

AV LOCALIZATION



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THE TONY AV KIT



Tony
TO Navigate You



AV Kit for Any Vehicle

SENSOR INDEPENDENT



LiDAR – RADAR – Camera – GPS/IMU
Make & Model Swappable

CONFIGURABLE BEHAVIOR



Full Autonomous Manuever Suite
Rapid Extensibility

CONTROLS INDEPENDENT



Drive-By-Wire Interfaces
& Bolt-in Autonomy Kit Options

AV POSE

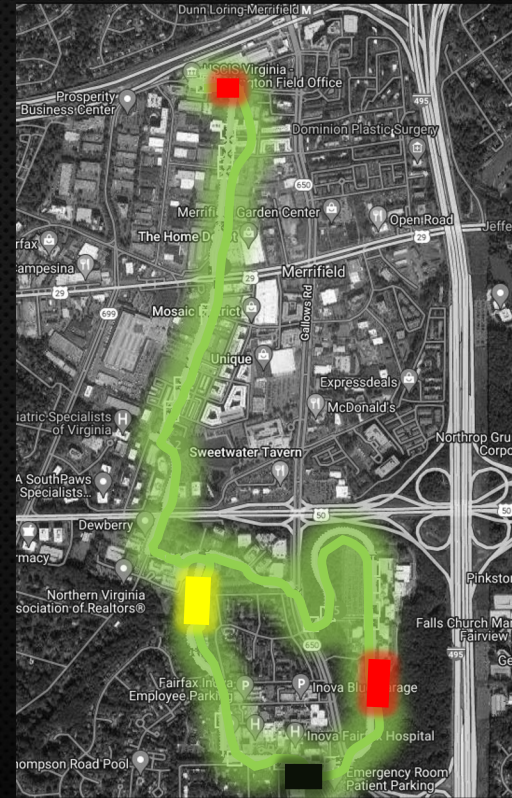
- **MAP:** High-def map of ODD
- **MISSION:** Provide destination
- **GO:** Navigate to destination

- **Position**
- **Orientation**
- **Speed**
- **Acceleration**
- **Orientation rates**



GPS-BASED GUIDANCE

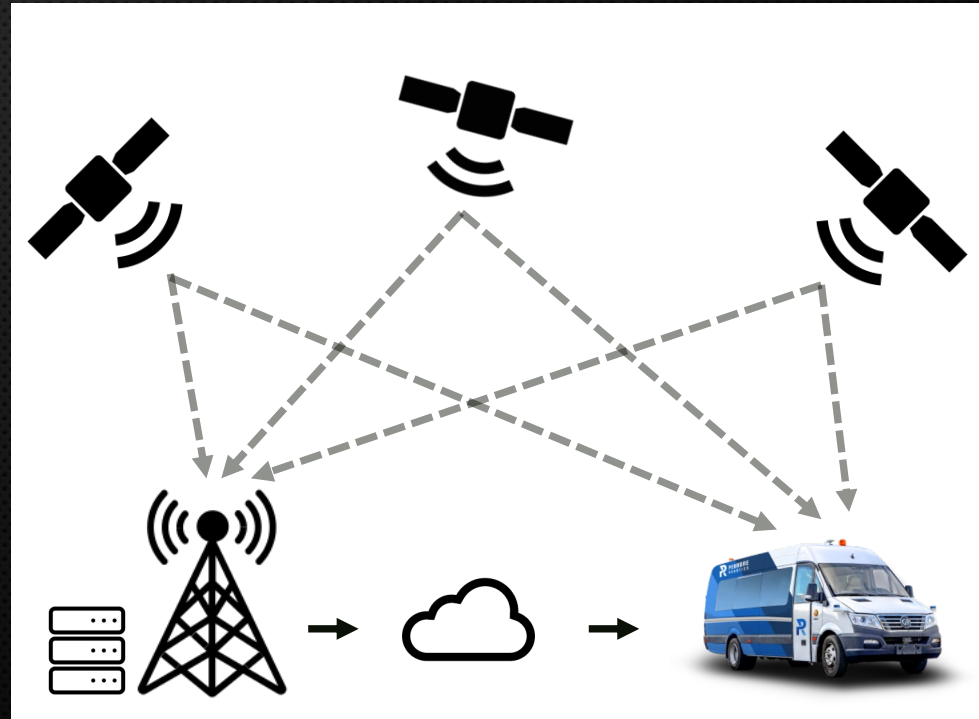
- ODDs with surveyable GPS
- Characterization of routes
- Dual antennas
- Static & dynamic heading
- Encoders & position derived speed
- Flexible constellation selection
- Built-in & augmented filtering



RTK CORRECTIONS

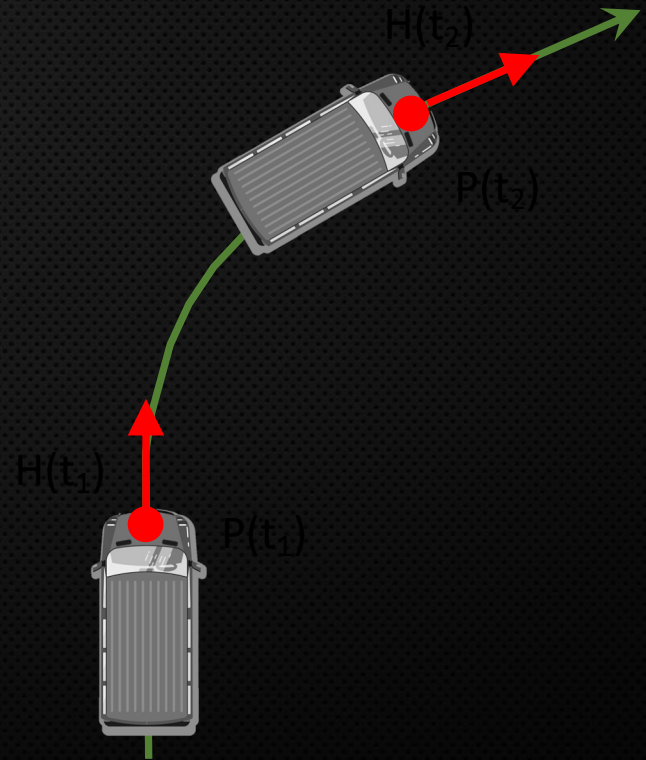
RTK: Real Time Kinematics

- Correction service for position accuracy
- Cellular-based corrections
 - Redundant cell service
 - Signal enhancement
- Satellite-based corrections
- Fixed base stations



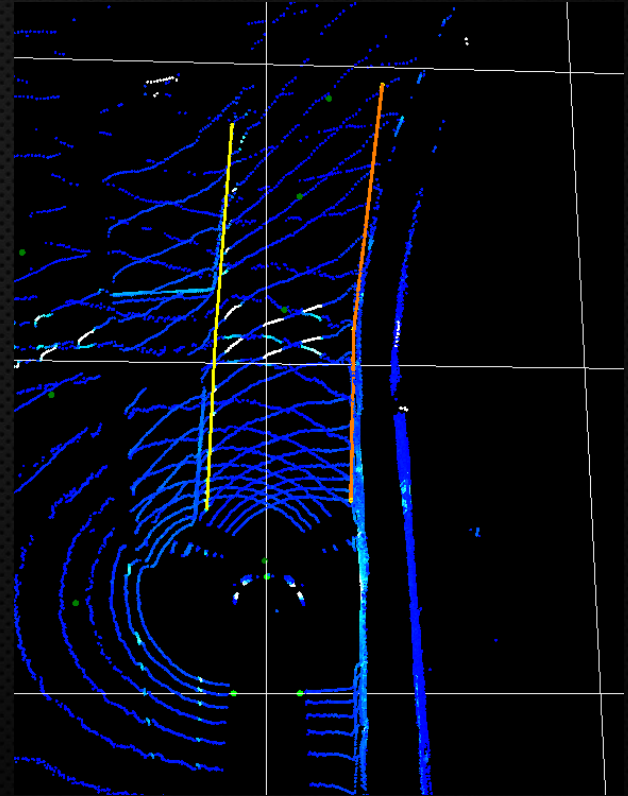
DEAD RECKONING

- Projection of positions & heading in degraded conditions
- Built-in dead reckoning
- Augmented dead reckoning
- Short distance “patch”



LANE KEEPING

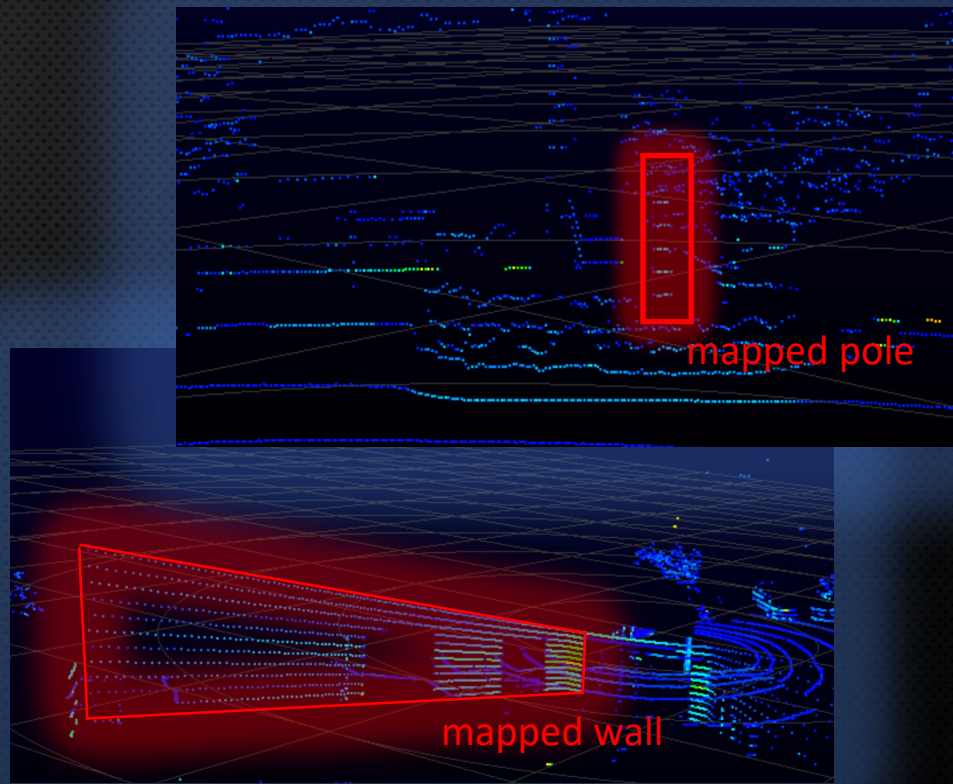
- Lane lines & curbs
- Paved/gravel/grass/dirt transitions
- LiDAR-based lane detection
- Lateral position alignment
- Longitudinal position estimation



SLAM

SLAM: Simultaneous Localization And Mapping

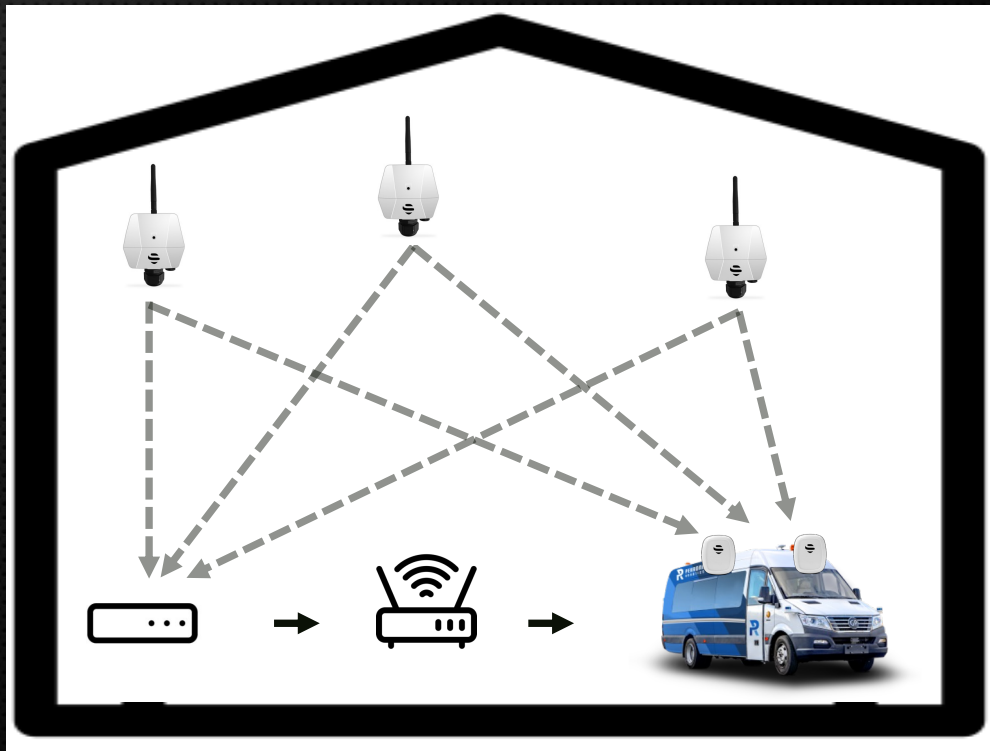
- Map reliably detected environmental features
- Detect features while operating
- Triangulate location
- Use of walls for guidance
- Keep it simple



UWB

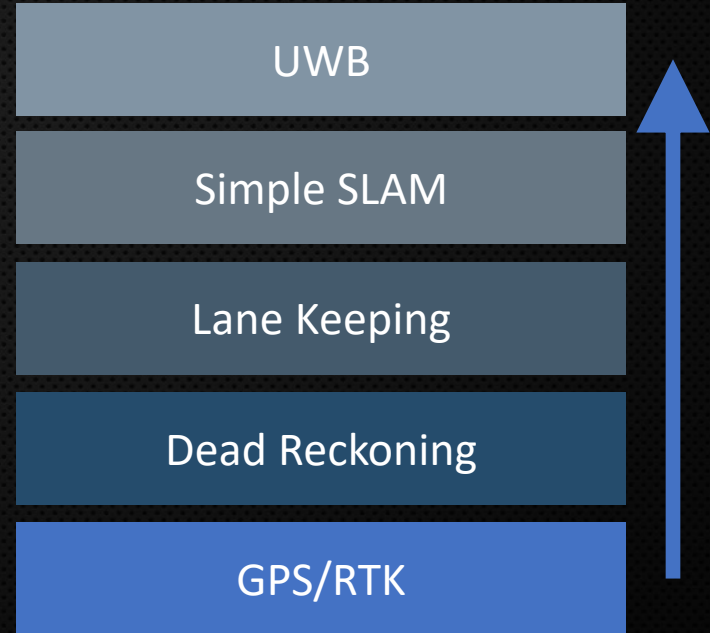
UWB: Ultra Wide Band

- **Complex and expansive indoor environments**
- e.g. parking garages
- **Mount anchors in infrastructure**
- **Place two tags on AV**
- **Obtain tag positions on vehicle**
- **Derive position & heading**



LAYERED & REDUNDANT DESIGN

- **GPS/RTK as foundation**
- **Dead Reckon for patches**
- **Lane Keeping for longer patches where available**
- **Simple SLAM for simple fixed features or walls**
- **UWB for complex indoor environments**



GRACEFUL DEGRADATION

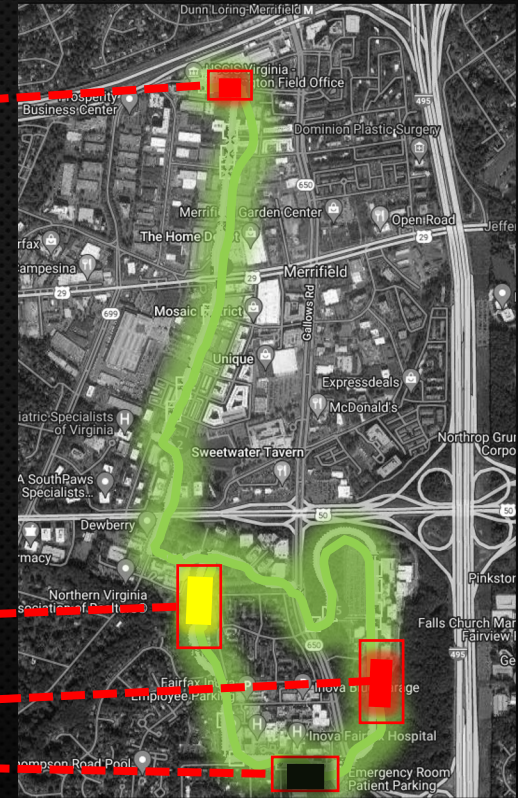
- Configurable max speeds based on modes
- Lower max speeds based on mode confidence
- Switch modes based on confidence during operation
- Build confidence and speed cues into maps
- Come to halt if no further recourse - teleop

Dead Reckon Zone

Lane Keeping Zone

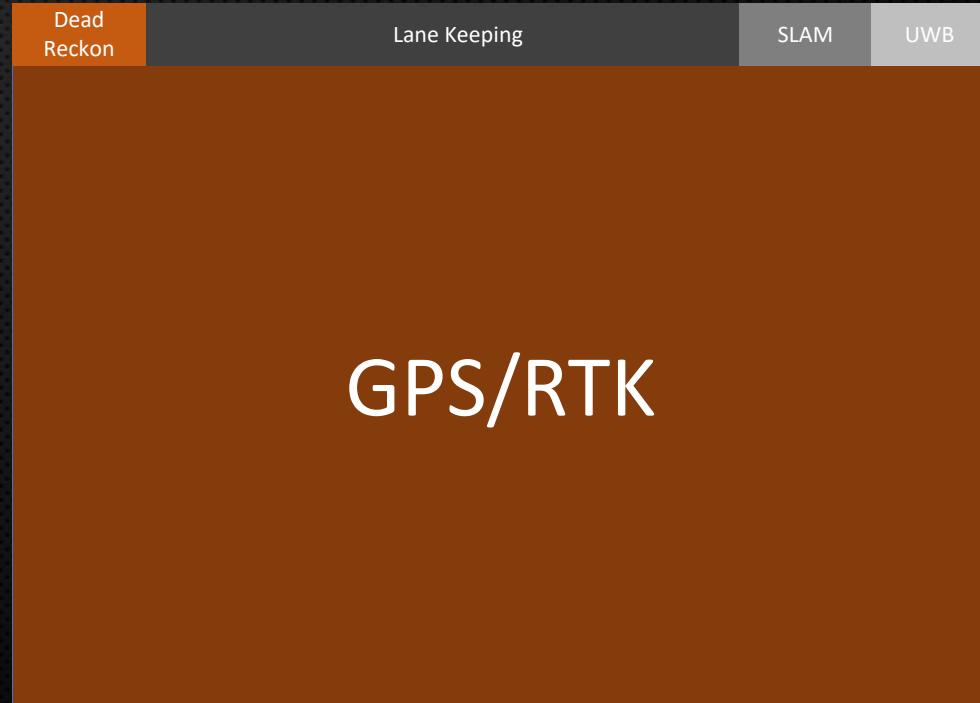
SLAM Zone

UWB Garage Zone



LAYERED & REDUNDANT DESIGN

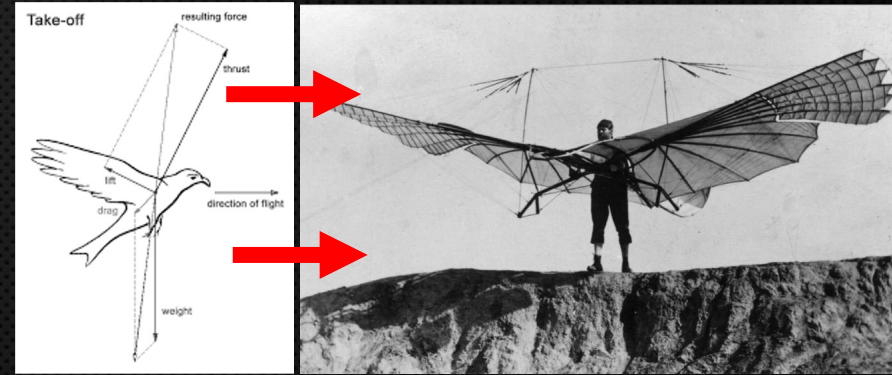
- **GPS/RTK can provide 95%-100% coverage for targeted L4 ODDs**
- **Dead Reckon & Lane Keeping to patch through outages**
- **Simple SLAM for simple environments**
- **UWB for complex indoor environments**



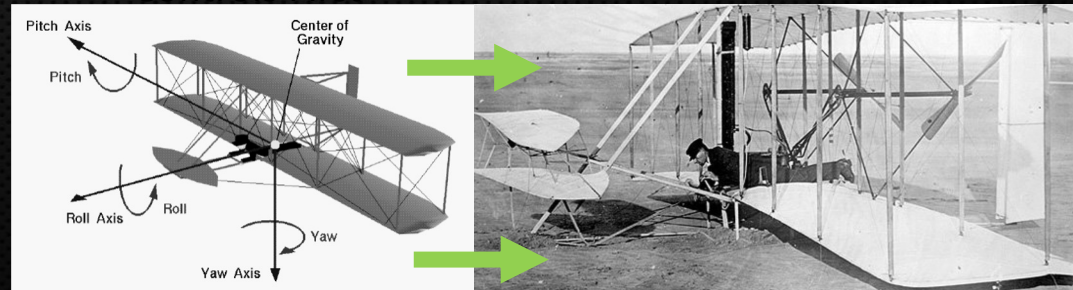
PITFALLS OF SLAM & MACHINE LEARNING

- SLAM evolved from indoor nav in labs & offices
- Poorly suited for complex and changing environments
- SLAM & Machine Learning (ML) as probabilistic vs deterministic augmentation
- Probabilistic bio-inspiration vs Deterministic controls first approach

“Bio-Inspired”



“Controls First”



LEAD WITH DETERMINISM

- L4 ODDs can be characterized for GPS/RTK
- 95%-100% coverage across many ODDs
- Lead with determinism
- Gracefully degrade with other modes
- Redundancy of algorithms



SUMMARY

- Many L4 ODDs for autonomy now
- Quality & bolstered GPS/RTK gives broad coverage in L4 ODDs
- Alternate localization modes patch and cover GPS-denied zones
- Graceful degradation and redundancy for safety & reliability

- *Robust and deterministic full autonomy available for L4 ODDs*

- *AVs with real ROI proven and viable NOW*



THANK YOU

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