

# GPS-Free Navigation

Greg Duckworth



# Extreme environments for Navigation and Geo-location



**Robots in Rubble**

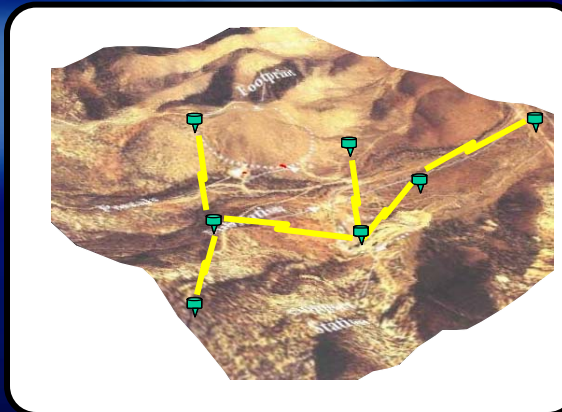
**Under Heavy Foliage**



**Forces Inside Buildings**

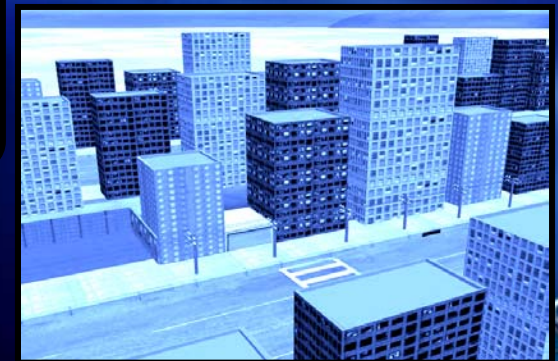


**Inside Caves**



**Unattended Ground Sensors**

**Urban "Canyons"**

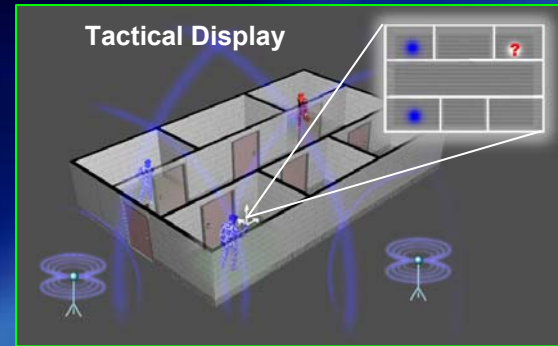


THE GAP



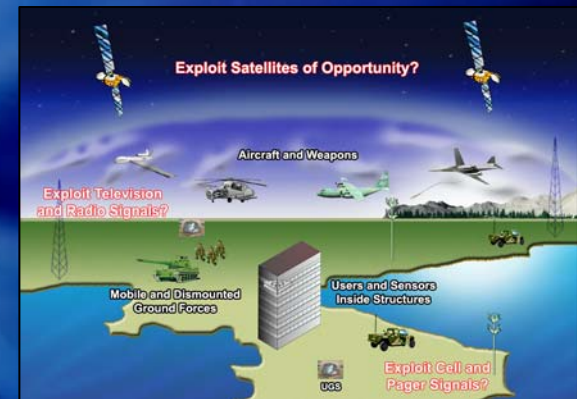
- MORE STUFF:

- Additional actively emitting augmentation in-theater



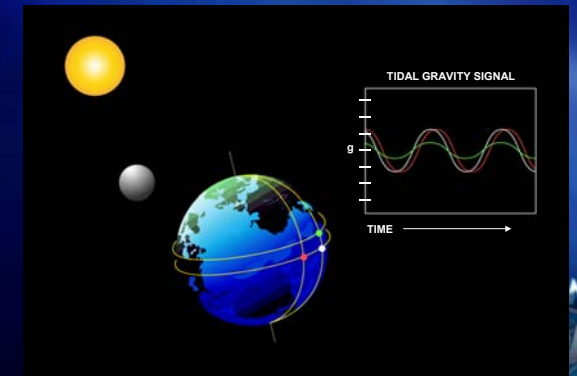
- FREE STUFF:

- Exploits existing man-made signals of opportunity in-theater
- May have “reference stations” near theater



- NO STUFF:

- Use “natural” signals of opportunity



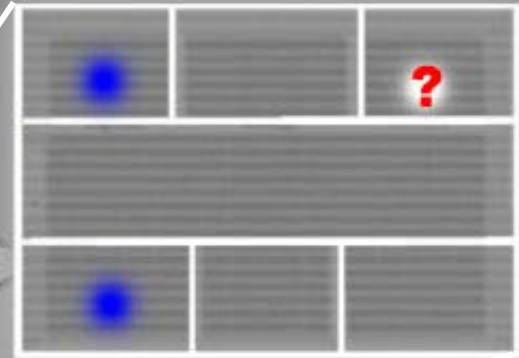
# Solution: Pseudolites for Navigation



THE GAP

# Challenge: Indoor Navigation

Tactical Display





# Navigation via Signals of Opportunity (NAVSOPP)



# “No Stuff”



## TIDAL GRAVITY SIGNAL

