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inside unmanned systems
INSIDE ENGINEERING, POLICY AND PRACTICE

DUAL CHANNEL RTK FOR UAS: STATE OF THE ART & SCIENCE IN CAPABILITIES AND BENEFITS

Tuesday, September 11, 2018

10 a.m. PDT • Noon CDT • 1 p.m. EDT
6 p.m. BST • 7 p.m. CEST

WELCOME TO

Dual Channel RTK for UAS: State of the Art & Science in Capabilities and Benefits

James Poss, Maj Gen
(ret)USAF
CEO
ISR Ideas

Stuart Riley
Director of Engineering
Trimble

Howard Loewen
CEO
MicroPilot Inc.

Jay Tilley
CTO
Visual Intelligence

Co-Moderator: Lori Dearman, Executive Webinar Producer

Who's In the Audience?

A diverse audience of over 320 professionals registered from around the globe, representing the following industries:

- 23% Professional User
- 19% GNSS equipment manufacturer
- 18% System Integrator
- 16% Government
- 9% Product/Application Designer
- 15% Other

Welcome from *Inside GNSS*

Richard Fischer
Publisher
Inside GNSS
Inside Unmanned Systems

Welcome from *our sponsor*

Joe Carey
Director, Strategic Initiatives
Trimble Integrated Technology

Today's Moderator

James Poss, Maj Gen
(ret)USAF
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Poll #1

What qualities of a position can be improved by using a dual or triple band (L1/L2/L5) RTK system vs. an L1-only RTK system. (select two)

A. Acquisition time

B. Accuracy

C. Better tracking

D. Effectiveness of error resolution

E. L1 RTK is good enough

UAS Challenges
Dual Band GNSS for RTK

Stuart Riley
Director of Engineering
Trimble

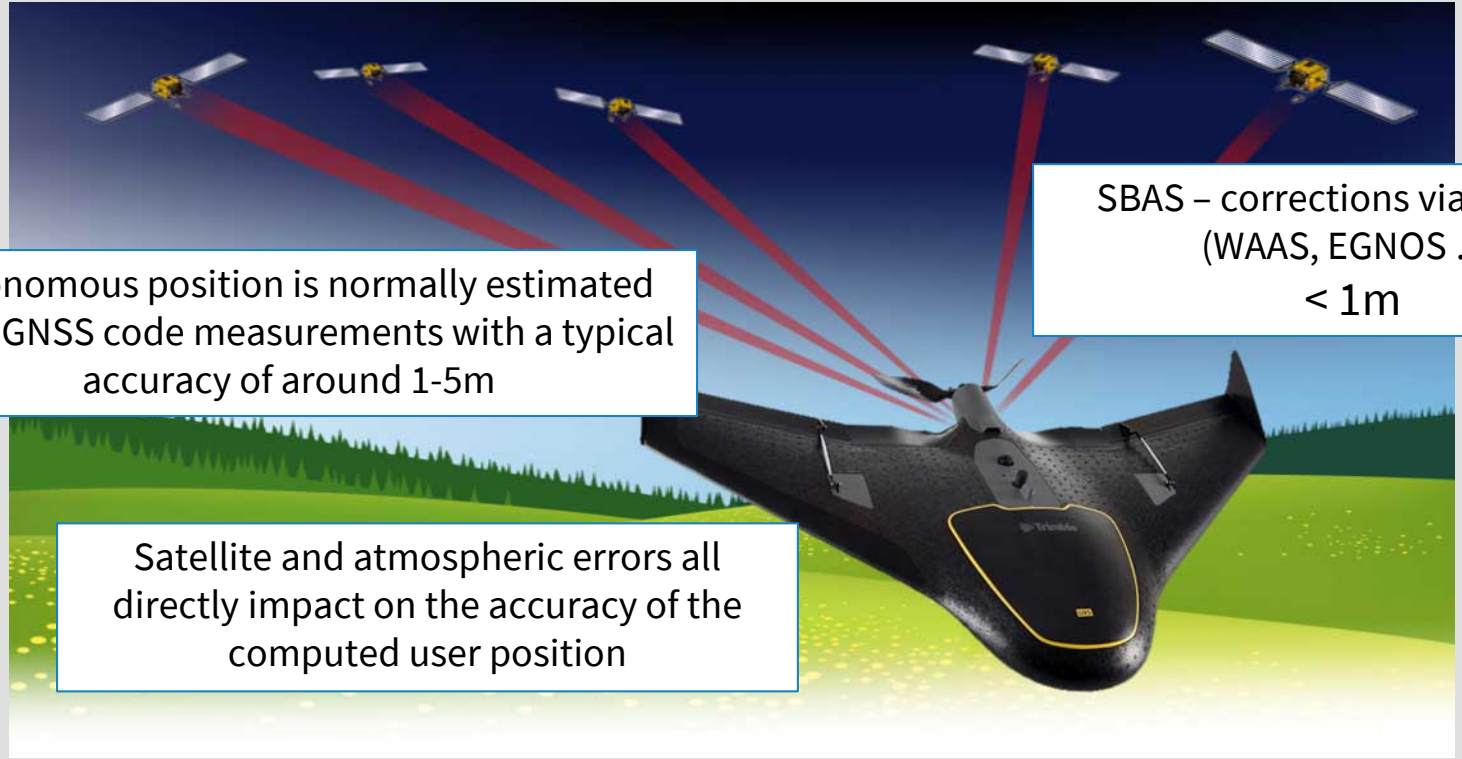
Overview

- Error sources/challenges
- Single vs Dual frequency RTK
- Pseudorange performance
- Critical Considerations
- Multi-GNSS
  - Dual / triple band support
- Integration tools

Error Sources

- Propagation effects
  - Ionospheric delay
  - Tropospheric delay
- Satellite effects
  - Clock & orbit error
  - Biases
- Inertial
  - Lever arm setup
  - IMU quality/temperature/age effects
- Antenna
  - Where is the electrical phase center?
    - Relating the position to a physical location on the UAV
  - Signal reception
    - Gain pattern
    - Jamming performance (1dB compression point of the LNA)
    - Multipath
- Receiver
  - Tracking quality
    - Pseudorange (a.k.a code) performance varies widely
    - Carrier tracking
  - PVT engine performance
  - Biases

Mapping and GIS applications



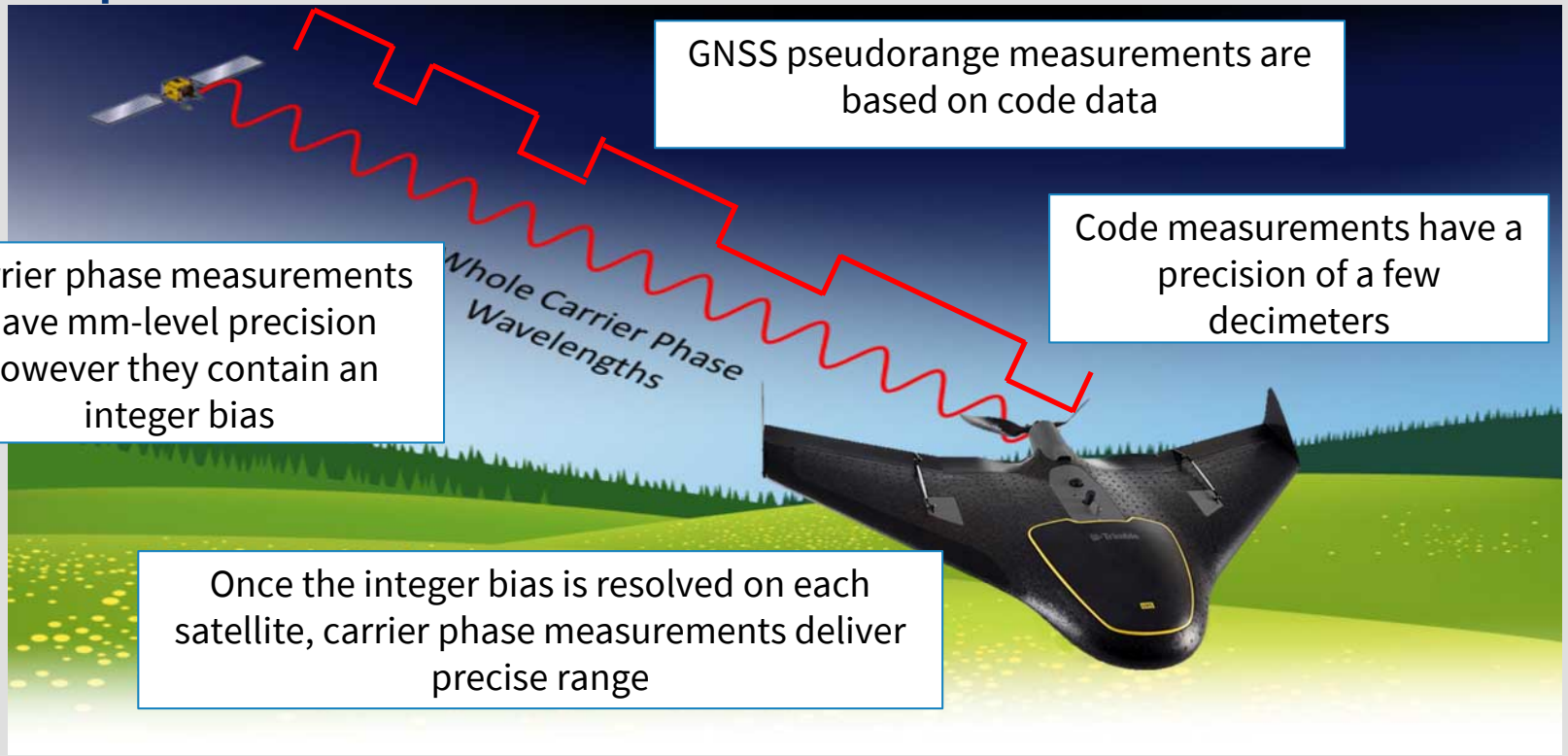
Autonomous position is normally estimated using GNSS code measurements with a typical accuracy of around 1-5m

SBAS – corrections via satellite (WAAS, EGNOS …)

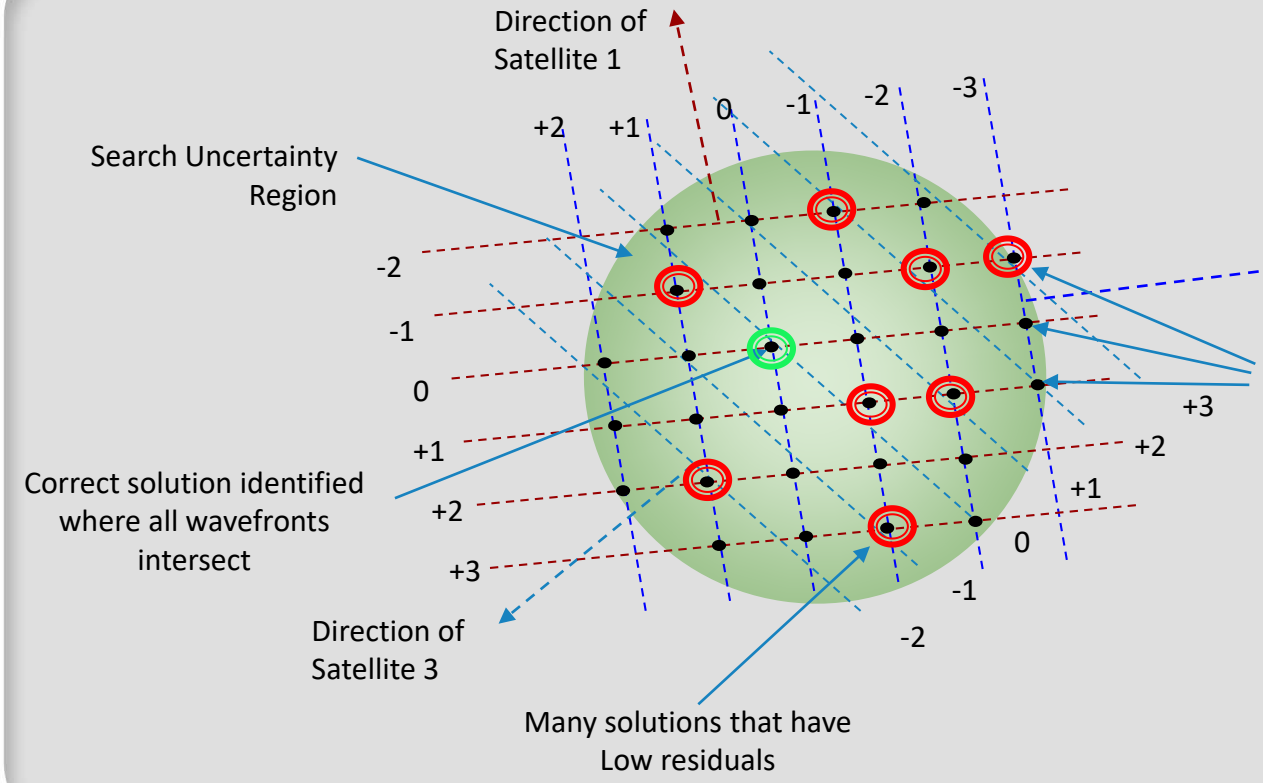
< 1m

Satellite and atmospheric errors all directly impact on the accuracy of the computed user position

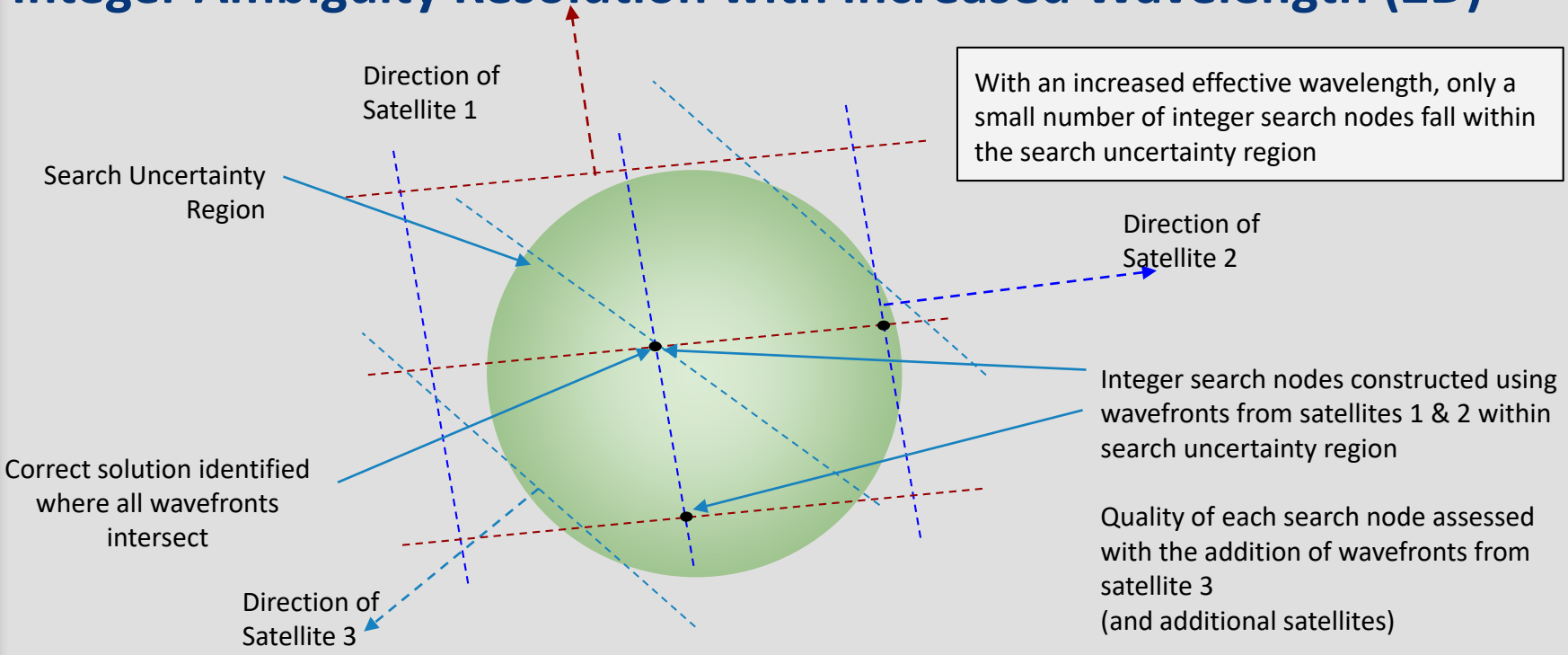
Carrier phase versus code



Integer Ambiguity Resolution Problem (2D)



Integer Ambiguity Resolution with Increased Wavelength (2D)

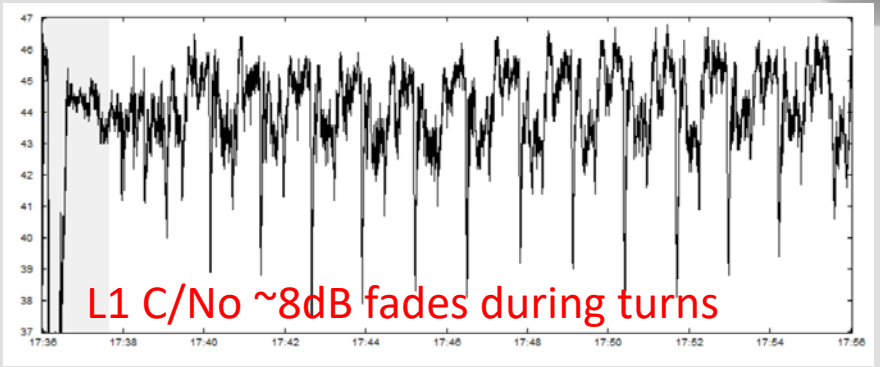


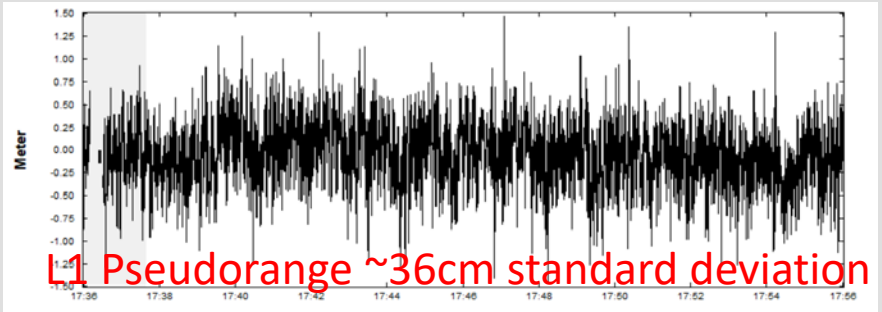
With an increased effective wavelength, only a small number of integer search nodes fall within the search uncertainty region

Integer search nodes constructed using wavefronts from satellites 1 & 2 within search uncertainty region

Quality of each search node assessed with the addition of wavefronts from satellite 3
(and additional satellites)

Pseudorange Noise

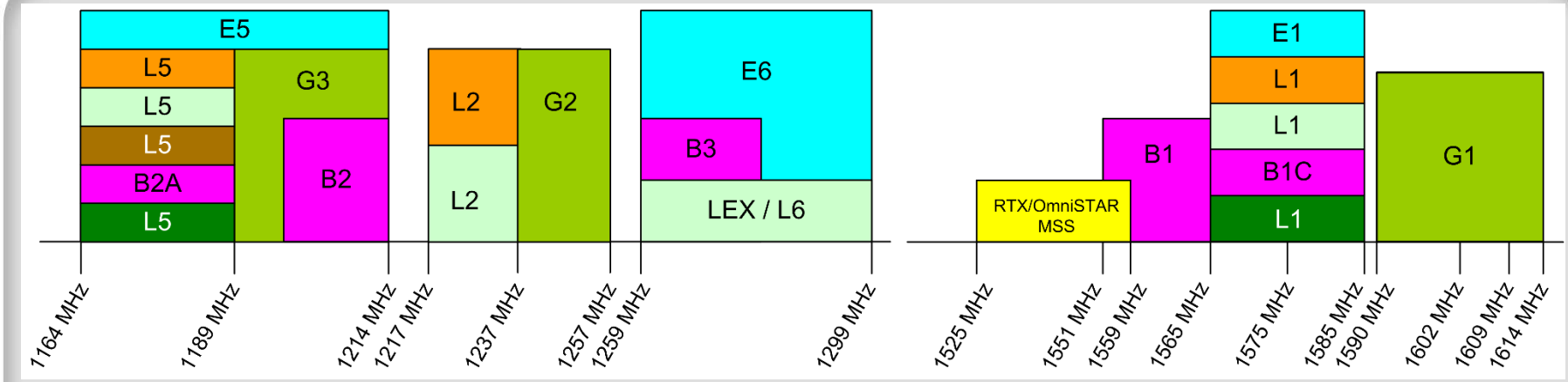




Critical Considerations

- Post-process vs Realtime
- Base Setup/Location
  - L1 only RTK requires relatively short baselines
  - Dual band can handle longer baselines (10km+)
- PPP (Precise Point Positioning)
  - No customer base required
  - Corrections over internet or MSS satellite link
  - Near RTK performance (e.g. Trimble's RTX 2cm 2D)
- Antenna placement
  - Masking during banking
  - EMI
- Code versus Carrier performance
  - Code (pseudorange) solutions can use frequency locked data, RTK requires phase lock
  - Phase lock requires stronger signal strength than frequency lock
  - Pseudorange performance is critical to setting the search region
- Radio Link
  - RTK requires a radio link
  - Need to be able to share the UAVs communication link

GNSS Spectrum



Most GNSS systems have triple frequency support

- Further strengthens the RTK solution

Highest performance profession products use all available signals

- Improves overall robustness

GPS (US)
Galileo (Europe)
Glonass (Russia)
MSS
QZSS (Japan)
IRNSS (India)
Beidou (China)
SBAS

UAV GNSS System Options

- Single antenna GNSS only
  - Lowest power / smallest form-factor
- GNSS only or GNSS / INS
  - INS provides attitude
  - Allows the position to be generated at any location on the platform
- Dual antenna
  - Provides near instantaneous platform heading
  - GNSS only integrated with inertial
- Other features to consider
  - Data logging
  - Integration simplicity
  - Output format
  - Physical output (RS232, CAN, Ethernet …)

Single Antenna
Dual Band
GNSS

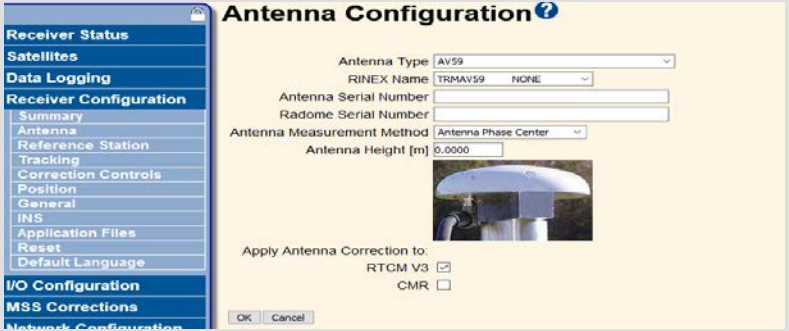
Dual Antenna
Dual Band
GNSS

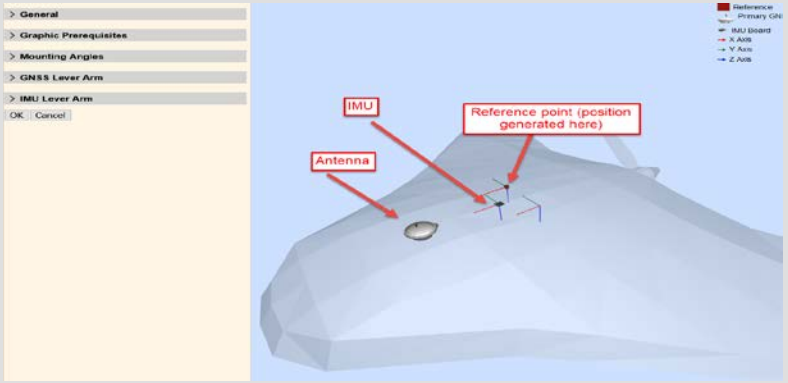
Single Antenna
Dual Band
GNSS+INS

Dual Antenna
Triple Band
GNSS+INS

Integration Tools [1]

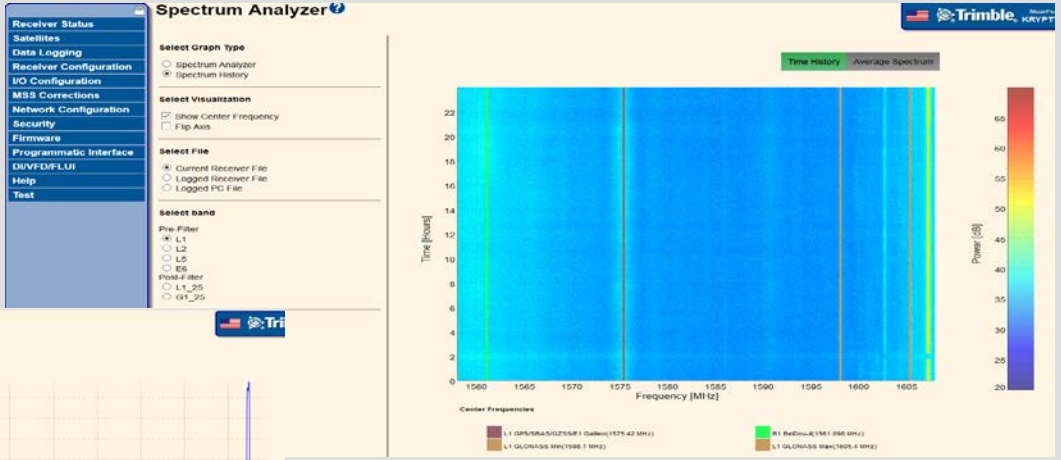
- GNSS provides position at the antenna phase center
  - For optimal support use a model of the antenna in the RTK processing
  - Large set of built in models
- Inertial
  - Provides attitude
  - Refer phase center to physical location
    - E.g. focal point of a camera
  - Lever arms are difficult to setup
    - Web based tool
    - Allows pan/zoom
    - Antenna, IMU and reference points move as data is entered

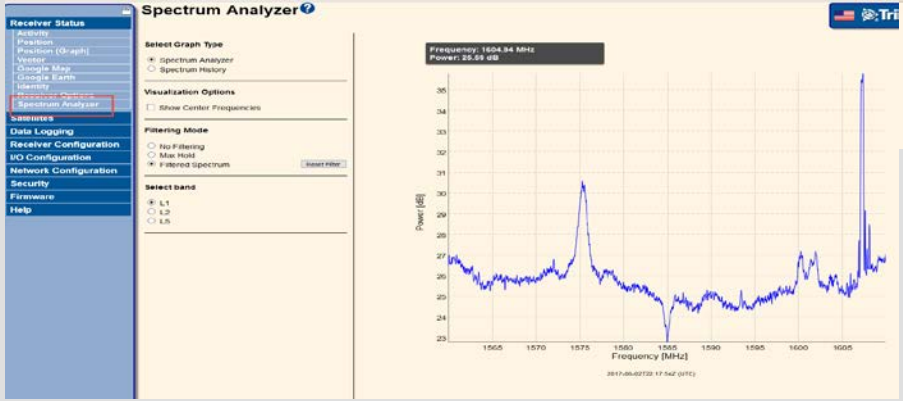




Integration Tools [2]

- Many installations have self jamming issues
  - E.g. poorly screened cables
  - Often difficult to diagnose
- Built in spectrum analyzer
  - Instantaneous spectrum
  - History up to 24 hours
  - Zoom / pan tools





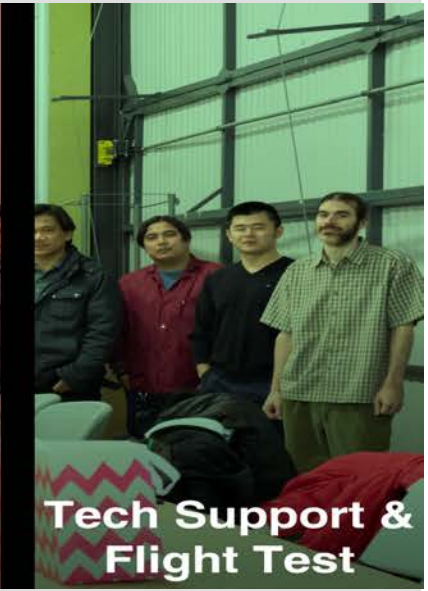
Professional UAV Autopilots

Howard Loewen
CEO
MicroPilot Inc.

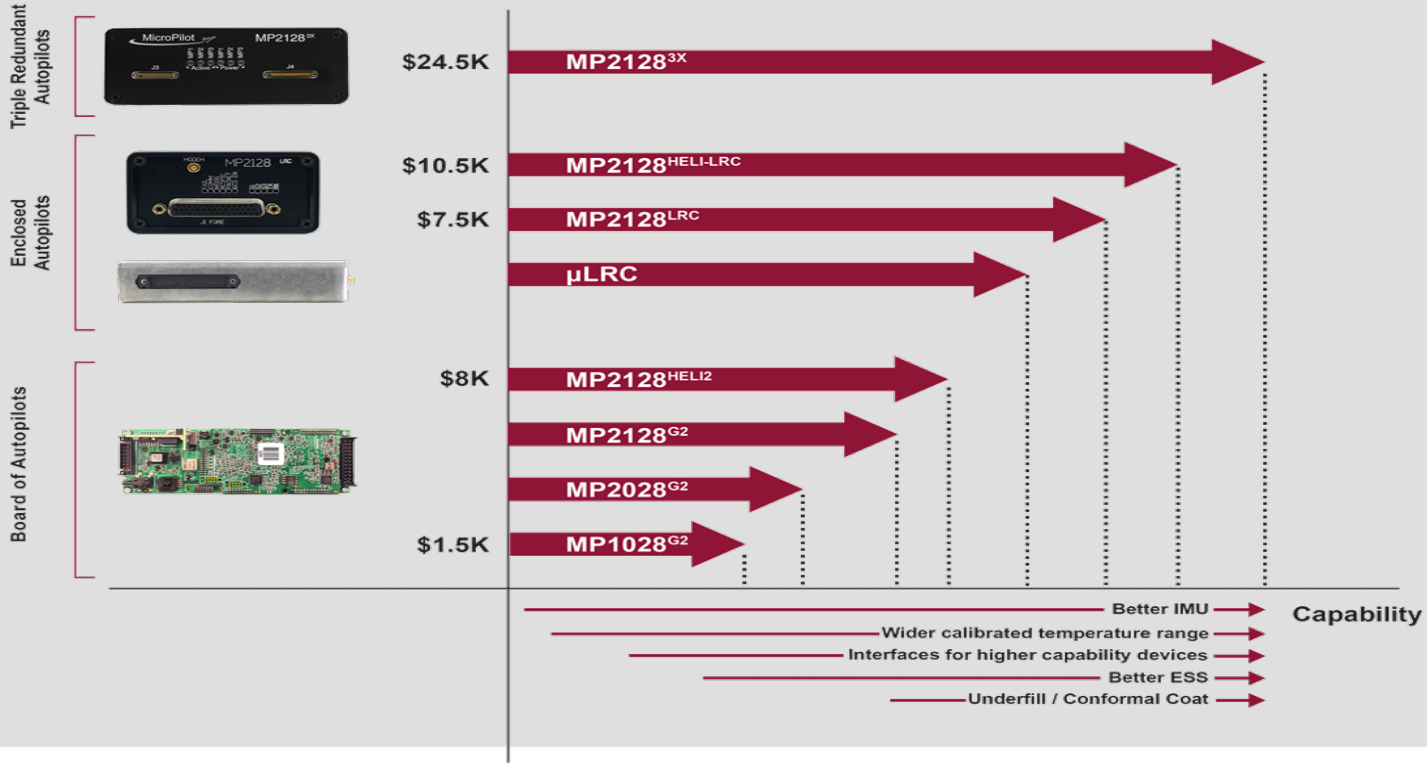
Who We Are


Software & Hardware

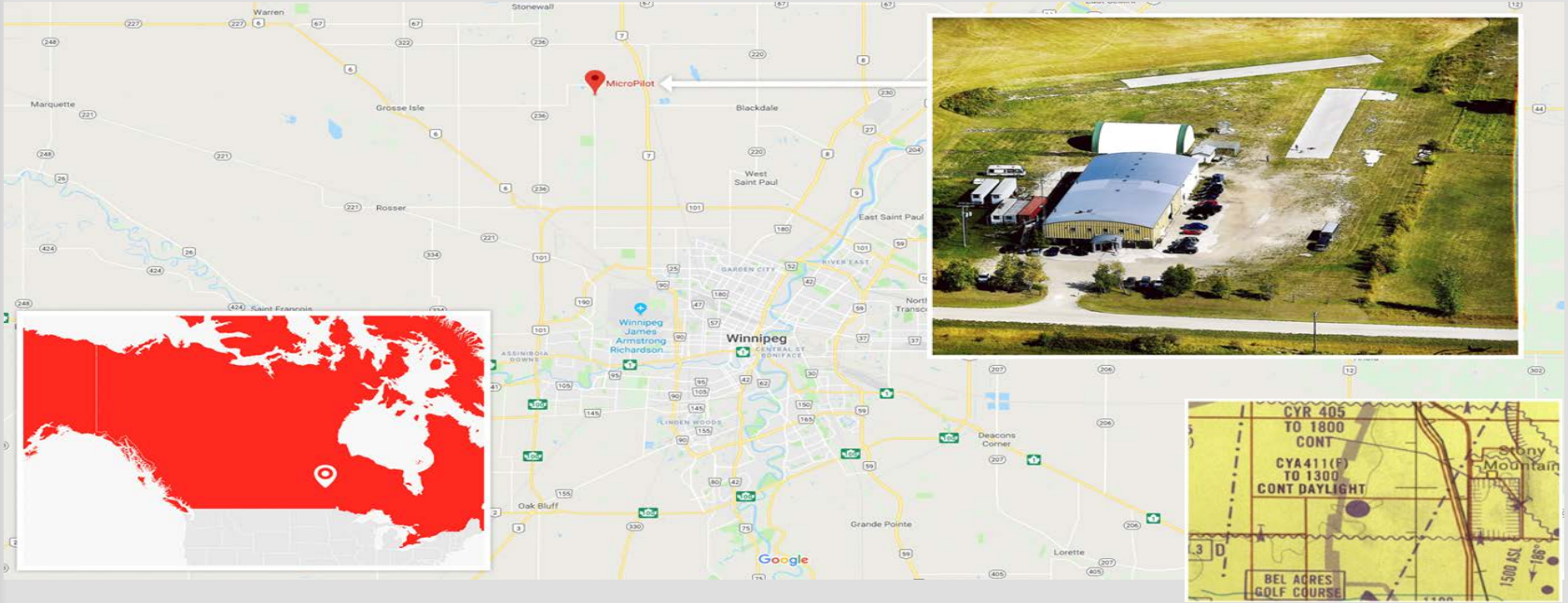

Sales, Marketing
& Admin


Tech Support &
Flight Test

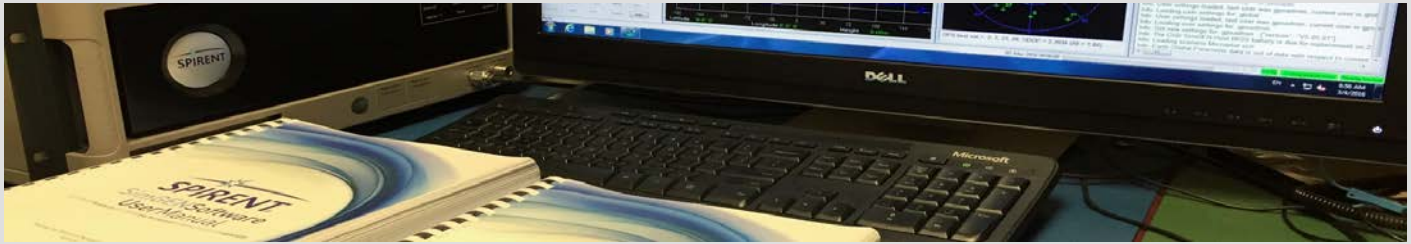
What We Make


Triple Redundant Autopilots
Enclosed Autopilots
Board of Autopilots
MicroPilot
MP2128ˢˣ
MP2128
$24.5K
MP2128³ˣ
$10.5K
MP2128HELI-LRC
$7.5K
MP2128LRC
µLRC
$8K
MP2128HELI2
MP2128G2
MP2028G2
$1.5K
MP1028G2
Capability
Better IMU
Wider calibrated temperature range
Interfaces for higher capability devices
Better ESS
Underfill / Conformal Coat

Our Facilities

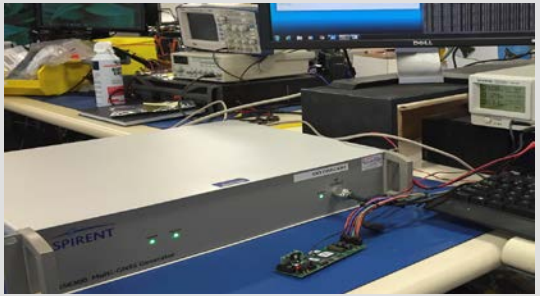


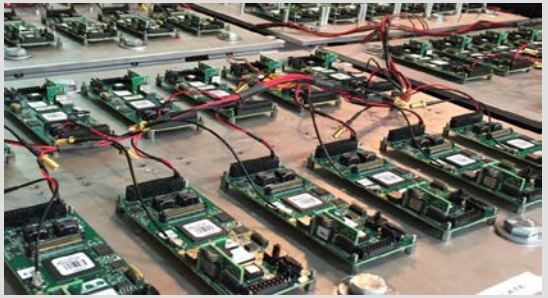
Product Development



How we Make Autopilots

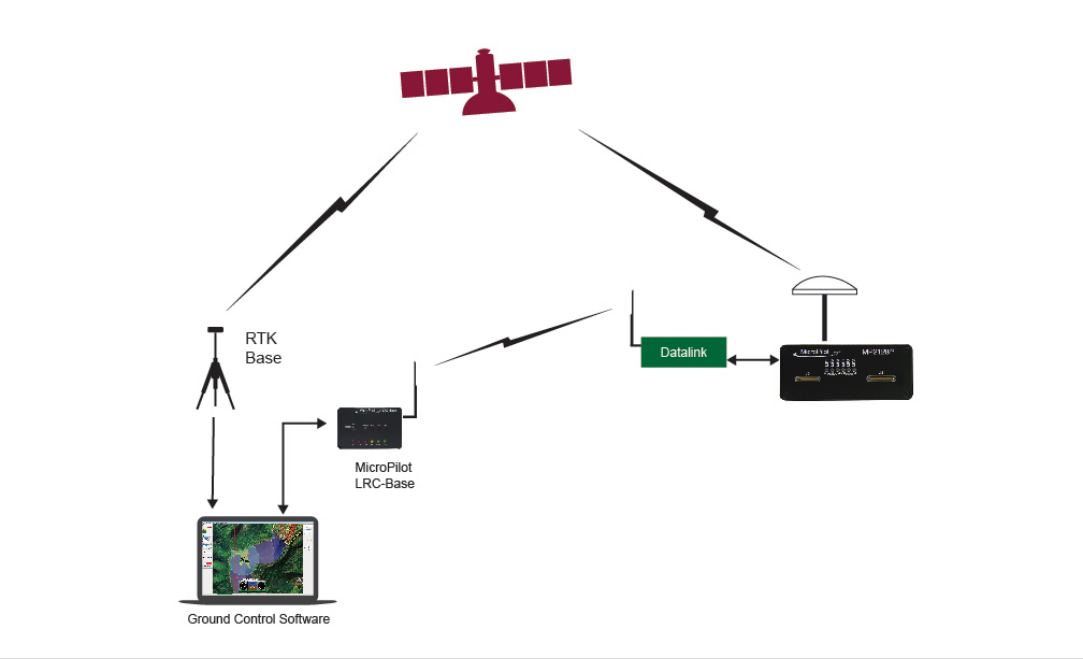
How We Make Autopilots



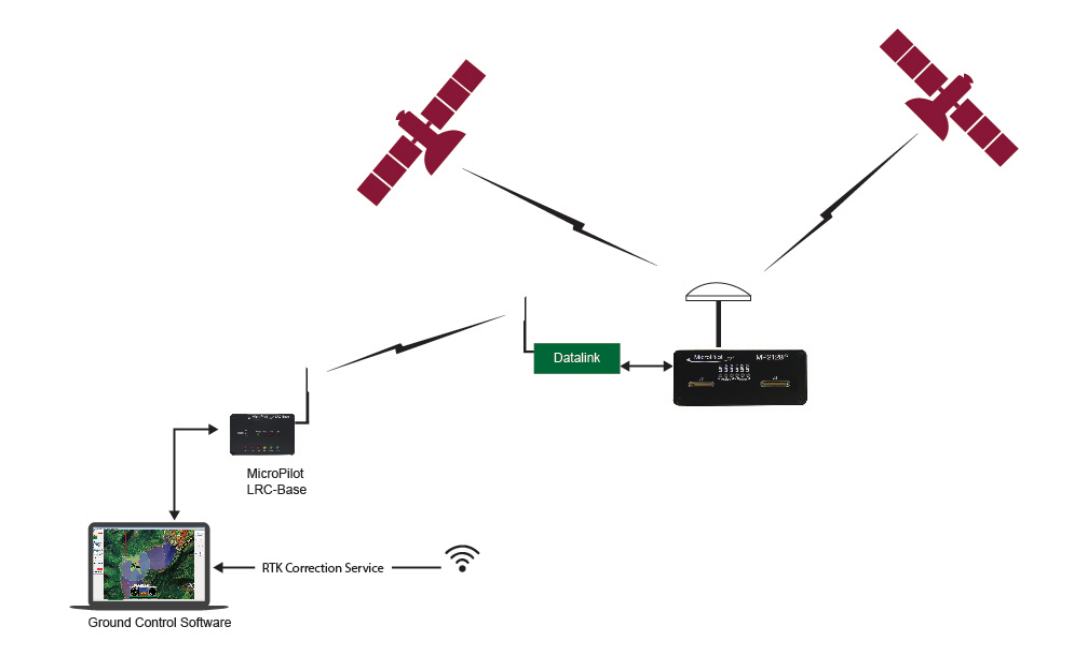


Typical Customers

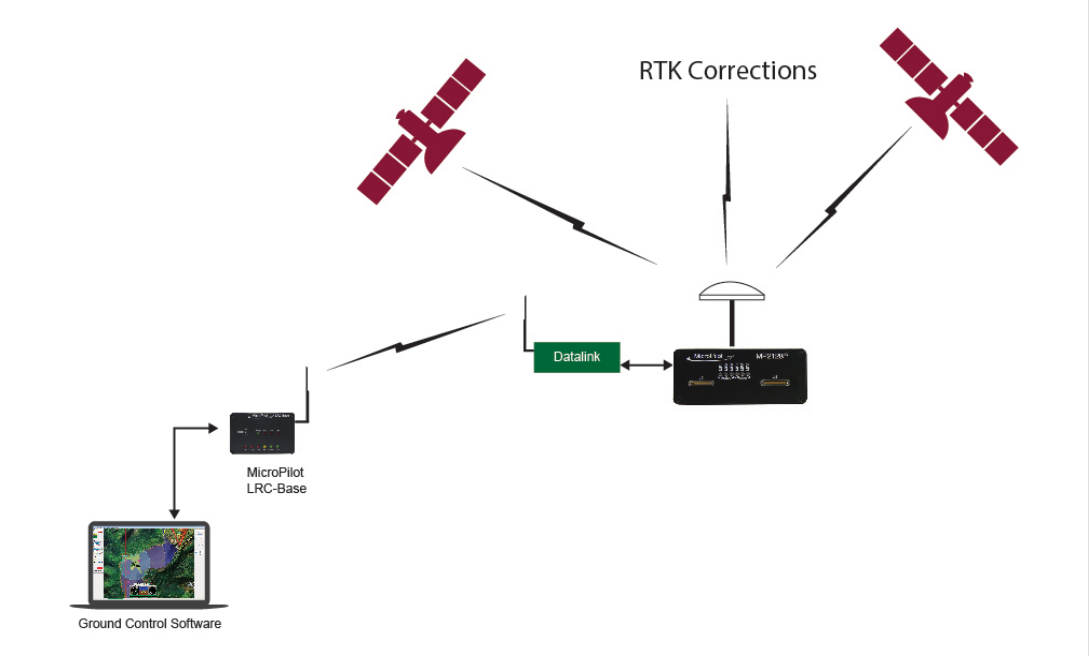
RTK Base


RTK
Base
Datalink
MicroPilot
LRC-Base
Ground Control Software

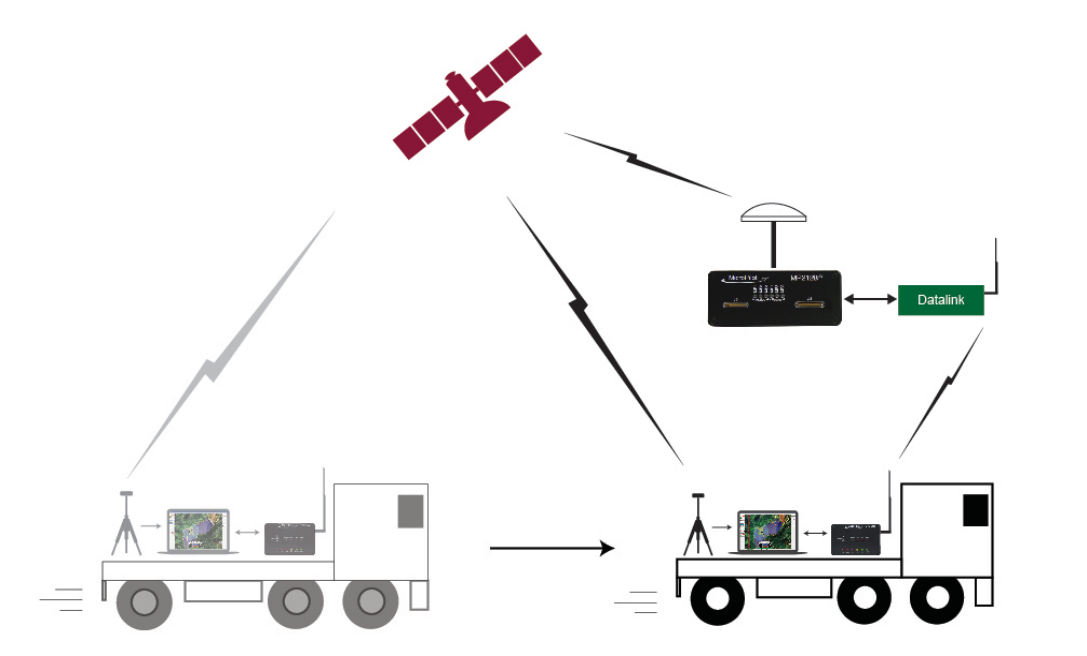
RTK Correction Service



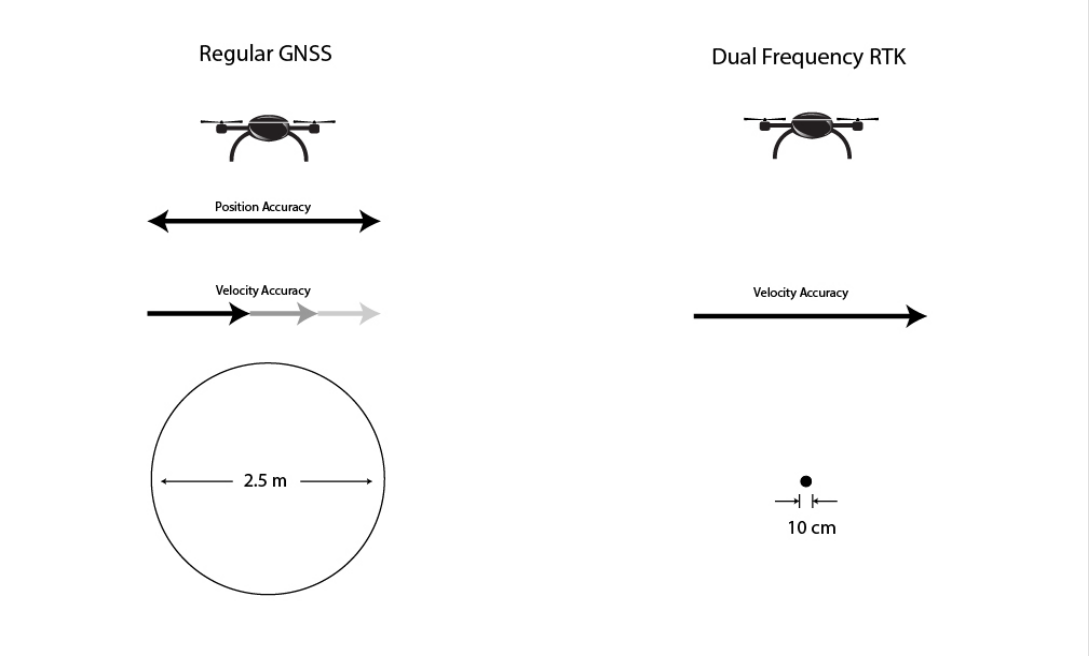
RTK Satellite Correction



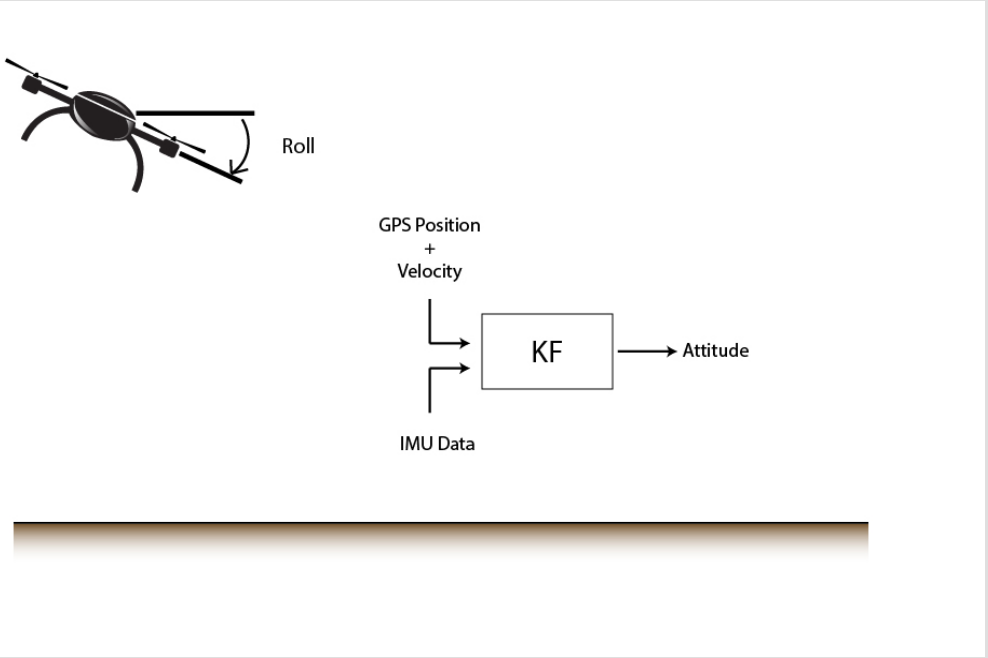
RTK Moving Base Line



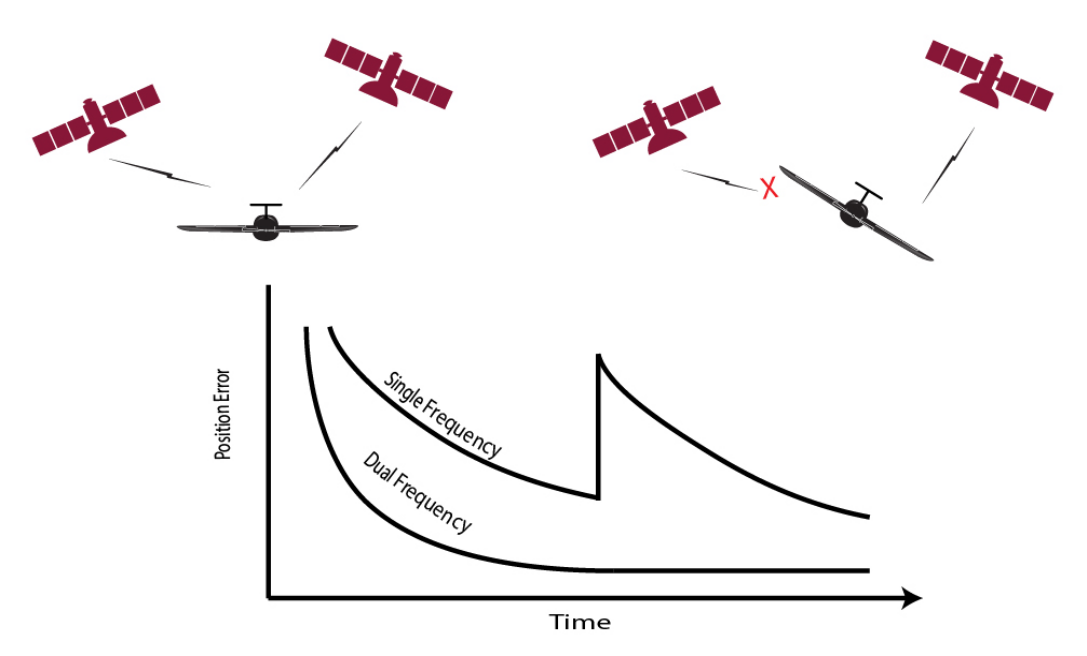
Location Accuracy



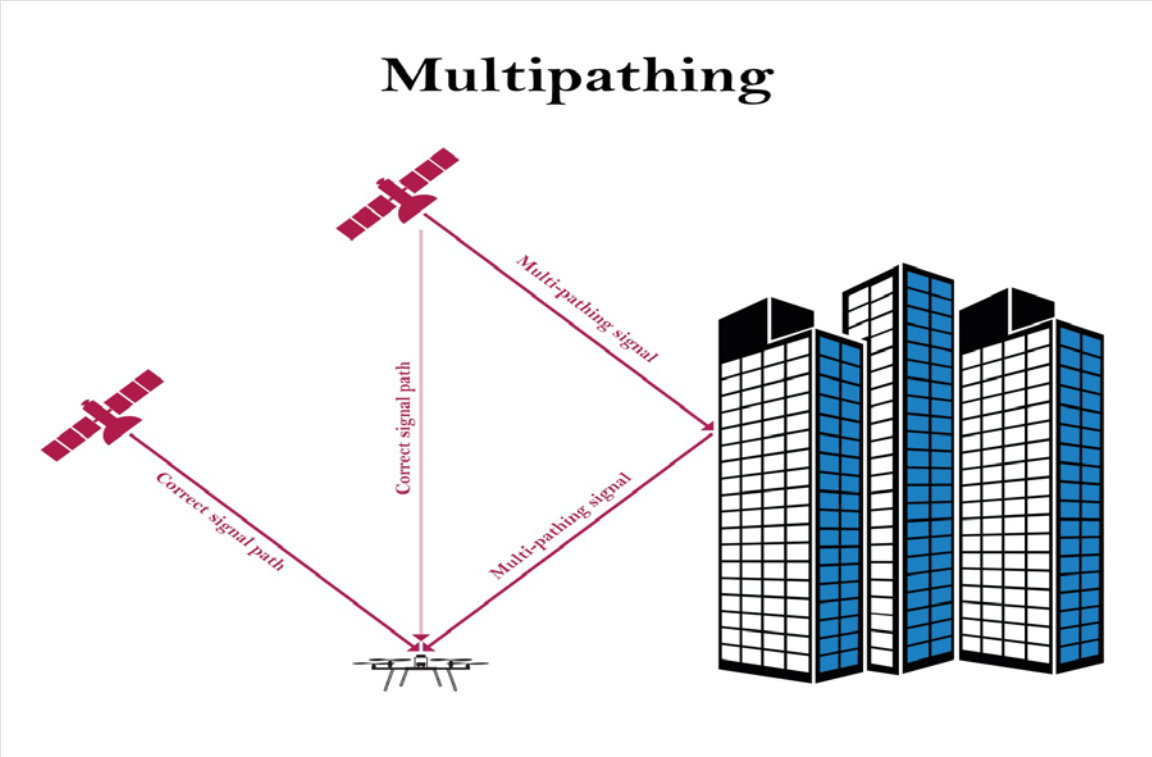
Attitude Accuracy



RTK Time to Converge



Multipathing



Ask the Experts – Part 1

James Poss, Maj Gen
(ret)USAF
CEO
ISR Ideas

Stuart Riley
Director of Engineering
Trimble

Howard Loewen
CEO
MicroPilot Inc.

Jay Tilley
CTO
Visual Intelligence

Moderator: General James Poss

Poll #2

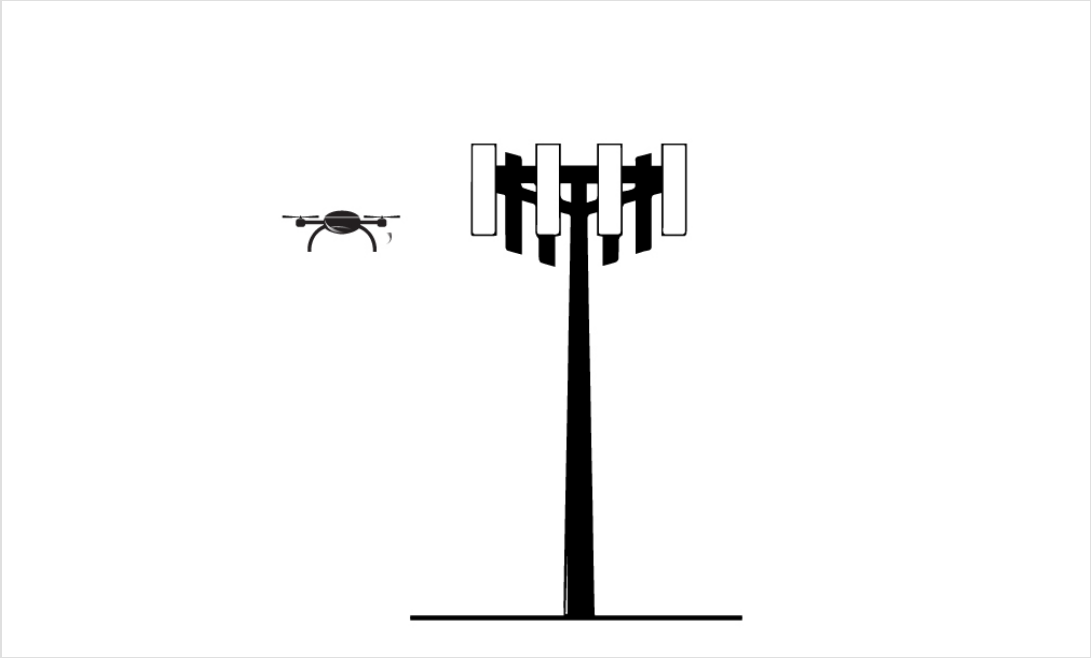
What are the most common issues that impact your position fix? (select two)

A. *Multipath*
B. *Jamming*
C. *Spoofing*
D. *Atmospheric interference*
E. *Other environmental factors - signal obstruction, radio interference*

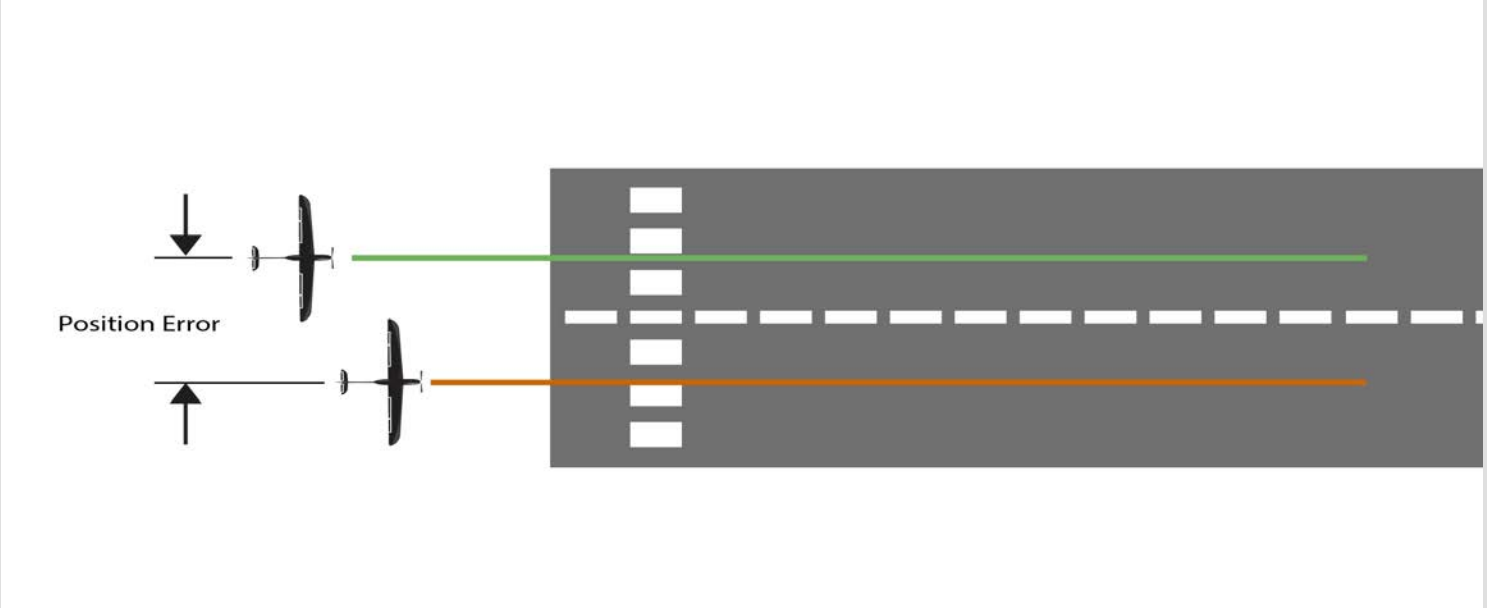
Professional UAV Autopilots
Part II

Howard Loewen
CEO
MicroPilot Inc.

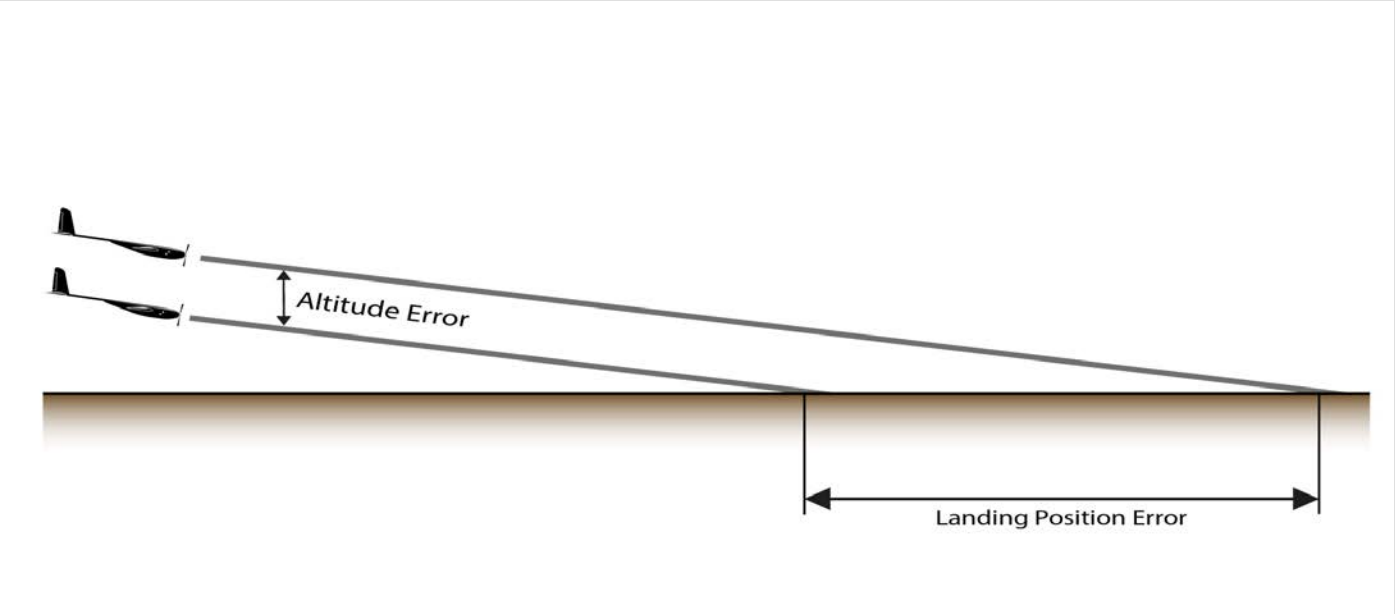
Tower Inspector



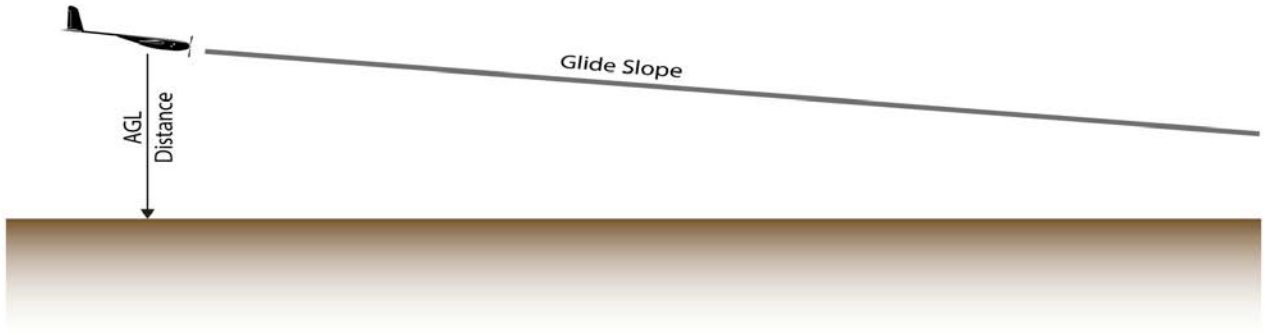
Launch And Recovery



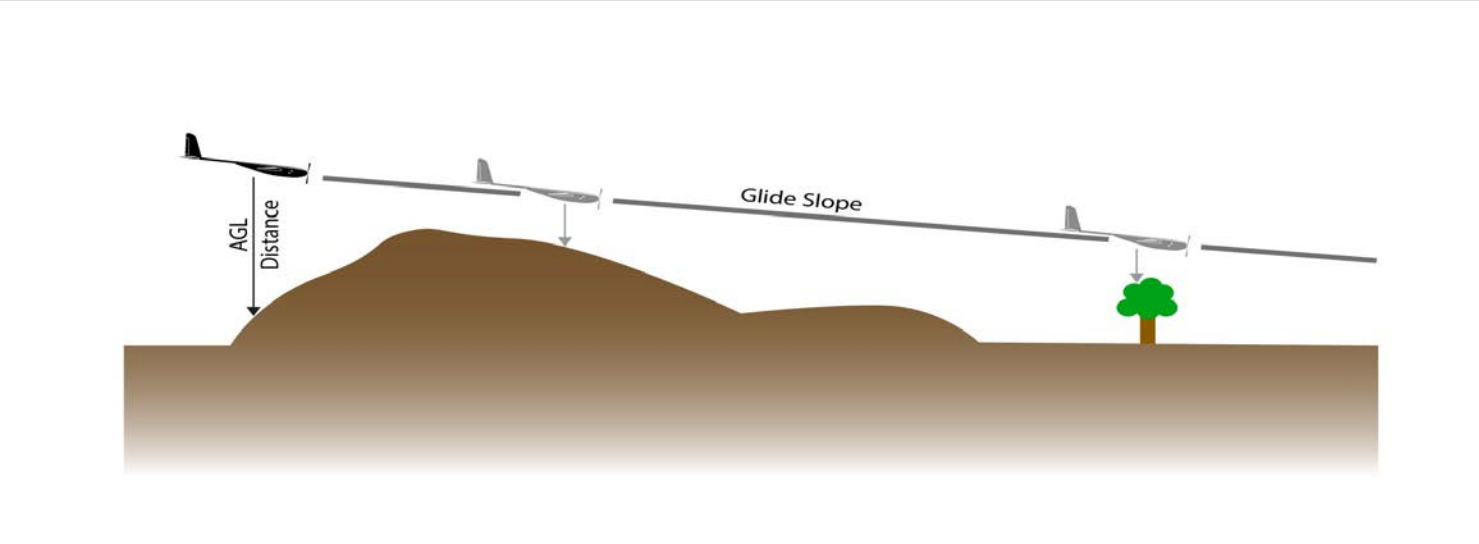
Launch and Recovery



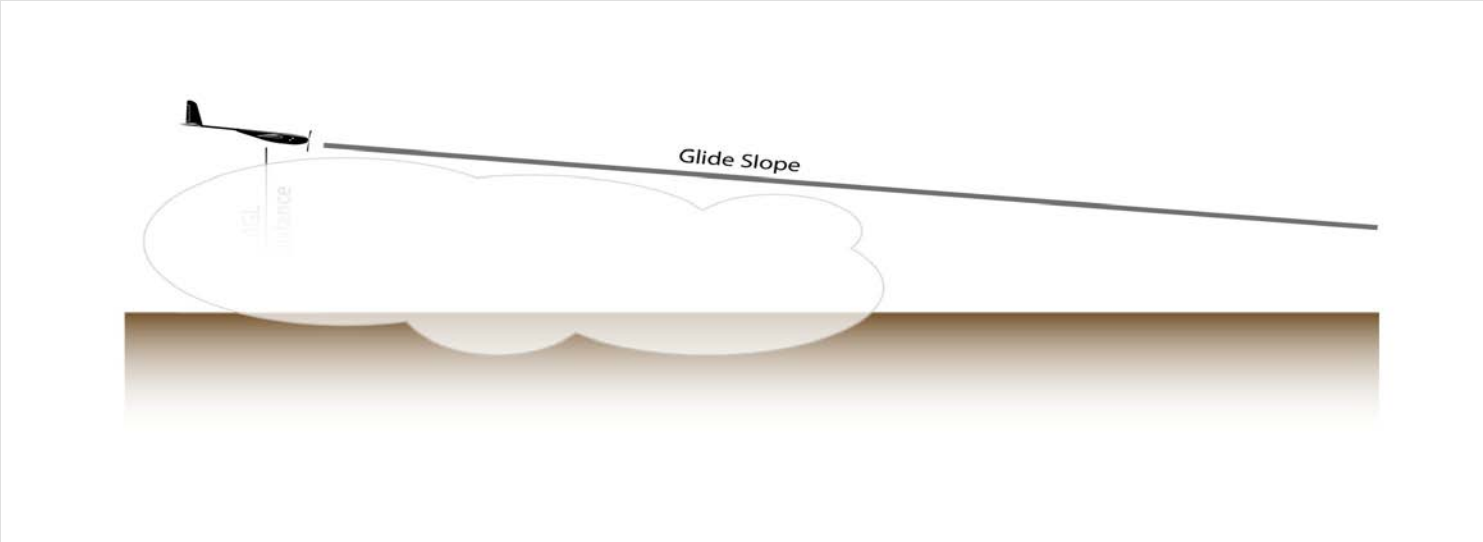
Launch And Recovery



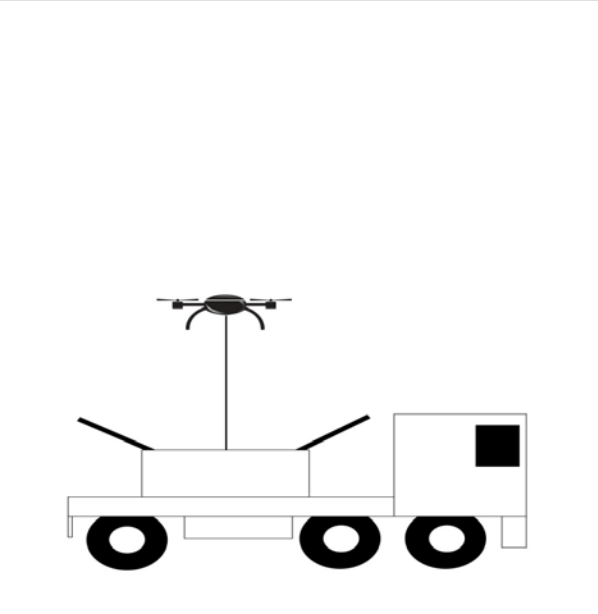
Glide Slope Management

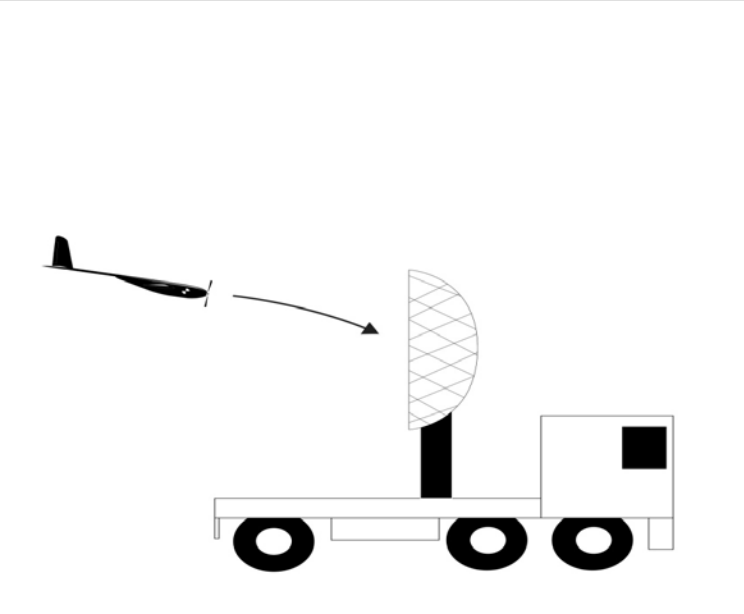


Launch and Recovery

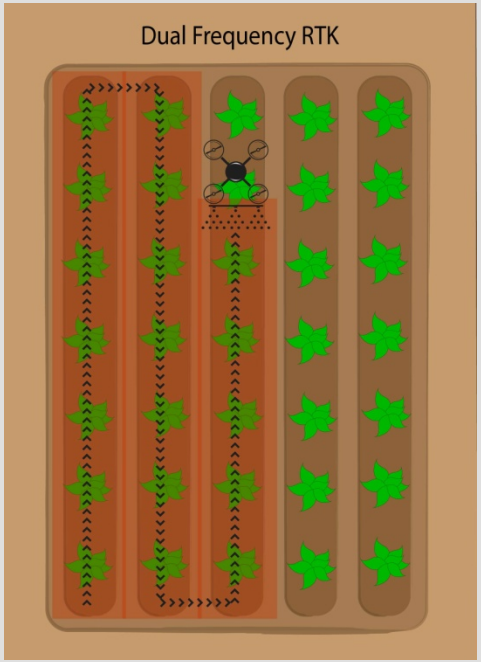


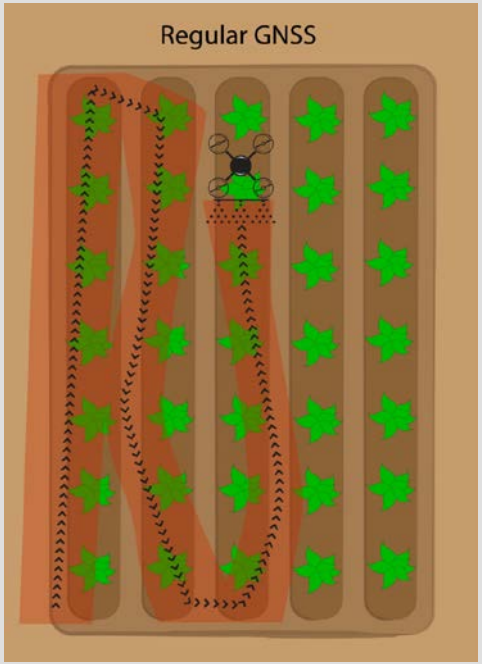
Moving Launch or Recovery



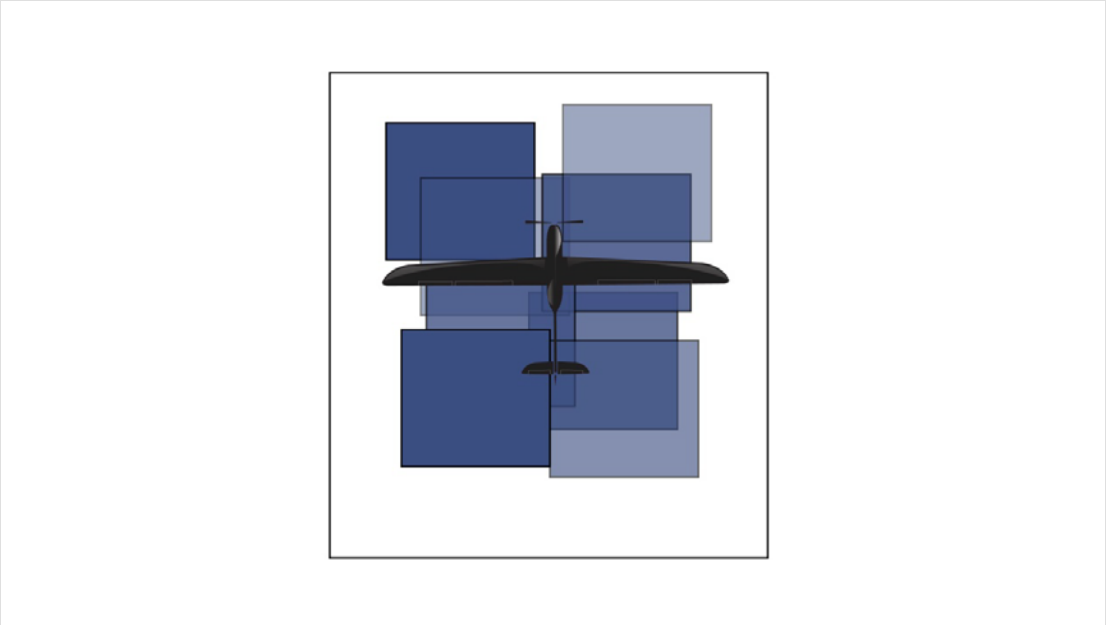


Crop Spraying

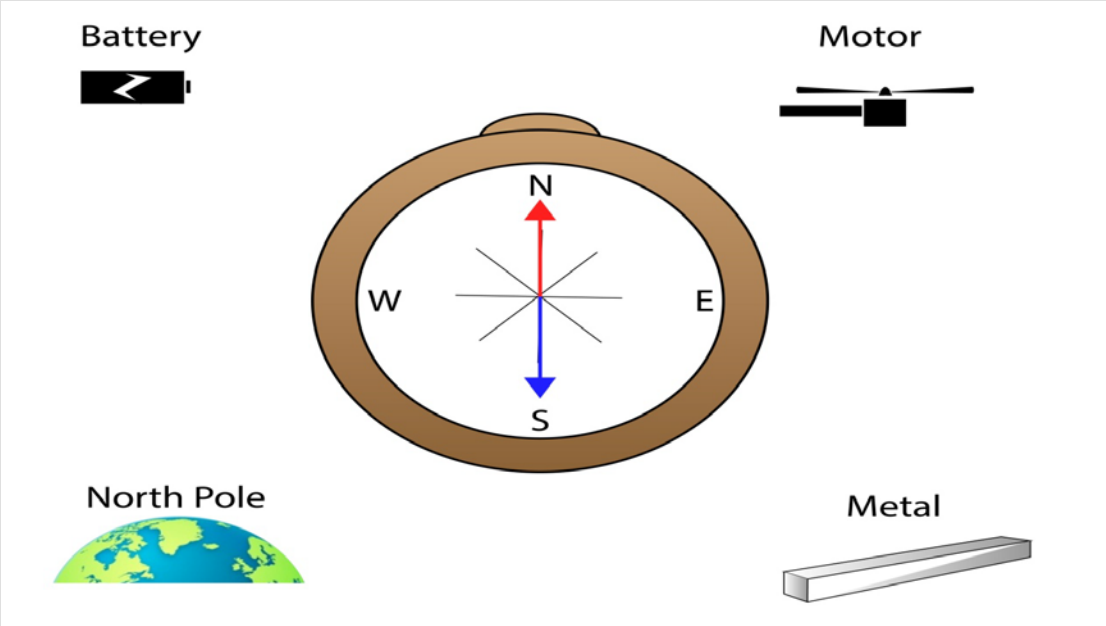




Surveying Without Control Points



Compasses Suck!!



Professional UAV Autopilots

Thank You

High Accuracy UAS Applications

Jay Tilley
CTO
Visual Intelligence

Agenda

- Who We Are
- Our Solutions
- What Is Positional Accuracy?
- Market Need for Positional Accuracy
- How We Achieve High Positional Accuracy
- Application Use Cases

Who We Are

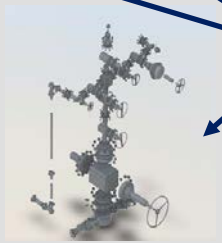
- Founded in 2003 as a mapping services company
- Restructured in 2016 to become a technology R&D company focused on developing a unique software and hardware sensor array architecture for the drone industry
- Based in Houston, Texas
- Privately Owned and Funded
- Owns numerous array hardware and software patents that support its technology

Visual Intelligence Solution Overview

- We fuse cameras into a Metric Super Sensor (Array)
- A single 50-200 megapixel sensor built is an array of cameras with advanced software for multi-mission capability in a single platform
- Sensor stability and accuracy to pixel-level relative accuracy

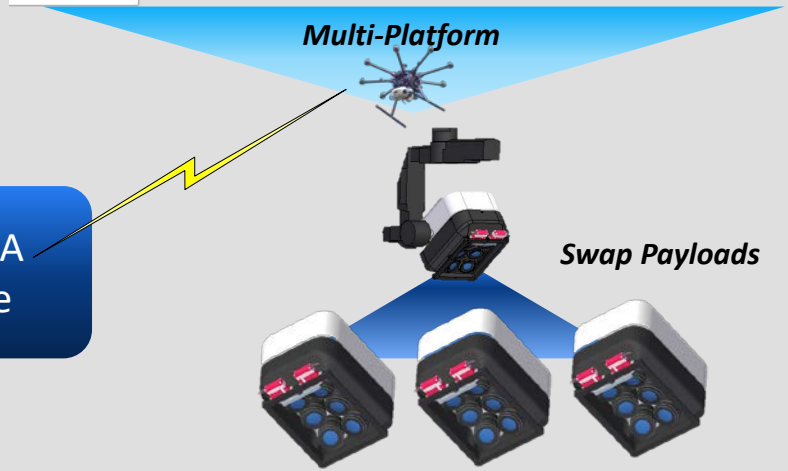
Orthos/Ag/DSM's

Targeting



3D and CAD Models

iOne STKA Software



Color Imager Infrared Reconnaissance

Processing Workflow

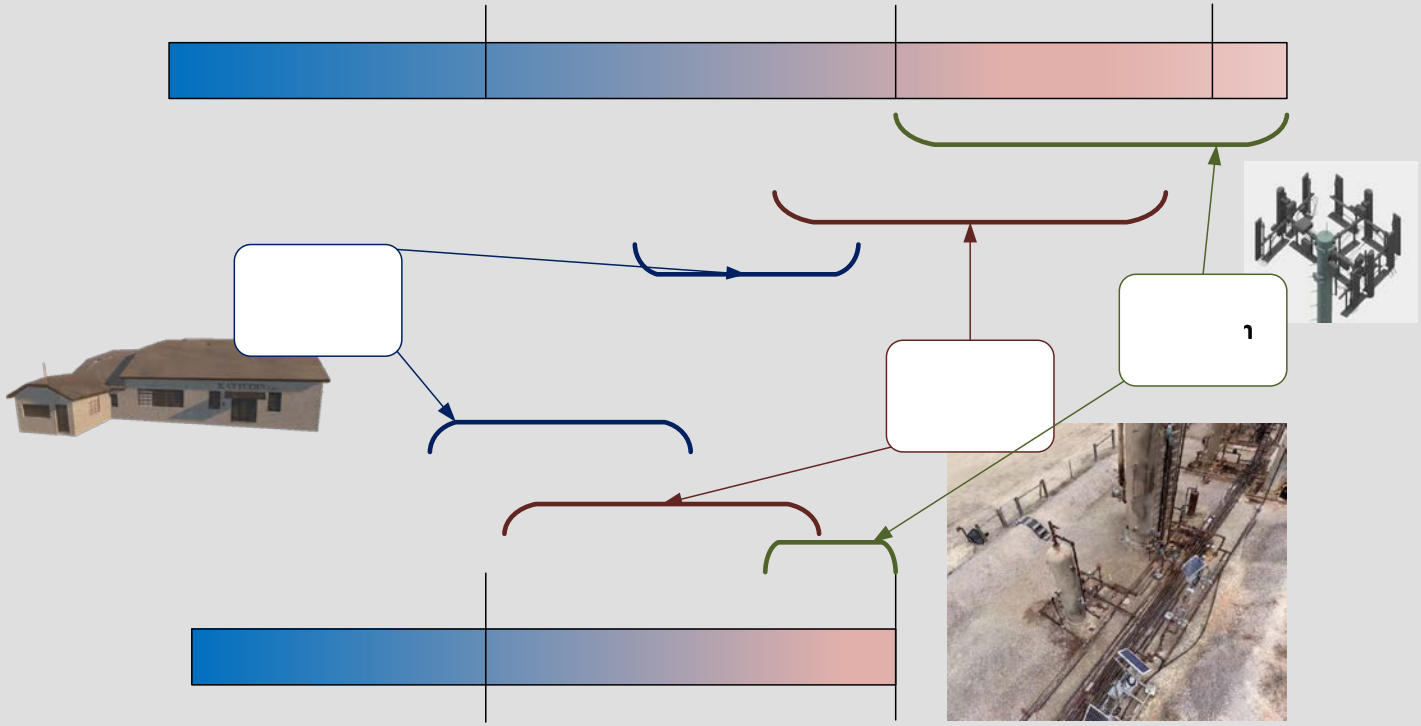
What is Positional Accuracy?

- Real accuracy is an aggregate of many errors sources that flow down to a X,Y,Z metric with a statistical representation
- The bottom-level accuracy quoted for a “system” is stated as relative accuracy and absolute accuracy
- Relative accuracy means one can measure an object to a specific accuracy and precision
- Absolute accuracy defines where on the earth that object exists to an accuracy and precision

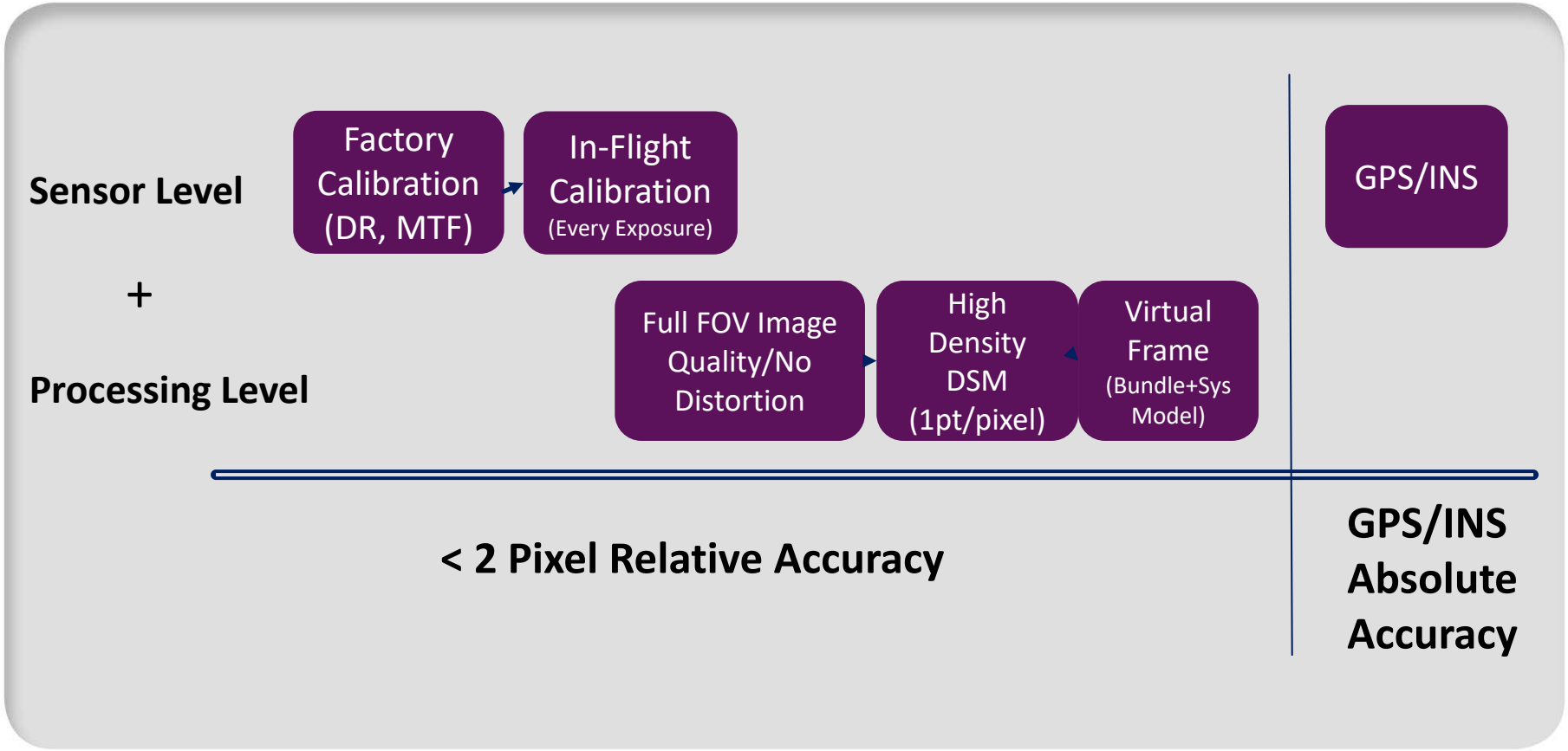
Relative Accuracy
(Measure Objects)

Absolute Accuracy
(Position on Earth)

Market Need for Positional Accuracy



How We Achieve High Positional Accuracy



Value of High Resolution

- High Relative Accuracy Requires High Spatial Resolution

2 inch Resolution

1 cm Resolution

1 mm Resolution

Most Use Cases Need Fast Processing in Addition to Accuracy

Building 3D Vector Model

Number of Mesh Points: 1.2M
Data File Size: 600 MB

2-5 mins | 15 mins | 90 mins | 4-6 hrs. | 90 mins | 90 mins

Mission Planning → Collection → Pre-Processing → Auto 3D → Optimal 3D (Manual)

Quick-Look 3D Point Cloud

Number of Points: 25M
Data File Size: 50-70 MB's

Dense Building 3D Point Cloud

Number of Points: 86M
Data File Size: 200 MB's

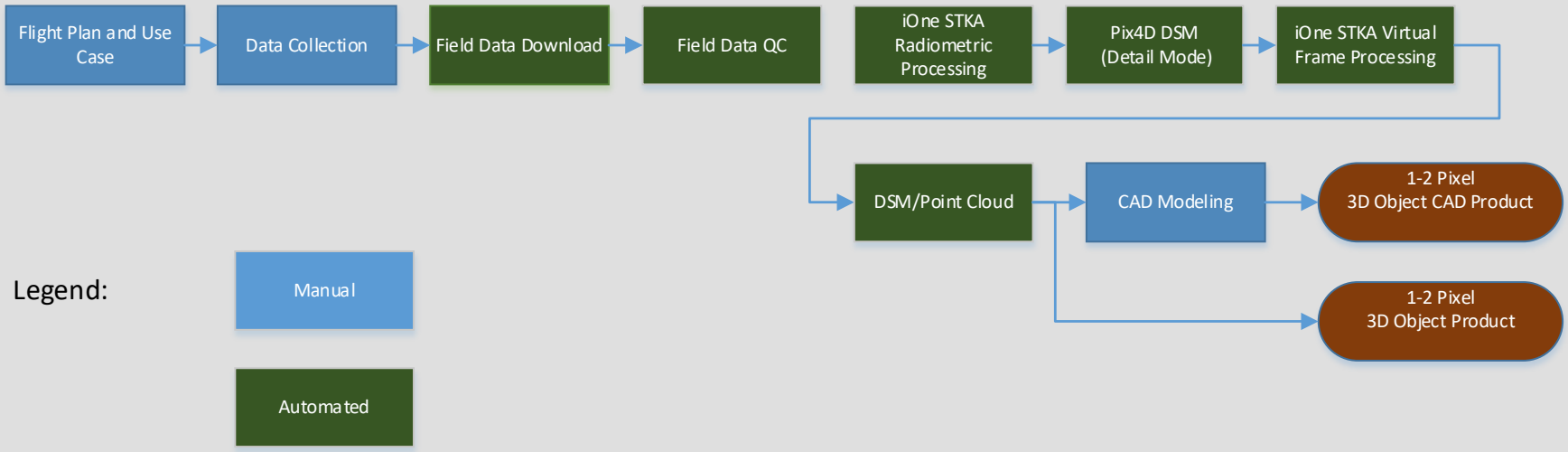
Edited 3D Vector Model

Application Use Cases

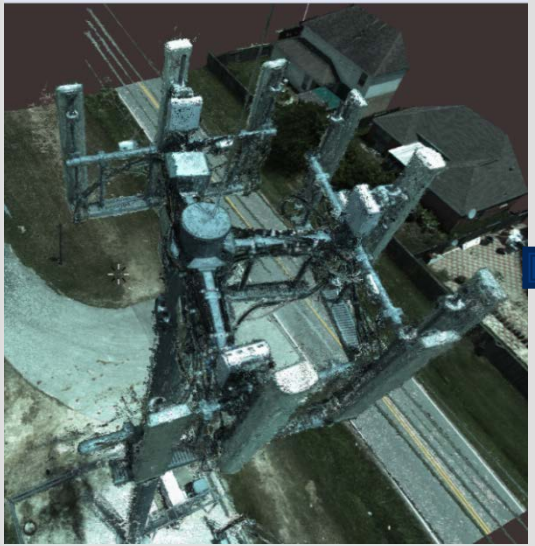
- Commercial Use Cases
  - Telecom √
  - Oil and Gas √
  - Precision Agriculture
  - Survey and Mapping

- DoD/Intel Use Cases
  - Targeting √
  - Persistent Surveillance
  - Training and Simulation

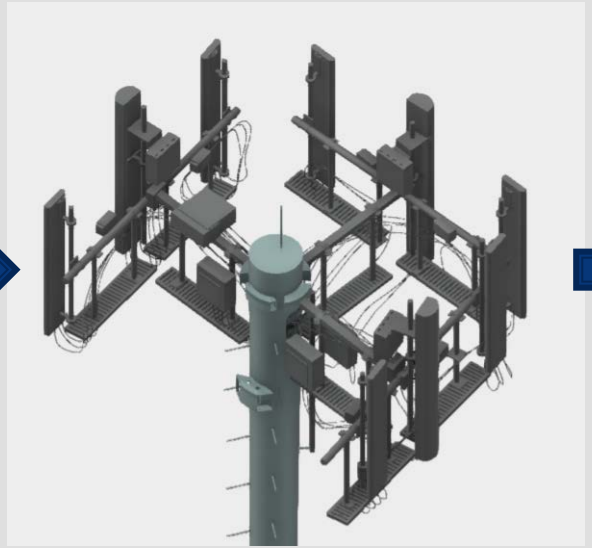
Process Chain to Build 3D Models



Tower Model Products



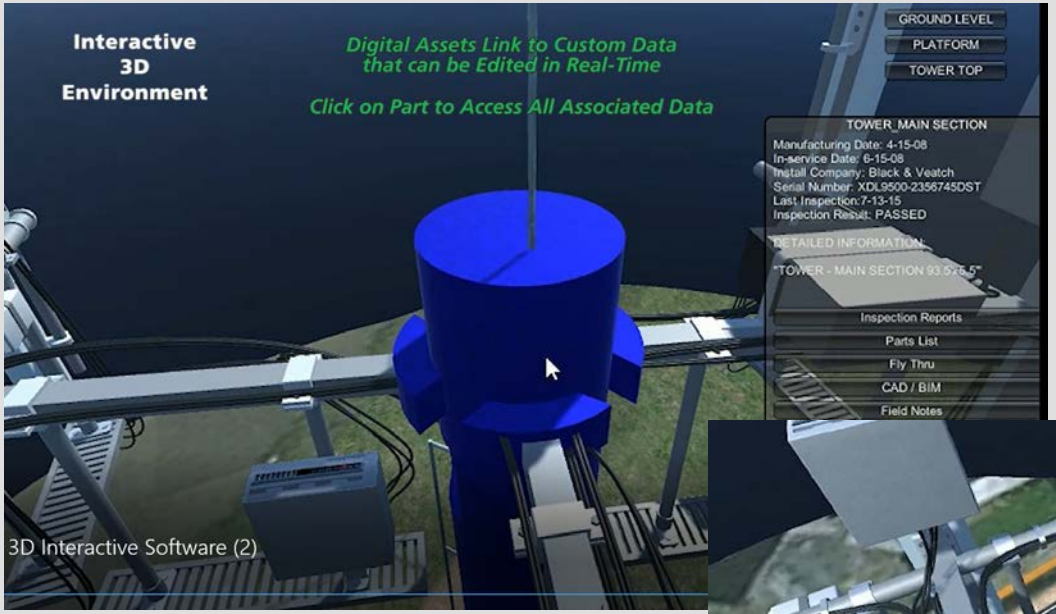
3D Point Cloud From Centimeter Imagery



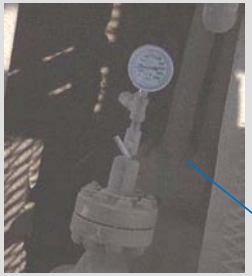
CAD Model From Point Cloud

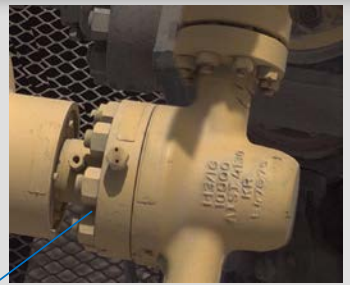
Textured 3D Model From CAD Model

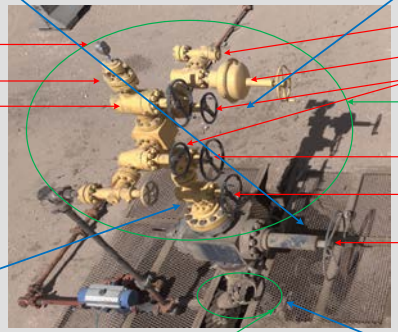
Value of Millimeter Class Imaging and 3D Modeling

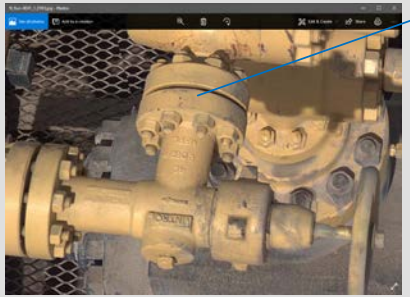


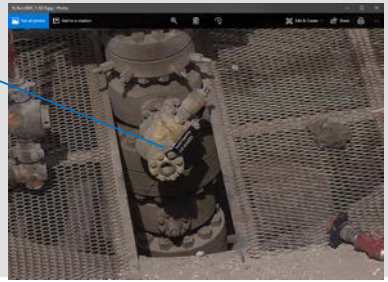
Asset Management Requires High Resolution and Accuracy







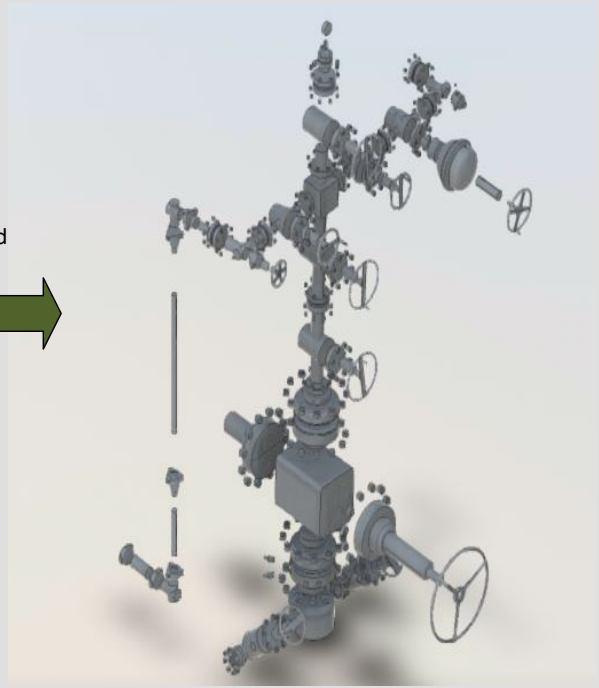




Millimeter-class Resolution and Accuracy Needed for CAD

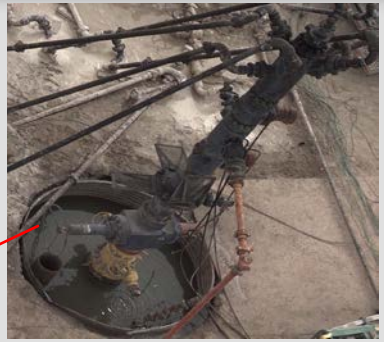
Well Head Products

Processed Into:



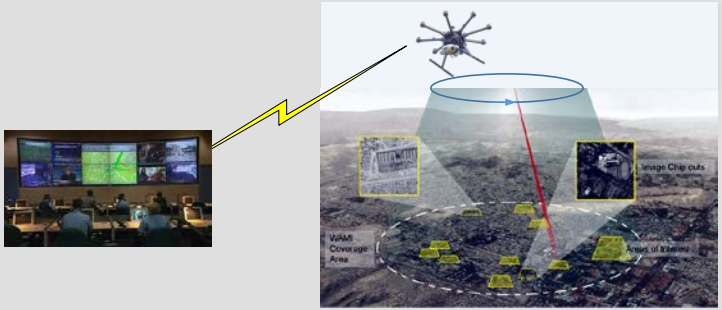
Revit CAD Model

Virtual Operations Maintenance

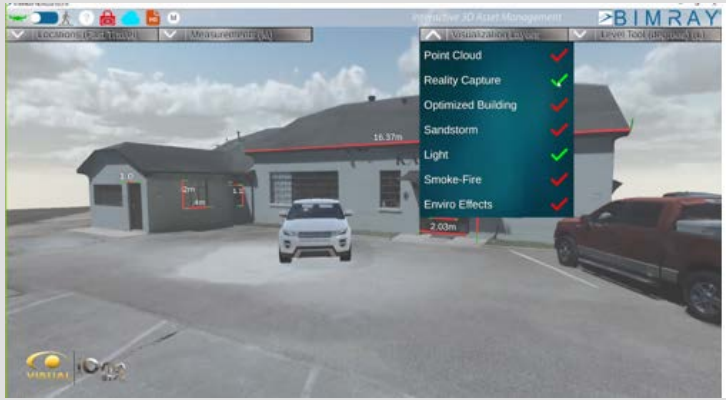


DoD/Intel Applications

- Visual Intelligence draws from 15-years of array technology experience addressing next generation needs of the DoD including:
  - Rapid 3D Modeling and Annotation for Tactical Intelligence (Delivery in Hours to Millimeter Resolution)
  - Simultaneous Wide-Field-of-View and Centimeter-level GSD across a city-scale areas (requires multiple systems depending on resolution requirements)
  - Centimeter Targeting Location Accuracy
  - Imagery at Video Rates (Comm System Dependent)



Persistent Surveillance Enabled by
Wide Field, FMV Capable Sensor Arrays



Tactical Image Analysis With Targeting and
Measurements to Centimeter Accuracy or Better

Multi-Level Model Maintain Relative Accuracy

Point Cloud Model

(Automated)

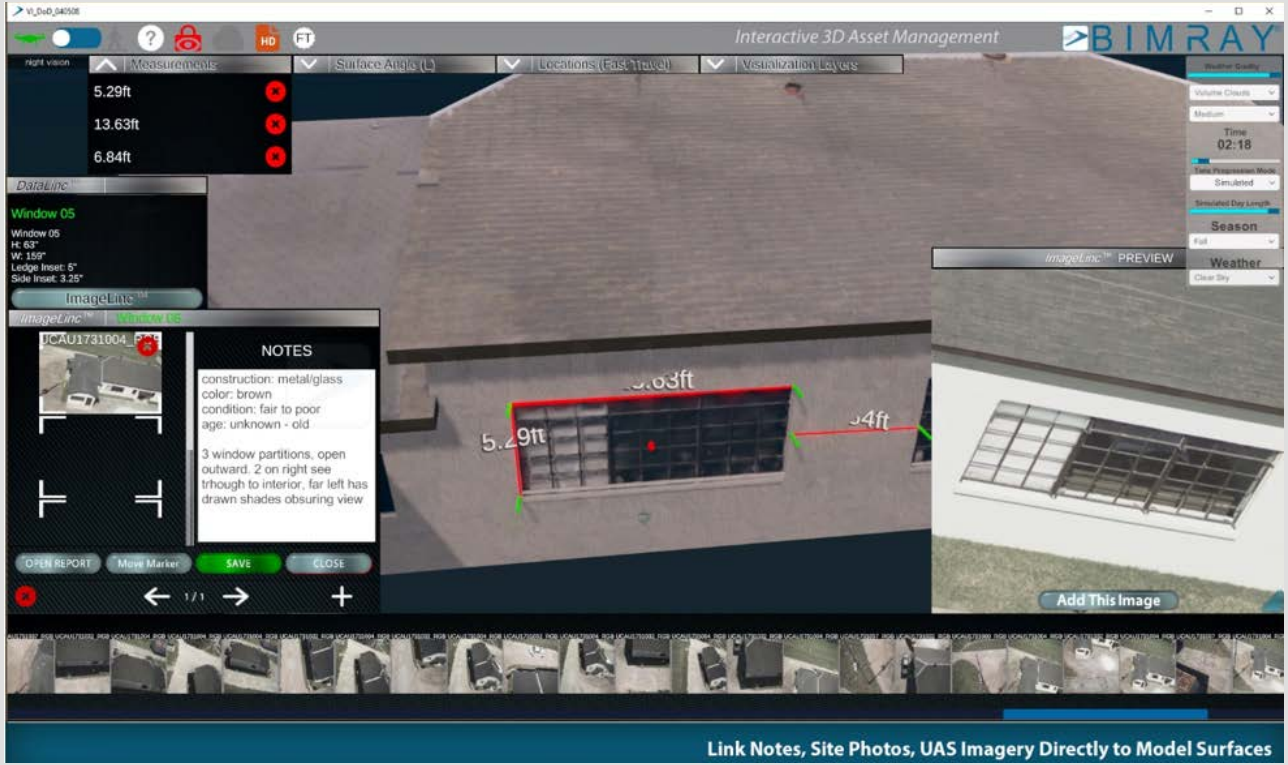
Automated Mesh (Vector) Model

(Automated)

Edited Mesh (Vector) Model

(Manual Editing)

Real-time Mensuration and Materials Analysis



Overhang and Low Hanging Small Object Measurement

Low Hanging Cables

Clearance Areas

Mobility Obstructions

Summary

- High relative accuracy is essential to capitalize on the value of increasingly accurate and reliable GPS sensors
- As greater accuracy is available from UAS platforms, new markets will be ready to capitalize
- Increased accuracy is critical to success of asset management and operations in Telecom, Oil and Gas, and DoD/Intel Markets

Poll #3

The most important factors in determining which positioning solution to utilize are (select two):

A. Form factor - size, weight and power
B. Post-processing software
C. Repeatability and stability
D. Ease of integration
E. Cost

For More Information

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