Autonomous Agriculture
The Need for GNSS Safety
Critical Systems

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Global Positioning Solutions and Services

- Head office located in Calgary, Canada
- More than 400 employees
- Part of the Hexagon Group
- 25+ Years in GNSS
- Market leader in our space with >50% market share.

High Accuracy and Reliability
Trends in GNSS.....

90s and early 2000s: Accuracy
- Positioning techniques
- DGPS, RTK
- Multipath mitigation

Now: Availability
- Multi-constellation:
  - GPS, GLONASS,
  - Galileo, Beidou
- Sensor Fusion
- Position + orientation

Future: Safety & Reliability
- Safety of Life applications
- Functional Safety and Integrity
- Protection from spoofing/jamming
Increasing Demand for Safety in Guidance

IEC EN 61508

DO-178C DO-254

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ISO 25119 ISO/FDIS 18497 (draft) ISO 10975

ISO 10975

EN 50126 EN 50128 EN 50129

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Robotics in Agriculture Tomorrow

• Continue to operate semi-autonomously as we do today plus:
  ➢ Make better use of big data;
  ➢ Operate independent of human input;
  ➢ Operate independent of the time of the day;
• But not without safety!
How GNSS fits into Autonomous Agriculture

- GNSS has been in use for well over two decades to guide equipment through fields — along with a host of other ag-related, site-specific applications.
- GNSS dominates as the source of Absolute PVT for the autonomous control of agricultural vehicles.
- A fully autonomous tractor will need 100% availability in all conditions and locations.
  - All weather, all field conditions, all visibility conditions.
- GNSS plays a critical role but cannot be the sole positioning source.
- A fusion of multiple sensors is required with GNSS playing a key role. Time alignment of sensor data is needed as well as positioning.
GNSS requirements for autonomous driving

- Position accuracy “Goal” - < 2” 3-sigma
  - needed for vehicle to vehicle applications
  - Automotive accuracy goal is 3’ 3-sigma
- Data rate outputs > 10 Hz
- 3D Position and Velocity outputs
- Multi-frequency, Multi-constellation, Multi-engine receiver and antenna
  - Improves overall accuracy
  - Required to assist in solution convergence time
  - Increases position availability - more satellites in view
- Supporting precise corrections service (PPP) required over satellite, as well as seamless/error constrained transition between RTK and PPP.
- Functional Safety
  - ISO25119 Development
  - Integrity outputs to support protection levels
  - Authentication function
Positioning Technology Options

- To allow for ubiquitous positioning at the decimeter level we believe a Precise Point Positioning (PPP) level of service is required.
- RTK is certainly more accurate (cm level) but infrastructure costs are high, unreliable and unnecessary.
Defining Safety for a Navigation System

- **Integrity** = degree to which you can trust the information being provided by a navigation system.

- **Continuity** = ability of any navigation system to execute its function through a specified time period or operation.

- **Accuracy** = degree to which the estimated solution from a navigation system conforms to the true solution.

- **Availability** = percentage of the time that a system can be used for navigation purposes.
Path to an GNSS Integrity Solution

- The targeted performance of a position solution from a safety perspective has been described with the following requirements:
  - The GNSS Receiver shall provide a dynamic protection level indicating the maximum undetected Error for Position, Velocity, Heading & Time
  - Maximum undetected Position Error $\Rightarrow$ Safety “Goal” < 2m
  - Maximum undetected Velocity Error $\Rightarrow$ Safety “Goal” < 0.1 m/s
  - Maximum undetected Heading Error $\Rightarrow$ Safety “Goal” < 0.5 °
  - Maximum undetected Time Error $\Rightarrow$ Safety “Goal” < 0.1 ms
  - The GNSS Receiver shall fulfill Protection Limit requirements for times $\geq$ 70 sec after Start up
  - The GNSS Receiver must detect leaving the Safety Limit < 1 sec, with ASIL B, AgPL C
  - Failure rate shall be under $10^{-7}$ / hour

How to achieve these levels will require development of capabilities beyond current state of the art.
Questions?