Space-Based Tracking for Conservation

Zac Manchester
Stanford Robotic Exploration Lab
Tiny Satellites

- Gyroscope
- Magnetometer
- Radio
- Solar Cells
- Microcontroller
- Antenna
Ground Station
Range Testing

I'm Down Here
On Orbit Test
Signals

ChipSat Signal
KickSat Mission

Video Courtesy Ben Bishop
Animal Tracking
Arctic Tern
Arctic Tern Migration

Migration routes of the arctic tern
(Source: CAFFs Arctic Flora & Fauna - 2001)
Existing Tags
Argos
**Argos**

<table>
<thead>
<tr>
<th>Location class</th>
<th>N comparisons</th>
<th>CLS estimates * (metres)</th>
<th>Our estimate (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>54</td>
<td>&lt; 250</td>
<td>400 ± 200</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>250 - 500</td>
<td>700 ± 700</td>
</tr>
<tr>
<td>1</td>
<td>133</td>
<td>500 - 1500</td>
<td>800 ± 700</td>
</tr>
<tr>
<td>0</td>
<td>108</td>
<td>&gt; 1500</td>
<td>2300 ± 2700</td>
</tr>
<tr>
<td>A</td>
<td>398</td>
<td>No accuracy</td>
<td>1400 ± 2500</td>
</tr>
<tr>
<td>B</td>
<td>546</td>
<td>No accuracy</td>
<td>1800 ± 3900</td>
</tr>
</tbody>
</table>

Based on green (n = 5) and leatherback (n = 4) turtles undertaking internesting, migration and foraging movements in the South Atlantic Ocean.

ICARUS
A Different Approach
Experiments
Frequency Stability

Frequency Drift (Hz) vs. Time (s)
Position Accuracy

![Graph showing the relationship between velocity error (cm/s) and tag position error (km). The graph displays a linear trend with an increasing tag position error as the velocity error increases.](image-url)
Conclusions

• Doppler positioning can provide position fixes with much lower energy consumption than GPS.

• Positioning within 100 meters for stationary tags.

• Significant room for improvement over existing solutions.