BBoIP
Black Box over IP

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Agenda

1. Introduction: The Idea
2. System Overview and Requirements
3. The FDRP Protocol
4. Security Considerations
5. Conclusion

Introduction: The Idea

- Safety and Security: Highest Priority.
- One accident in every 1.5 million flights (2007).
- When a plane does fall, hours, days, even weeks before accident investigators determine the cause.
- It's silly to have a personal real-time alarm if stock goes down and not having access to flight records only until scuba drivers retrieve and the black box is analyzed!

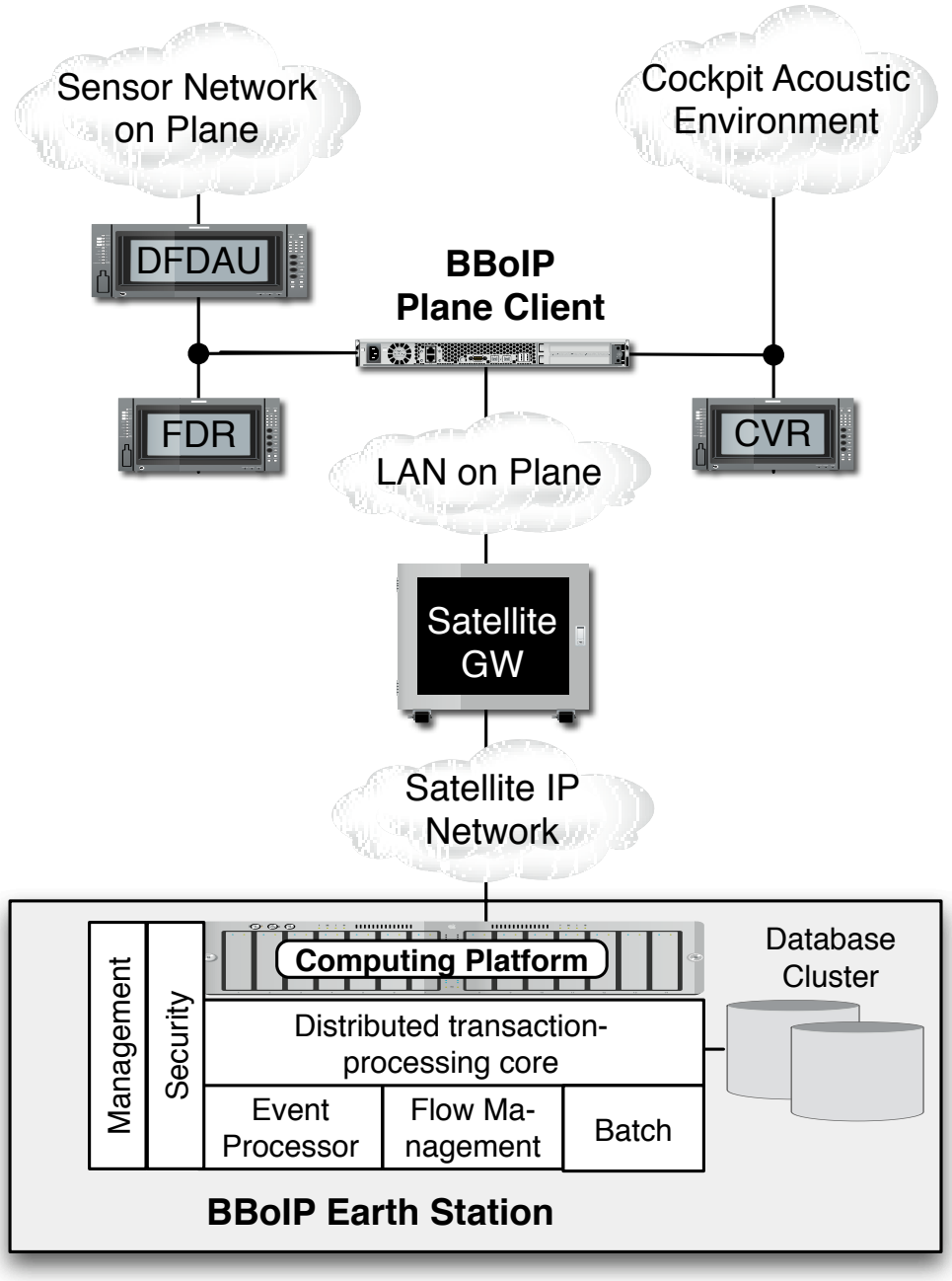
➔ Certainly unacceptable for family victims.

System Overview

Plane Network: ARINC

Satellite: INMARSAT BGAN SWIFTBROADBAND

Terrestrial Network: Private IP or Internet?



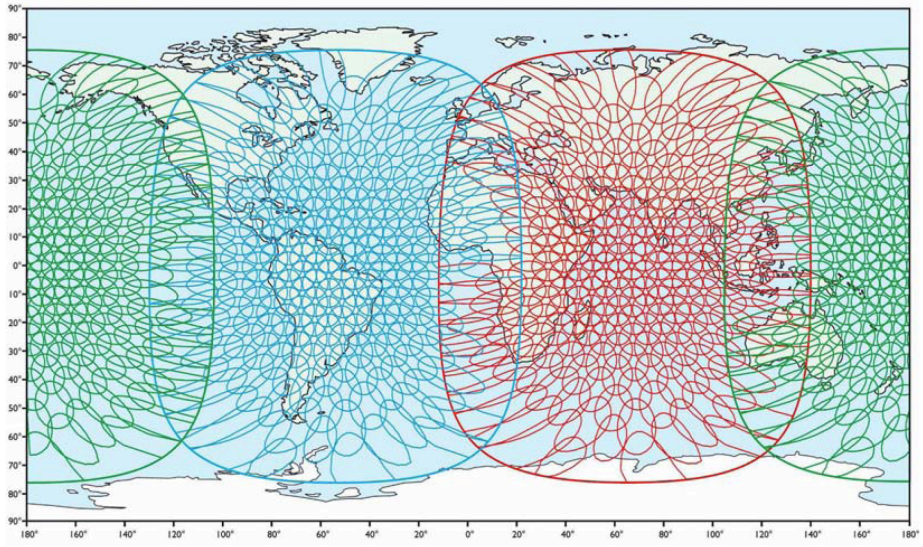
Requirements

- FAA/EUROCONTROL Requirements for FDR+CVR
  - 88 flight parameters → 752 bps
  - 4 audio channels
- Black Box Manufacturers' typical rates
  - 128, 256, 512 wps (between DFDAU and FDR)
  - 12 bits per word
  - 256*12 = 3072 bps assumed from now on
- Audio was analog until recently.
- Audio + FDR data rate required: 59.072 kbps

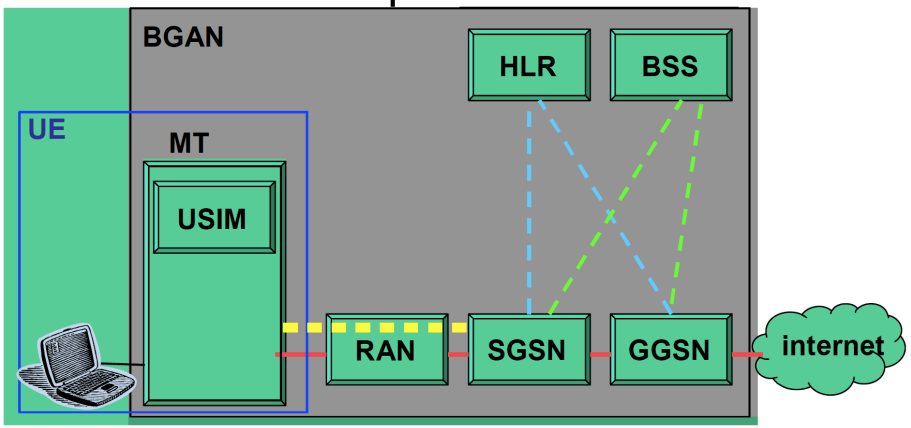
SWIFTBROADBAND

- Global coverage
- L-band MSS spectrum covers 1626.5-1660.5 MHz and 1525.0-1559.0 MHz
- 228 digitally formed beam spots
- Programmable and reconfigurable coverage in orbit
- 630 channels with 200kHz BW
- Based on 3GPP standards
- 95% worst case scenario availability
- Data Rates: 332 to 492 kb/s

Inmarsat's I-4 satellite coverage



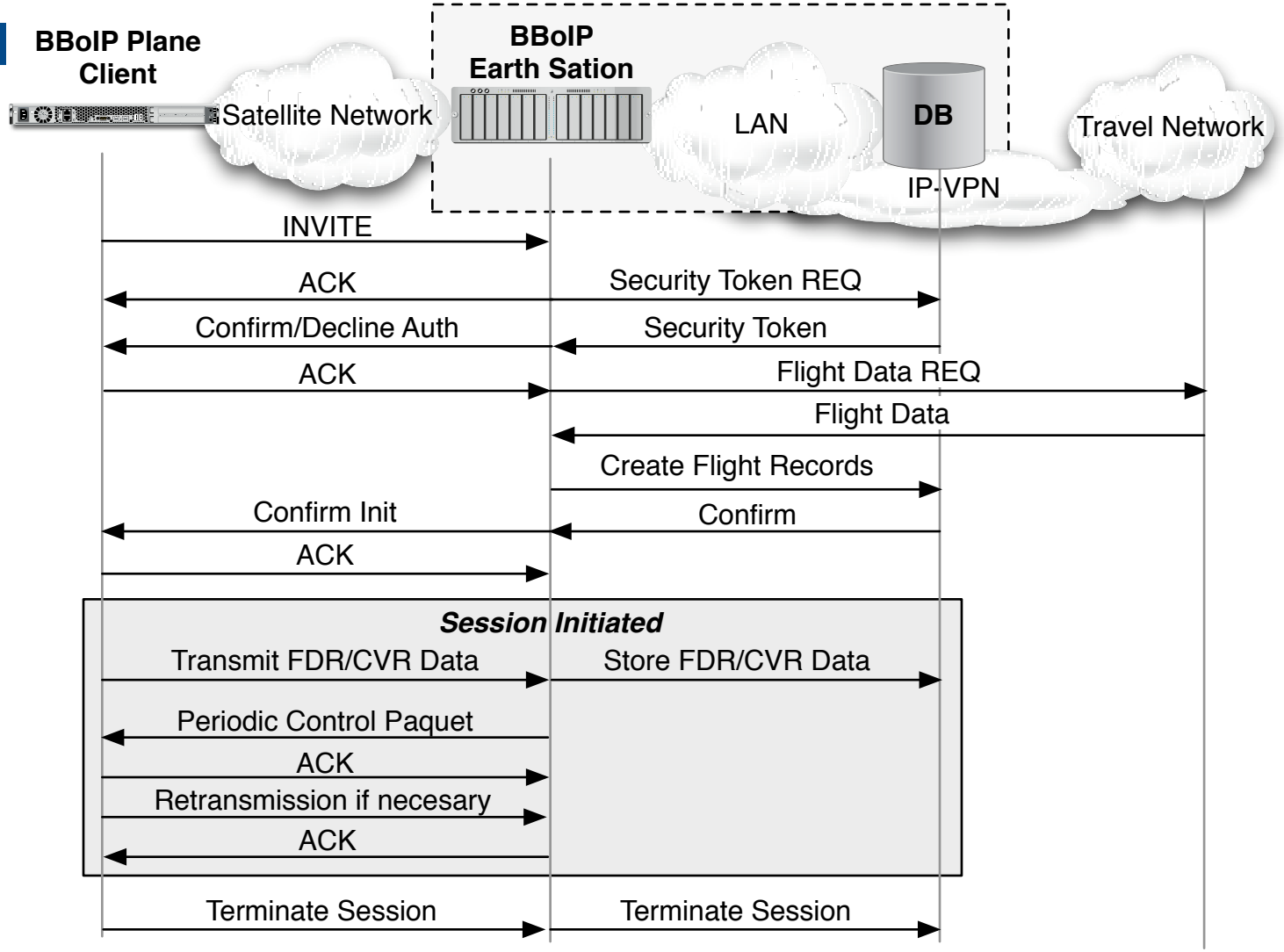
BGAN Arquitecture



VoIP Experience to the Rescue

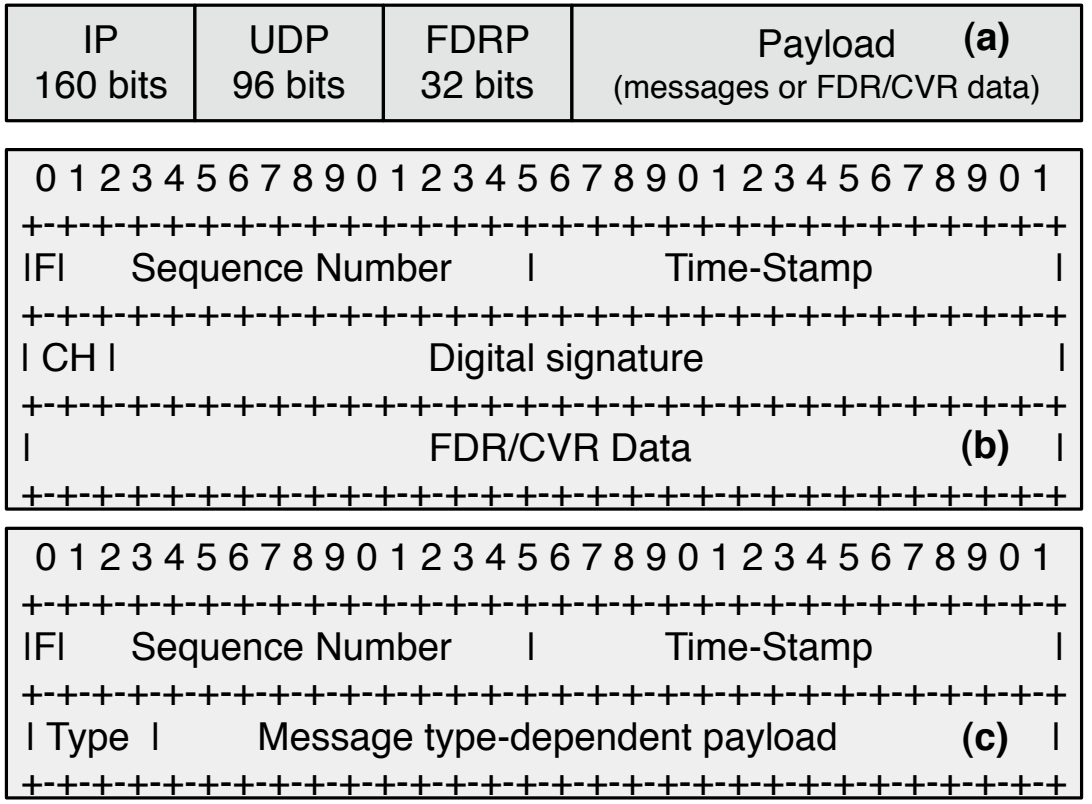
- BBoIP is a real-time app → UDP
- Signaling: SIP, heavy overhead, too flexible
- RTP: considerable weight
- IAX: Same port for signaling and streaming, but also heavy overhead
- A new and simple protocol specifically for the application
- After all, 20 000 potential clients
- Flight Data Remote Protocol (FDRP)

The FDRP Signaling Flow



The FDRP Anatomy

- Bit F : Message or Data
- CH : Channel number (1-5)
- Message Types
  - INVITE
  - ACKNOWLEDGE
  - CONFIRM AUTHENTICATION
  - CONFIRM SESSION INITIALIATION
  - REINVITE
  - CONTROL
  - RETRANSMIT



BBoIP Key Features

- Secure Login
- Session reestablishment
- Digitally signed packets over public networks
- Periodic Control Packet: Every 30-3000 s
  - Including jitter, latency, number of lost packets, sequence number of lost packets.
- Lost Packet Retransmission

Security Considerations

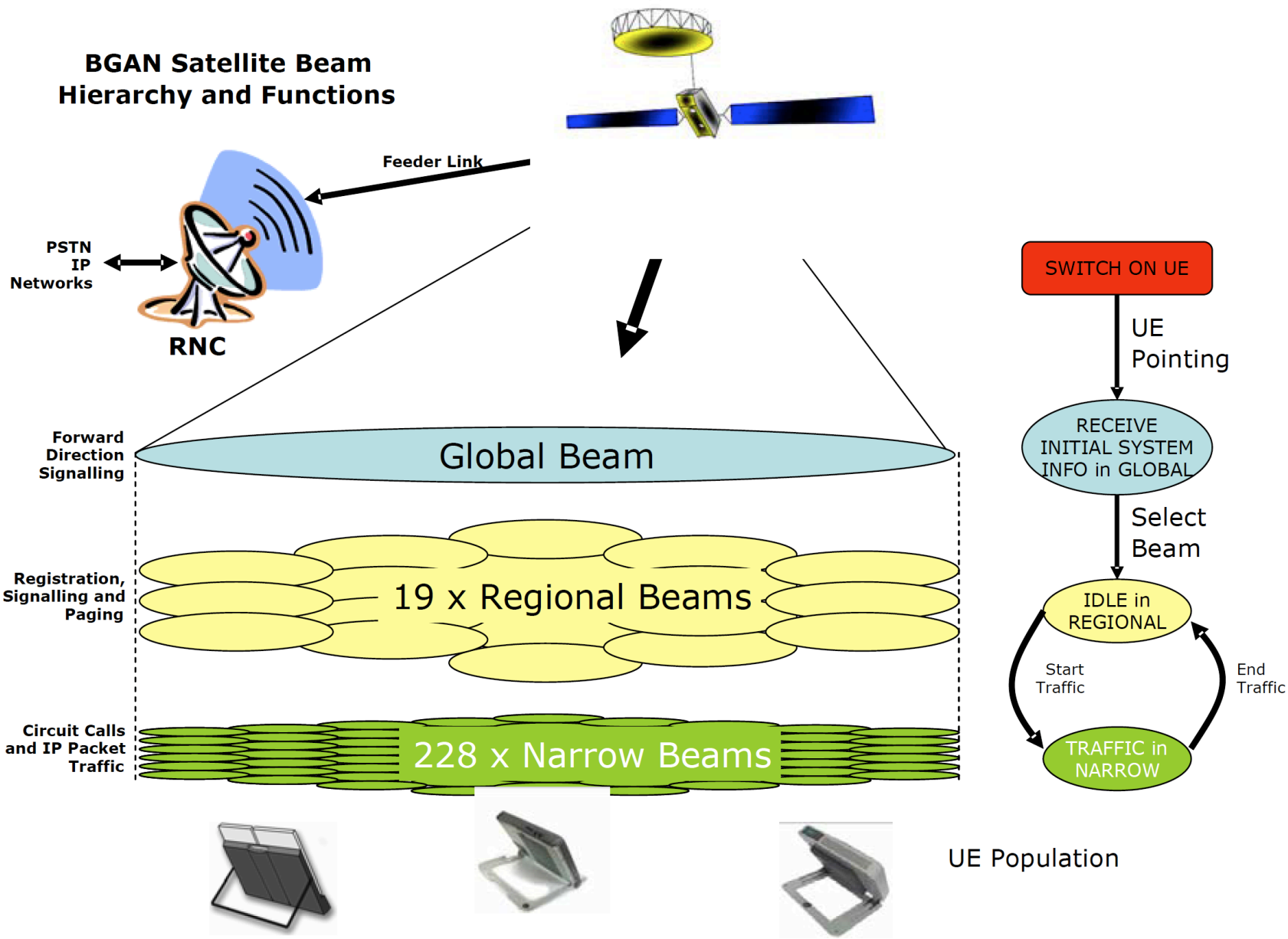
- Link Failure or Packet Loss
  - Buffering at the BBoIP client
  - Session recovery through reinvite
  - Retransmission at higher rates
- DFDAU data is already encrypted and secret key owned by manufacturer.
- Interception, Modification, Session Hijack and DoS attacks can be prevented/mitigated through
  - Knowledge base correlation techniques
  - White lists
  - Private IP Network
  - VPN tunnels

Economics

- Stakeholders: Inmarsat, Ground Operator, Airlines, Regulators.
- SATCOM System $50-$300 kusd
- Commercial tariff: $13 usd for a 3-hour flight
- Total Speed Required
  - IP + UDP + FDRP + FDR Data = 3648 bps
  - IP + UDP +FDRP + 4 CVRs = 70.4 kbps (combined)
    = 114 kbps (separate)
- Estimated Recurring Cost of Satellite Transmission
  - $\$3.75\times10^{-8}$ usd/bit
  - 40 million hours of commercial flights
  - Equivalent to 20 cents increase per passenger for 120 min flight.

Conclusions

- BBoIP System must have regulator support
- Work in development
  - FDRP protocol simulation and evaluation
  - Embedded system design and prototype for BBoIP Client
- Future Work
  - Earth servers and ground operations design
  - A lot of lobbying
- Applications
  - Real-Time accident cause determination
  - Accident alerts
  - Pilot Training and Evaluation


BGAN Satellite Beam
Hierarchy and Functions
Feeder Link
PSTN
IP
Networks
RNC
Forward
Direction
Signalling
Global Beam
Registration,
Signalling and
Paging
19 x Regional Beams
Circuit Calls
and IP Packet
Traffic
228 x Narrow Beams
SWITCH ON UE
UE
Pointing
RECEIVE
INITIAL SYSTEM
INFO in GLOBAL
Select
Beam
IDLE in
REGIONAL
Start
Traffic
End
Traffic
TRAFFIC in
NARROW
UE Population

SWIFTBROADBAND Performance

Condition	Source (ATS)	Service provider Network	Inmarsat core network	RAN delay	To-satellite C-band Propagation	Satellite processing	From-satellite L-band Propagation	Aircraft Processing/ Queuing (output of BGAN equipment)
Unencrypted	10	10 – 30 …100? (tbc)	10	200	~130	< 5	140	~120

Uplink Delay (ms)
From Earth Station to BBoIP Client on Airplane