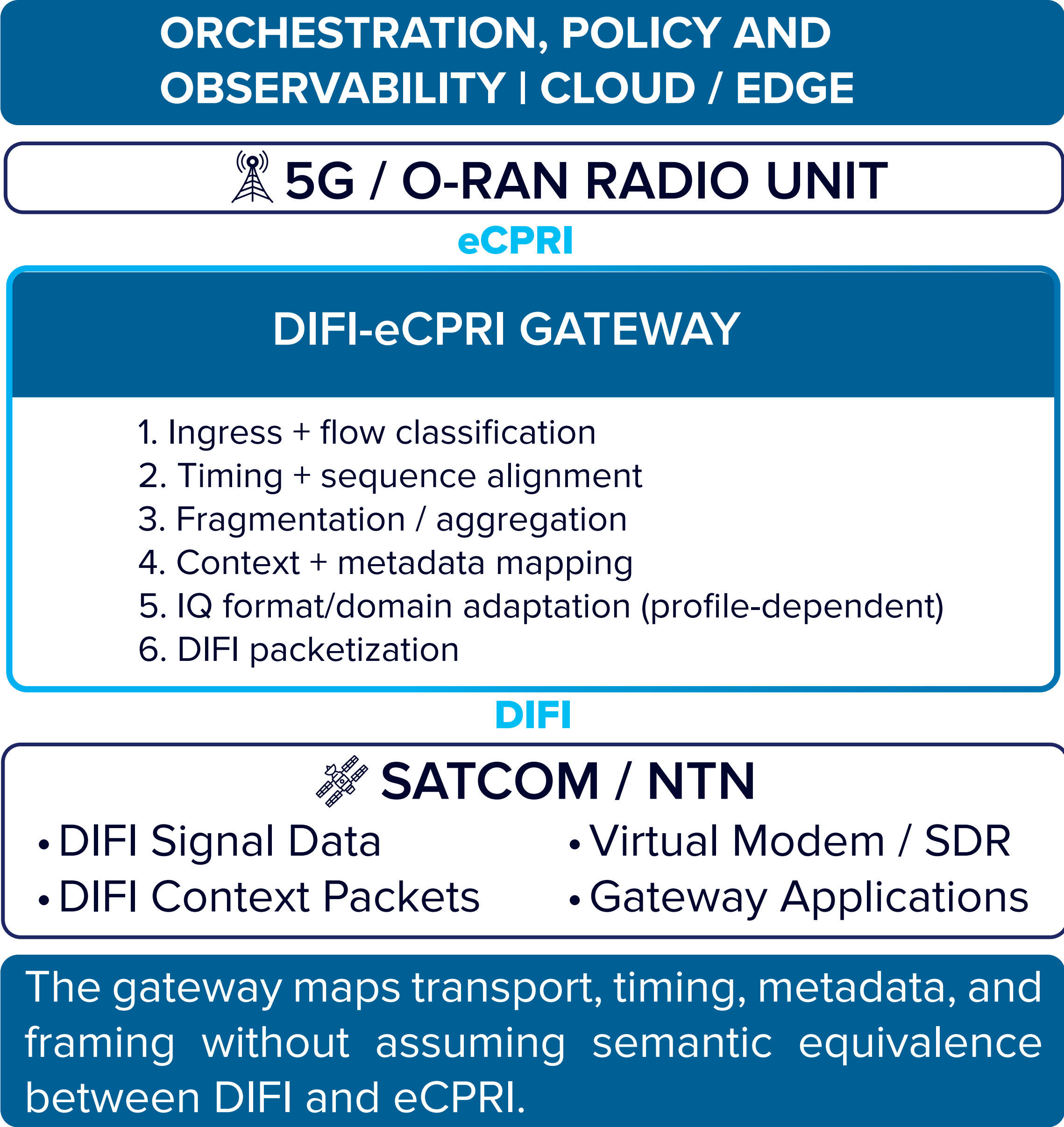
**THROUGHPUT**  
Bandwidth · CPU · memory

**LATENCY + JITTER**  
End-to-end · tail behavior

**REPLAY FIDELITY**  
RF · timing · context repeatability

**KEYWORDS:** DIFI | eCPRI | digital intermediate frequency | virtualized SATCOM | O-RAN | NTN | IEEE 1588 | SDR interoperability  
**REFERENCES:** [1] DIFI Consortium, ISTO Std 4900-2021, v1.3.0, 2025; [2] CPRI Cooperation, eCPRI Interface Specification v2.0, 2019; [3] IEEE Std 1588-2019

### 2. PROPOSED INTERWORKING ARCHITECTURE



### 4. MAPPING PROFILE

| eCPRI INPUT        | GATEWAY RESPONSIBILITY                | DIFI OUTPUT           |
|--------------------|---------------------------------------|-----------------------|
| User-plane payload | Adapt IQ format/ domain + repacketize | Signal data packets   |
| Timing + sequence  | Map to a defined time reference       | Timestamps + counters |
| Radio metadata     | Map available and configured metadata | Context packets       |
| Flow identity      | Classify / bind                       | Stream-context        |

**ANALYZE → SPECIFY → IMPLEMENT → REPLAY → MEASURE**  
Define a narrow, testable mapping profile before implementing the programmable data path.

### A SOFTWARE-DEFINED GROUND SEGMENT



**OBJECTIVE:**  
Decouple radio front ends from processing and move translation, capture, replay and observability onto reusable COTS/cloud-edge infrastructure.  
**CONCEPT ONLY:**  
No functioning gateway or measured performance yet.

### B EXPECTED CONTRIBUTIONS

**REFERENCE ARCHITECTURE**  
Cross-domain DIFI–eCPRI interworking  
**MAPPING PROFILE**  
Payload · timing · context · flow  
**PROGRAMMABLE GATEWAY**  
COTS / cloud-edge deployment blueprint  
**VALIDATION METHOD**  
Deterministic capture · replay · measurement  
**MIGRATION PATH**  
Reuse existing radio + SATCOM assets.

**6. SCOPE & NEXT STEP**  
**CURRENT SCOPE:** Proposed one-way eCPRI-to-DIFI mapping. Input profile, timing reference and supported DIFI classes remain to be defined.  
**CONCLUSION:** A constrained eCPRI-to-DIFI gateway may support shared digital RF infrastructure. Feasibility remains to be validated for a defined signal format, context and timing profile.  
**NEXT STEP:**  
Publish reproducible interoperability measurements  
Define and implement a minimum mapping profile.