

TrackIO: Tracking First Responders Inside-Out

Ashutosh Dhekne‡, **Ayon Chakraborty,**
Karthik Sunderesan, Sampath Rangarajan

‡UIUC, NEC Labs America

Emergency Responders Getting Entrapped



FIREHOUSE FORUMS | SUBSCRIBE | BUYER'S GUIDE | IN PRINT | ADVERTISE

LEADERSHIP APPARATUS RESCUE SAFETY & HEALTH OPS & TRAINING CAREERS & EDU

HOME | LODDS | MA FIREFIGHTER DIES AFTER GETTING TRAPPED

MA Firefighter Dies after Getting Trapped

Worcester firefighter Christopher Roy, 36, was trapped on the second floor of an apartment building during a multiple-alarm fire early Sunday.

MELISSA HANSON DECEMBER 9, 2

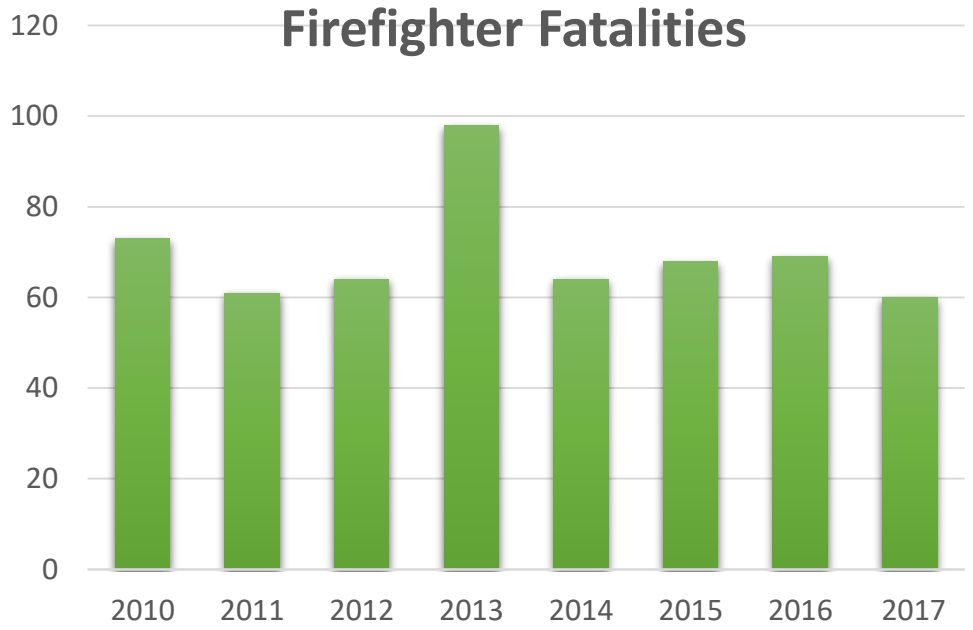
MASSLIVE.COM, SPRINGFIELD, MASS

0

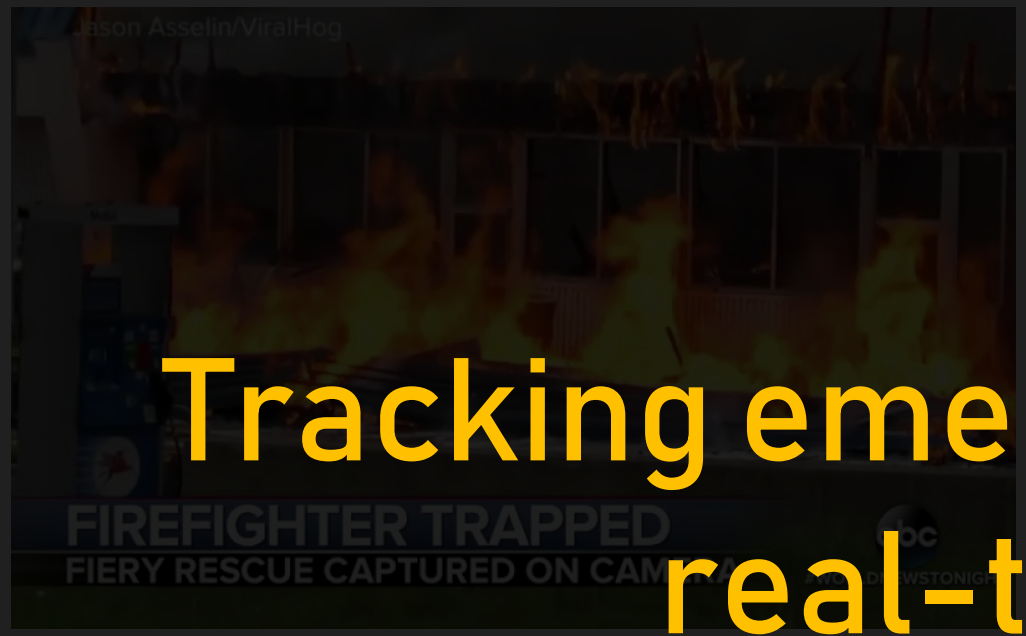
FireRescue1 NEWS PRODUCTS VIDEOS TOPICS TRAINING SAFETY

Firefighter trapped in Chicago elevator during rescue

When rescuing elevator stalled, other firefighters considered breaking through wall to enter elevator shaft



Emergency Responders Getting Entrapped



FIREHOUSE FORUMS | SUBSCRIBE | BUYER'S GUIDE | IN PRINT | ADVERTISE

LEADERSHIP APPARATUS RESCUE SAFETY & HEALTH OPS & TRAINING CAREERS & EDU

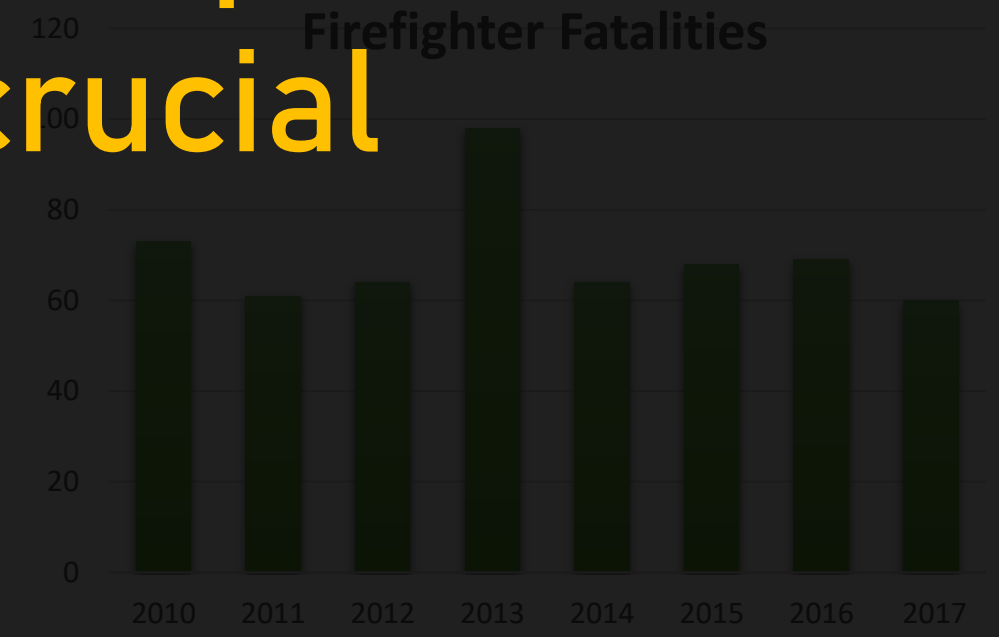
HOME | LODDS | MA FIREFIGHTER DIES AFTER GETTING TRAPPED

MA Firefighter Dies after Getting Trapped

Worcester firefighter Christopher Roy, 36, was trapped on the second floor of an

MASSLIVE.COM, SPRINGFIELD, MASS

Tracking emergency responders in real-time is crucial



FireRescue1 NEWS PRODUCTS VIDEOS TOPICS TRAINING SAFETY

Firefighter trapped in Chicago elevator during rescue

When rescuing elevator stalled, other firefighters considered breaking through wall to enter elevator shaft

Tracking Personnel Indoors is Challenging



No access to GPS indoors.

Inertial sensors (IMUs) can drift drastically with time ultimately losing track of the position.

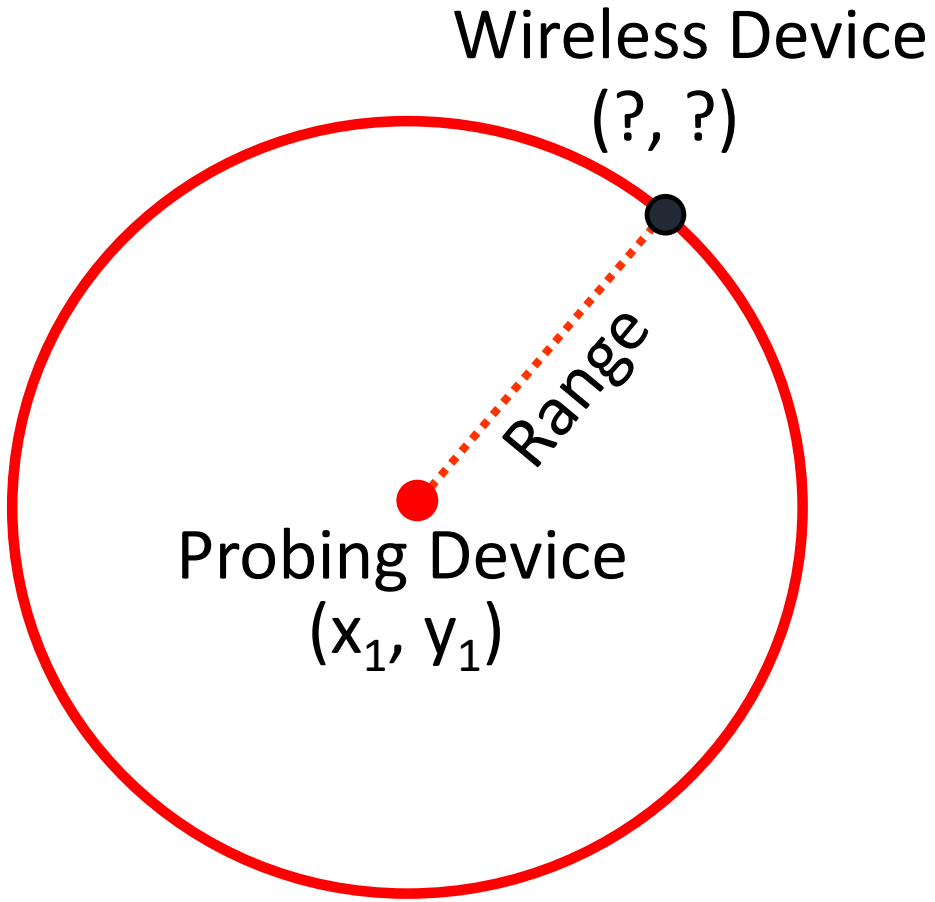
No access to indoor infrastructure. Positioning solutions involving Wi-Fi or BLE (Bluetooth) beacons are impractical in such situations.

Tracking needs to be real-time.

Wireless Positioning in a Nutshell

Ranging is fundamental. Infer the distance between two wireless devices.

However, ranging from a single vantage point is insufficient to resolve the location.

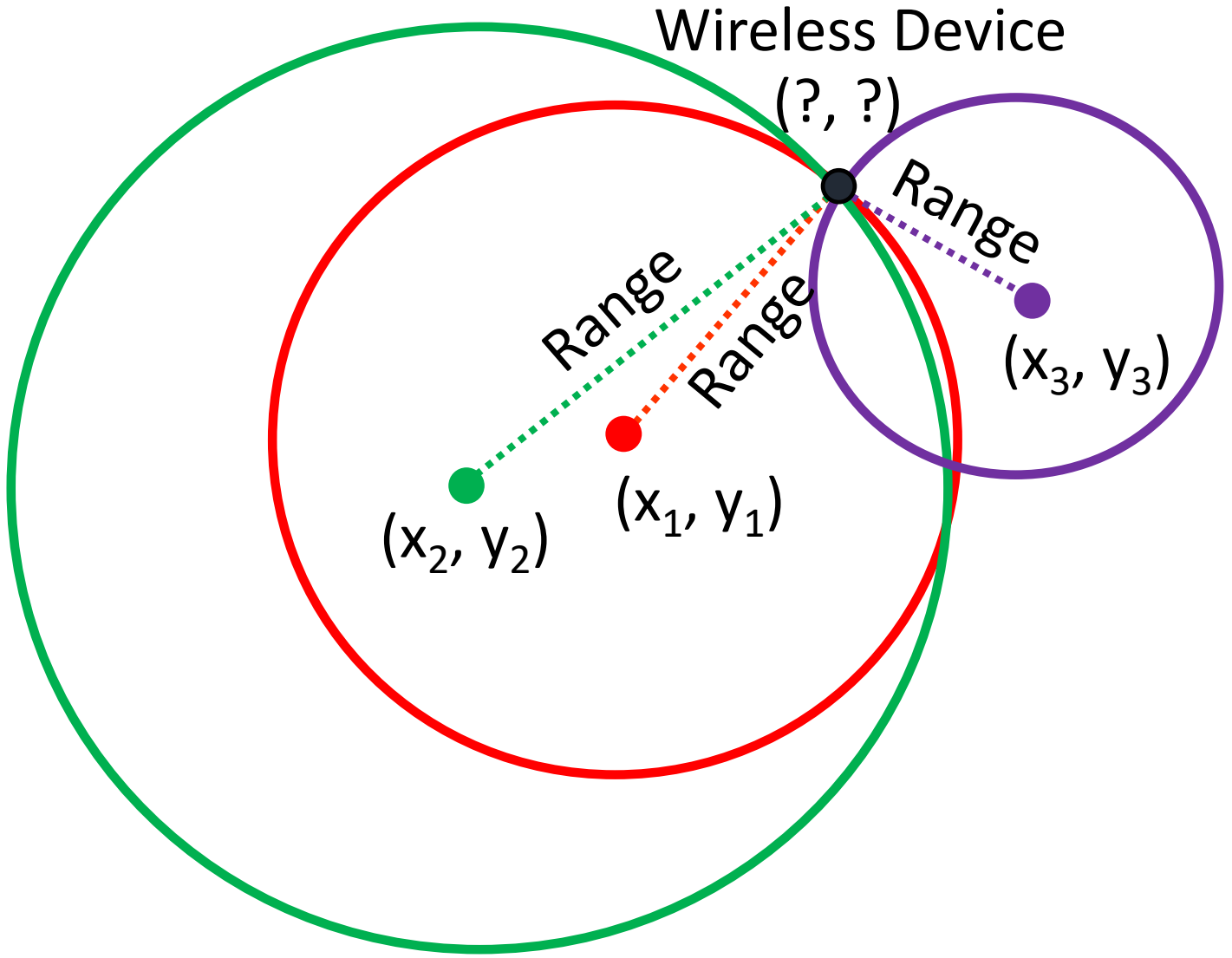


Wireless Positioning in a Nutshell

Ranging is fundamental. Infer the distance between two wireless devices.

However, ranging from a single vantage point is insufficient to resolve the location.

At least, 3 probing locations are required to resolve location in 2D. 4 in case of 3D. (multilateration)



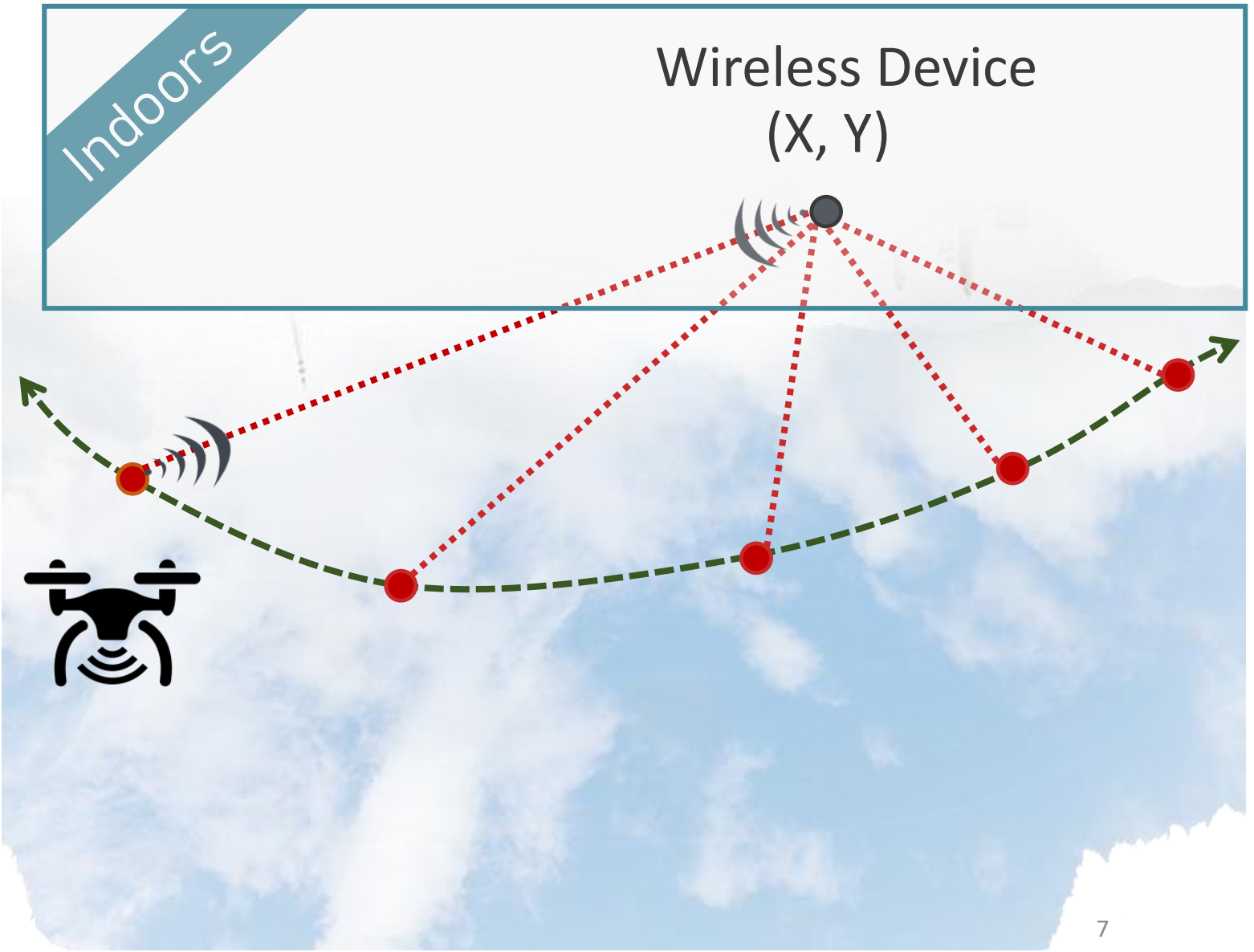
Multilateration Performance

Precision of the estimated range

Ultra-Wideband (UWB) technology offers ranging accuracy upto 10 centimeters

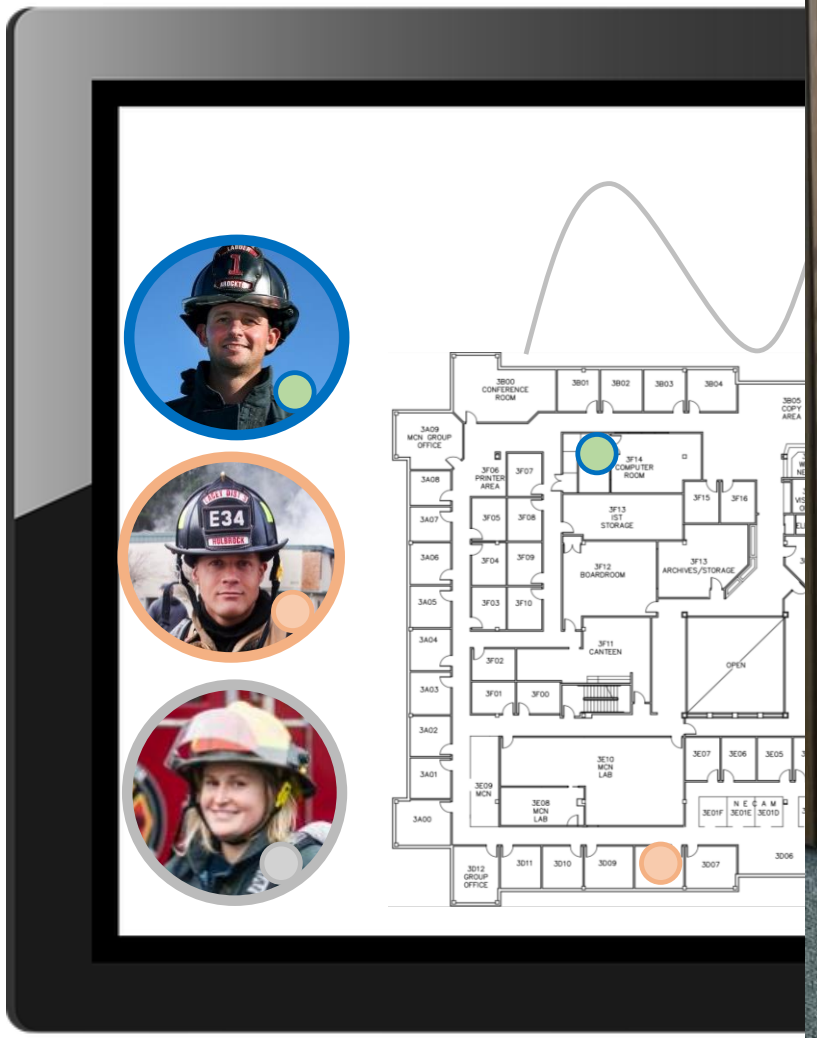
Flexible vantage points in 3D aerial space

UAVs or drones are attractive options for realizing such flexibility in 3D space



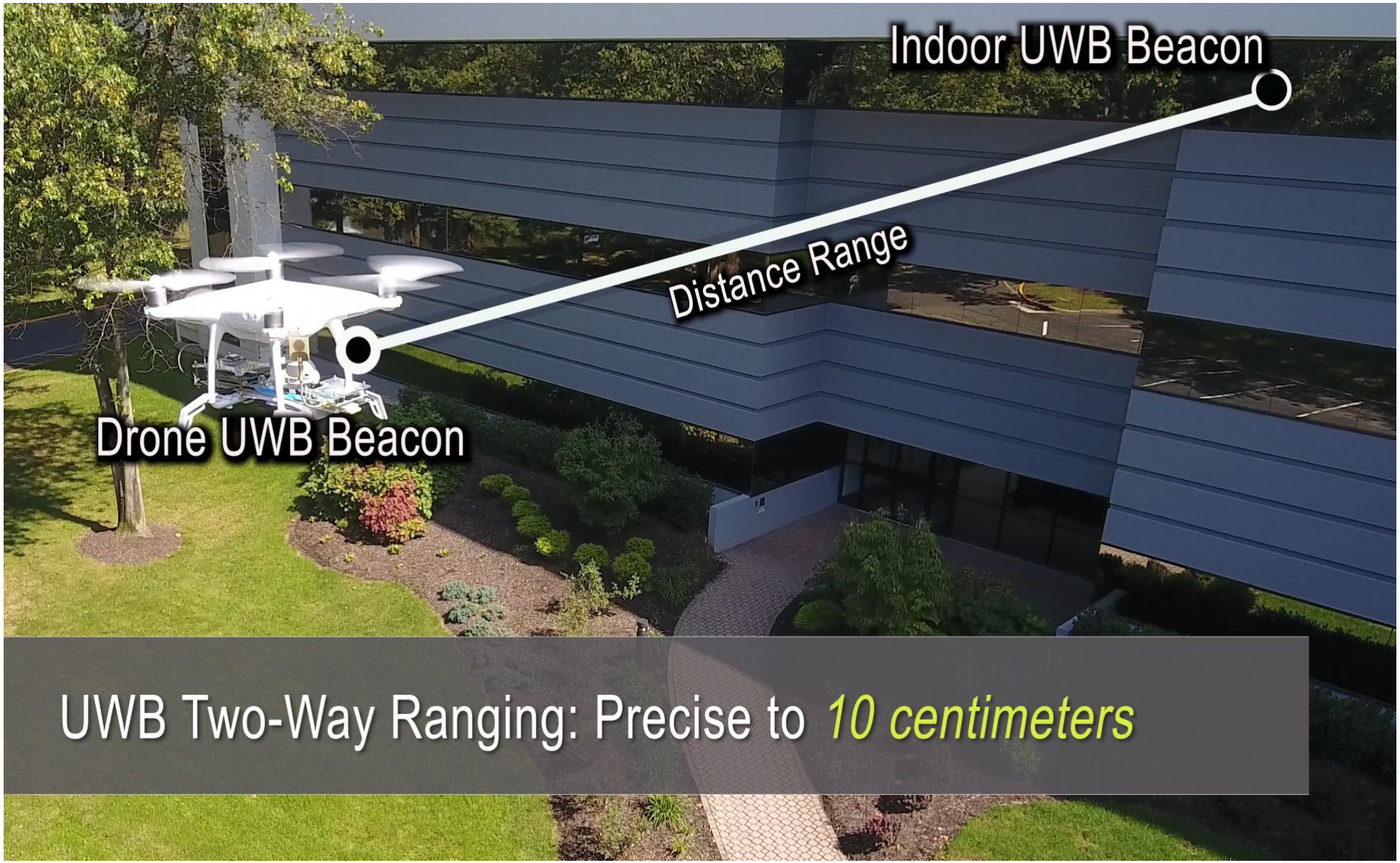
The TrackIO Solution

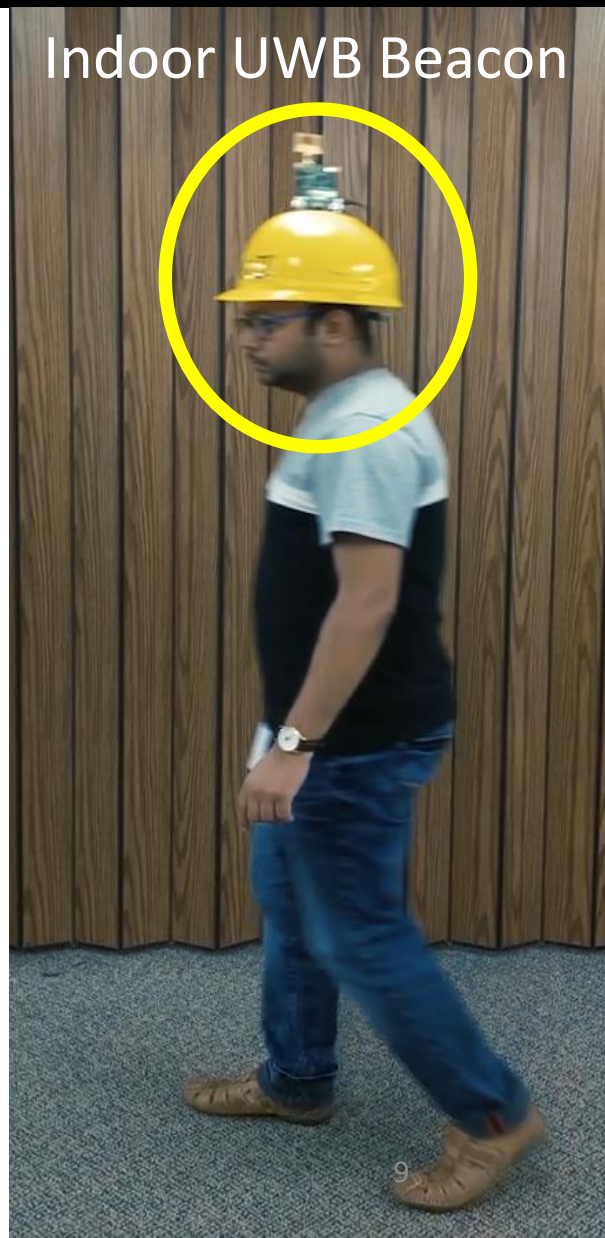






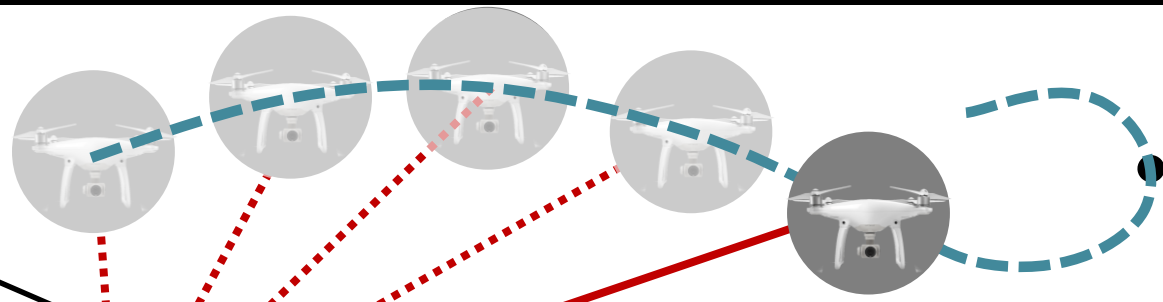
The TrackIO Solution



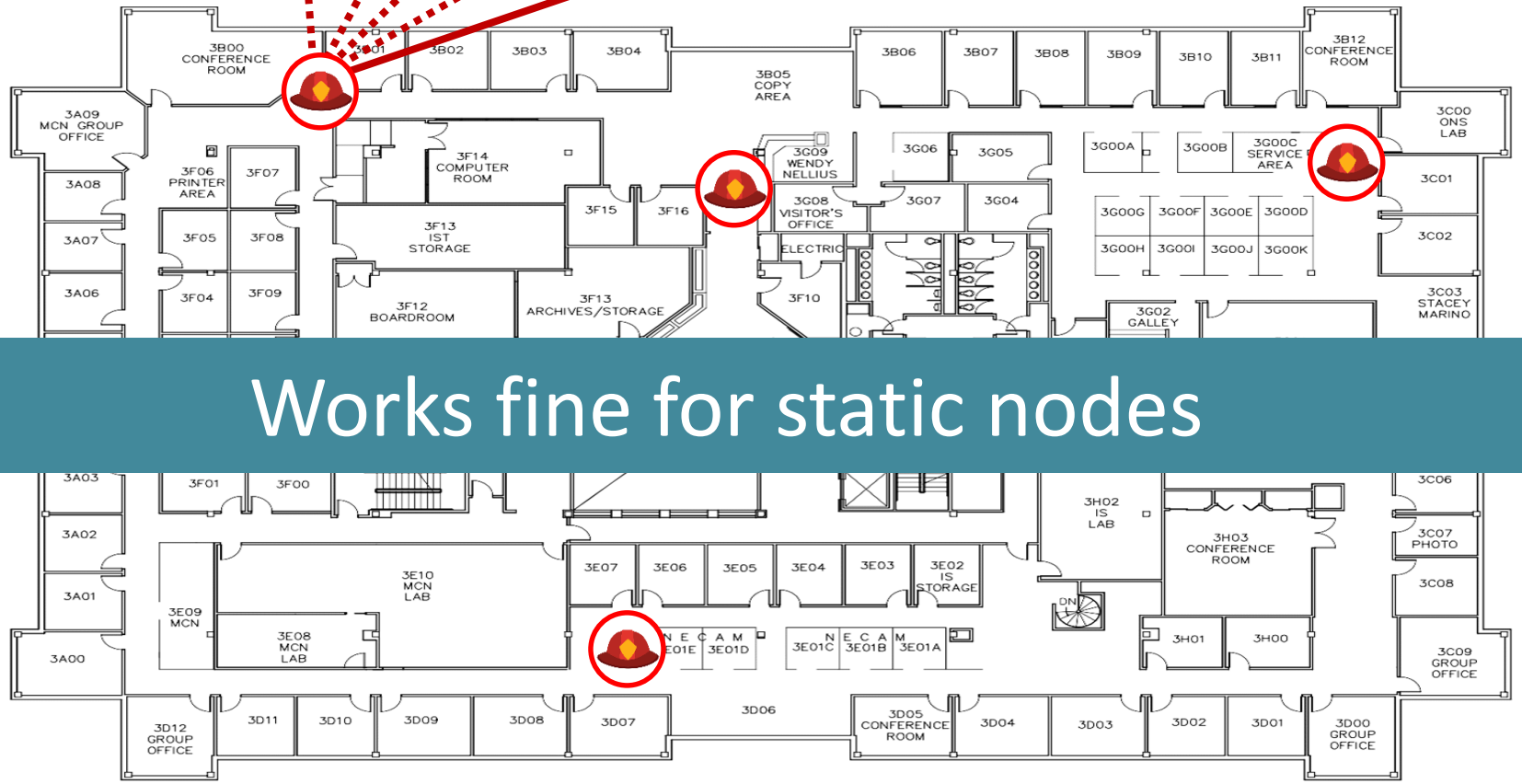


Towards TrackIO Solution

UAV collects many ranges over time



UAV trajectory forms a synthetic aperture

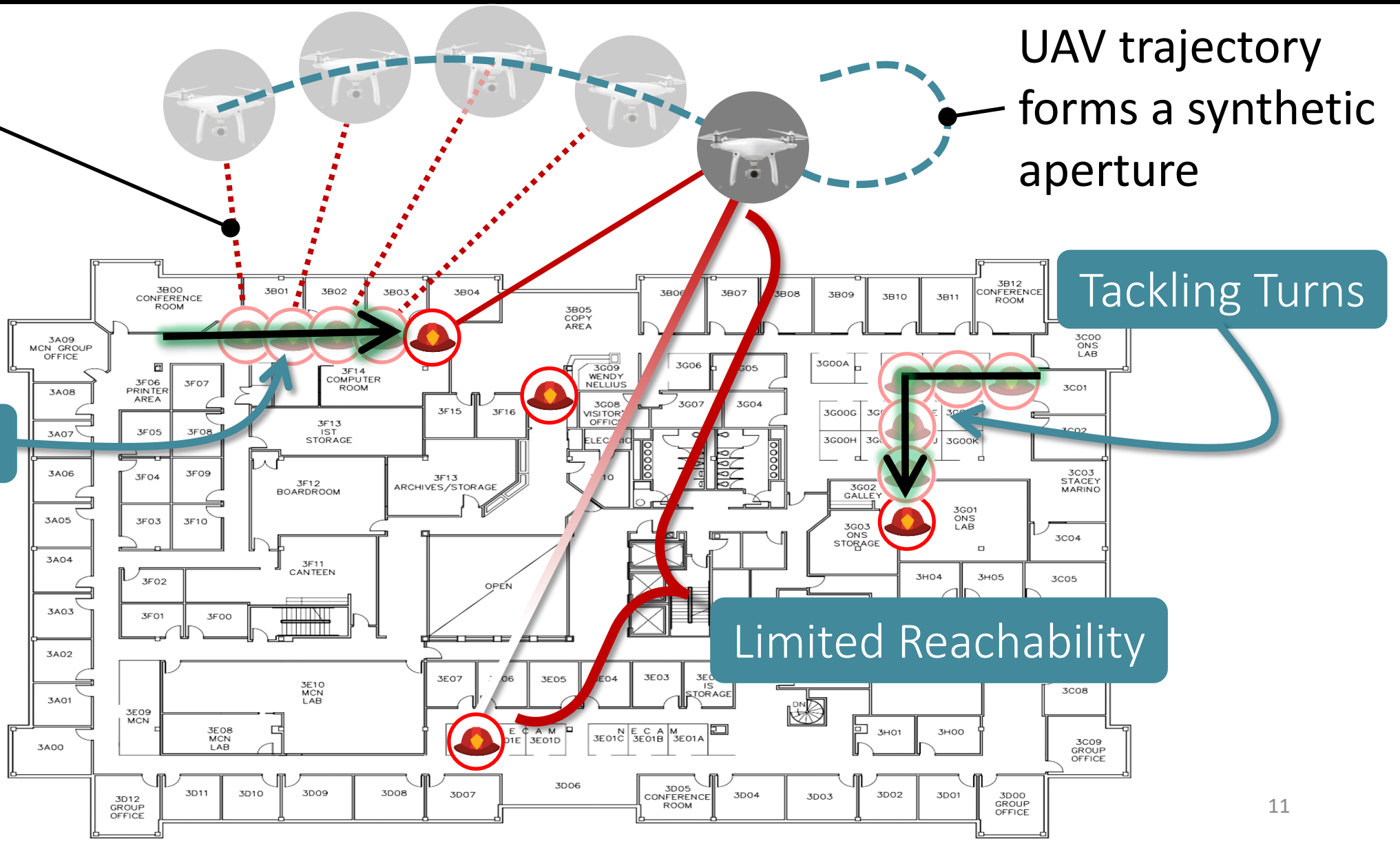


Works fine for static nodes

Design Challenges

UAV collects many ranges over time

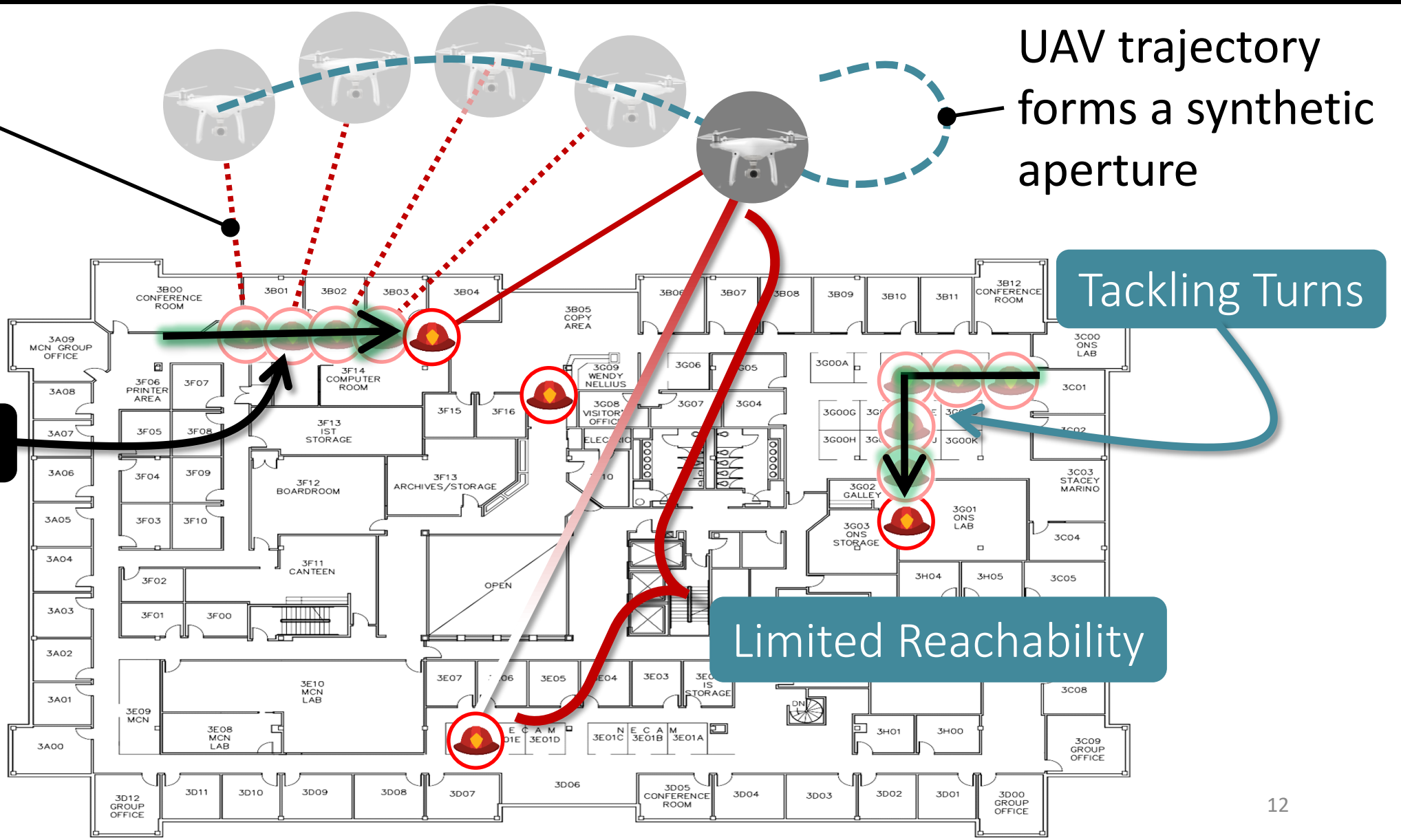
UAV trajectory forms a synthetic aperture



Design Challenges

UAV collects many ranges over time

UAV trajectory forms a synthetic aperture



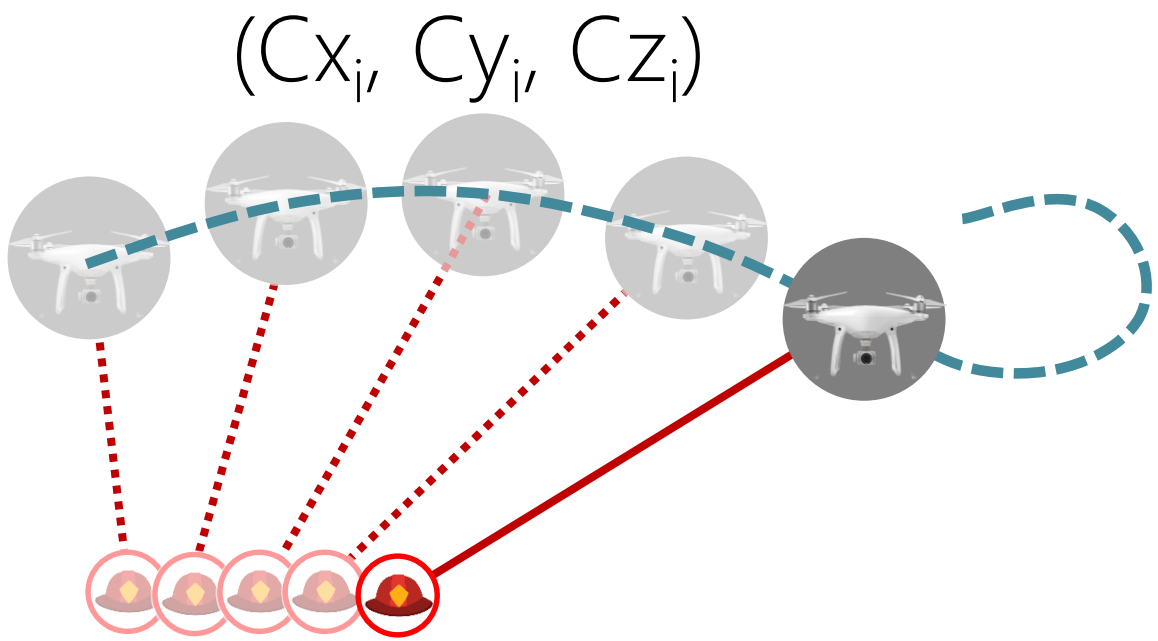
Node Mobility: Solve for Velocity

$$R_i = \sqrt{(Cx_i - x_i)^2 + (Cy_i - y_i)^2 + (Cz_i - z_i)^2}$$

Drone Locations

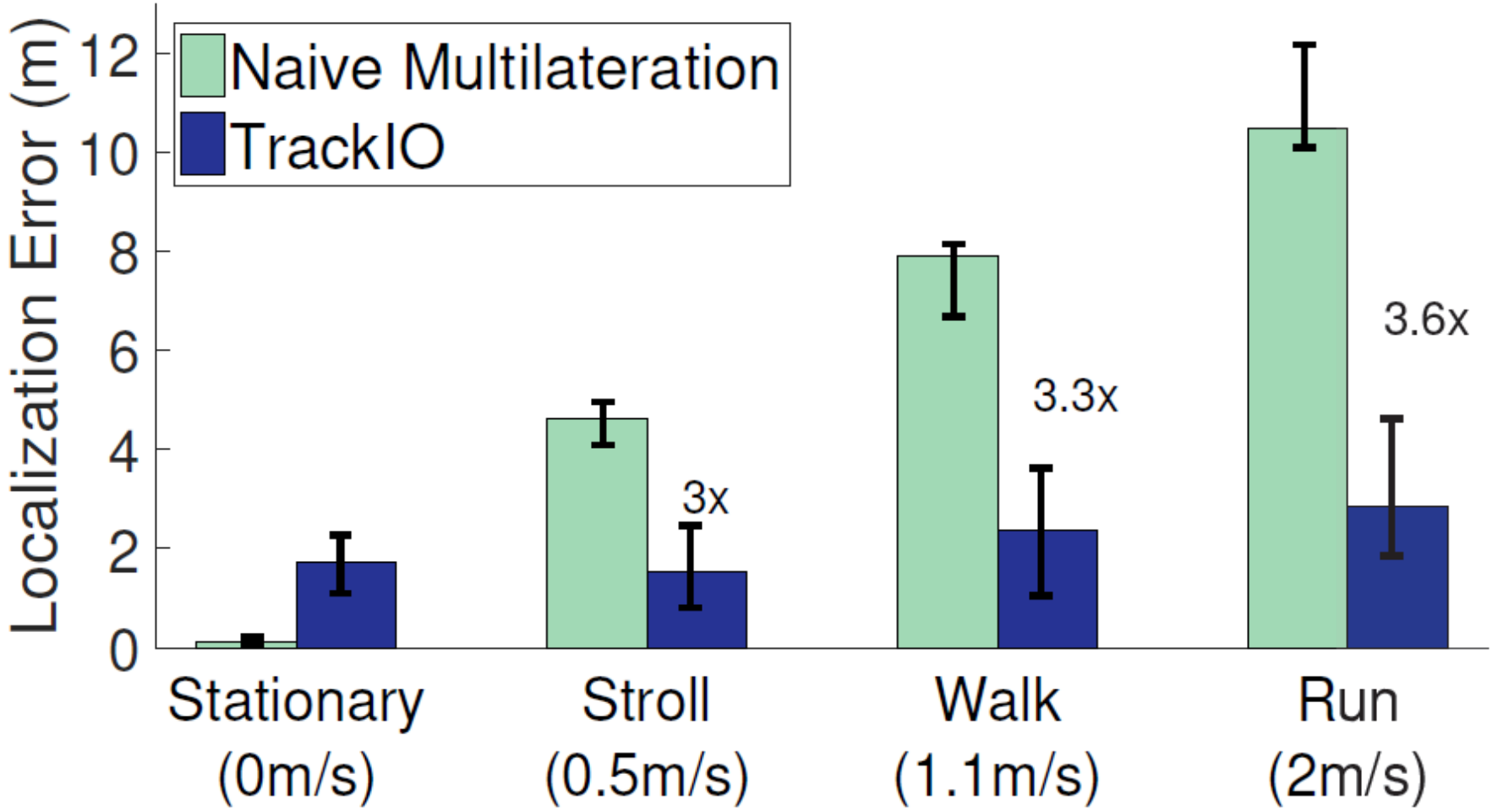
$$x_i = x_{i-1} + V_x \,.\Delta T_i = x_1 + V_x * \sum_{j=1}^{i} \Delta T_j$$

$$y_i = y_{i-1} + V_y \,.\Delta T_i = y_1 + V_y * \sum_{j=1}^{i} \Delta T_j$$



$$\underset{x_1,\, x_2,\, V_x,\, V_y}{\textbf{argmin}} \quad f = \sum_{i=1}^{n} ((Cx_i - x_i)^2 + (Cy_i - y_i)^2 + (Cz_i - z_i)^2 - R_i^2)^2$$

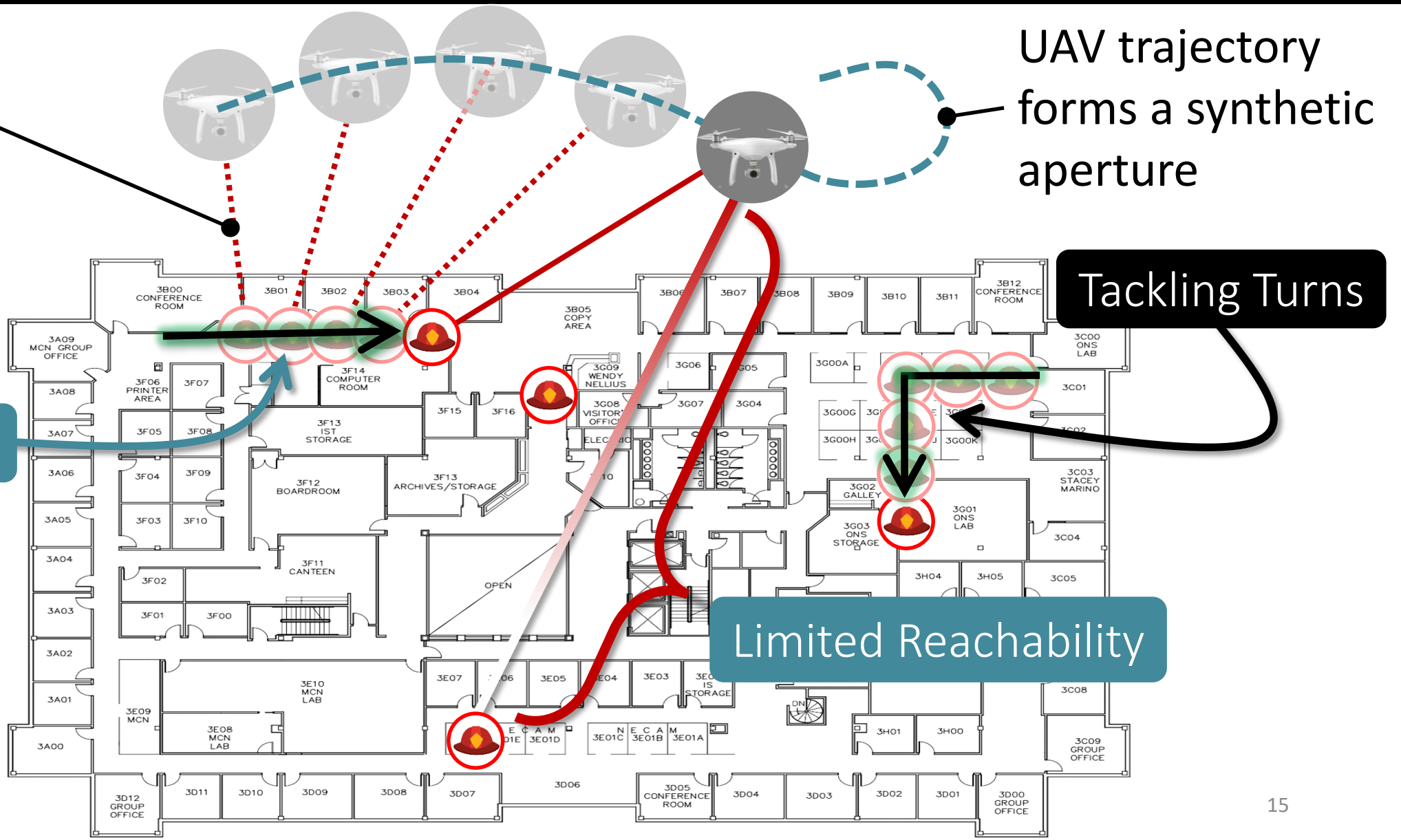
Tracking Velocity Vector Improves Performance



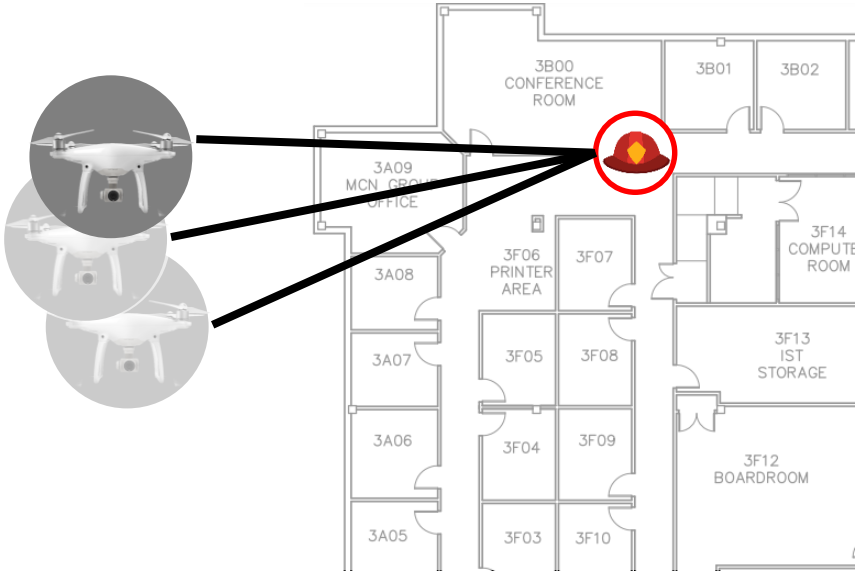
Design Challenges

UAV collects many ranges over time

UAV trajectory forms a synthetic aperture



Tackling Turns: Adaptive Aperture

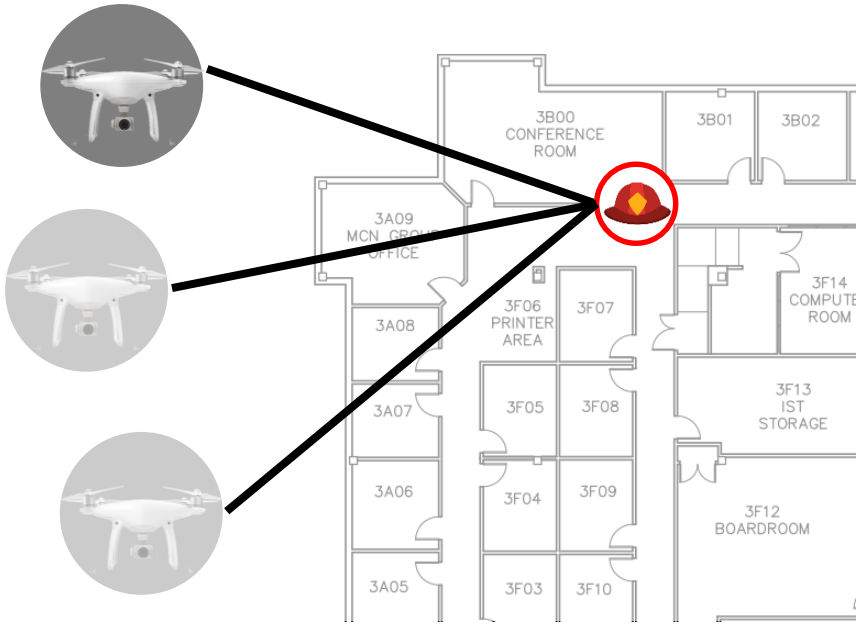


Smaller Aperture ⇨ Less Historic Data

✗ Poor Localization Accuracy

✓ Adapts Quickly to Velocity Changes

vs

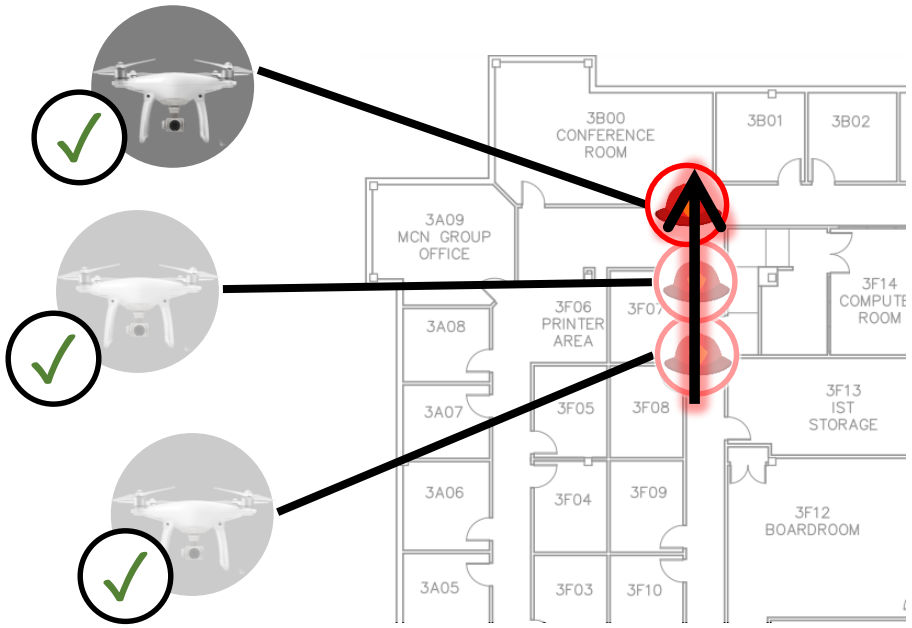


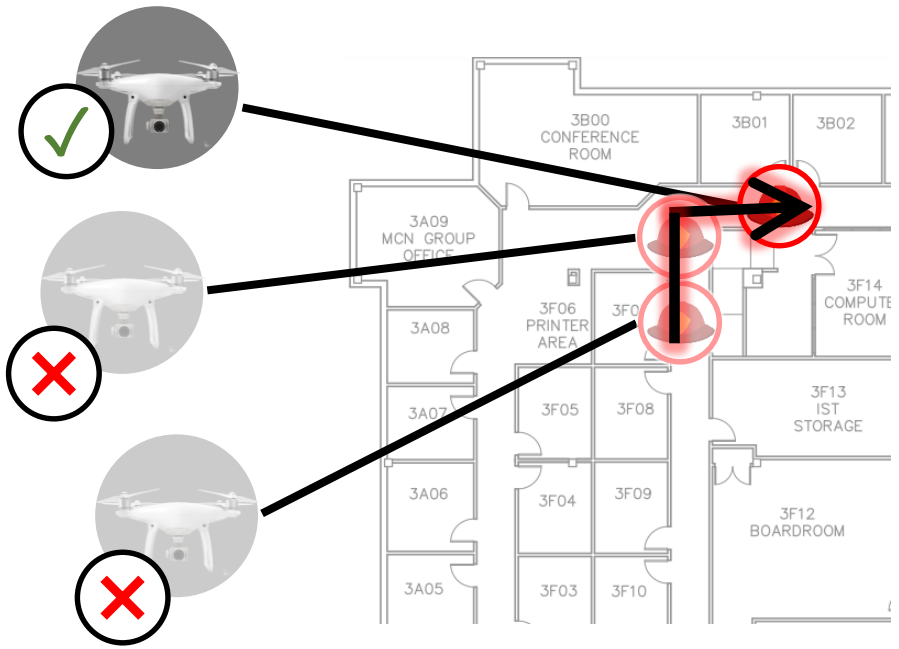
Larger Aperture ⇨ More Historic Data

✓ Good Localization Accuracy

✗ Adapts Slowly to Velocity Changes

Tackling Turns: Adaptive Aperture



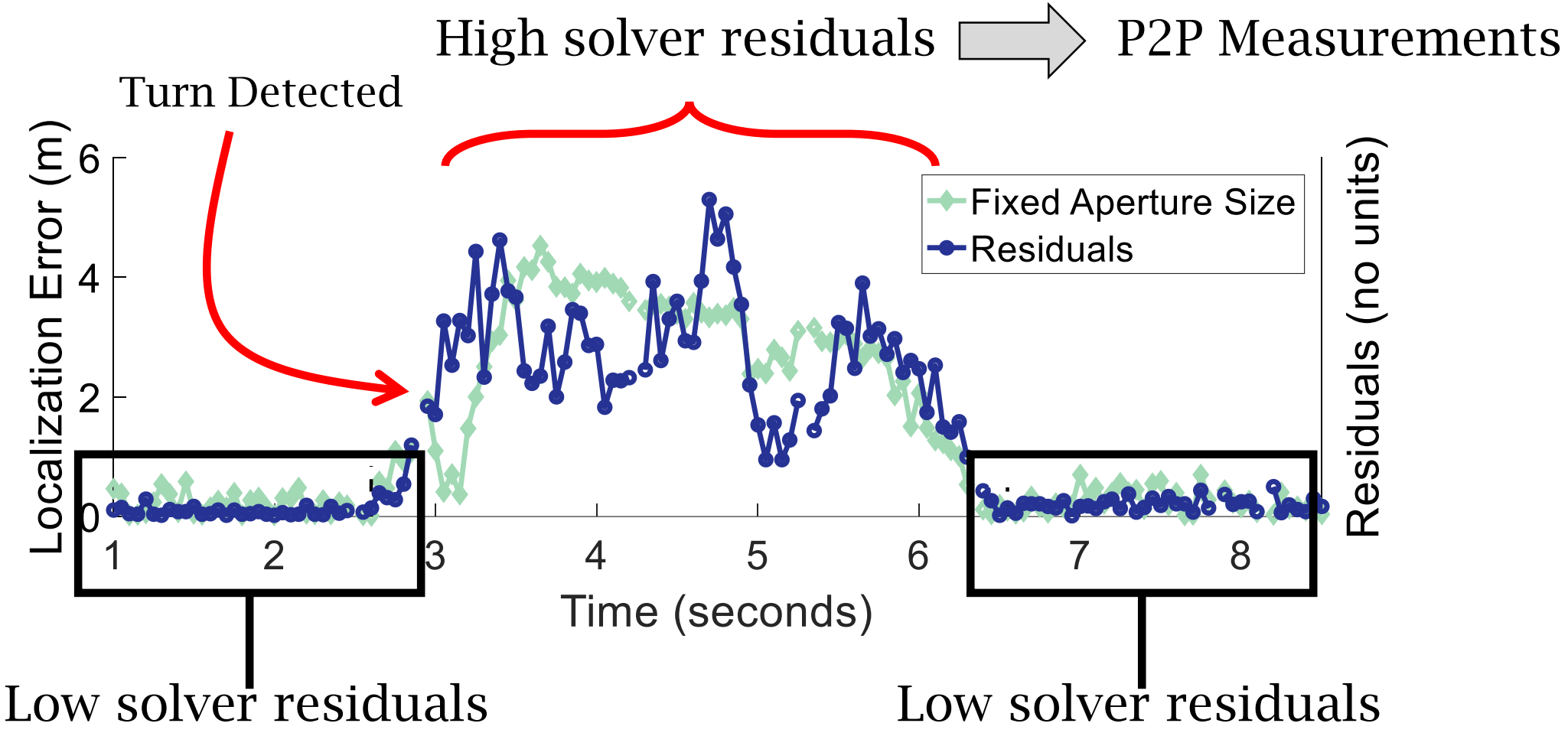


Uniform Velocity ⇨ Larger Aperture

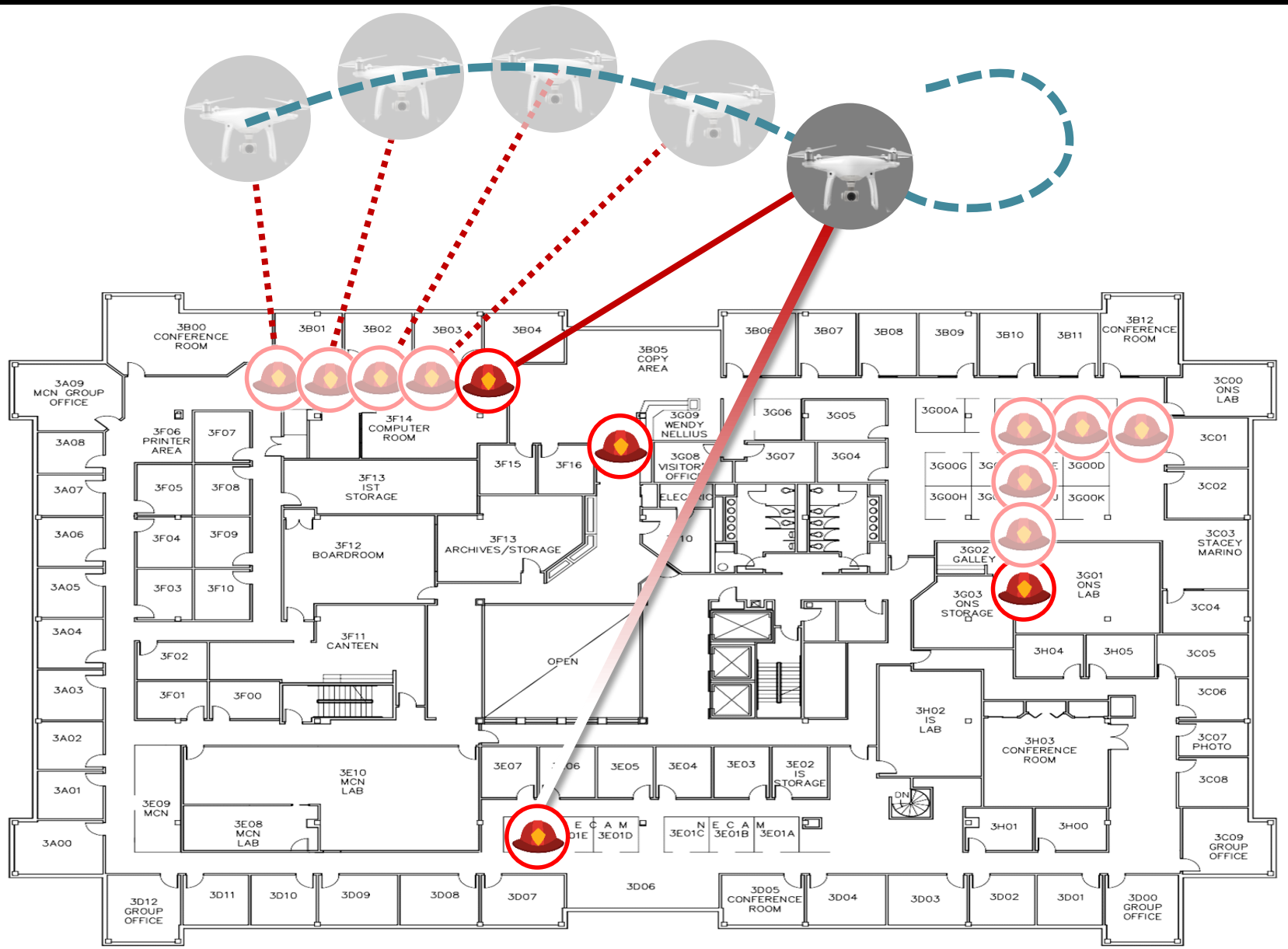
Non-Uniform Velocity ⇨ Restart Aperture

Change in velocity is estimated by sudden changes in the solver's residual

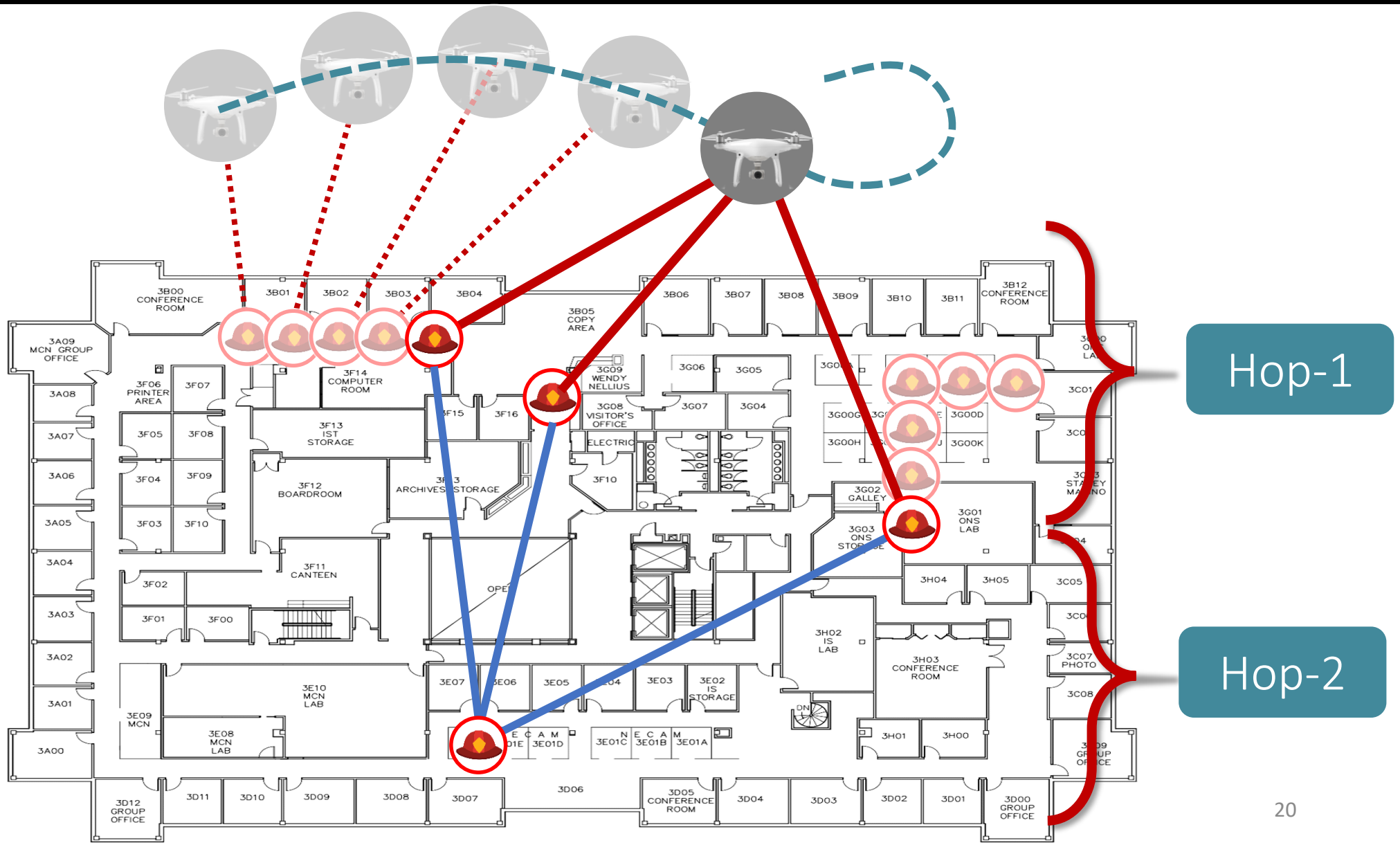
Reliability of Turn Detection



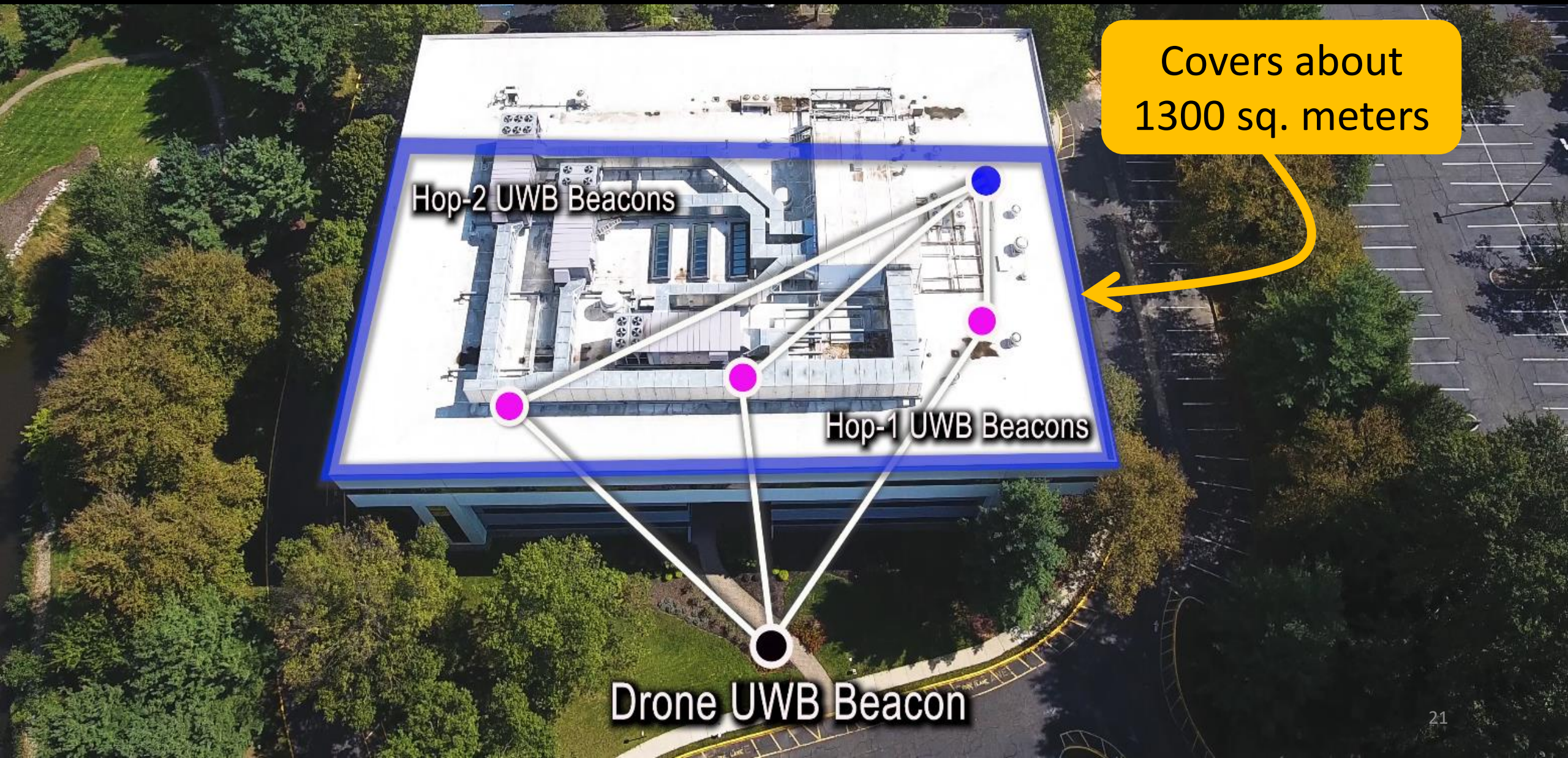
Limited Reachability: Multihop Ranging



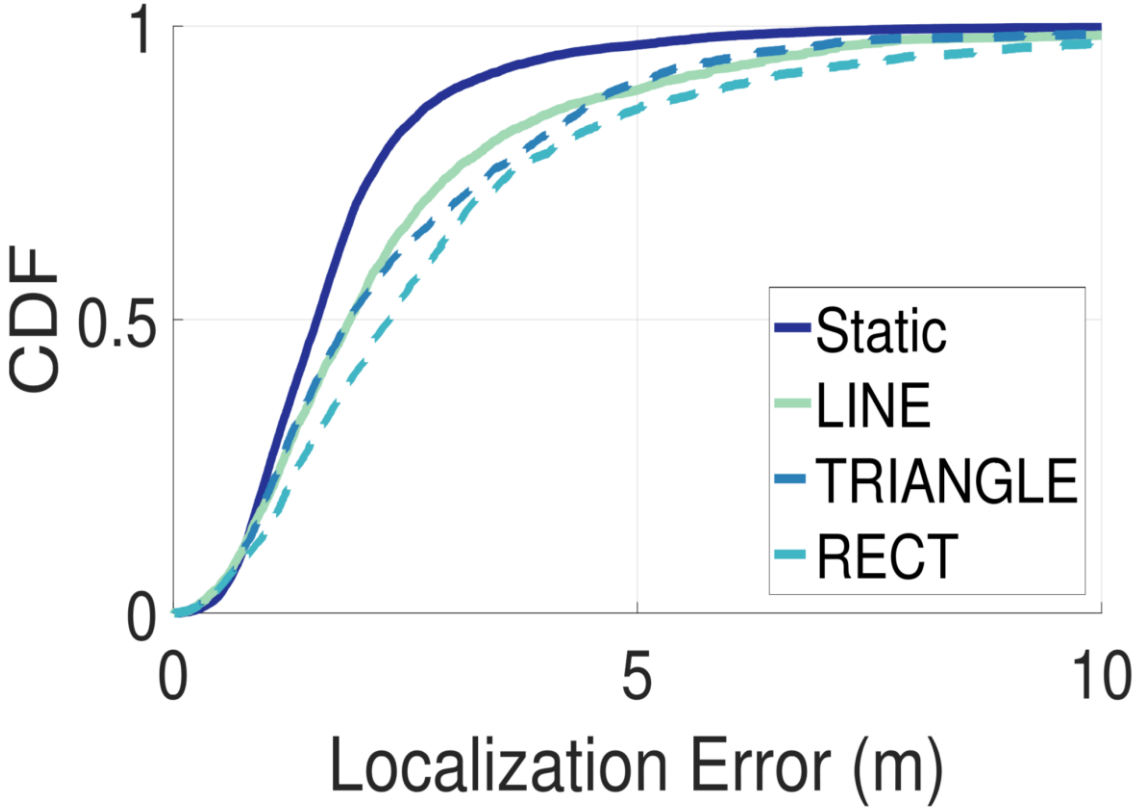
Limited Reachability: Multihop Ranging

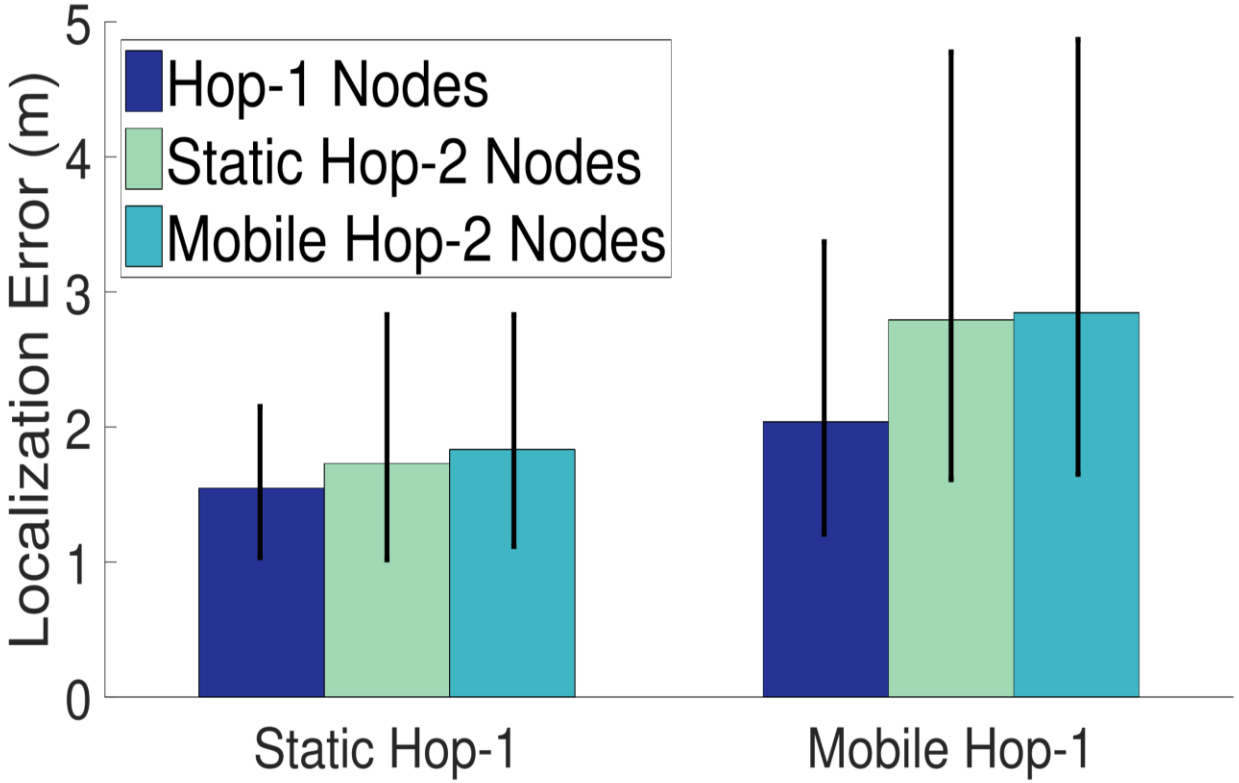


TrackIO Performance

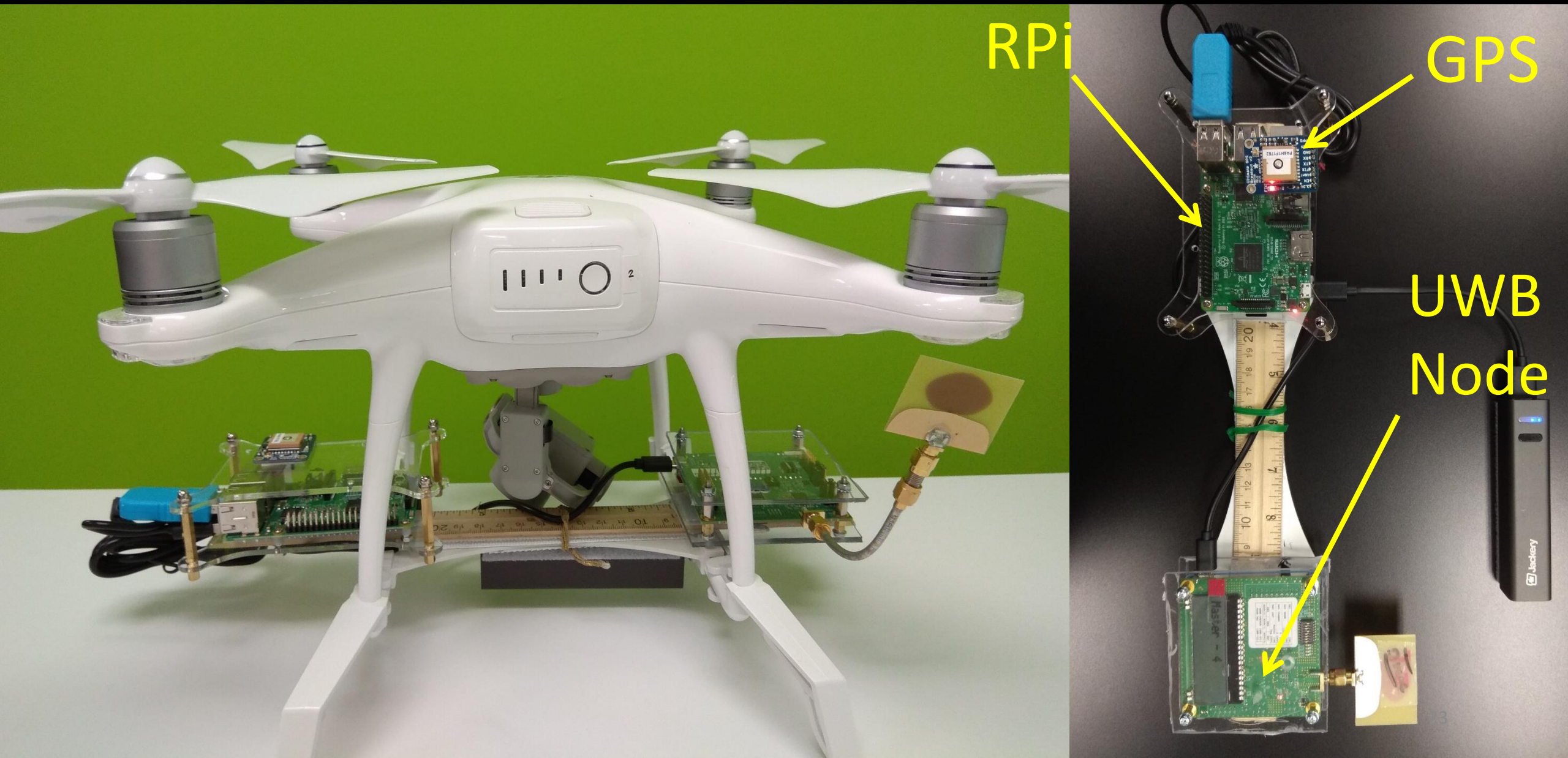


TrackIO Performance





TrackIO UAV



Salient Points

- TrackIO offers a localization solution without the dependence of pre-deployed indoor infrastructure.
- UWB technology provides accurate ranging, which combined with the flexible UAV trajectory offers localization accuracy as good as 1 – 2 meters.
- TrackIO's multi-hop ranging protocol helps deeper penetrability indoors.
- Various fire departments and government entities has already shown reasonable interest in our tracking technology for subsequent commercialization.

Please visit the link for a demo.

http://www.nec-labs.com/trackio

\Orchestrating a brighter world

NEC

Thank You

Ayon Chakraborty
ayon@nec-labs.com