Kymeta™ u8 Terminal Prototype Field Trial

In March 2020, a team of Kymeta engineers performed a field trial of a prototype of the new Kymeta™ u8 terminal that was demonstrated at SATELLITE 2020. The new u8 is the culmination of 7 years of research and 2 years of field experience with the first-generation u7 terminal. A host of new features, including seamless switching between satellite and cellular networks, ensures your connection never drops – even while on the move.

The u8 terminal is a complete connectivity solution ready to provide on-the-go

Fig 1: Scenes from the field trial

communications when and where you need it. The u8 terminal is designed along with our signature electronically steered, low profile u8 antenna that mounts easily on vehicles and vessels to provide seamless hybrid satellite/cellular connectivity.

The purpose of the trial was to evaluate system maturity and key performance parameters leveraging Kymeta's revolutionary metamaterials-based technology across a wide array of environments to identify any possible issues and for continued areas for improvement. The u8 terminal has been re-engineered from previous models for increased terminal performance and adaptability delivering greater flexibility to address the customers' needs working towards making mobile global.

The main areas evaluated were:

- Connectivity (satellite and cellular) and data rate/SNR expected in various regions
- Pointing and satellite tracking
- System stability
- Cross-polarization and compression on the move
- Effects of shock and vibration
- Integration and design validation

The Kymeta team traveled 3502 miles from Washington, DC through Atlanta, GA, Dallas, TX, Albuquerque, NM, Salt Lake City, UT north to Boise, ID, and further northwest to the destination of Seattle, WA.

This route took the u8 terminal through:

- Heavily wooded areas and forests
- City driving and urban canyons
- Remote areas and cellular deserts
- Flat, open plains
- Mountain and canyons
- High and low signal-to-noise ratios (SNRs)
- Heat, cold, and humidity

The team used the internet connection from the terminal for following activities while on SATCOM:

- Teleconferencing via digital audio
- Performing office related work (WebEx calls, VPN connectivity, server utilization, etc.)
- Downloading large files
- Streaming movies/music
- Web browsing

Consistent web browsing was the one area where usage of the advanced multi-WAN fusion capabilities of the u8 terminal was identified as critical, especially when in the urban canyon and forested environments. But using just the wireless internet link provided by the u8 terminal, the team performed the above activities—including consistent web browsing—without frustration.

Connectivity performance

During the trial, Kymeta u8 terminal had 100% connectivity on the move

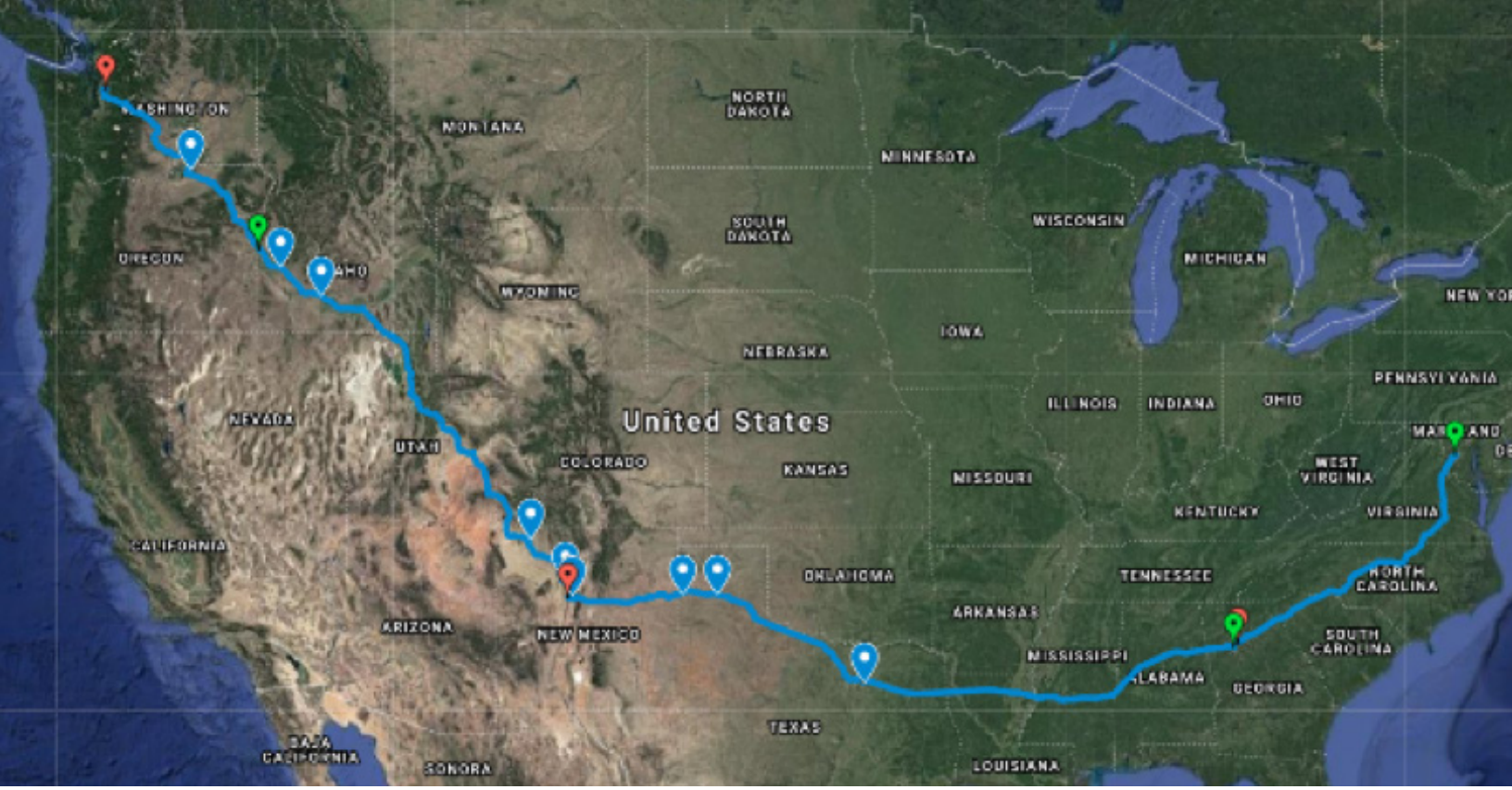

Fig. 2 Route of the field trial

with line of sight. This means that the vehicle maintained 100% internet connectivity, either via the satellite or cellular connection. At times SATCOM was obscured, at times cellular was not available, validating the value of the hybrid solution for continuous total connectivity.

In terms of individual network connectivity Cellular only covers 70% and Satellite covers 100%, with line of sight, of the continental U.S. Between the two connectivity platforms, Kymeta's hybrid solution demonstrated seamless coast-to-coast connectivity on the move with field trails of its new product and service.

Also, during the field trial, the downlink speeds were often able to burst to 8 Mbps or greater with uplink speeds up to 2 Mbps, easily meeting the product design target of a 5×2 network. This result validated the performance estimates, and SNR analyses performed during the design phase and matched real-world performance across the various signal strengths and geographic areas evaluated.

Pointing and satellite tracking

Consistent with the high SATCOM connectivity performance, the Kymeta pointing and tracking capabilities performed remarkably well during the trial. The engineers attempted to stress the system by performing edge case scenarios such as finding locations on the road that would allow the vehicle to safely reach the peak turn limit, including U-turns at legal locations, curvy roads with hairpin turns and circling around traffic circles multiple times. During the most extreme edge case scenarios tested, the pointing and tracking system maintained a lock on the satellite. The robustness of the system's ability to stay locked and close the link was validated every time. As an example of these extreme edge cases, the team found that Arches Scenic Dr at the Arches National Park, UT put forward the best set of condensed opportunities

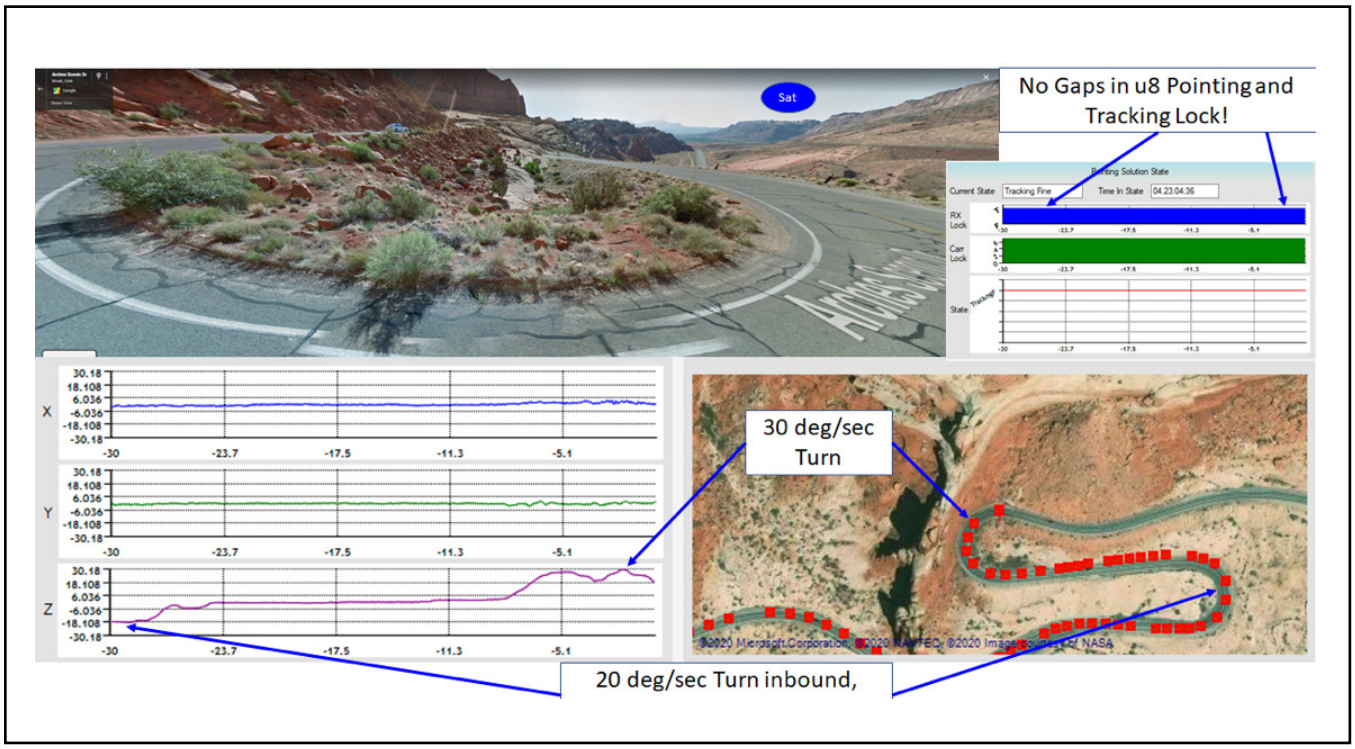

Fig. 3 Hairpin turn on Arches Scenic Drive at Arches National Park, UT

for stressing the mobile tracking system. Figure 3 (above) shows the two hairpin turns near the entrance to the park. The figure shows that this road allowed the vehicle to achieve turn rates of 20° to 30° per second on inbound and outbound legs while maintaining a tracking lock on the satellite.

Additionally, the park has recently built a small traffic circle near the park entrance/exit. The vehicle rounded the circle numerous times and achieved a sustained turn rate of 35° to 40° per second (Figure 4). Identical to the hairpin turns, connectivity to the satellite was maintained. Performance in this edge case exceeds the requirements that Kymeta established for the required performance, indicating the robustness of the u8 terminal design even during the early alpha prototype stage.

Cross-polarization and up-converter compression

As SATCOM system interoperability is often evaluated, fixed, consistent RF performance on the move is a critical metric for interoperability with a wide array of satellite service operators (SSO). While on the move, the team, working with the SSOs, performed standard commissioning tests. The purpose was to evaluate Kymeta's holographic beamforming accuracy on the move and further stress the pointing and tracking algorithms. These tests were successfully performed 100% hands-off by the Kymeta engineers, and the SSOs could not tell the vehicle was moving. In open environments, there was no noticeable difference in performance between on-the-move and fixed communication.

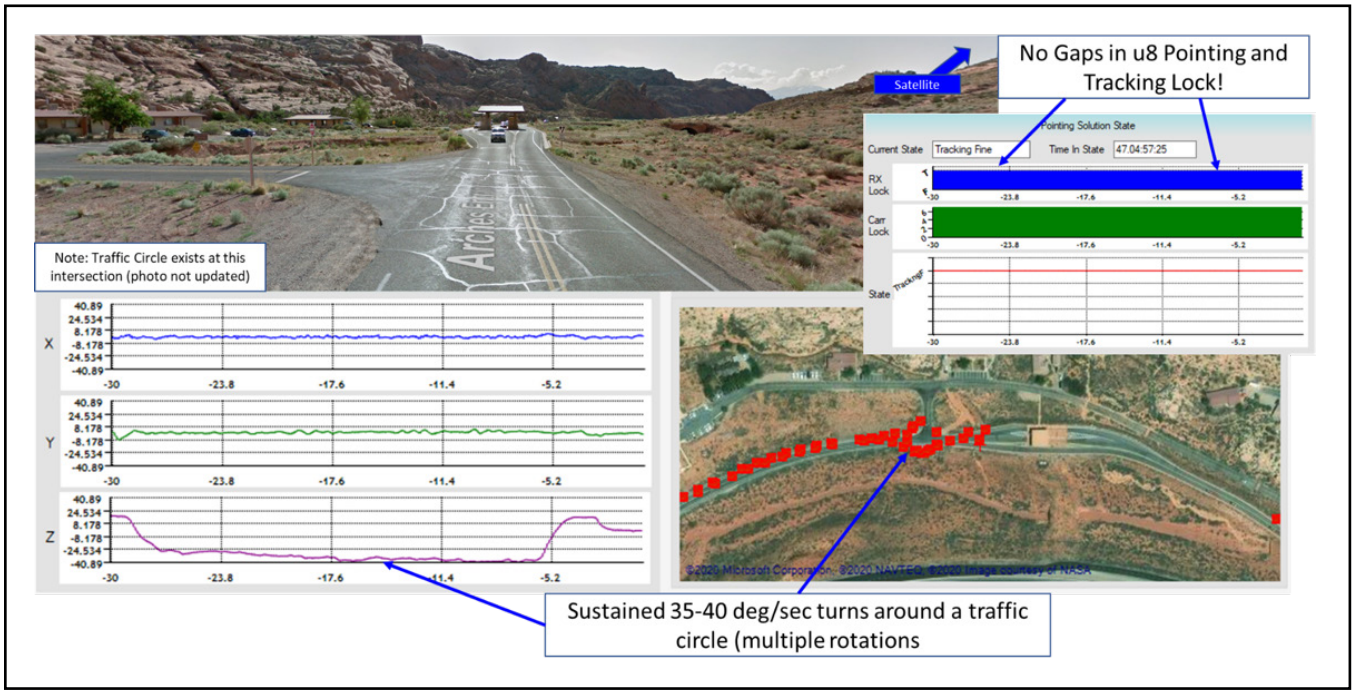

Fig.4: Traffic circle on Arches Scenic Drive at Arches National Park, UT

System stability

During the trial, the engineers did not encounter a single system fault nor a need to restart the system during operation. The system was connected via a signal wire to the vehicle's switched ignition, so it was easy to turn on. The system turned on when the car was turned on. This automatic powerup was simple and reliable.

Environments

During the trial, the vehicle with install terminal encountered heavy rains, freezing

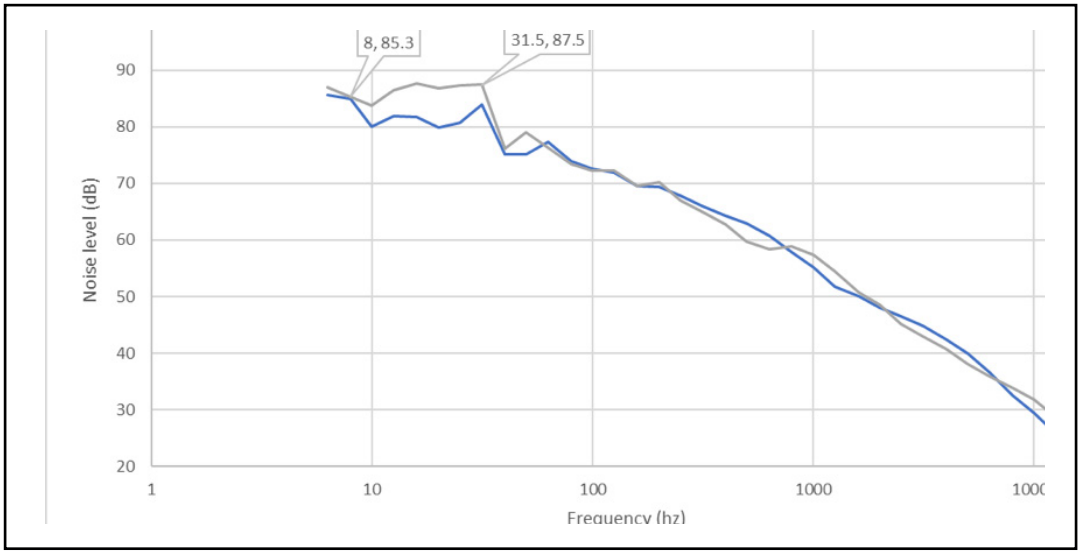

Fig. 5
Acoustic measurements during 80 MPH highway driving

temperatures, hot sunny days, wind, and dry and humid environments. The varied environments had no noticeable effect on system performance. During freezing temperatures, the Kymeta engineers utilized the integrated terminal heating capabilities, the embedded systems easily kept the terminal in its effective thermal operating range.

Effects of shock and vibration

The system remained unaffected while tracking satellites as the vehicle drove on bumpy roads, rough highways, highway rumble strips, and through large potholes. While performing closed-loop tracking, there were no identified shock or vibration effects on the system at any speed on any road type.

Noise creation

The Kymeta team evaluated the system at vehicle speeds ranging from 0 MPH to 80 MPH to identify any resonances or vibration-induced rumbling in the cabin. The road noise increased in an acceptable and predictable manner consistent with other roof mounted accessories.

The engineers recorded the vehicle noise profiles with and without an air dam, which while providing a slight decrease in low-frequency noise and vibration as shown in Figure 5 (previous page). The results show that the system requires little to no noise mitigations devices due to is low profile.

Figure 5 additionally shows that with and without an air dam the noise is generally broadband, “white” or “pink” noise, without resonance peaks. This follows the observation that there was no discernable whistling heard by Kymeta engineers during the evaluation.

Figure 6: Traffic circle on Arches Scenic Drive at Arches National Park, UT

Summary

The real testing, real results, field trial validated the design architecture of the u8 terminal and provided better than expected performance for an alpha prototype. Furthermore, the trial highlighted the power of Kymeta's u8 terminal hybrid solution for ubiquitous coverage. Figure 6 above, is most certainly a beautiful spot on a New Mexico highway, and it also represents the start the 60+ minutes of driving that had only 5 minutes of cellular connectivity, better known as a cellular desert. This is another real-world example of why a hybrid, comms-on-the-move solution from Kymeta is so important in all regions of the world.

THE KYMETA u8 BRINGS TO MARKET THREE VERY IMPORTANT FACTORS FOR SUCCESS:

CONTINUOUS CONNECTIVITY

100% Total connectivity over the entire drive via the hybrid communications system

AGILITY

Stable system performance without any recorded faults or failures

ROBUSTNESS

A robust satellite tracking algorithm that can stand up to harsh maneuvers

THE NEW u8 TERMINAL IS DESIGNED ALONG WITH OUR SIGNATURE ELECTRONICALLY STEERED, LOW PROFILE u8 ANTENNA TO:

REVOLUTIONIZE MOBILE COMMUNICATIONS

On satellite and hybrid satellite-cellular networks with its groundbreaking metamaterials-based antenna.

MOUNT ON ANY MOVING PLATFORM, ANYWHERE IN THE WORLD

Can be connected to a Ku-band LEO or GEO satellite and hybrid networks with ease using a Kymeta solution.

OFFER A PIONEERING DESIGN WITH AN UNPARALLELED SIZE, WEIGHT, POWER, AND COST PROFILE

Relative to phased array solutions delivering a unique value proposition to customers demanding convenient, affordable, always-on connectivity that is easy to use.

BUILT ON A UNIQUE TECHNOLOGY

That is customer tested and validated and offers a continuous connectivity experience that provides competitive differentiation.

READY TO MEET OUR CUSTOMERS' NEEDS

In verticals such as First Responders, Enterprise, Military, Government and Small Crafts, packaged and ready for use, and as simple as a wireless plan, with the Kymeta u8 terminal and Kymeta Connect.