Proposal for a Joint NASA/KSAT Ka-band RF Propagation Terminal at Svalbard, Norway

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Project Element – Technology Development
Discipline – Advanced Studies

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August 2010

Keeping the universe connected.

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Kevin McCarthy
Armen Caroglanian
Why are these studies important?

As science mission data throughput demands increase, it is desired by NASA to characterize the site-dependent atmospheric propagation effects at Ka-band frequencies to manage expectations for NEN system performance.

**Propagation Study Goals:**

- Determine expected site-dependent low level signal attenuation at Ka-band for NEN sites.
- Determine extent of increase in system noise temperature at Ka-band for NEN sites.
- Determine extent of high level signal attenuation, scintillations and depolarization effects at Ka-band for NEN sites (IF A SATELLITE OPPORTUNITY EXISTS).
Benefits to NASA/KSAT

- Enhanced system planning through accurate determination of expected Ka-band attenuation and depolarization performance
- Improve mission planning to manage expectations/maximize mission success and data throughput
- Enhance fidelity of current ITU-R and global propagation models
- Augment current propagation databases with new data in an area of the world where no previous Ka-band propagation measurements currently exist
- Prepare for deployment of NEN Ka-band polar network
Ka-Band Rain Attenuation Measurements

1991 – 2004: Collected 36 Station-Years
Advanced Communications Technology Satellite (ACTS)

Developed the Ka-Band ITU-R Attenuation Model
(not accurate on average of ~ 3 – 6 dB @ 90%)

2007 – Present: Collected 5 Station-Years

Ka-Band Amplitude and Phase Characterization of
Goldstone Deep Space Network (DSN) Tracking Complex

Ka-Band Amplitude and Phase Characterization of White
Sands/Guam Tracking and Data Relay Satellite System
(TDRSS) Ground Terminals
# Lessons Learned From Site Characterization

<table>
<thead>
<tr>
<th>Location</th>
<th>Frequency: Station Years</th>
<th>Lessons Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairbanks, Alaska 20.2 GHz</td>
<td>5 st. yrs.</td>
<td>Cloud Effects</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td>Scintillation</td>
<td></td>
</tr>
<tr>
<td>British Columbia, Canada</td>
<td>20.2 GHz: 5 st. yrs.</td>
<td>Fade Duration</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td>Scintillation effects</td>
<td></td>
</tr>
<tr>
<td>Fort Collins, Colorado</td>
<td>20.2 GHz: 5 st. yrs.</td>
<td>Melting layer</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tampa, Florida</td>
<td>20.2 GHz: 5 st. yrs.</td>
<td>Rain and snow effects</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td>Polarimetric radar</td>
<td></td>
</tr>
<tr>
<td>Las Cruces, New Mexico</td>
<td>20.2 GHz: 6 st. yrs.</td>
<td>Subtropical Zone</td>
</tr>
<tr>
<td>TDRS GN 27.5 GHz: 5 st. yrs.</td>
<td>Site Diversity</td>
<td></td>
</tr>
<tr>
<td>Norman, Oklahoma</td>
<td>20.2 GHz: 5 st. yrs.</td>
<td>Scintillation</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td>TDRS ancillary data</td>
<td></td>
</tr>
<tr>
<td>Clarksburg, MD</td>
<td>20.2 GHz: 5 st. yrs.</td>
<td>* Phase Decorrelation</td>
</tr>
<tr>
<td>ACTS 27.5 GHz: 5 st. yrs.</td>
<td>Rain Rate</td>
<td></td>
</tr>
<tr>
<td>Ashburn, VA</td>
<td>20.2 GHz: ~1 st. yr.</td>
<td>Depolarization</td>
</tr>
<tr>
<td>SOMD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humacao, Puerto Rico</td>
<td>20.7 GHz: 1.5 st. yrs.</td>
<td>Tropical Zone</td>
</tr>
<tr>
<td>SOMD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldstone, California DSN GN</td>
<td>20.2 GHz: 3.5 st. yrs.</td>
<td>* Phase Decorrelation</td>
</tr>
<tr>
<td></td>
<td>Cloud Effects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Desert Zone</td>
<td></td>
</tr>
</tbody>
</table>
Alaska (90% of Radiometer and Beacon agreement extremely high)

Note: Based on climatological similarities/differences with Alaska, Svalbard site expected to have good radiometer/beacon agreement ~99% of time (lower rain rate region)
Lessons Learned

1 – Design Links based on actual data (~5 years, but 3 is reasonable)

2 – 1 dB extra margin at 27 GHz vs. 20 GHz at >99% weather
Proposed NASA/KSAT Ka-Band Campaign

PRIMARY GOALS –
- Radiometric observations of sky brightness temperature at relevant frequency and elevation angle of operation to determine increase in system noise temperature and attenuation

SECONDARY GOALS –
- Measurements of atmospheric depolarization and scintillation effects if satellite of opportunity (possessing a K/Ka-band beacon) can be identified.
- Higher fidelity attenuation data (>99% availability level) utilizing beacon signal measurement

A Space Act agreement between NASA and KSAT would be required

  ± Each party brings to the table the funding and expertise and analyzed data is made available to KSAT

Expected financial costs from both NASA and KSAT
Proposed NASA/KSAT Ka-Band Campaign

**NASA Responsibilities**

- Construction and system testing of RF Propagation Terminal
- Perform installation of propagation terminal and radome at Svalbard site
- Assist in system diagnostics and repair, if necessary
- Analysis of recorded data

NASA to provide the following hardware:
KSAT Responsibilities

±  Preparation of site (cement pads, **CABLE CONDUITS**, infrastructure, data transfer, etc.)
±  Assist in propagation terminal installation at Svalbard site
±  Monitoring of propagation terminal operation, addressing potential system issues, if necessary
±  Provide external access to data (internet connectivity)

KSAT to provide the following infrastructure:
# ROM Proposed Effort

<table>
<thead>
<tr>
<th>NASA Funding</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Propagation Terminal (Beacon Receiver + Radiometer) *</td>
<td>$15K</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Propagation Terminal Radome (Galileo Composites) **</td>
<td>$20K</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Shipping Costs **</td>
<td>$10K</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Contractor Labor (Construction/Operations)</td>
<td>$30K</td>
<td>$20K</td>
<td>$20K</td>
<td>$20K</td>
</tr>
<tr>
<td>Travel (estimate $5K/trip/person)</td>
<td>$20K</td>
<td>$10K</td>
<td>$10K</td>
<td>$10K</td>
</tr>
<tr>
<td>Total:</td>
<td>$95K</td>
<td>$36K</td>
<td>$36K</td>
<td>$36K</td>
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</table>

<table>
<thead>
<tr>
<th>KSAT Funding</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Preparation **</td>
<td>$75K</td>
<td>--</td>
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<td>--</td>
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<tr>
<td>Contractor Labor **</td>
<td>$50K</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<tr>
<td>Site Operator Support (0.1 WYE) **</td>
<td>--</td>
<td>$30K</td>
<td>$20K</td>
<td>$20K</td>
</tr>
<tr>
<td>Data Access (Internet Services)</td>
<td>--</td>
<td>$2K</td>
<td>$2K</td>
<td>$2K</td>
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<tr>
<td>Total:</td>
<td>$125K</td>
<td>$32K</td>
<td>$22K</td>
<td>$22K</td>
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</table>

* Propagation Terminal cost reduced for FY11 budget due to use of FY10 funding for hardware procurements
** Svalbard costs are best estimates derived from Guam construction costs (may not fully address issues concerned with climate)
# Proposed Schedule/Milestones

<table>
<thead>
<tr>
<th>CY 2010</th>
<th>CY 2011</th>
<th>CY 2012</th>
<th>CY 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware Procurement for Propagation Terminal</td>
<td>Svalbard Site Survey</td>
<td>Construct Propagation Terminal</td>
<td>System Check-Out/ Characterization of Propagation Terminal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Schedule derived for Calendar Year (CY)
REFERENCES


G. Feldhake, Dr. Ailes-Sengers, Comparison Of Multiple Rain Attenuation Models With Three Years Of Ka-Band Propagation Data Concurrently Taken At Eight Different Locations, Third Ka-Band Utilization Conference, 1997.


REFERENCES


QUESTIONS?
New Mission Drivers Summary
11 Missions Launching in Next 7 Years Require NEN Upgrades

<table>
<thead>
<tr>
<th>Mission &amp; Launch Date</th>
<th>FY11</th>
<th>FY13</th>
<th>FY14</th>
<th>FY16</th>
<th>FY17 +</th>
<th>ScanSRD Requirement</th>
<th>Total # of Drivers</th>
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<tbody>
<tr>
<td>OQPSK Modulation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>12</td>
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<tr>
<td>LDPC Decoding</td>
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<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>CFDP</td>
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<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>SLE</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>Data Rate &gt;150 Mbps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>Other Services</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Notes:
1) NEN support commences
2) McMurdo X-Band Freq. Expansion
3) Lunar: WS-1 (Multi-Mission)
4) MTRS-2

Scanning Testbed: X
LDLCM: X
IRIS: X
OCO-2: X
LADDE: X
GPM-Core: X
SMAP: X
ICESat-II: X
CLARREO-1: X
DESDyniLidar: X
CLARREO-2: X

12 MetOp
13 ScanTestbed
13 LDLCM
14 IRIS
14 OCO-2
15 LADDE
15 GPM-Core
15 SMAP
15 ICESat-II
15 CLARREO-1
15 DESDyniLidar
15 CLARREO-2
3 Other Services