DEFENSE PNT IN CHALLENGED ENVIRONMENTS
BEFORE WE BEGIN

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SPEAKERS

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TALEN-X

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TRX SYSTEMS
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PRODUCT MANAGER, RUGGED PNT
OROLIA
ABOUT OROLIA

A world leader in assured positioning, navigation and timing (PNT) solutions that improve the reliability, performance and safety of critical, remote or high-risk operations.

PNT Key Capabilities by Industry

- **Aerospace**
  - Distress/Safety Systems (GADSS)
  - Air Traffic Mgmt.
  - Emergency Mgmt.

- **Enterprise**
  - Network Timing
  - Financial Services
  - Maritime Domain Awareness
  - Critical Infrastructure/911

- **Government**
  - Emergency Management
  - Maritime Domain Awareness
  - Critical Infrastructure/911

- **Maritime**
  - GMDSS
  - Vessel Monitoring Systems
  - Automatic Identification System (AIS)

- **Defense**
  - Assured PNT
  - C4ISR
  - Combat SAR

- **Space**
  - Atomic Clocks
  - Low-Noise Oscillators
  - Satcom

- **Transportation**
  - Unmanned Autonomous Systems

With locations in more than 100 countries, Orolia provides virtually failsafe GPS/GNSS and PNT solutions to support government and commercial applications worldwide.
GNSS IS GREAT...

...UNTIL IT’S GONE.
PNT IS REQUIRED BY MANY CRITICAL SYSTEMS

- Navigation and Maneuver
- Command and Control
- Sensor Platforms
- Communications
- Tactical Networks
- Unmanned Vehicles
PNT IN LAND OPERATIONS

Command and Control

- Individual navigation
- Communications networking and security
- Digital blue force tracking
- Decisionmaker situational awareness
- Synchronize operations
PNT in Land Operations

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Intelligence, Surveillance, and Reconnaissance
- Adversary posture and activities
- Identify critical decision points
- Outmaneuver the opponent
# PNT in Land Operations

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<th>Intelligence, Surveillance, and Reconnaissance</th>
<th>Time Sensitive Targeting</th>
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<td>Outmaneuver the opponent</td>
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<td>Minimize collateral damage</td>
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# PNT in Land Operations

## Command and Control
- Individual navigation
- Communications networking and security
- Digital blue force tracking
- Decisionmaker situational awareness
- Synchronize operations

## Intelligence, Surveillance, and Reconnaissance
- Adversary posture and activities
- Identify critical decision points
- Outmaneuver the opponent

## Time Sensitive Targeting
- Locate high-value targets
- Engage before the target is lost
- Assessment
- Minimize collateral damage

### Assured PNT =
- Faster, better informed decisions
- Greater synchronization
- Force Multiplication

= Doing More With Less!
WHAT HAPPENS WITHOUT PNT?

- Poor PNT Availability
- Non-Secure Voice Communications
- Map and Compass
- Analog Map Tracking
- Information Gaps
- Slower Actions

Military Effectiveness

- Secure Digital Communications
- Digital Navigation
- Digital Blue and Red Tracking
- Superior Awareness
- Faster Actions

Assured PNT
TRUE RESILIENCE = DEFENSE IN DEPTH

- INTERFERENCE
- JAMMING
- SPOOFING

- GNSS
- ANTI-JAMMING
- DATA INTEGRITY
- SPOOFING DETECTION
- COMPLEMENTARY PNT SIGNALS
- INTERNAL PNT REFERENCES

PNT-RELIANT SYSTEM
OROLIA PNT SOLUTIONS

INTERFERENCE

JAMMING

SPOOFING

FLEXIBLE - CONFIGURABLE - SCALABLE

GPS / GALILEO / GLONASS / BEIDOU

PASSIVE AJ ANTENNA

ACTIVE AJ ANTENNA

SAASM / M-CODE / PRS

BROADSHEILD JAM/SPOOF DETECTION

ALT SIGNALS / ODOMETER / RANGING / PSEUDOLITES

IMU / OSCILLATOR / ATOMIC CLOCK

VersaPNT-RELIANT SYSTEM
OPERATING IN GPS-DISRUPTED ENVIRONMENTS: THREATBLOCKER

Tim Erbes
Chief Technology Officer
Talen-X
OVERVIEW

• It is known that GPS-disruption can affect missions

• The ability to access trusted PNT data in these environments is critical

• Talen-X is working to develop a solution that assures the integrity of PNT data
  • ThreatBlocker

• This technology can enable modern land-warfare systems to operate in GPS-disrupted environments
THREATBLOCKER: HOW IT STARTED

JNC 2017


Phillip B Hess and Philip A Dafesh
The Aerospace Corporation
WHAT IS BLISS?

- Technology developed by The Aerospace Corporation
- Blind Interference Signal Suppression (BLISS)
- Digital processing technique to suppress jamming signals.
WHAT IS BROADSHIELD?

- Technology developed by Talen-X
- Jamming and Spoofing detection software.
WHAT IS THREATBLOCKER?

ThreatBlocker

BroadShield
- Jamming Detection
- Spoofing Detection

BLISS
- Jamming Suppression
- RF Disconnect

TALEN-X

AEROSPACE
Assuring Mission Success
THREATBLOCKER
ARCHITECTURE

ThreatBlocker

RF IN  RF  RF OUT

PWR  uBlox  uBlox
PPS1  ADC  DAC
PPS2  IQ  IQ
JAM  BLISS
SPOOF  FPGA
OFF
THREATBLOCKER
INSTALLATION

Antenna

Exposed RF

ThreatBlocker

Power
5V

Protected RF

GPS Receiver
THREATBLOCKER PROTOTYPE
THREATBLOCKER JAMMING PERFORMANCE
LAB TEST: CA VS MATCH SPECTRUM

Average C/No of Tracked SVs
By Receiver Over Time

- uBlox_Normal
- uBlox_Protected

↑30JS  → 60JS  → 90JS → 90JS  → 60JS  → 30JS↓

- Jamming Suppression Activated
- Protected GPS Receiver
- Signal Lost At 90 J/S
- Unprotected GPS Receiver
- Signal Lost At 45 J/S
- 40 dB

Time (seconds)
THREATBLOCKER JAMMING PERFORMANCE
REAL WORLD DRIVE BY 250 WATT CHIRP

Without ThreatBlocker

With ThreatBlocker

Fourth Highest C/No Map
Panorama by Talon-X

“No Nav” for 4 km

“No Nav” for 1 km
THREATBLOCKER JAMMING PERFORMANCE
REAL WORLD CAR WASH 1000 WATT CHIRP

Without ThreatBlocker

Fourth Highest C/No Map
Panorama by Talen-X

Motion

45 J/S
40 J/S

“No Nav” for 10 km

With ThreatBlocker

Fourth Highest C/No Map
Panorama by Talen-X

Motion

80 J/S

“No Nav” for 0.3 km
DENIAL AREA OF 100 WATT JAMMER WITHOUT THREATBLOCKER
DENIAL AREA OF 100 WATT JAMMER WITH THREATBLOCKER

35 dB improvement
CONCLUSION

- ThreatBlocker can detect jamming, detect spoofing, protect from jamming, and protect from spoofing
- Small Size, Weight and Power (SWaP)
- Inline system
  - Compatible with legacy and modernized downstream PNT systems
- Enable operations in GPS-disrupted environments
GPS-DENIED LOCATION FOR DISMOUNTED PERSONNEL
INTENTIONALLY DENIED, INDOORS AND UNDERGROUND

Carol Politi – President and CEO

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TRX SYSTEMS: GPS-DENIED LOCATION AND MAPPING

Ubiquitous Personnel Location and 3D Mapping:
Inside buildings, underground, in dense urban and GPS-denied areas

Network Coverage Validation and Sensor Mapping (LMR, LTE, Radiation, etc.)
Situational Awareness for National Security Events, Critical Infrastructure, Incident Response
Dismounted Tracking and Mapping within Urban and GPS-denied environments

[Logos and emblems of various organizations]
GPS-DENIED LOCATION AND MAPPING CHALLENGE

- GPS does not work indoors, underground is inaccurate in dense urban areas, and is easily jammed.
- For operations indoors and underground, map data required for optimal situational awareness is often unavailable, difficult to manage.
- Solutions for locating and mapping without GPS are often high SWaP or rely on infrastructure.
DISMOUNT GPS-DENIED NAVIGATION – KEY NEEDS

- Location urban canyon, indoors, underground, triple canopy, intentionally denied
- Low SWaP solution, integrated in soldier systems, easy to use
- Operation within denied environments for extended periods
- Robust to extended communications outages
LOW SWAP SENSORS HAVE MANY ERROR SOURCES

<table>
<thead>
<tr>
<th>Inertial</th>
<th>RF/Ranging</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Measure relative motion</td>
<td>• Signal strength (e.g., BLE) - useful over very short distances, highly affected by environment</td>
</tr>
<tr>
<td>• Relatively low power and processing</td>
<td>• Narrowband sources support high propagation distance, not precise</td>
</tr>
<tr>
<td>• Compensation of sensor drift is the major issue</td>
<td>• UWB Time of flight - medium range, not yet embedded in all devices</td>
</tr>
</tbody>
</table>

**Pressure**

- Measure relative elevation
- Susceptible to environmental interference

**Magnetometers (compass)**

- Deliver heading, magnetic features
- Significant magnetic disturbances indoors, near vehicles/equipment

**Light**

- Detects IR, visible light
- Device can be under coat

**Acoustic**

- Noise signatures and acoustic ranging
- Platform filtering varies, some frequencies can be heard

**Optical**

- Can measure relative motion, support feature matching
- High computation and power
- Highly affected by lighting and texture of environment
- Lenses can be blocked, get dirty

---

**Low SWAP sensors available for navigation are prone to errors over time, due to building or environmental conditions, and due to human motion.**
Inertial “dead reckoning” alone is infrastructure-free but accumulates error over distance travelled.

Other inputs - intermittent GPS, map data, and UWB/BLE ranging, etc. are needed to “constrain” inertial results and provide accurate location over extended periods.
<table>
<thead>
<tr>
<th>Layered, Multi-Sensor Fusion Approach is Needed – Key Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initialization</strong></td>
</tr>
<tr>
<td>Key parameters include start position, heading, user mounting location and gait; learned from GPS, beacons or manual input</td>
</tr>
<tr>
<td><strong>Sensor Fusion</strong></td>
</tr>
<tr>
<td>Inertial sensors (gyro, accel, compass) plus pressure and other Android based sensors used to calculate movement in local frame</td>
</tr>
<tr>
<td><strong>Satellite and Terrain Data</strong></td>
</tr>
<tr>
<td>Provides for placement of user in global frame with latitude, longitude and altitude above sea-level; allows for 3D visualization</td>
</tr>
<tr>
<td><strong>Building or Tunnel Data</strong></td>
</tr>
<tr>
<td>Shape files give 3D construct; learned data provides structural (stairs, entrances, elevator) constraints</td>
</tr>
<tr>
<td><strong>Collaborative Ranging</strong></td>
</tr>
<tr>
<td>Position inputs can be shared between users, allowing users with high accuracy or assured position source to initialize team</td>
</tr>
<tr>
<td><strong>Inferred Mapping</strong></td>
</tr>
<tr>
<td>Learned RF (cellular, Wi-Fi, BT) data combined with structural data can be geo-referenced to deliver location assistance data</td>
</tr>
<tr>
<td><strong>Beacons</strong></td>
</tr>
<tr>
<td>Ranging to optional UWB and/or BLE beacons provide constraints where these can be dropped or placed</td>
</tr>
</tbody>
</table>
PERSON TO PERSON RANGING – BASIC APPLICATION

Navigator – SAASM GPS, STL, good map skills, etc. Team member – GPS jammed

UWB ranging (cm level accuracy) and communications

Source: TRX Systems NEON
INTEGRATION INTO “SYSTEM OF SYSTEMS” SUPPORTS LAYERING OF POSITION/NAVIGATION CONSTRAINTS

- Sensor fusion & mapping delivers relative location
- Fusion with GPS, known waypoints, dropped anchors supports initialization, individual dismount constraints
- Ultra-wideband sub-meter relative location between devices allows assured position sharing
- Location constraints from 3rd party sensors or systems (UAVs, vehicles and other positioning sources)
- Indoors/underground, structural information can be used to create map, store user path

Source: TRX Systems NEON

UAVs

Nett Warrior/ATAK Source: TRX Systems NEON

Ground Vehicles/Rooİots

Fixed/dropped References

A WORLD WEBINAR, BROUGHT TO YOU BY: orolia GOVERNMENT
## PERFORMANCE GIVEN LAYERED CONSTRAINTS

<table>
<thead>
<tr>
<th>Available Sensor Input And Constraints</th>
<th>Estimated Accuracy</th>
<th>Dependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inertial Sensor Fusion</td>
<td>3-7% of distance traveled</td>
<td>Accuracy degrades over distance/time without corrections</td>
</tr>
<tr>
<td>+ UWB ranging</td>
<td>&lt;1 meter relative accuracy</td>
<td>Person to person</td>
</tr>
<tr>
<td>+ Building shape files</td>
<td>5-15 meters</td>
<td>Dependency on size of building</td>
</tr>
<tr>
<td>+ Preplanning (WiFi, Structural features)</td>
<td>4-10 meters</td>
<td>Use NEON Mapper to preplan building; More features = better accuracy</td>
</tr>
<tr>
<td>+ UWB Beacons</td>
<td>1-5 meters</td>
<td>Low density deployment at chokepoints (entrances) or dropped during operations</td>
</tr>
<tr>
<td>+ BLE Beacons</td>
<td>3-7 meters</td>
<td>Low density deployment at chokepoints (entrances, etc.)</td>
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Source: TRX Systems NEON

Outdoor GPS-Denied 2/2018

3D Indoor Tracking GPS-Denied 10/2017

Underground Subway 2/2018
TRX NEON DISMOUNT LOCATION SERVICE

- Real-time, 3D location calculated every step
- Fusion of sensor fusion, map data and ranging technologies
- Android smartphone paired with optional inertial measurement unit
- API delivers lat/long, altitude, floor level, map data; accepts position constraints
- ATAK plug-in supports integration with soldier systems

*Can be embedded in standard cellular as well as third party custom devices (e.g., radiation detectors, assured PNT devices, etc.)*

Source: TRX Systems NEON
INTEGRATION INTO MILITARY SYSTEMS & CONOPS

Access to GPS

Integration with ATAK, SAASM (Rockwell RSR)
Source: TRX Systems NEON

Underground GPS Denied Track
Source: TRX Systems NEON

Tunnel Entry
## Growing Commercial GPS-Denied Use

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Super Bowl LI Houston, TX</strong></td>
<td>Law enforcement, EMTs at Super Bowl LI in Houston</td>
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<tr>
<td></td>
<td>~2M square feet and 7 levels of 3D tracking</td>
</tr>
<tr>
<td></td>
<td>Improved situational awareness &amp; safety, reduced radio traffic</td>
</tr>
<tr>
<td><strong>Immigration and Customs Checkpoint</strong></td>
<td>24x7 situational awareness at large border checkpoint</td>
</tr>
<tr>
<td></td>
<td>7 floors, indoor and outdoor 3D coverage</td>
</tr>
<tr>
<td></td>
<td>Integrated with Operations and Command Center</td>
</tr>
<tr>
<td><strong>Active Violence Exercise Grand Central Terminal, NYC</strong></td>
<td>DHS first responder exercise in Grand Central Terminal involving NYPD, FDNY, and others</td>
</tr>
<tr>
<td></td>
<td>3D situational awareness for remote command center</td>
</tr>
<tr>
<td><strong>Radiation Mapping DARPA/DHS</strong></td>
<td>Tracking of law enforcement within transport hubs</td>
</tr>
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<td></td>
<td>Mapping radiation from low-cost, body worn detectors to support dirty bomb detection</td>
</tr>
<tr>
<td><strong>Signal Mapping and Signal Geolocation</strong></td>
<td>Public safety radio, cellular, and WiFi geolocation and mapping</td>
</tr>
<tr>
<td></td>
<td>Mapping of signals from cellular devices and high capability test and measurement devices (e.g., Anritsu)</td>
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Source: TRX Systems
QUESTIONS?
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