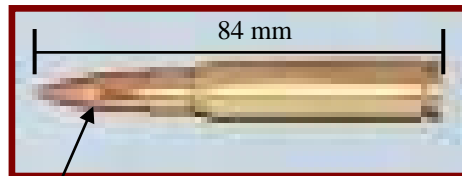**Presentation to the**
NDIA 9th Annual Systems Engineering Conference,
San Diego, CA, October 26, 2006

Hypothetical Military CONOPs for Wireless Sensor Networks

84 mm

Sensor Embedded in the Round

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What are "Ubiquitous Wireless Sensor Nets?"

- A Network of hundreds, thousands, or millions of micro-scale or nano-scale devices used to instrument some physical space…
  - Machinery Instrumentation
  - Habitat Monitoring
  - Inventory and Asset Tracking
  - Battlefield
  - Perimeter Surveillance
- Features of Sensor Nets
  - Power Plant (Generation, Scavenging and Storage)
  - Detectors (CBRN, Acoustic, SIGINT, EO/IR, etc.)
  - Computational Layer
  - At least one communications medium
  - Camouflage
  - Efficient software functions primarily concerned with communications and resource management

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Whose doing what?
What are they doing?

MIT
(Teller et al)

UCLA
(Estrin, et al)

Berkeley
(Pister, Hollar, Culler et al)

Cornell
(Zhou, Haas, Yao et al)

Device Design

QoS

Energy Management & Scavenging

Security & Encryption

2D & 3D Self Localization

Query Processing

Routing Protocols

Pattern Recognition

Signal Disambiguation

USC, Harvard, Rutgers, UVA, URI, dozens or hundreds of Universities

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What's the problem with the market?

- **No Standard for judging/measuring the suitability of a particular solution**
  - **Mission Life**
  - **Sense Modalities**
  - **Intranet and Internet Communications**
  - **Efficiencies**
  - **Latencies between detection and comms**
  - **Security/Encryption**
  - **Method of deployment**
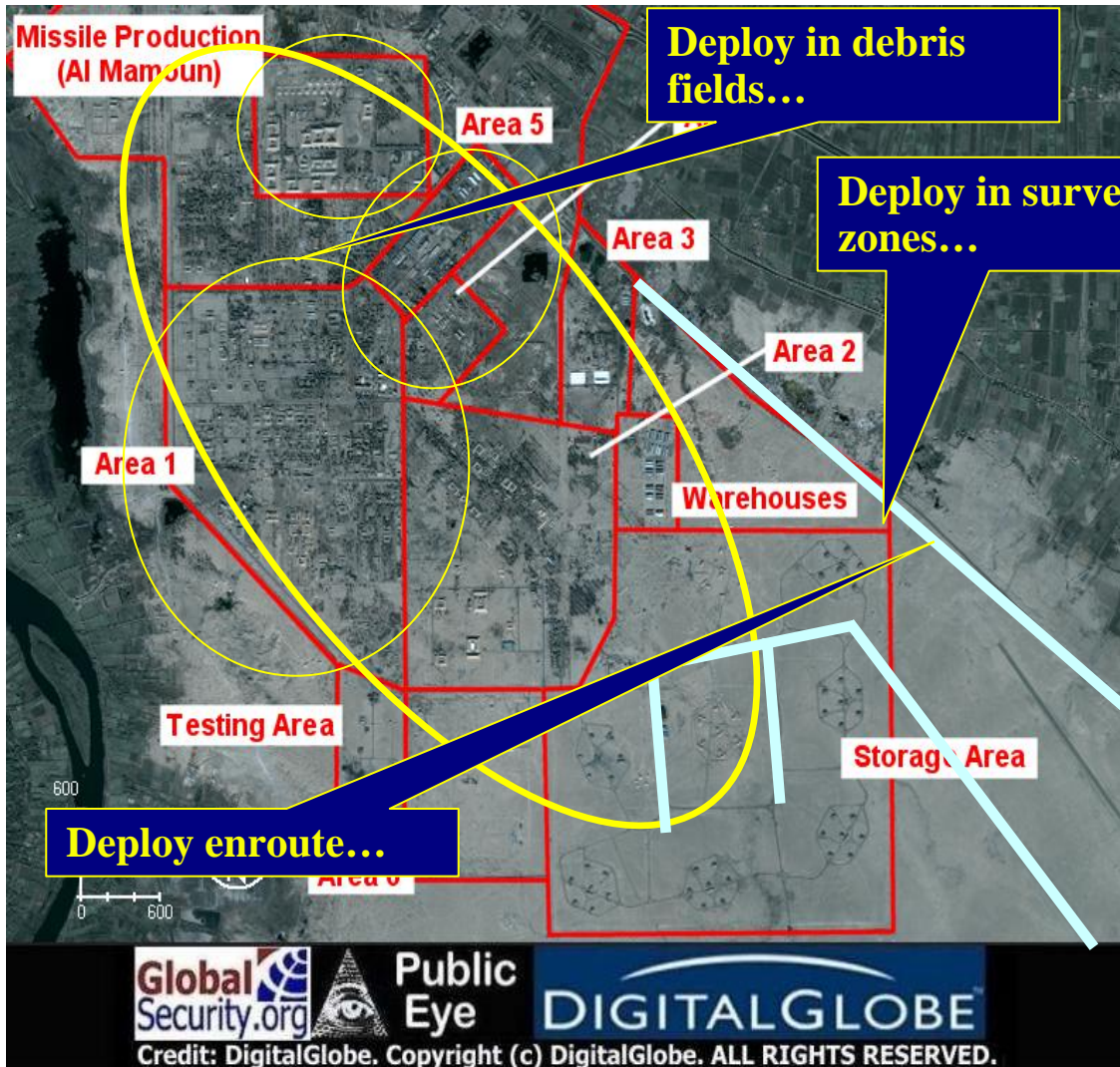 - **Form factor**
  - **Disposability**

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Sound Familiar?

- **In the 1980s, this was the case with Database Software Offerings…**
    - **Which was best?**
    - **What kinds of tasks were "typical?"**
    - **Were Updates, Deletes, Inserts or Queries the activity that drove acquisition decisions?**

- **Transaction Processing Council Benchmarks**
    - Designed to provide standard, typical transactions designed to assist in evaluating software and system performance
    - TPC-A (OLTP Update Intensive DB Transactions)
    - TPC-B (non-OLTP, DB Performance Stress Testing)
    - TPC-C (OLTP, complex, concurrent DB transactions)
    - Others

Proposal

Create an
"Industry Standard"
portfolio of military and commercial
"Missions"
that isolate the problem spaces solvable
by UWSNs!

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A Typical UWSN Ground Deployment – Al Qa Qaa **LONG TERM** CONOP

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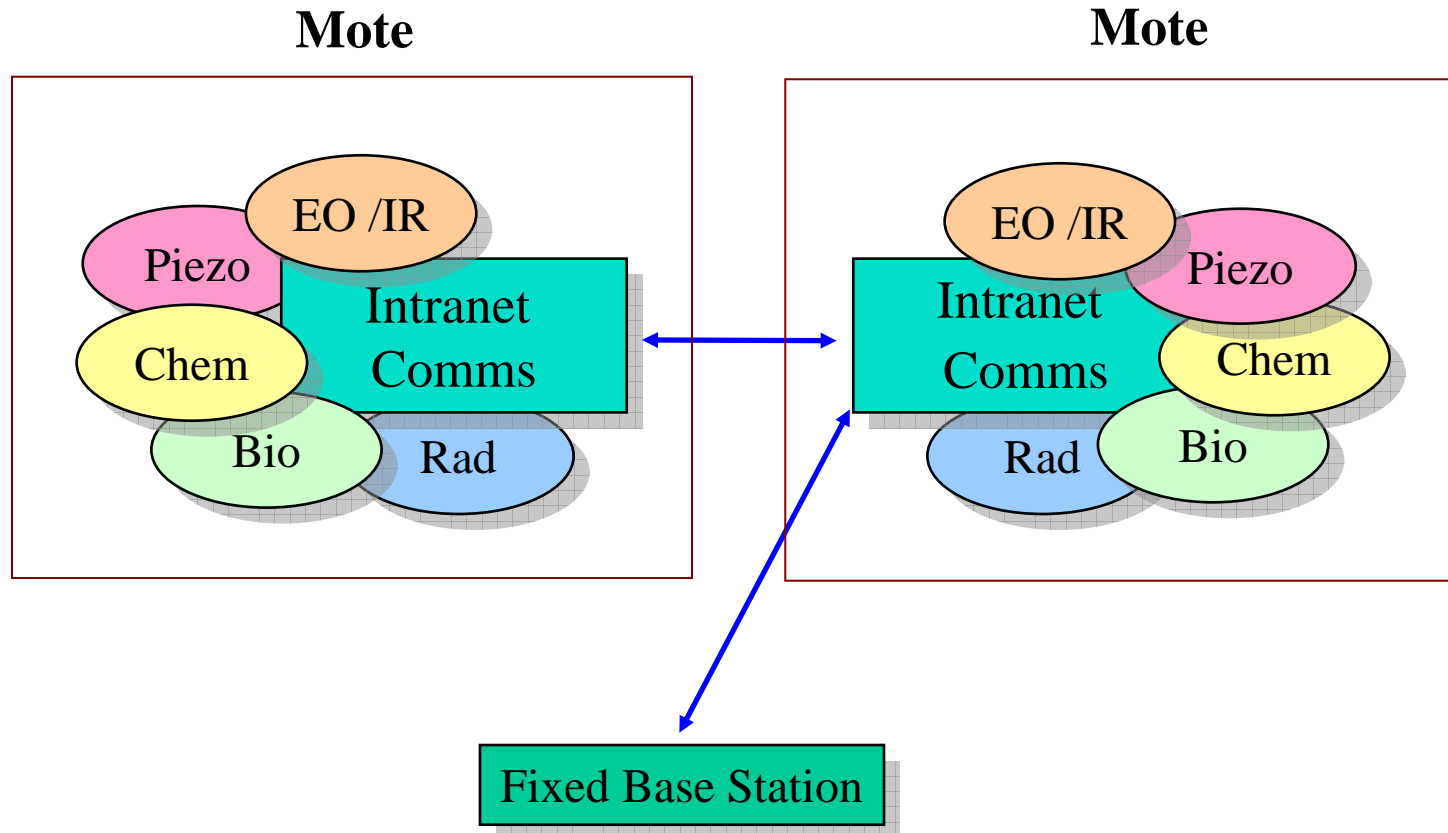All Rights Reserved, Image used with the permission for this presentation only.

- *Weeks/Months, not years!*
- *Larger Form Factor is OKAY!*
- *Solar Power is OKAY!*
- *Routing is easier*
- *ISM Band is OKAY!*
- *Video/Photo is Reasonable*
- *COTS is OKAY!*
- *Base stations – No Problem!*
- *Meteorological*

Notional System Block Diagram

Mote

Mote

EO /IR

Piezo

Chem

Intranet Comms

Bio

Rad

EO /IR

Piezo

Intranet Comms

Chem

Rad

Bio

Fixed Base Station

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A Typical UWSN Ground Deployment – Fallujah <u>*MEDIUM TERM CONOP*</u>

- *Some QoS*
- *Some Encryption*
- *Smaller Form Factor*
- *Smaller batteries*
- *Controlled Recharging*
  - *HPM?*
  - *Laser?*
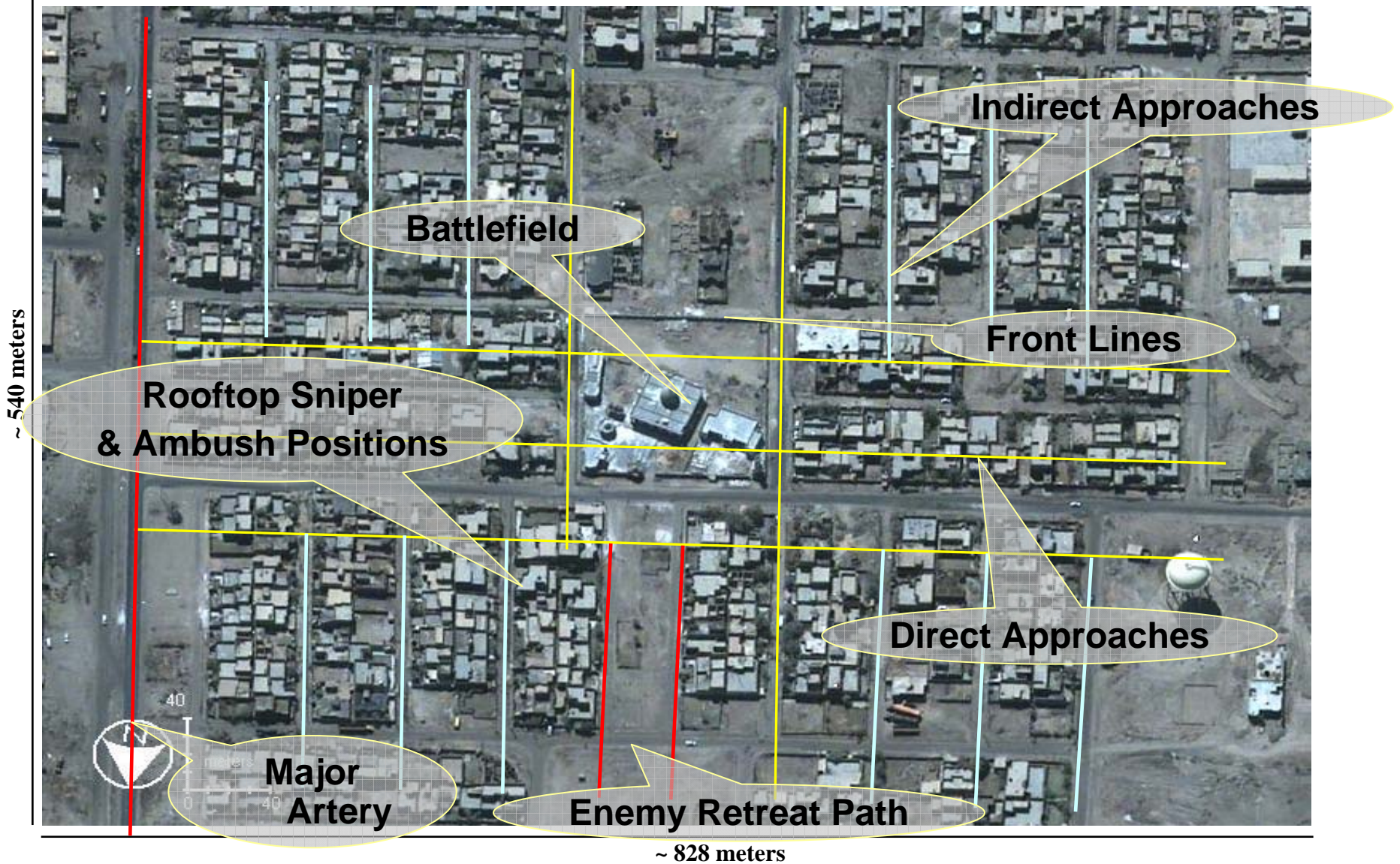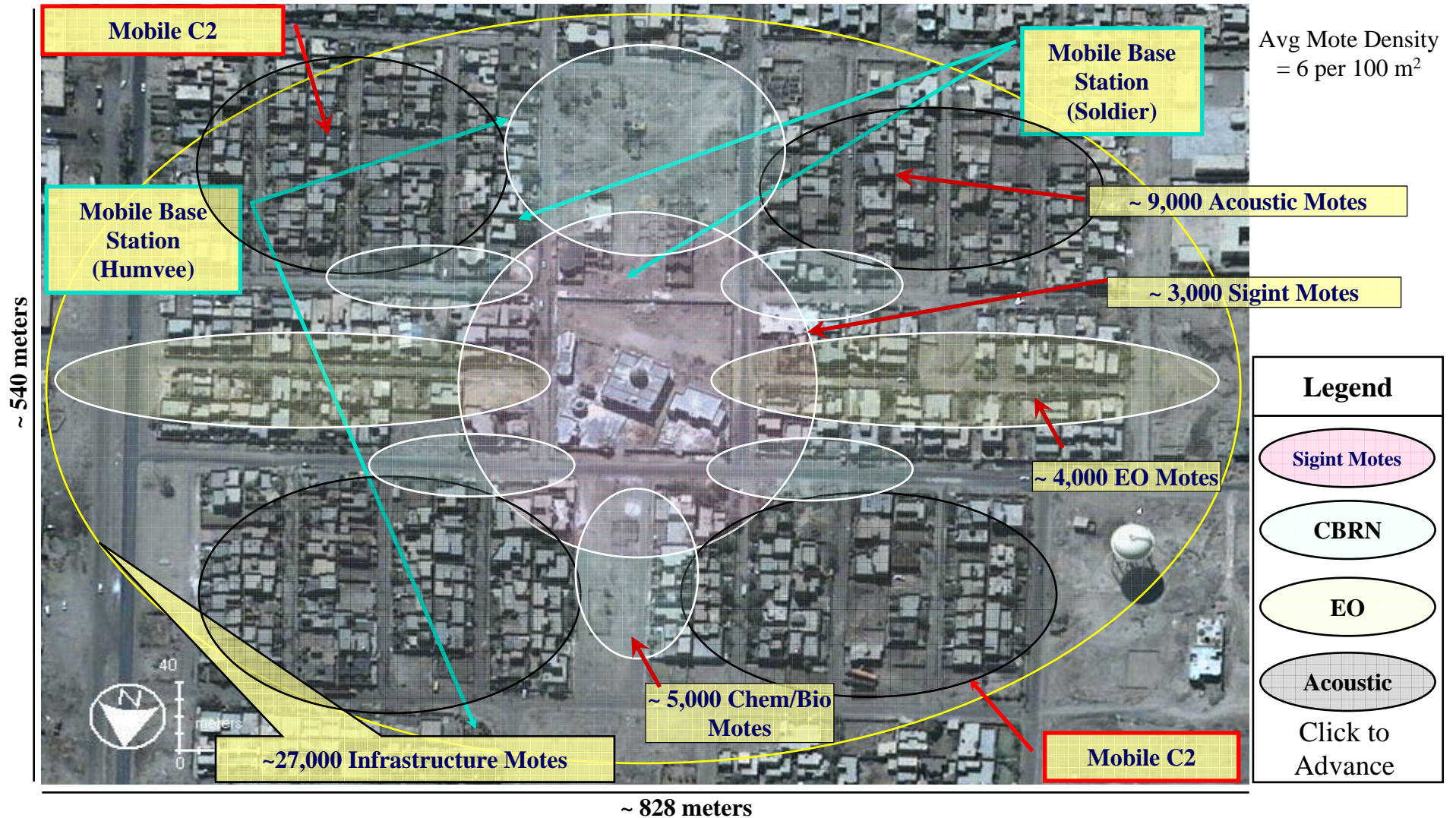- *Base stations problematic but selectively okay!*
- *Variety of Sensors*

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Defense of the Haj Musheen Abdul Aziz Az-Kubaysi Mosque - Fallujah

~ 540 meters

~ 828 meters

Indirect Approaches

Battlefield

Front Lines

Rooftop Sniper & Ambush Positions

Direct Approaches

Major Artery

Enemy Retreat Path

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Defense of the Haj Musheen Abdul Aziz Az-Kubaysi Mosque - Fallujah

Mobile C2

Mobile Base Station (Soldier)

Mobile Base Station (Humvee)

Avg Mote Density = 6 per 100 m²

~ 9,000 Acoustic Motes

~ 3,000 Sigint Motes

~ 4,000 EO Motes

~ 5,000 Chem/Bio Motes

~27,000 Infrastructure Motes

Mobile C2

~ 540 meters

~ 828 meters

Legend

Sigint Motes

CBRN

EO

Acoustic

Click to Advance

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Notional System Block Diagram
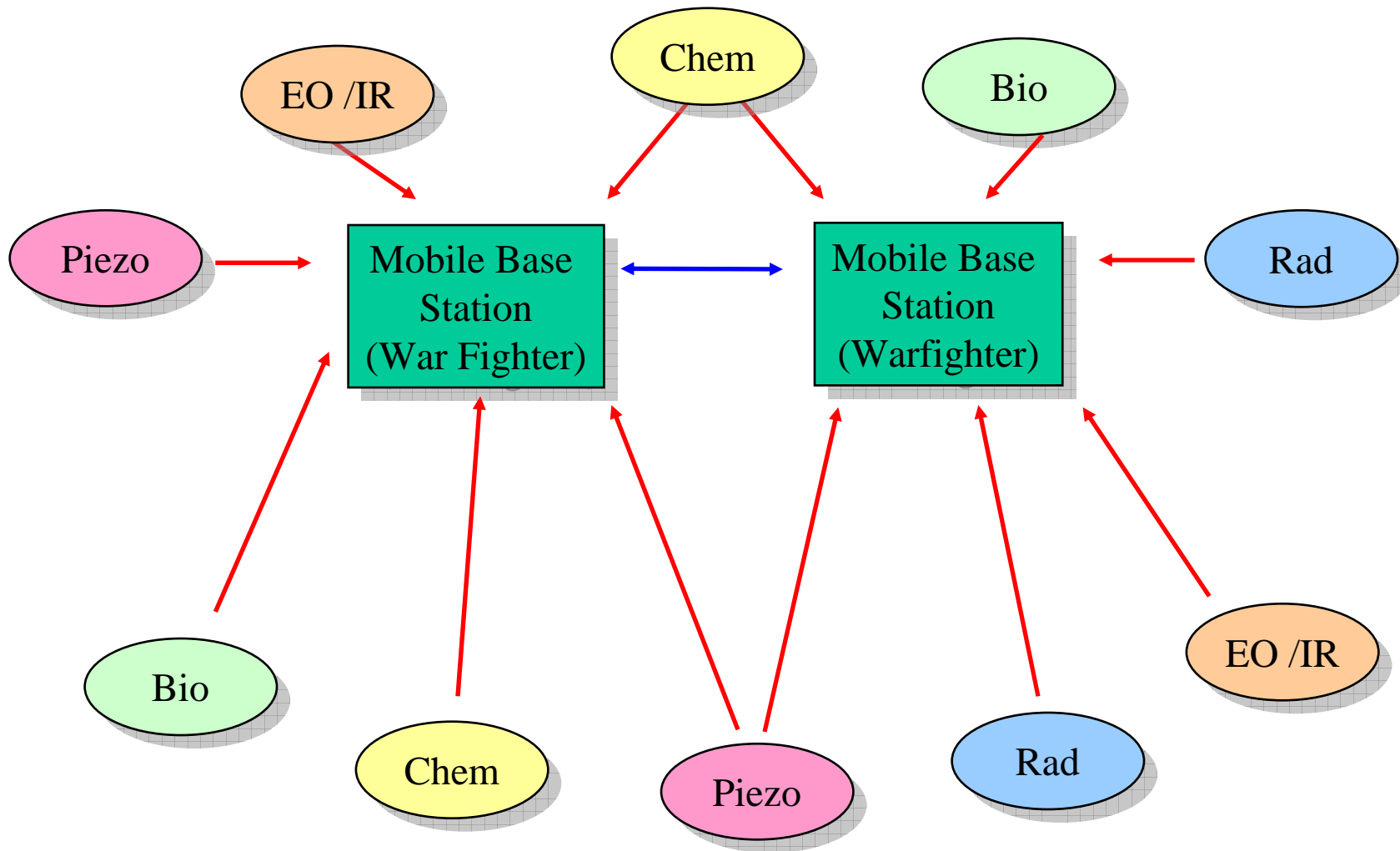
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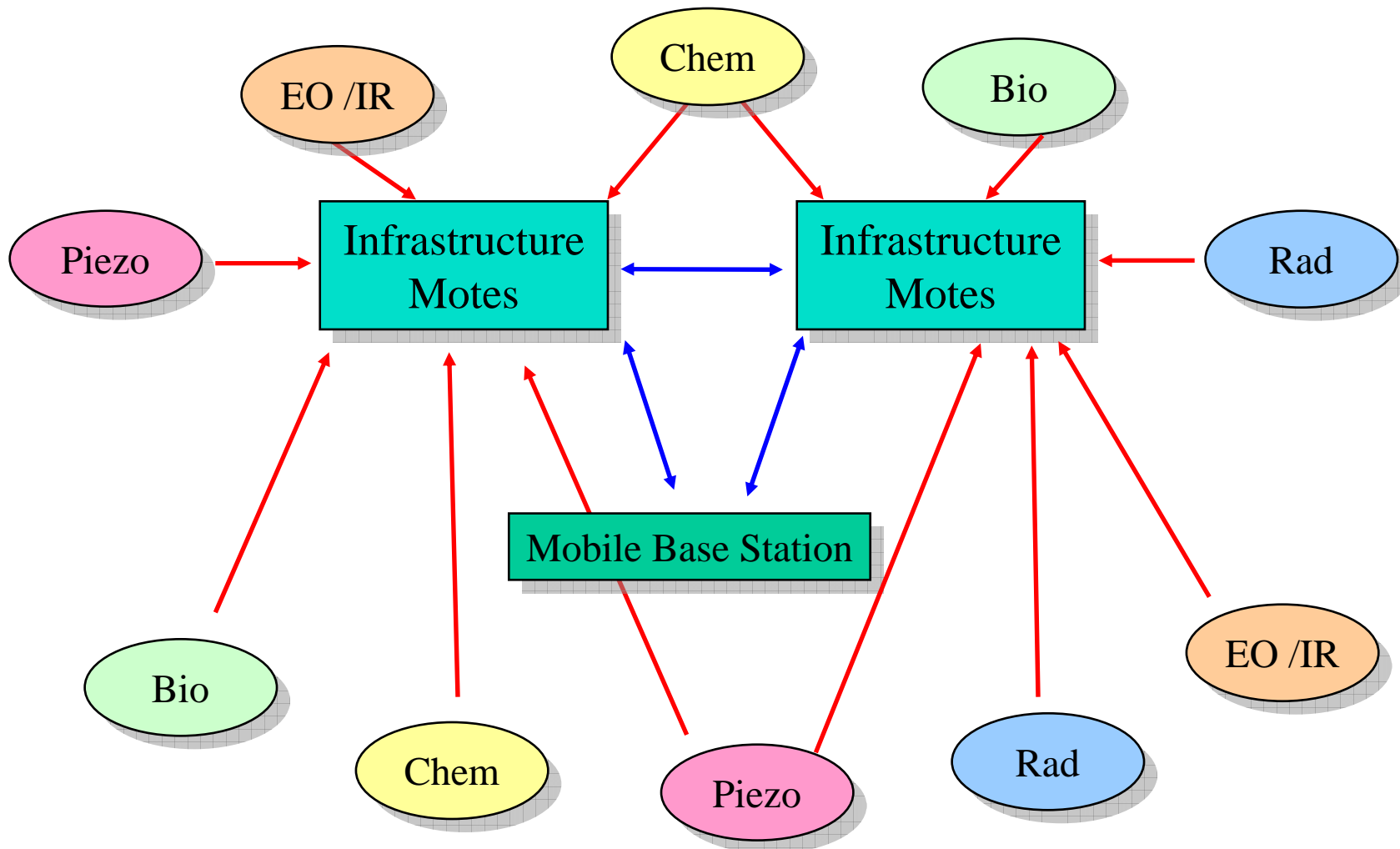
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- *No recharging*
- *Sufficient, not optimal*
- *Brute force routing ok*
- *Short battery life*
- *No encryption*
- *No anti-jamming*
- *QoS Essential*
- *Ad Hoc redeployment*
- *Networking optional*
- *No autonomous base station*
- *Possible Encryption*
- *Individual SitAware*
- *Inclusive Networking*

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Defense of the Haj Musheen Abdul Aziz Az-Kubaysi Mosque - Fallujah

Infrastructure Motes or Warfighters

50 Crosshair Motes

65 meters

30 meters

New routing plan

750 m^2 blast zone destroys ~ 45 motes

Danger!

Danger!

Legend	
Infrastructure Mote	
Crosshair Mote	
Dismounted Mobile Base w/HUD	

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Notional System Block Diagram

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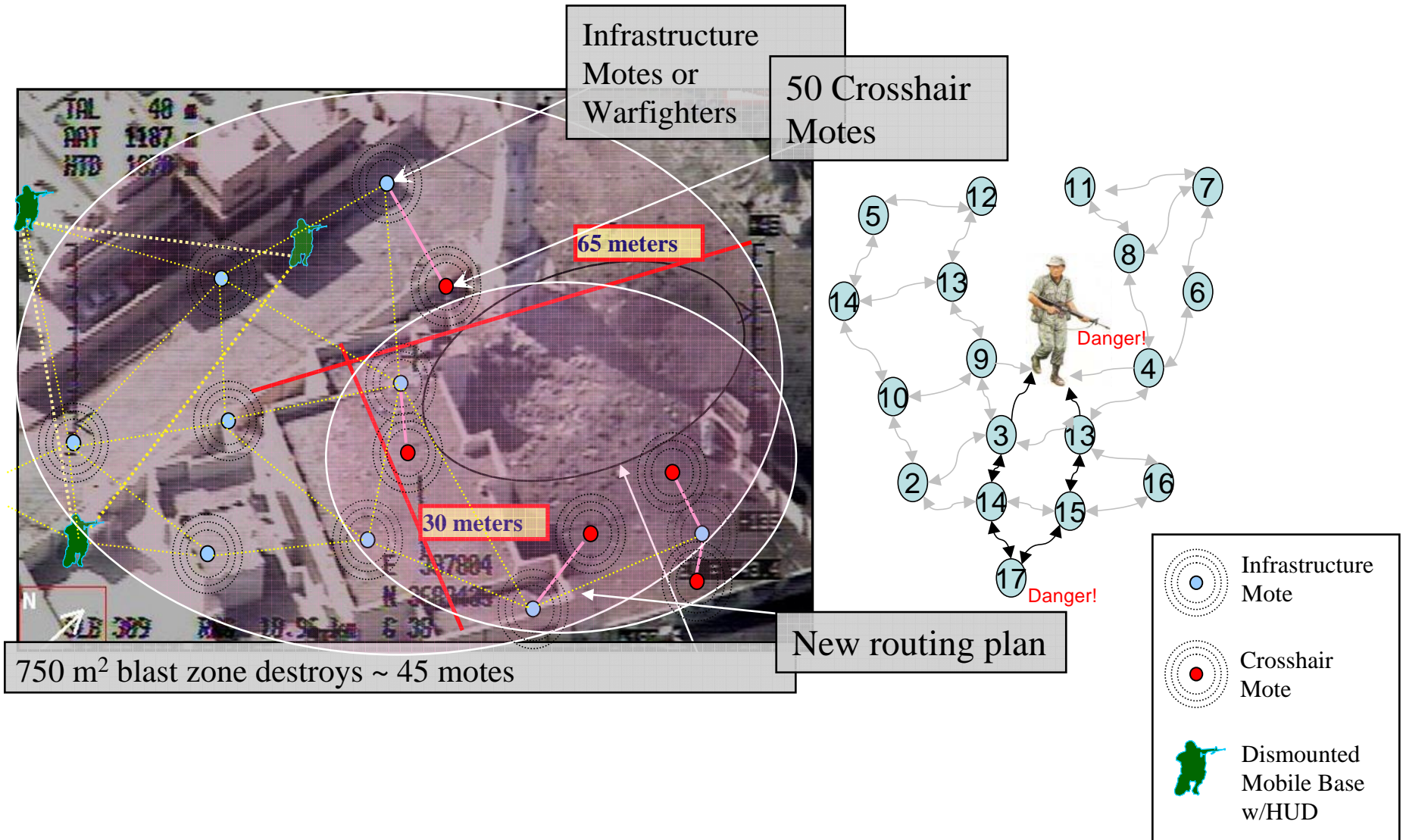
Plenty of Configurations

Deception

Aerial Deployment

84 mm

Sensor Embedded in the Round

Myriad Form Factors!

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Summary and Recommendation

- **Conclusions**
  - **3 Different Missions require 3 different approaches to UWSNs.**
  - **Missions for surface, subsurface, space, mountainous terrain, caves and other possible battlefields are required**
  - **Scientists and Engineers always produce better product when they understand the problem they're trying to solve!**

- **Recommendations to Academia, Industry & Government**
  - **Mission profiles should NOT specify the solution**
    - ➢ **Just the mission objective**
    - ➢ **The Nuances of the battlefield**
    - ➢ **The requirements for Situational Awareness/Understanding by warfighters & commanders**
  - **Mission profiles should be modeled (simulated), published, and continuously improved or refined in order to present…**
    - ➢ **The most realistic set of requirements**
    - ➢ **The probability spaces of mission variables**
    - ➢ **Missions that change dramatically before completion**
    - ➢ **Post mortem mission activities (cleanup)**

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Thanks!

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