Defining a Good Geofence for UAS

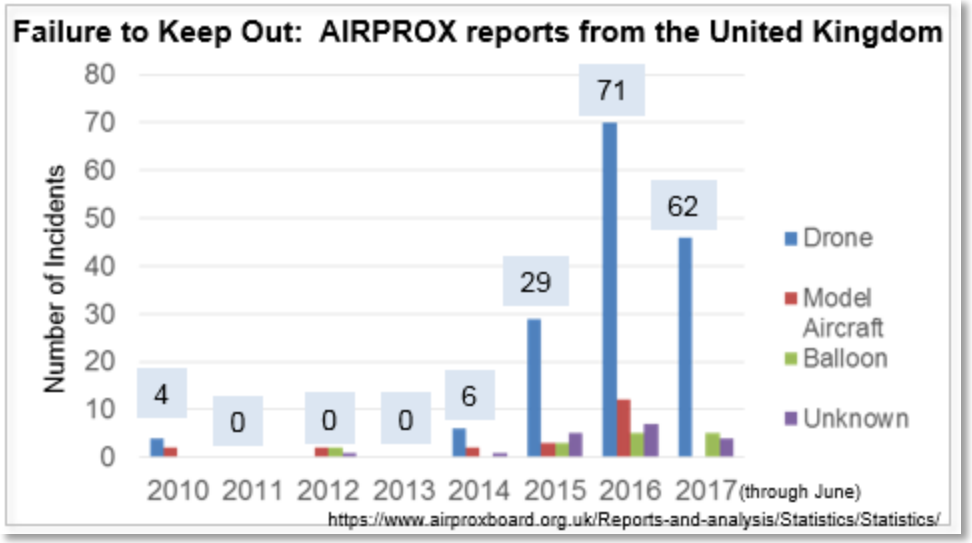
supporting Unmanned Aircraft System (UAS) Traffic Management (UTM)

Kelly Hayhurst
Evan Dill, Steve Young, and Russell Gilabert
NASA Langley Research Center
Hampton, Virginia 23681-2199 USA

Setting boundaries

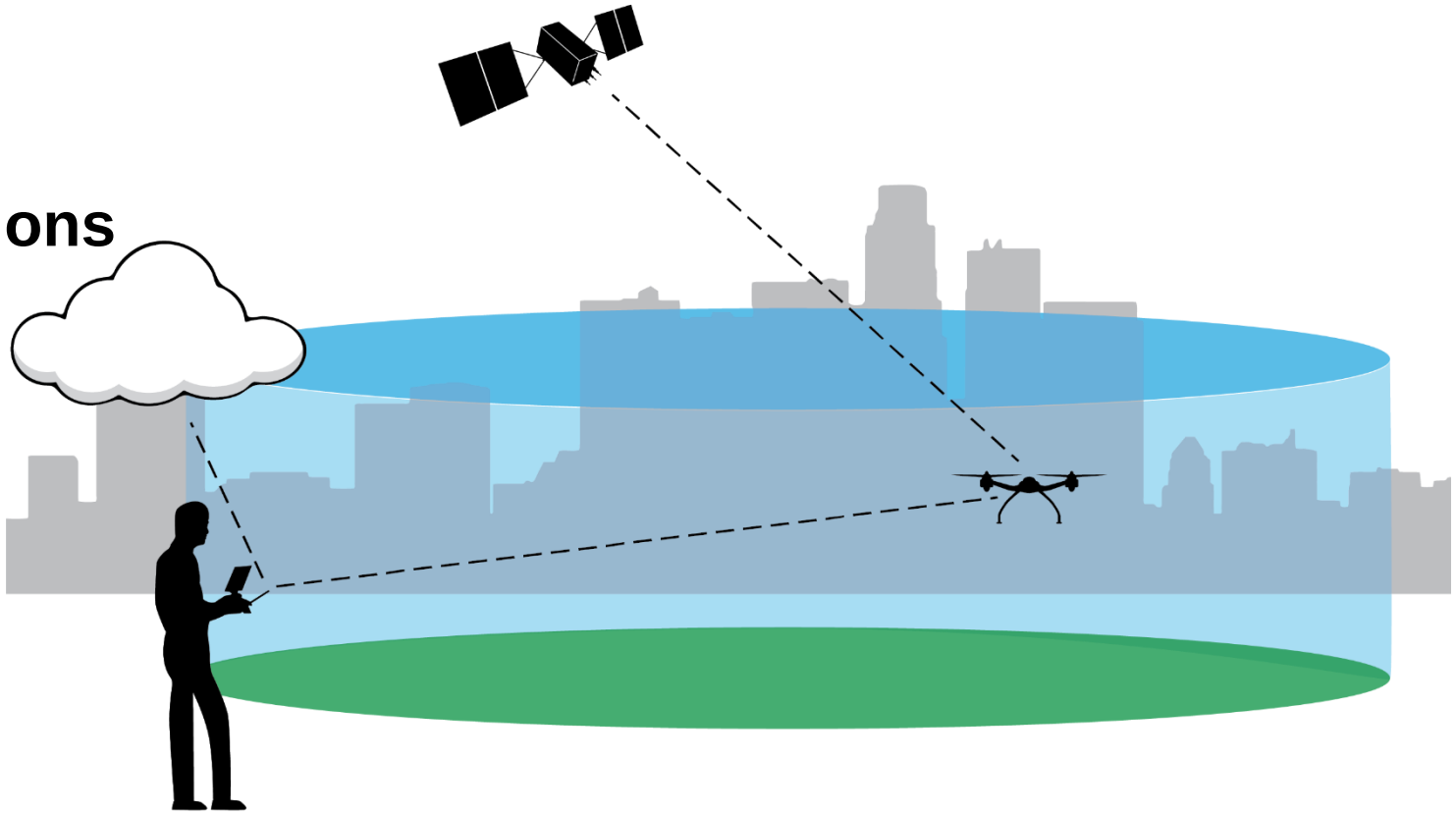
- **Function: keep out and keep in**
- **Hazard: geo-limitations breach**
- **Consequence: loss of safety margin**
- **Severity: potentially catastrophic**
- **Mitigation: systems and equipment that reliably enforce geospatial limitations**

Good geofences make good neighbors

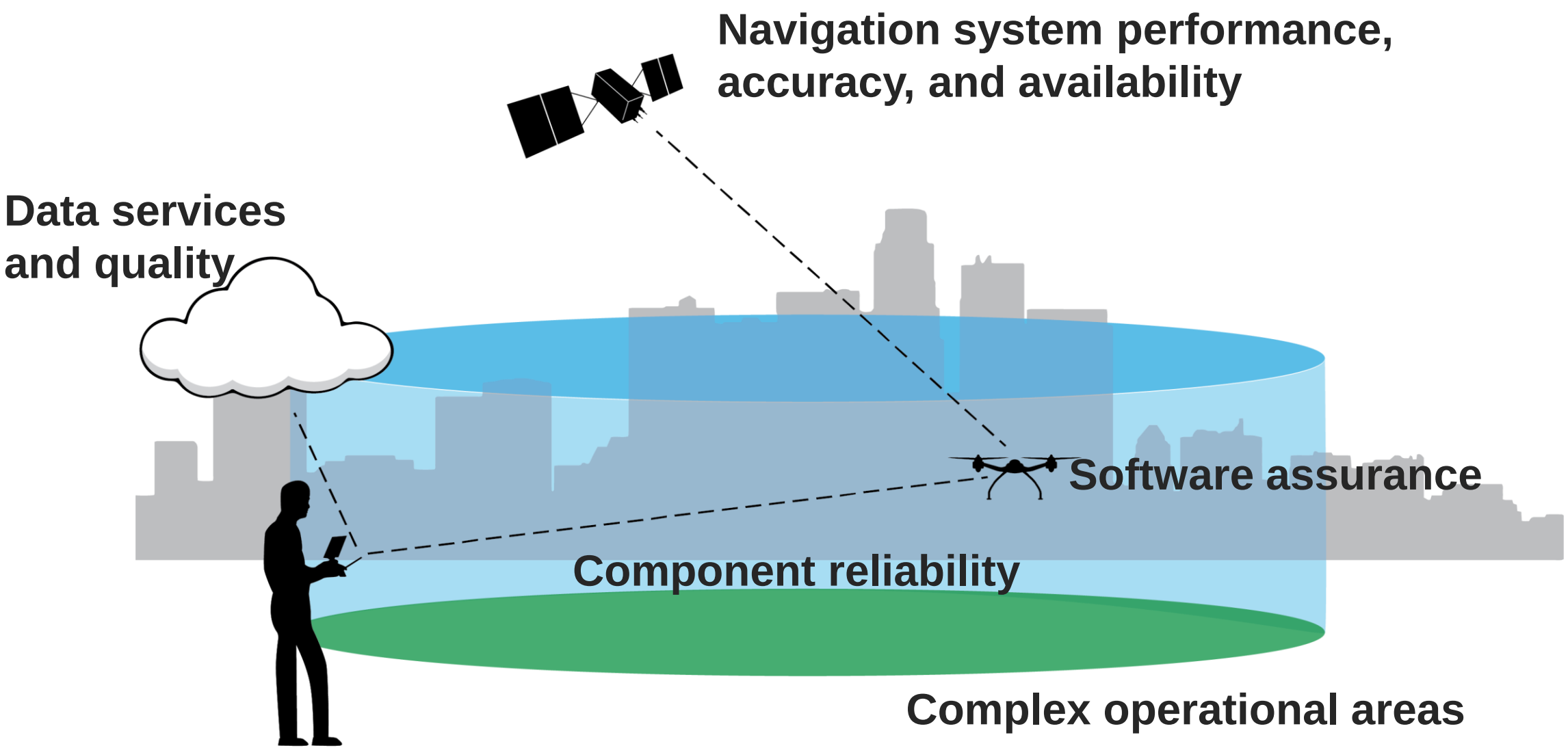


Geofencing system

- **Conceptually simple**
  - **Load geo-limitations**
  - **Navigate within limits**
  - **Identify impending violations**
  - **Act to avoid violations**
  - **Operate with a certified remote pilot**

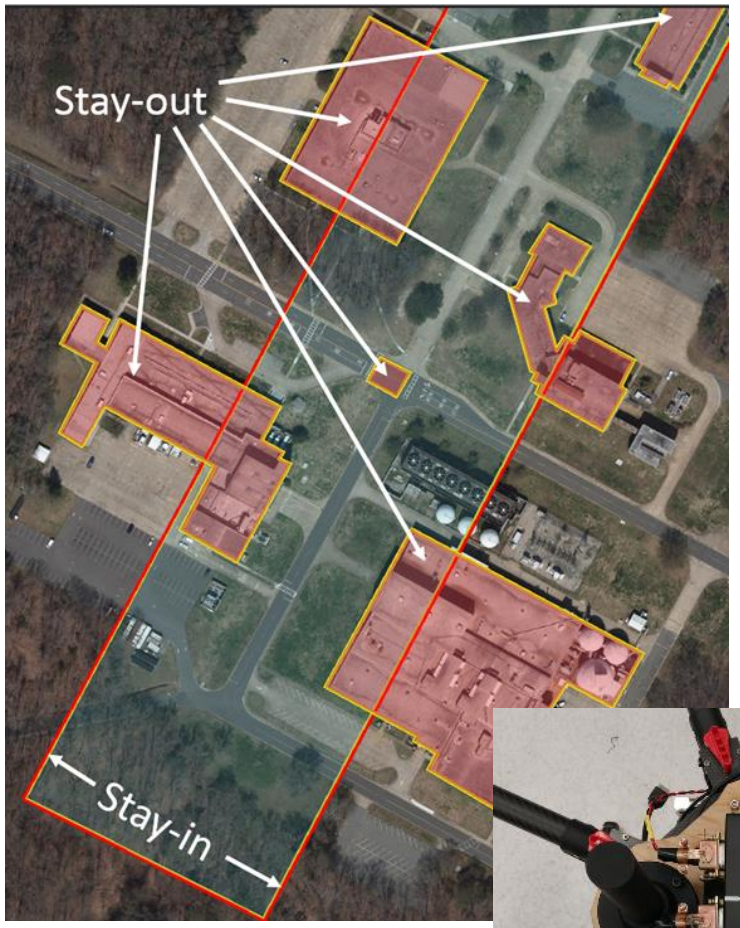


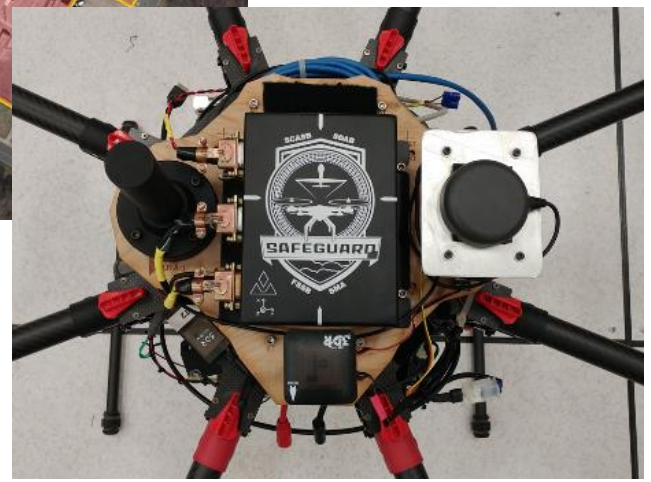
Challenges for a good geofencing system



Safeguard: a prototype reliable geofencing system

- Developed to support UTM for small to midsize drones
- Based on simplex architecture
- Independent, autonomous system
- Not reliant solely on GPS
- Formally verified algorithms for boundary detection
  - complex polygons
- Safety assurance emphasis
  - current prototype developed to NASA Class B software standards





Design and performance topics

Right data: operation, place, time, and constraints

Data from Operator & UTM

- Planning
  - mission planning
  - geo-limitations and boundary location
  - interference
  - infrastructure dependencies
- Input data quality
  - integrity, accuracy, timeliness, security

Reliable systems and equipment

Geofencing System

- Geo-limitation data handling
- Position and velocity estimation
- Situational awareness
- Detecting proximity
- Alerting about need for action
- Taking action to avoid limit breach
- Power

Concluding remarks

- **An unreliable system can cause a drone to end up in places where no pilot or controller would ever command them to go**
  - **good geofencing is necessary when failure consequence is high**
- **Data integrity is essential**
  - **geo-limitation and other operational constraints**
- **Reliable avionics are also essential**
  - **position and navigation**
  - **boundary detection in complex operational areas**
- **Safeguard research can help in developing criteria and standards for future geofencing systems**

Questions?

https://www.youtube.com/watch?v=GB8eid32d1A&feature=youtu.be

LARC-DL-Safeguard@nasa.gov