ITU Regional Seminar for RCC countries

Use of Ka-band for satellite communications systems and services

The Astrium experience

Almaty, September 5-7, 2012
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- Introduction
- Frequency Regulations
- Ka Applications and Market
- Ka band System and terminals
- Astrium experience
- Conclusion
Introduction

- Astrium is pleased to get this opportunity to present its experience in building Ka band satellites and systems.
- Information and Communication Technologies (ICT) infrastructures stimulate economical development but urgently need to be complemented by satellite coverage.
- Satellite provided applications efficiently benchmark with terrestrial applications and are crucial for underserved areas.
- Technology for Ka ground and space segments is mature and the deployment of a Ka satellite network can be completed in 3 years.
- Astrium leads High Throughput Satellite (HTS) segment and can build a Ka-band system adapted to specific Kazakh needs.
- Business could even be strengthen in combining civilian and military applications.
- Frequency coordination and suitable partnerships is part of a successful approach.
Ka-band interest

- Ka-band proposed for:
  - Spectrum advantage
    - Easier to coordinate (no operational system in orbit yet)
    - Access to large bandwidth
    - Reserve Ka-band frequency rights over Kazakhstan
  - Development of broadband services for commercial/corporate and government applications
    - Capacity
    - User throughput using small affordable terminals and developed network system
    - In line with Kazakh government policy to universal access to broadband services
  - Kazakhstan to become the first country of Central Asia to develop a broadband multi-beam system, following the already operational systems in Europe (Ka-Sat, Hylas) and in Middle-East (Yahsat-1A & 1B, Arabsat-5C).
Ka band capacity to meet increasing traffic demand

TOTAL CAPACITY BETWEEN 300 and 400 Gpbs

This is equivalent to the total capacity already available in C and Ku!
Broadband satellite capacity

- **Drivers for system capacity over a given service area are:**
  - Spectrum
    - 500 MHz exclusive Ka-band for user FWD and RTN in 2 polarisations
  - Spectral efficiency (bps/Hz)
    - Typically 2 bps/Hz on the FWD link and 1.5 bps/Hz on return link
  - Frequency re-utilisation factor over the service area
    - Number of beams/beam size: typically 0.5 to 1 deg
    - Frequency colouring scheme: typically 4 colours (giving 250 MHz/beam)

- **Indications of achievable capacities**

<table>
<thead>
<tr>
<th>Number of beams</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>80</th>
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</thead>
<tbody>
<tr>
<td>Spectrum/beam (250 MHz)</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Spectral efficiency FWD</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Spectral efficiency RTN</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Total capacity (Gbps)</td>
<td>4</td>
<td>9</td>
<td>13</td>
<td>18</td>
<td>70</td>
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</tbody>
</table>

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Kazakhstan Filings at 58.5°E – Ka band

- **Ka Band**
  - Needs covered through three generations of filings
    - KAZSAT-1 valid until 18/02/2012
    - KAZSAT-1M valid until 27/12/2013 declared « BIU » Q1 2012 (using LUCH-5A)
    - KAZSAT-1R with 14/11/2012 as priority date and valid until 30/03/2018
  - Favourable operational context
  - Securing the frequencies
    - Declaration of KAZSAT-1M bringing into use has been sent before validity date

- **Notified filings without operational satellite could be contested**
  *Filings would be suppressed if operational interferences occur*
  *Azeris have also filed Ka at 58.5°E (before KAZSAT-1R)*

- **General statement**
  - Ka band subject to coordination under ITU RR Art.9/11

<table>
<thead>
<tr>
<th>Direction</th>
<th>Ka Band</th>
<th>Filing</th>
<th>API</th>
<th>Validity</th>
<th>Coordination</th>
<th>Notification</th>
<th>Unfavourable</th>
<th>Resubmission of Notification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downlink</td>
<td>17.7-20.1 GHz</td>
<td>KAZSAT-1M</td>
<td>27/12/2006</td>
<td>27/12/2013</td>
<td>09/12/2005</td>
<td>02/08/2010</td>
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<td></td>
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<tr>
<td></td>
<td>20.1-20.2 GHz</td>
<td>KAZSAT-1M</td>
<td>27/12/2006</td>
<td>27/12/2013</td>
<td>09/12/2005</td>
<td>02/08/2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uplink</td>
<td>27.5-31 GHz</td>
<td>KAZSAT-1</td>
<td>18/02/2005</td>
<td>18/02/2012</td>
<td>09/12/2005</td>
<td>23/12/2009</td>
<td>30/11/2010</td>
<td>16/12/2010</td>
</tr>
</tbody>
</table>

**Direction**

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- **Validity**
- **Coordination**
- **Notification**
- **Unfavourable**
- **Resubmission of Notification**

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Applications driving demand for satellite capacity

- **Consumer**
  - Broadband Access
  - Component of Triple Play Offering

- **Enterprise**
  - Remote Access
  - VPN and Networking
  - SCADA and Machine-to-Machine (M2M)
  - Digital Cinema/Digital Signage
  - Interactive Distance Learning
  - Redundancy and Disaster Recovery
  - Nomadic/Maritime

- **Backhaul/Trunking**
  - Wireless Backhaul
  - International Trunking

Source: NSR - 2010
Segmentation of broadband access market

**Un-served Market**
- Areas located further than 5 km from next DSLAM or cable head-end, meaning no terrestrial broadband is available
- Unserved areas usually have a low population density, concerning **rural areas**

**Over-served Market**
- Areas within 3 km of next DSLAM, or with FTTH, near cable head-end
- Usually urban areas with **high population density**

**Underserved Market**
- Areas within approx. 3-5 km of a DSLAM. Broadband is available at a limited max. speed, up to few Mbps not allowing all kind of services (TV, VoD)
- Underserved homes are usually located in **suburban or urban areas**
Broadband services in Kazakhstan

- **Current situation in Kazakhstan**
  - General upturn in demand for Internet services
  - Internet penetration: 16% of population by end of 2010 (+400 bps on YTY basis)
  - Broadband penetration: 12% of population by end of 2010 (+300 bps on YTY basis)
  - OECD average is 25%

- **Development of Internet and broadband impacted by low-density terrestrial infrastructure**
  - Fixed-line penetration 26% of population with just 6.4% of households

- **Ambitious plan from Government to offer 100% broadband coverage by 2015**
  - but small fraction of population to remain out of reach of Fiber-To-The-Home or terrestrial wireless (WiMax, 3G) because coverage not economically viable
  - Ka band by satellite is The solution

- **Brodband services should also be of great interest for Security and Defence forces (communications / data relays).**
Fibre optic deployment cost per household in France (*)

- Only satellite will provide service to out of reach areas
- Elsewhere, satellite offer benchmarks terrestrial offers
- with easy reallocation of capacity

(*) : Source DATAR 02/2011
Consumer broadband access applications

The future digital home will require more bandwidth!

- Ultra high speed Internet
- HD and 3DTV
- Home security
- Home automation
- E-health

Ideal bitrates will be in the 5-10 Mbps range (downlink)
Consumer broadband access system scenario

- It is assumed that the targeted service is broadband interactive service to residential user -> It requires bi-directional links
- On the FWD link: TWTA operated with a single carrier at 0.5 dB below saturation.
- On the RTN link: TWTA operated with multiple carriers at 4.5 dB output back-off.
Satellite capacity

- New generation Ka satellites « throughput » compared to previous generation
Governmental services and applications

- Reliable and secure global bandwidth
- In-theatre communications solutions
- IP Connectivity
  - Broadband internet access
  - Close user group network
  - Site interconnection
  - Tele-presence
  - Backup services
  - Contribution/distribution
  - Trunking
  - SCADA/M2M
  - Multicast services
  - Mobile service

Source: Eutelsat presentation on Governmental services via KA-SAT
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System architecture, today deployed on Ka-Sat
Example of user terminals

Complete range of ODUs
- 67 cm Ka-band
- 96 cm Ku-band
- Automated installation tools for simplified antenna alignment and commissioning

Compact IDU
- Simple customer interfaces:
- Plug and play Ethernet 10/100 Mbps
- Contains all software needed to access the satellite
- Upgradeable via over-the-air software download

Source: Eutelsat presentation on Tooway

<table>
<thead>
<tr>
<th>IDU throughput</th>
<th>Download</th>
<th>Upload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic solution (&lt; 80cm/3W, &lt; 50dBW)</td>
<td>10Mbps</td>
<td>5Mbps</td>
</tr>
<tr>
<td>TCP/IP traffic</td>
<td>30Mbps</td>
<td></td>
</tr>
<tr>
<td>UDP traffic</td>
<td></td>
<td></td>
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Astrium experience in Ka-band payloads since 1989

Starting in the 80s’

- Olympus launched 1989
- W3A launched 2004
- Anik F3 launched 2007
- Nimiq 4 launched 2008
- Hylas launched 2010
- Astra 3B launched 2010
- KaSat launched 2010

All Ka Satellite ...Up to 80Gbps capacity

All the space you need

2011/ATB2-PS-0015

Astrium Proprietary and Confidential
Add-On Payload or Main mission

- Add-on offering more limited transponder count, but with potential to cross links with other embarked payloads (in Ku or C band)

- Typical for market entry, recent examples include:
  - Eutelsat W3A,
  - Telesat Anik F3 and Nimiq 4,
  - SES Astra 3B,
  - Yahsat-1A
  - Arabsat-5C
  - Express AM4
  - Express AM4R under construction

- Dedicated Ka band Satellites

  - HYLAS (AVENTI)
    - Flexible payload
  - Ka-Sat (EUTELSAT)
    - 80 beams
    - 70 Gbps capacity
  - Yahsat-1B (UAE)
    - Dual use (civil&mil)
Focus on Ka-Sat satellite

- Ka-Sat is the first multibeam Ka-band satellite over Europe, as well as one of the most complex and biggest satellites ever built by Astrium.

- Ka-Sat fits well within the Eurostar E3000 satellite product range, however some adaptations have been required due to the specific needs of the mission.

- Ka-Sat has been launched on Dec 29, 2010 and operated successfully since its deployment in orbit.
Bi-directional satellite communications between end user terminals and gateway
- 82 active user beams
- 8 gateways selectable among 10
- Pan European coverage
- 4 colour-scheme for efficient frequency re-use
Ka-Sat satellite deployed configuration in orbit

- Four antennas:
  - One antenna per colour
  - ~20 feeds in each array
  - 2.6m diameter deployable reflectors

Beacon’s horns
TCR horn
Red feed assembly
Yellow feed assembly
Green feed assembly
Blue feed assembly

EAST
SOUTH

RHCP
LHCP
Antenna multi-feed assemblies
Key features of the Eurostar E3000 platform for Ka-Sat

- **Triple floor E3000 version**
  - Largest size of mechanical platform

- **Radiative collector amplifiers**
  - Combined with high thermal efficiency required by the Ka mission

- **Large antennas with long focal length**
  - To achieve optimised performance, high gain and carrier to interferer ratio

- **Antenna Tracking System (ATS)**
  - Very high pointing accuracy required by the small cells

- **New mechanical concepts**
  - For antenna feed assembly supports, and reflector deployment and trimming

- **Plasma propulsion system**
  - To enable significant lifetime for such large spacecraft
Ka-Sat Main Characteristics

- **Satellite Main budgets**
  - **Power**
    - Spacecraft Power: up to 14 kW
    - Payload DC power: 11.2 kW
    - Solar Array Power: up to 16 kW
  - Satellite launch mass: > 6 tonnes
  - Orbital Manoeuvre life time: > 16 years

- **Orbit**
  - GEO, longitude 9°E

- **Launch**
  - Launch vehicle: Proton
  - Launch date: Dec. 29, 2010
Conclusions

Astrium:

- believes that introduction of Ka band will put Kazakhstan in a decisive position to join the club of nations developing broadband services;
- can propose state of the art infrastructure with flight proven heritage for space segment and mature technology for ground segment;
- would be pleased to discuss with Kazakhstan the Ka Kazsat-4 satellite mission and to propose various options;
- can fully support the sizing of a Ka system optimized for Kazakhstan:
  - Coverage & number of beams
  - Frequency plan & number of Gateways
  - Forward / Return asymetry ratio
  - Link budgets, Gateways and Terminals characteristics
  - Waveform, variable modulation, adaptative coding, 99.5% availability
- can envisage several scenarios including a dual-use system for both civil services and defence/security applications.