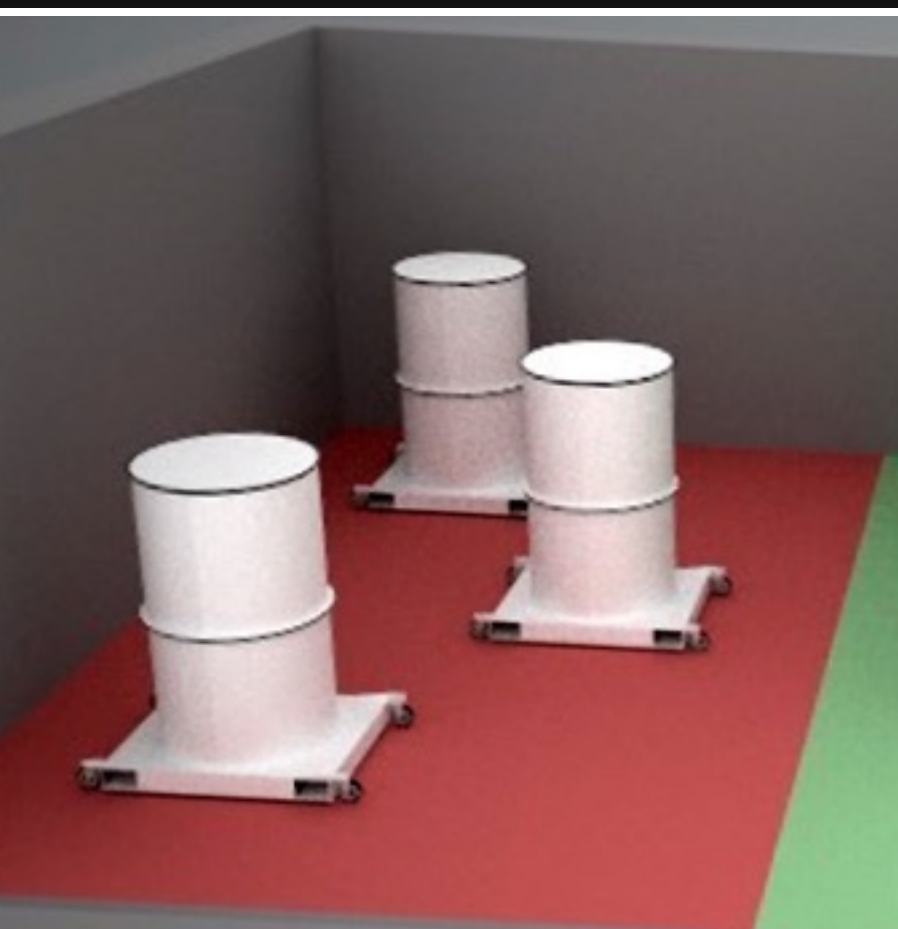




MINIMALLY INTRUSIVE VERIFICATION OF DEEP NUCLEAR WARHEAD REDUCTIONS

A FRESH LOOK AT THE BUDDY-TAG CONCEPT

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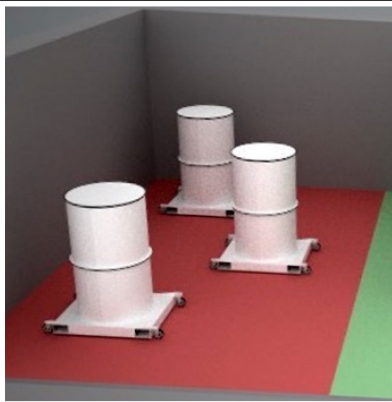
57th Annual INMM Meeting, Atlanta, Georgia, July 2016

BACKGROUND

VERIFICATION CHALLENGES OF DEEP(ER) REDUCTIONS

WHAT IS TO BE VERIFIED?

VERIFICATION CHALLENGES FOR NUCLEAR ARMS CONTROL AT LOW NUMBERS



1. VERIFY NUMERICAL LIMITS OF DECLARED WARHEADS

Requires techniques to account for (and identify) nuclear warheads in storage
for example, using (hashed) declarations and/or unique identifiers (UIDs)



2. CONFIRM AUTHENTICITY OF NUCLEAR WARHEADS

Requires dedicated inspection systems
for example, based on radiation-detection techniques (passive/active, neutron/gamma)



3. ESTABLISH CONFIDENCE IN ABSENCE OF UNDECLARED ITEMS OR MATERIALS

How to make sure that no covert warheads / materials exist outside the verification regime?
No silver bullet; not much different from NPT verification challenges

Source: Joint U.S.-U.K. Report, U.S. Department of Energy, May 2015 (middle) and Google Earth (bottom)

VERIFYING NUMERICAL LIMITS

TAGGING

TRANSFORMING A “NUMERICAL LIMIT” INTO A “BAN ON UNTAGGED ITEMS”

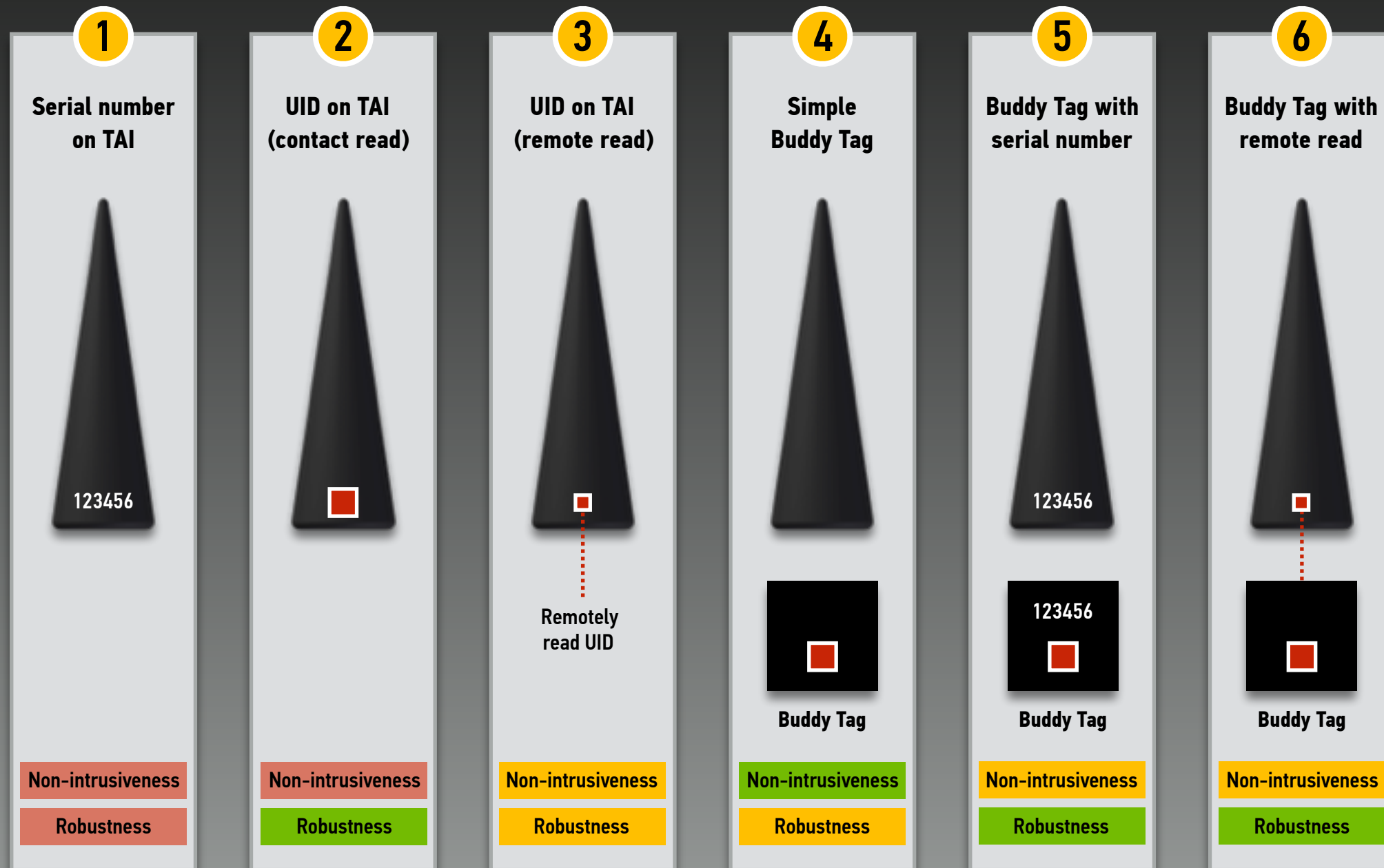


Source: www.automoblog.net

*Steve Fetter and Thomas Garwin, “Using Tags to Monitor Numerical Limits in Arms Control Agreements”
in Barry M. Blechman, ed., Technology and the Limitation of International Conflict, Washington, DC, 1989, pp. 33–54*

WARHEAD COUNTING OPTIONS

WITH VARIOUS LEVELS OF INTRUSIVENESS AND ROBUSTNESS



THE BUDDY TAG CONCEPT

WHAT THE BUDDY TAG IS NOT

tile

BUY TILE FOR \$25 ▶

MENU

Find your phone,
keys, anything.

My Buddy Tag

- Out-of-Range Alert**
Helps Prevent Lost Child
- Water Safety Alert**
Helps Prevent Drowning
- Panic Button**
Alert When Child is In Fear
- Last-Seen Location**
E-Mail Alert When Child is Lost

A Lost Child is a
Parent's Worst
Nightmare

My Buddy Tag

Keep Kids Safe

Shop Now

Source: www.thetileapp.com and www.mybuddytag.com

ELEMENTS OF THE BUDDY TAG

Tamper Indicating Enclosure

Unique Identifier

LED Display

State of health

Movement detected

Battery status

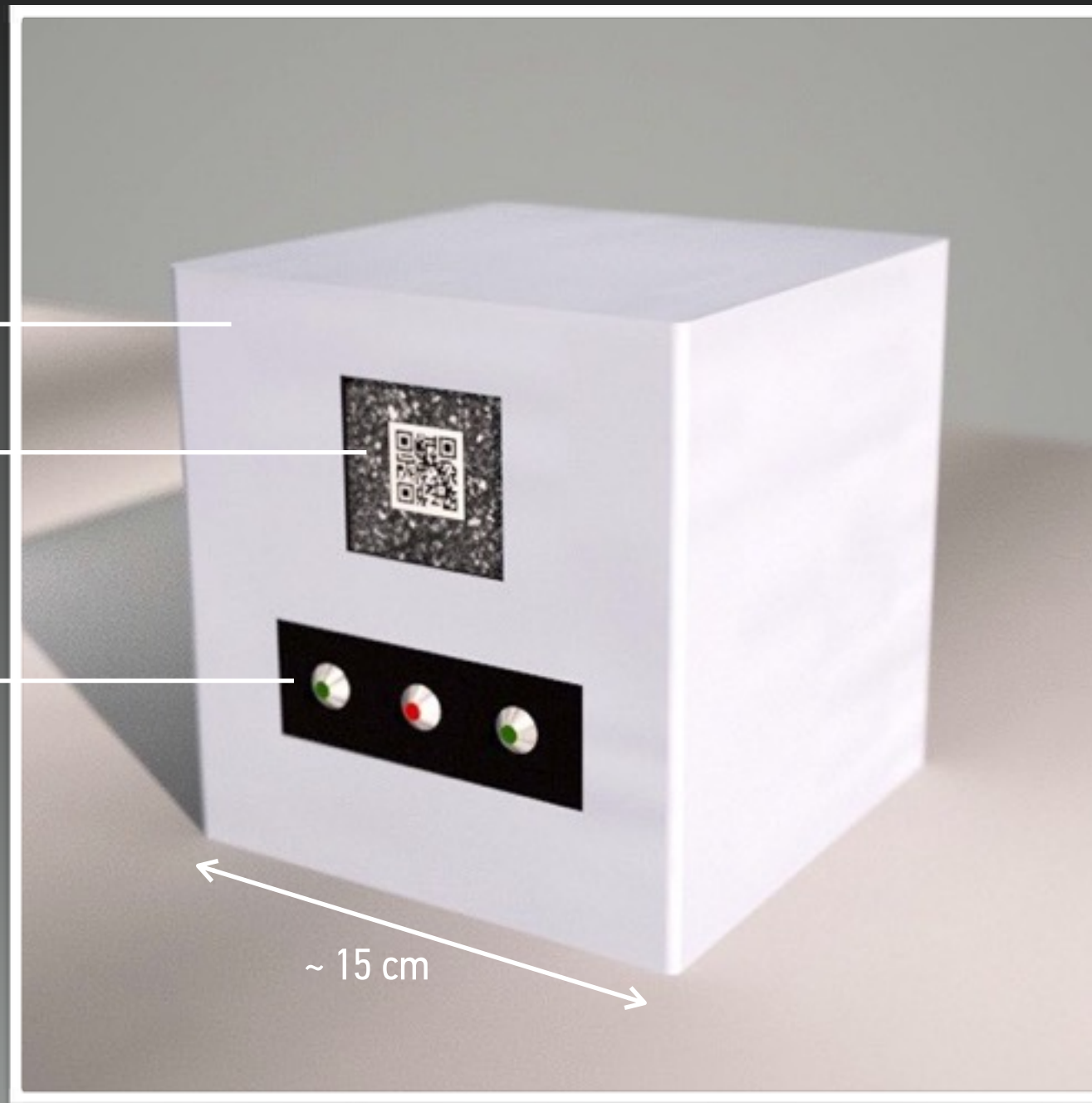


Image: Tamara Patton

OPTION FOR A MINIMALLY INTRUSIVE ONSITE INSPECTION

USING BUDDY TAGS WITHOUT DIRECT ACCESS TO TREATY ACCOUNTABLE ITEMS

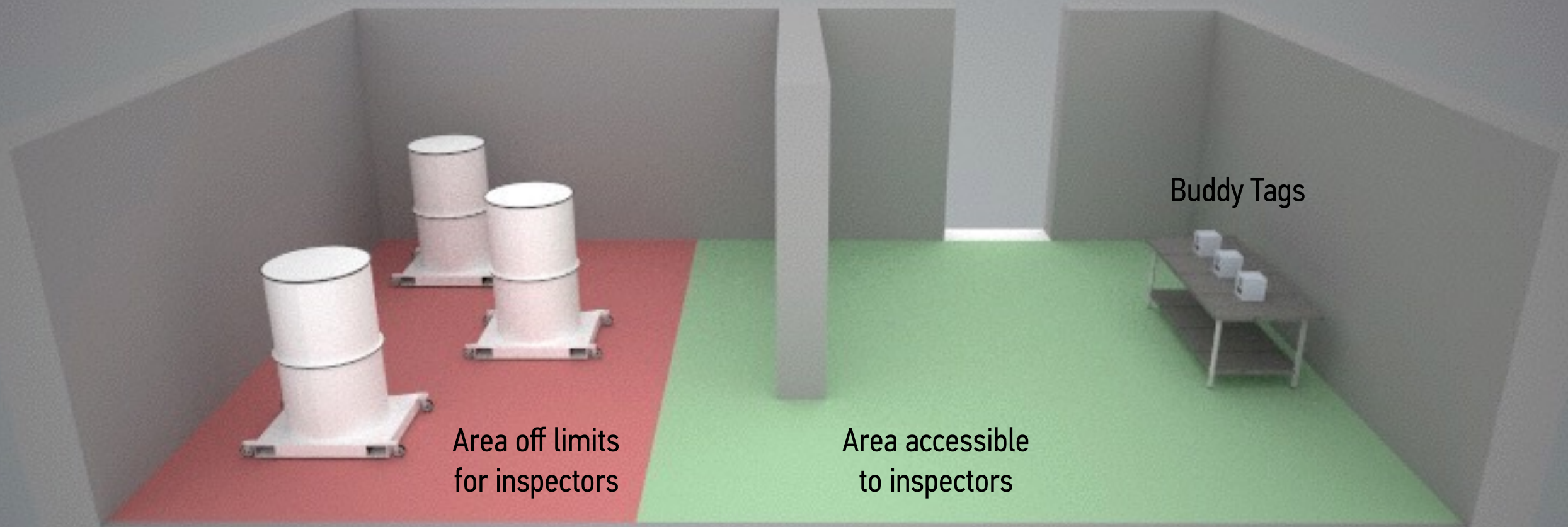


Image: Tamara Patton

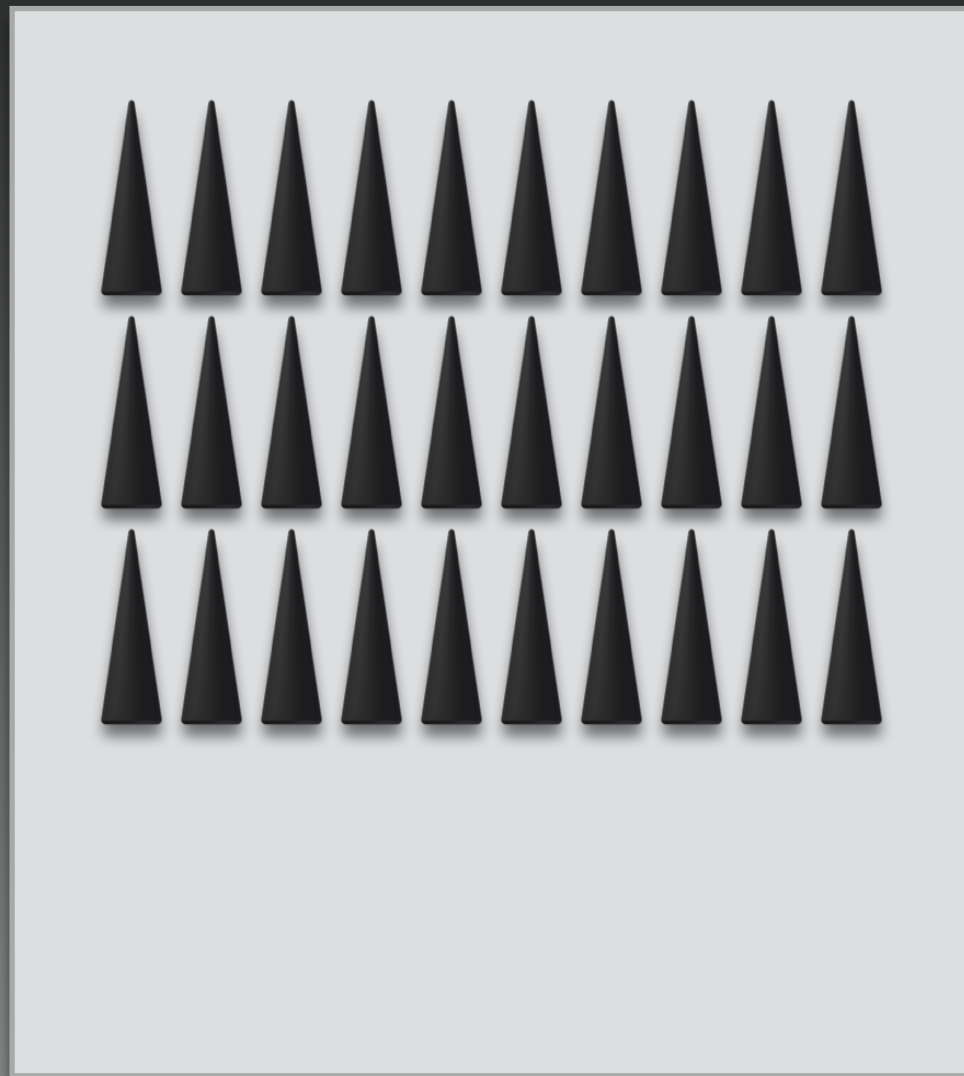
SCENARIO 1

(“DISHONEST HOST”)

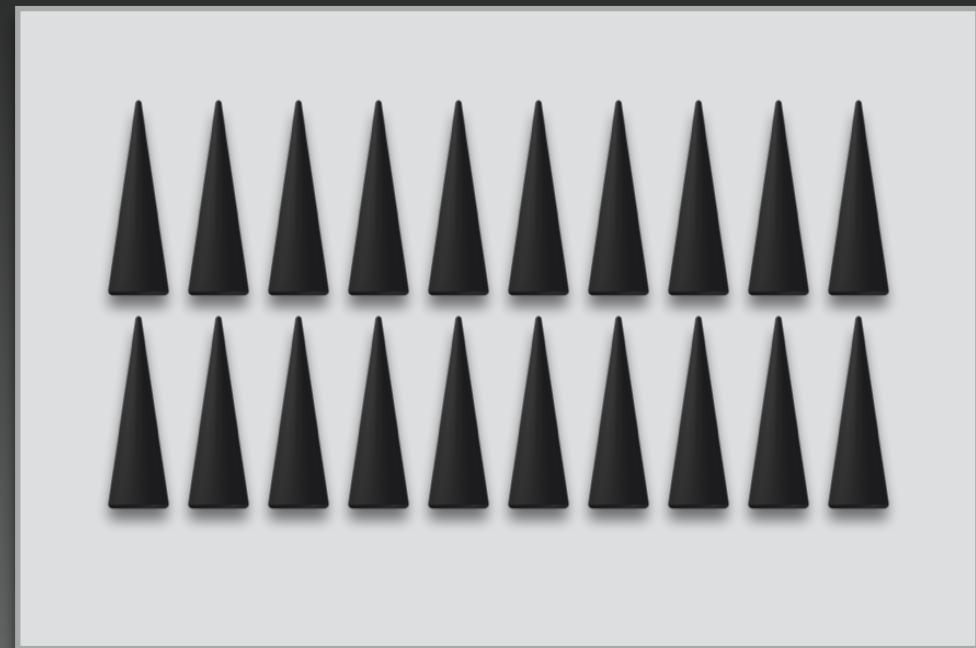
SCENARIO 1

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES

SITE A



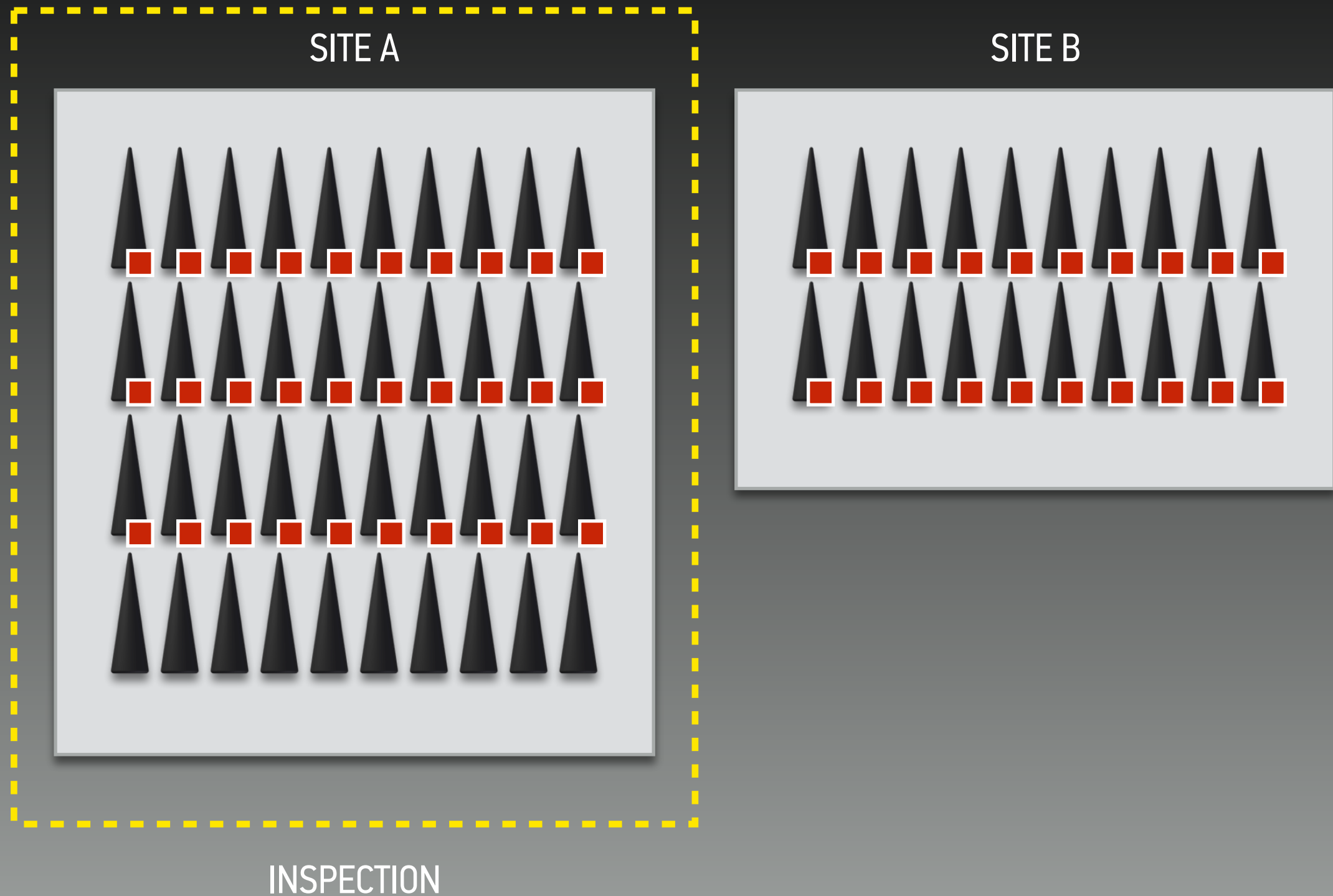
SITE B



In reality, there are 60 warheads

SCENARIO 1

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES



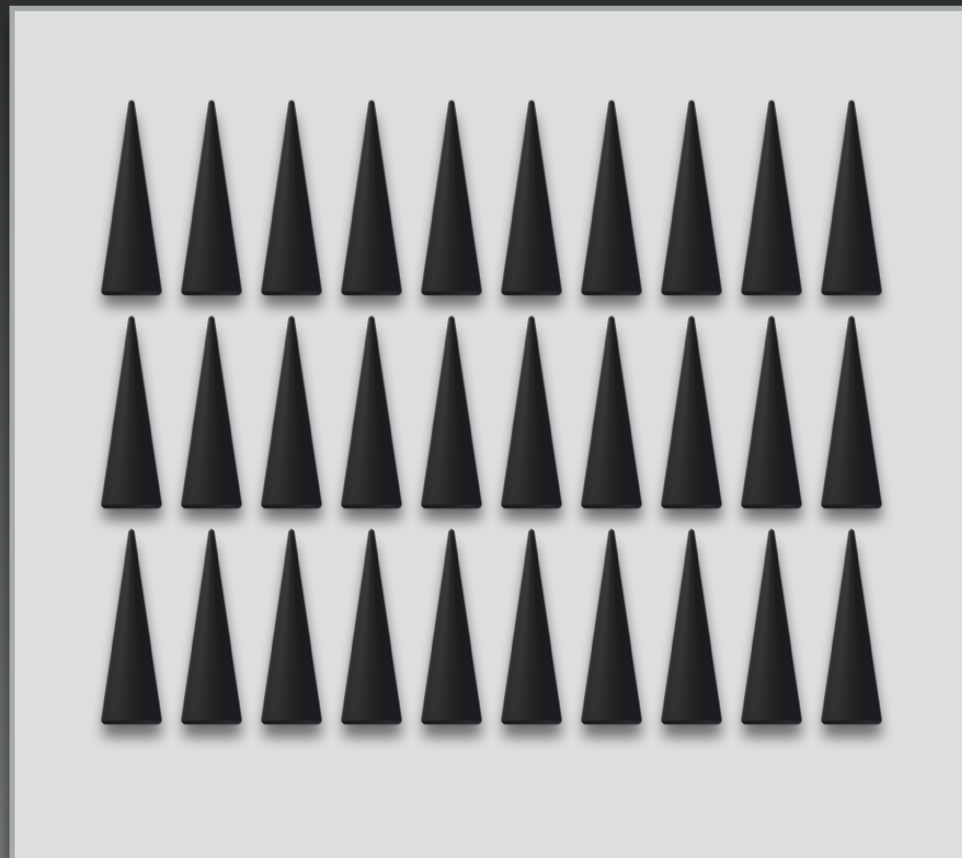
SCENARIO 2

("HONEST HOST")

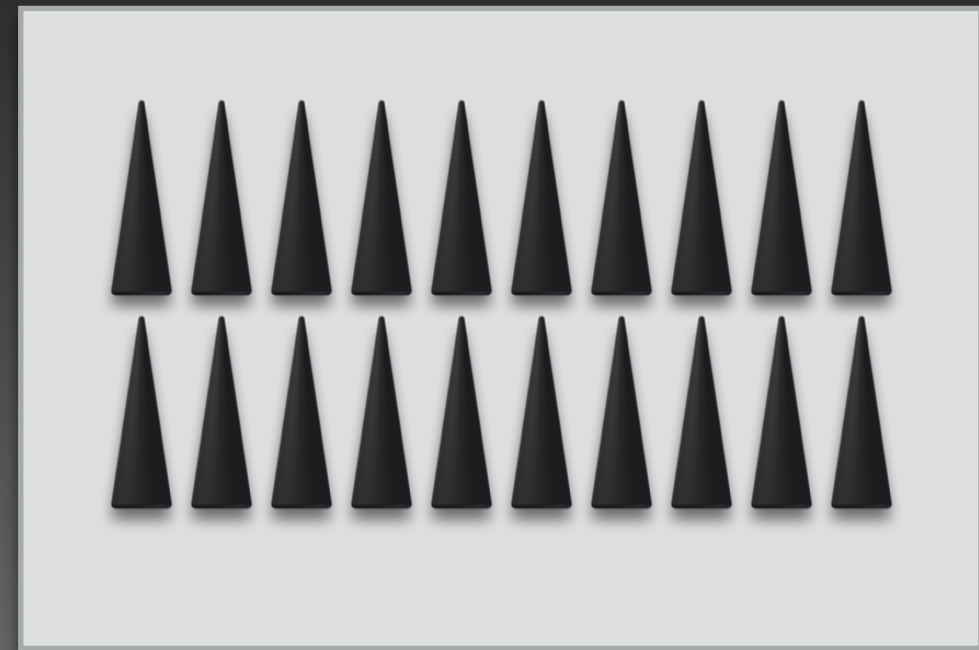
SCENARIO 2

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES

SITE A



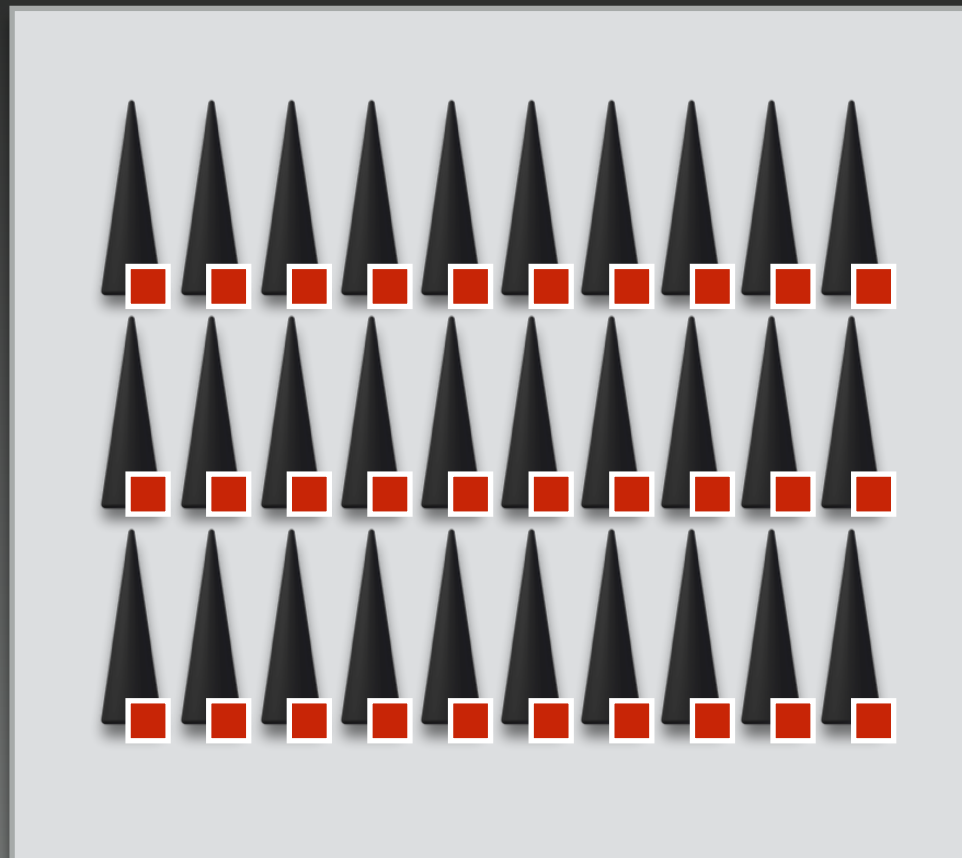
SITE B



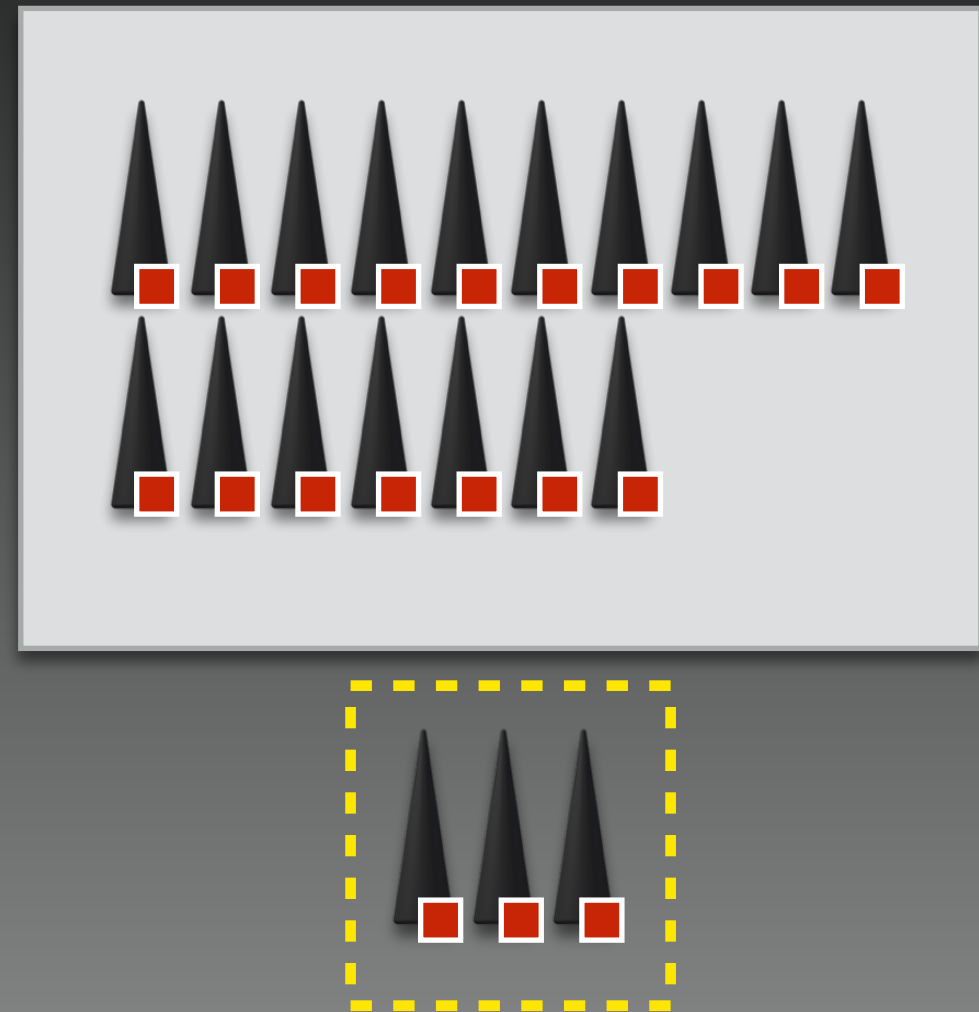
SCENARIO 2

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES

SITE A



SITE B



Some items are moved to a previously unknown third site (perhaps for maintenance)

Without buddy tags, the presence of these items may be considered suspect

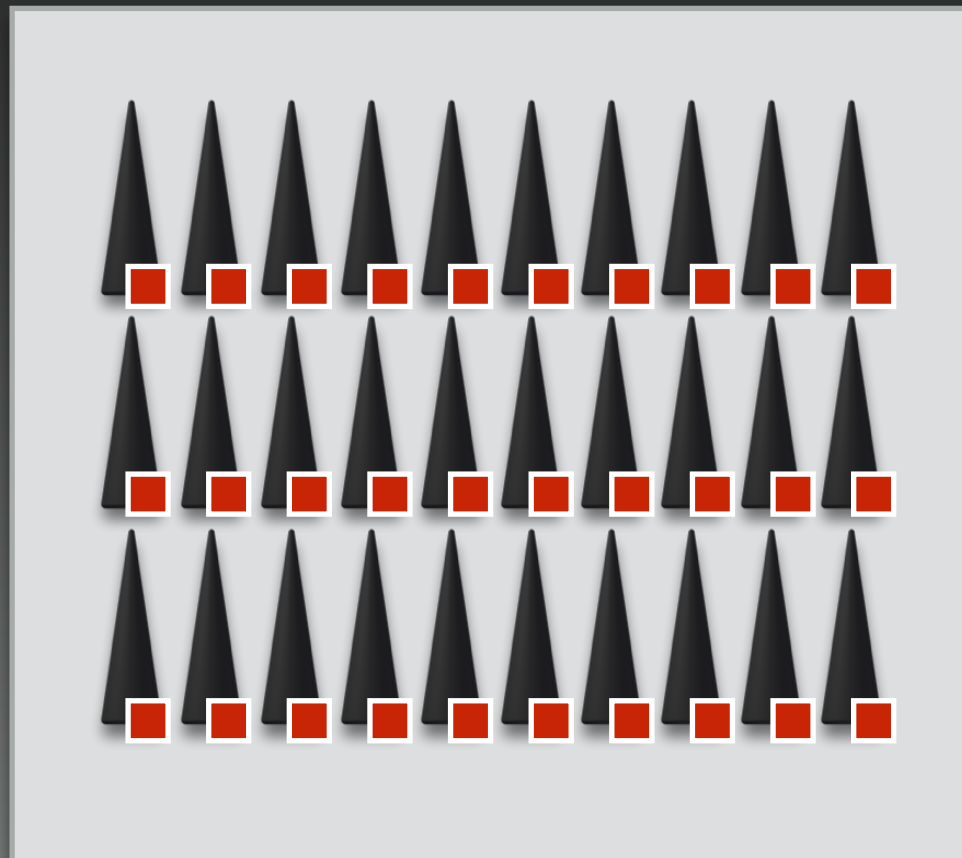
SCENARIO 3

("DISHONEST HOST REVISITED")

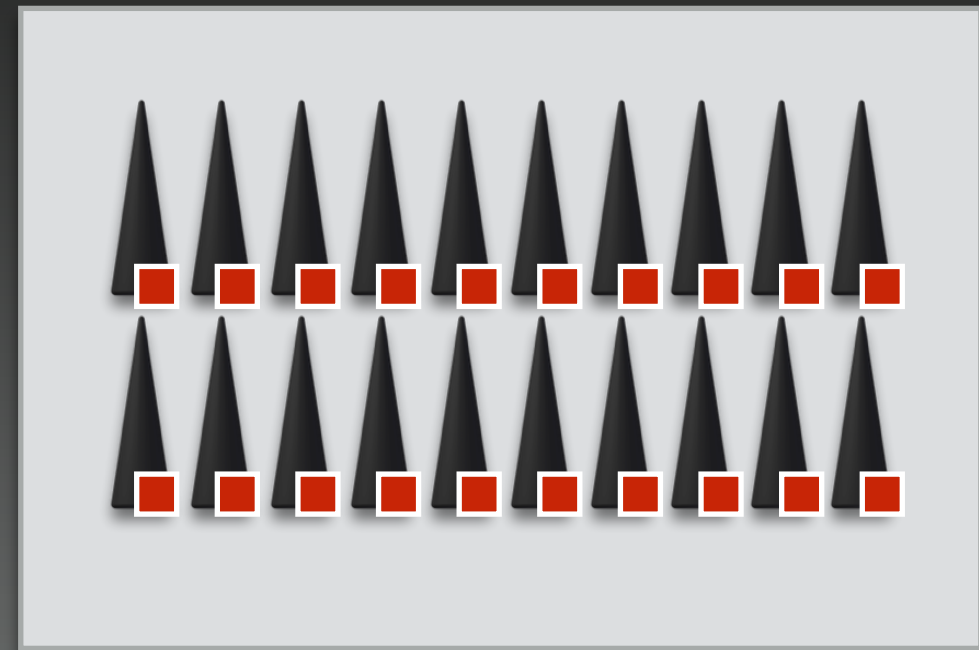
SCENARIO 3

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES

SITE A



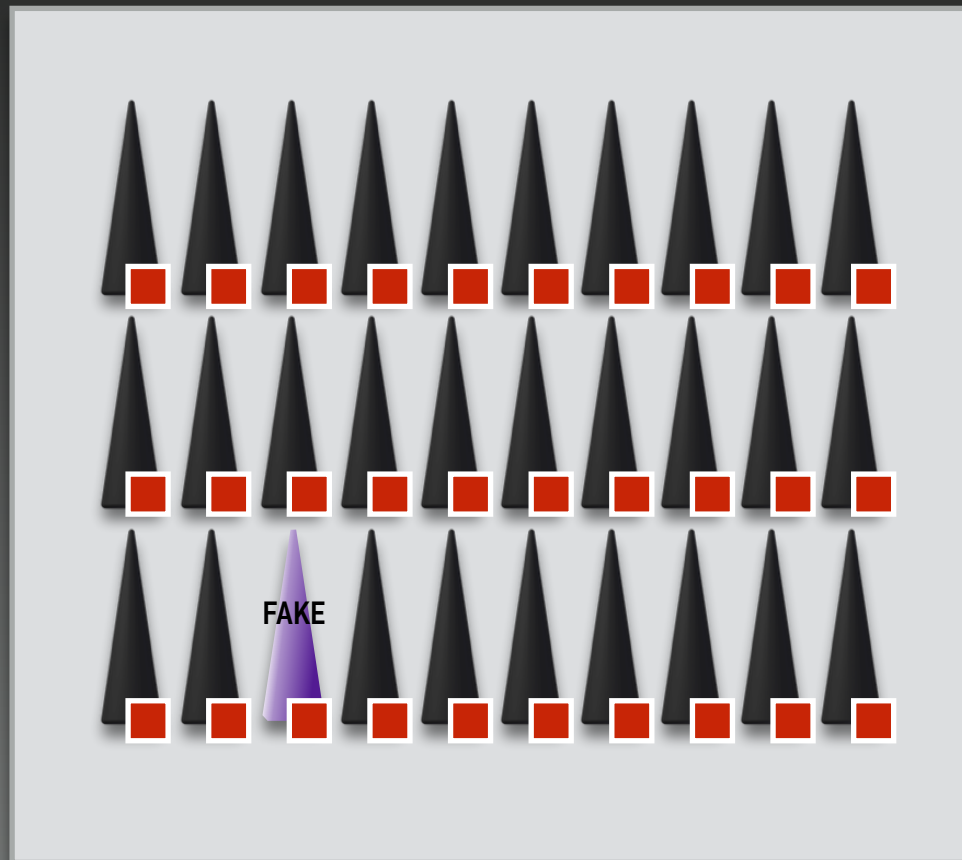
SITE B



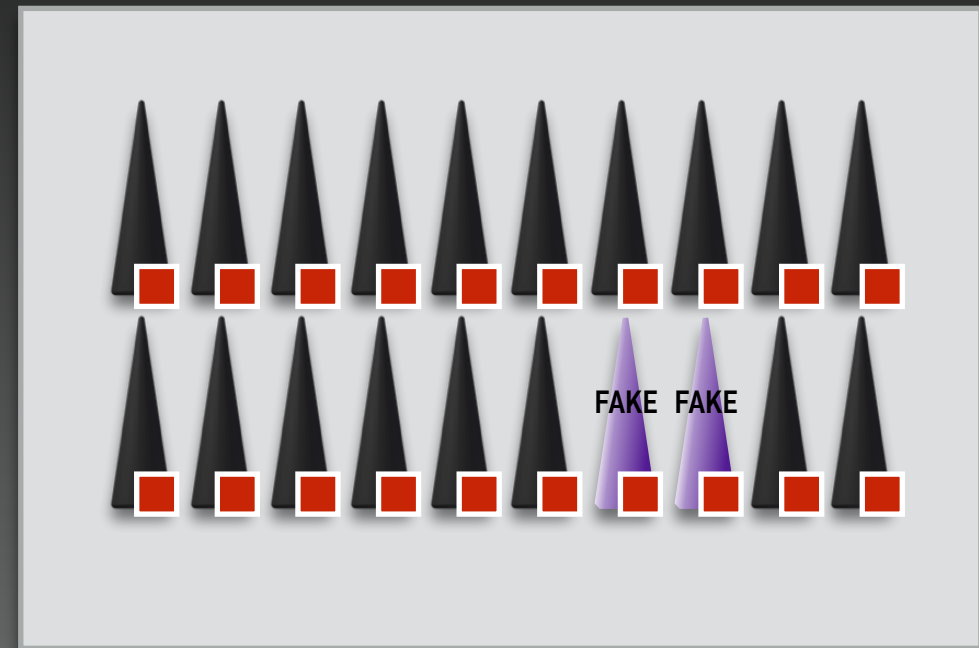
SCENARIO 3

PARTY HAS DECLARED 50 WARHEADS; THEY ARE STORED AT TWO (DECLARED) SITES

SITE A



SITE B



Essentially at any time, the host
could swap genuine warheads for mockups

This scenario is not captured with the basic buddy-tag concept
(but it introduces several complications for the host down the road)

ELEMENTS OF THE BUDDY TAG

Tamper Indicating Enclosure

Unique Identifier

LED Display

State of health
Movement detected
Battery status

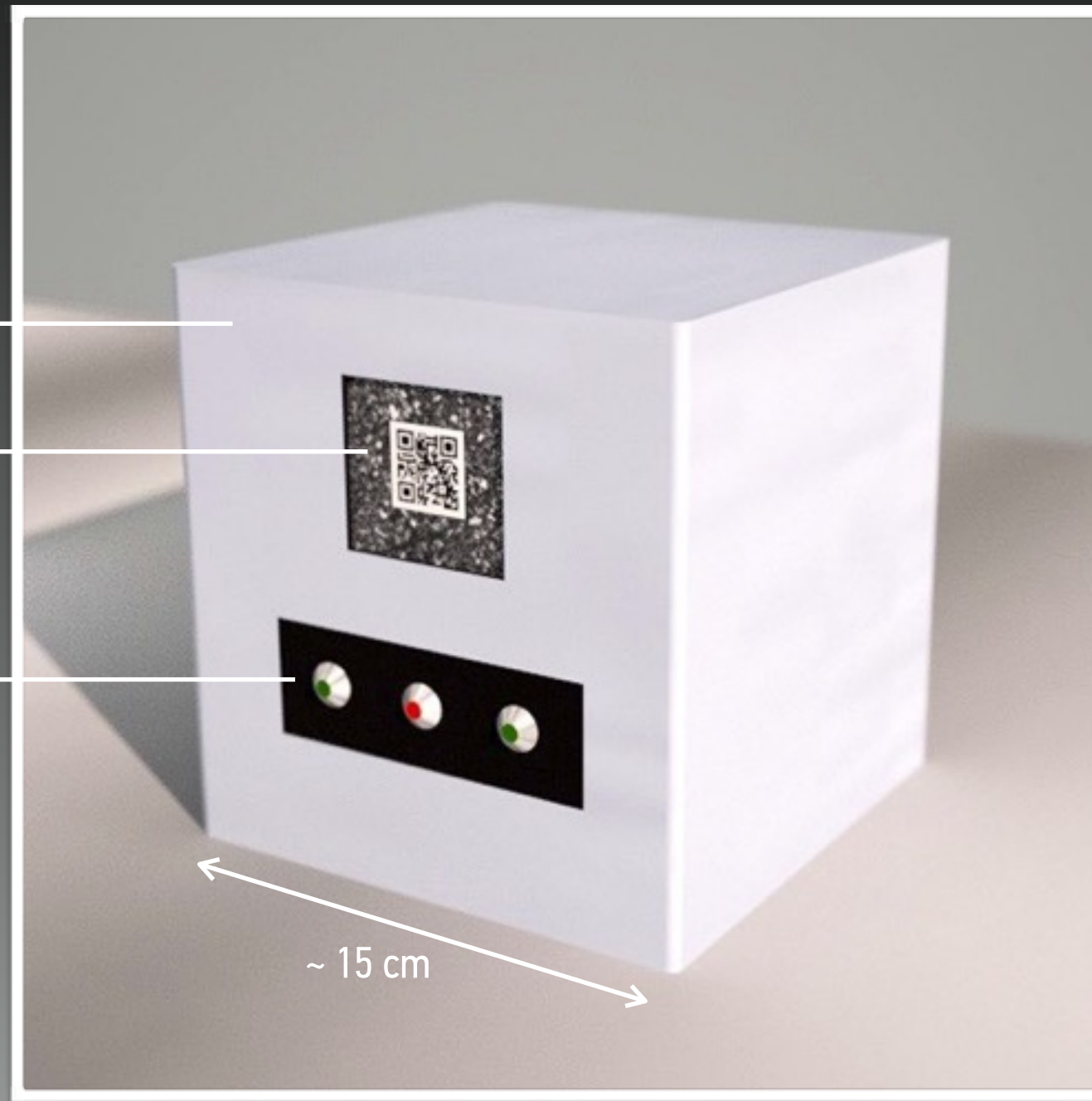


Image: Tamara Patton

MOTION-DETECTION SUBSYSTEM

CANDIDATE COMPONENTS

FOR USE IN THE MOTION-DETECTION SUBSYSTEM



ADXL362

Triple-axis accelerometer

Sensitivity: 1 mg/LSB

Price: \$15

Source: Sparkfun



ITG3200/ADXL345

Inertial measurement unit

Sensitivity: 4 mg/LSB

Price: \$40

Source: Sparkfun



STIM300

Inertial measurement unit

Sensitivity: 2 μ g/LSB

Price: \$8600

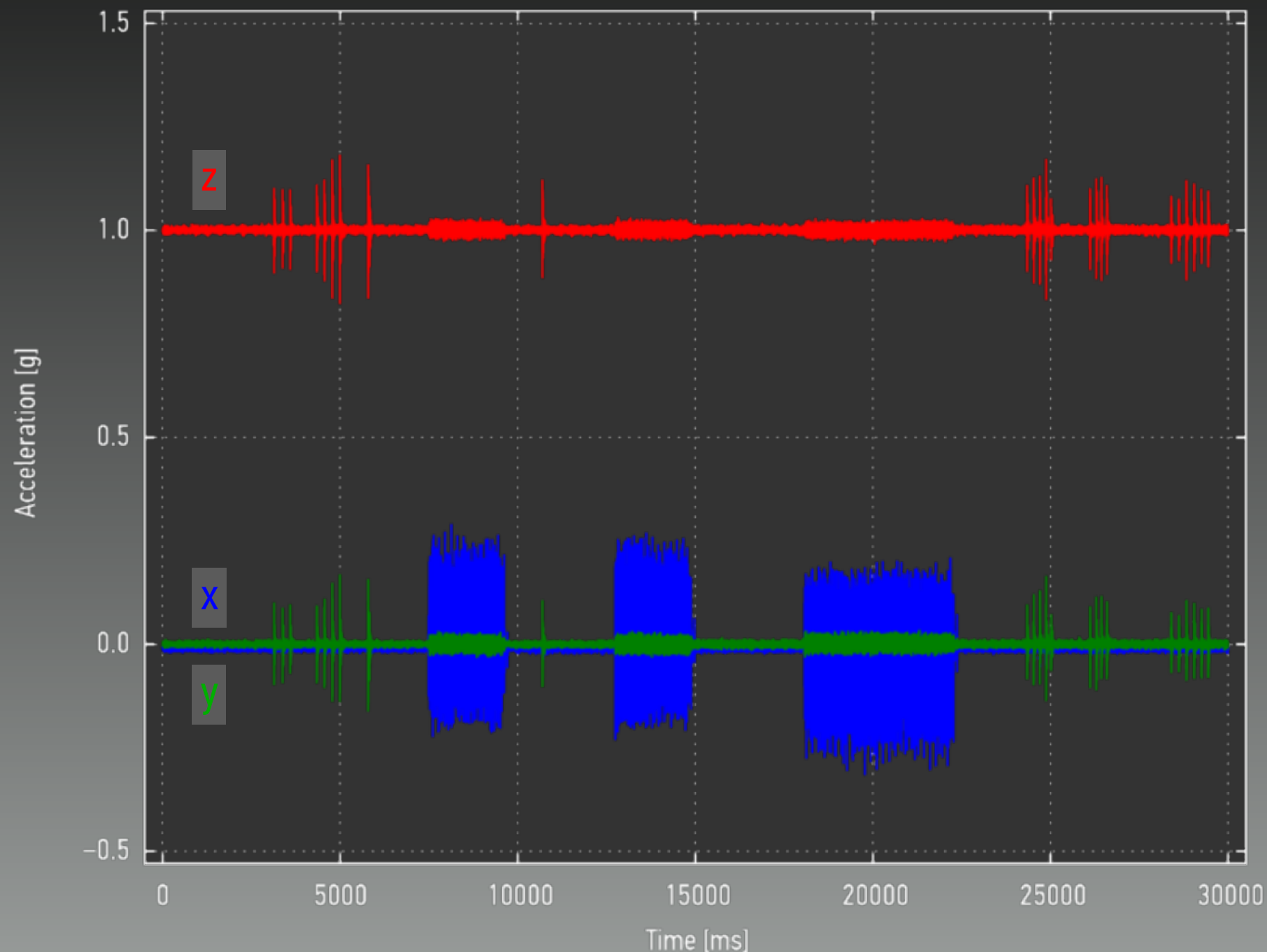
Source: Sensoror

All systems are strap-down systems based on micro-machined electromechanical systems (MEMS) technology

See damien.douxchamps.net/research/imu for a list of currently available units

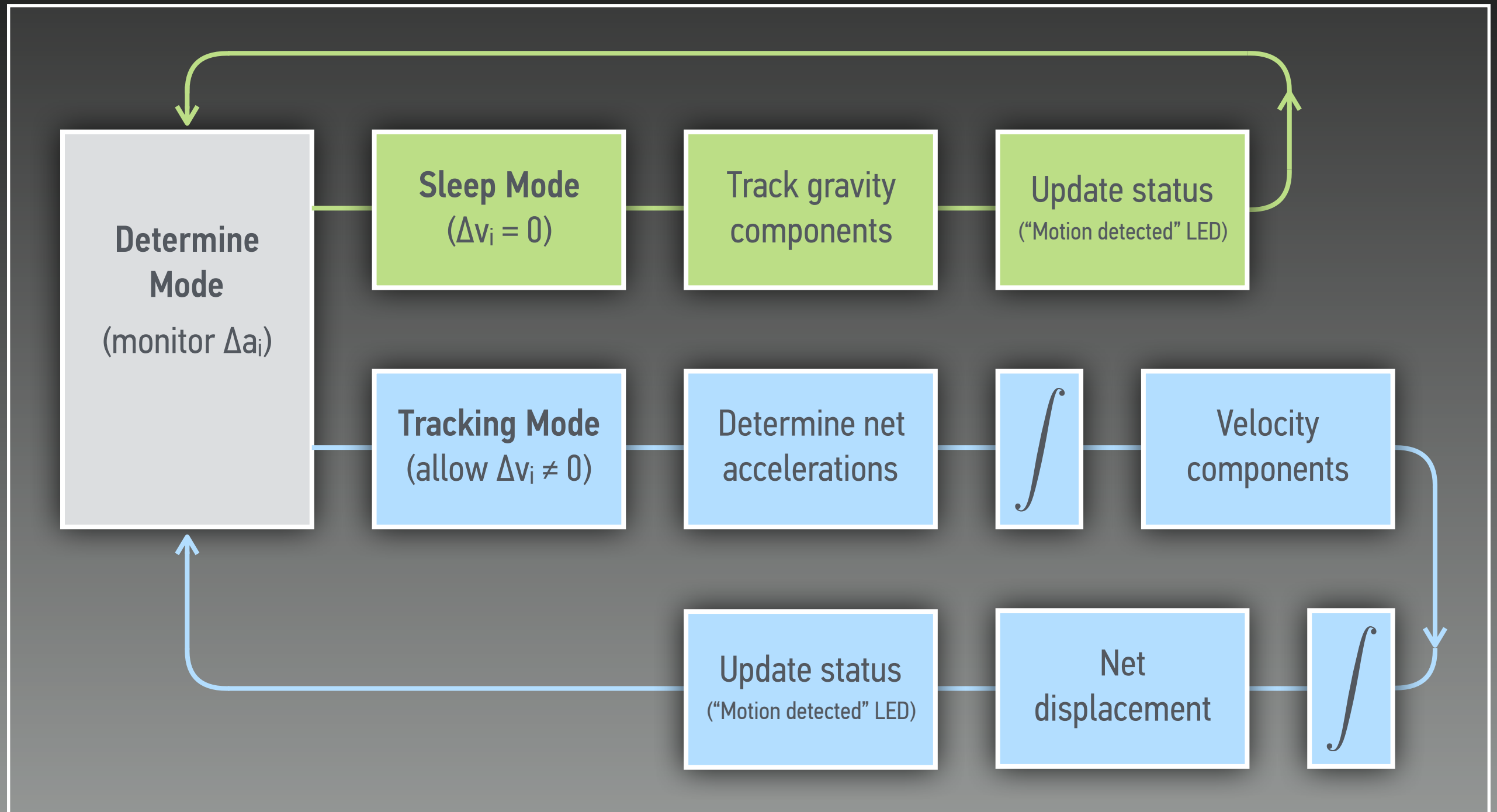
STIM300 RAW DATA

6000 DATA POINTS PER SECOND FROM ACCELEROMETERS AND GYROSCOPES



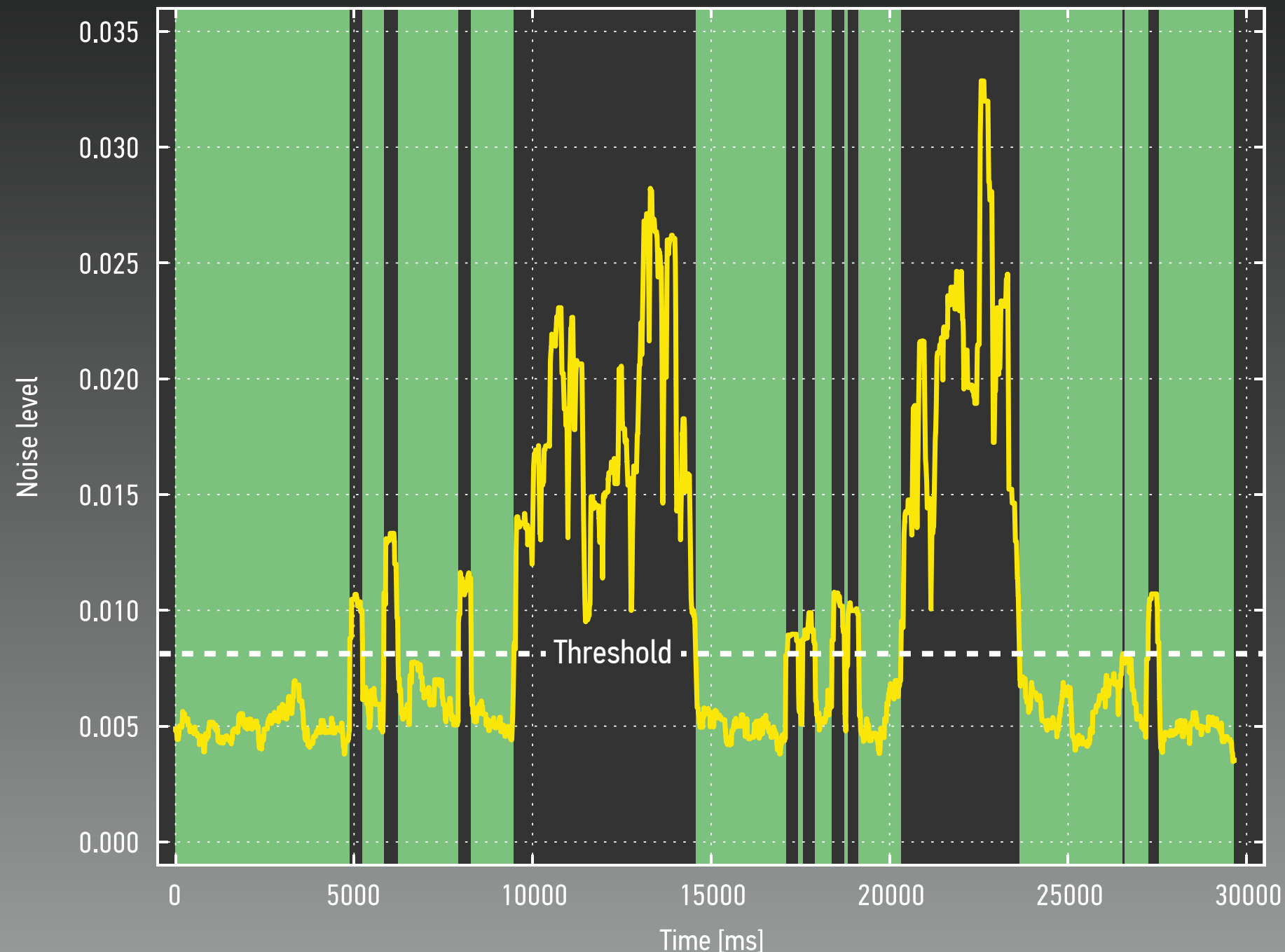
(See www.youtube.com/watch?v=Vy9MBpdNt00 for a typical test sequence)

MODE OF OPERATION



SAMPLE DATA SET AND BUDDY TAG'S RESPONSE

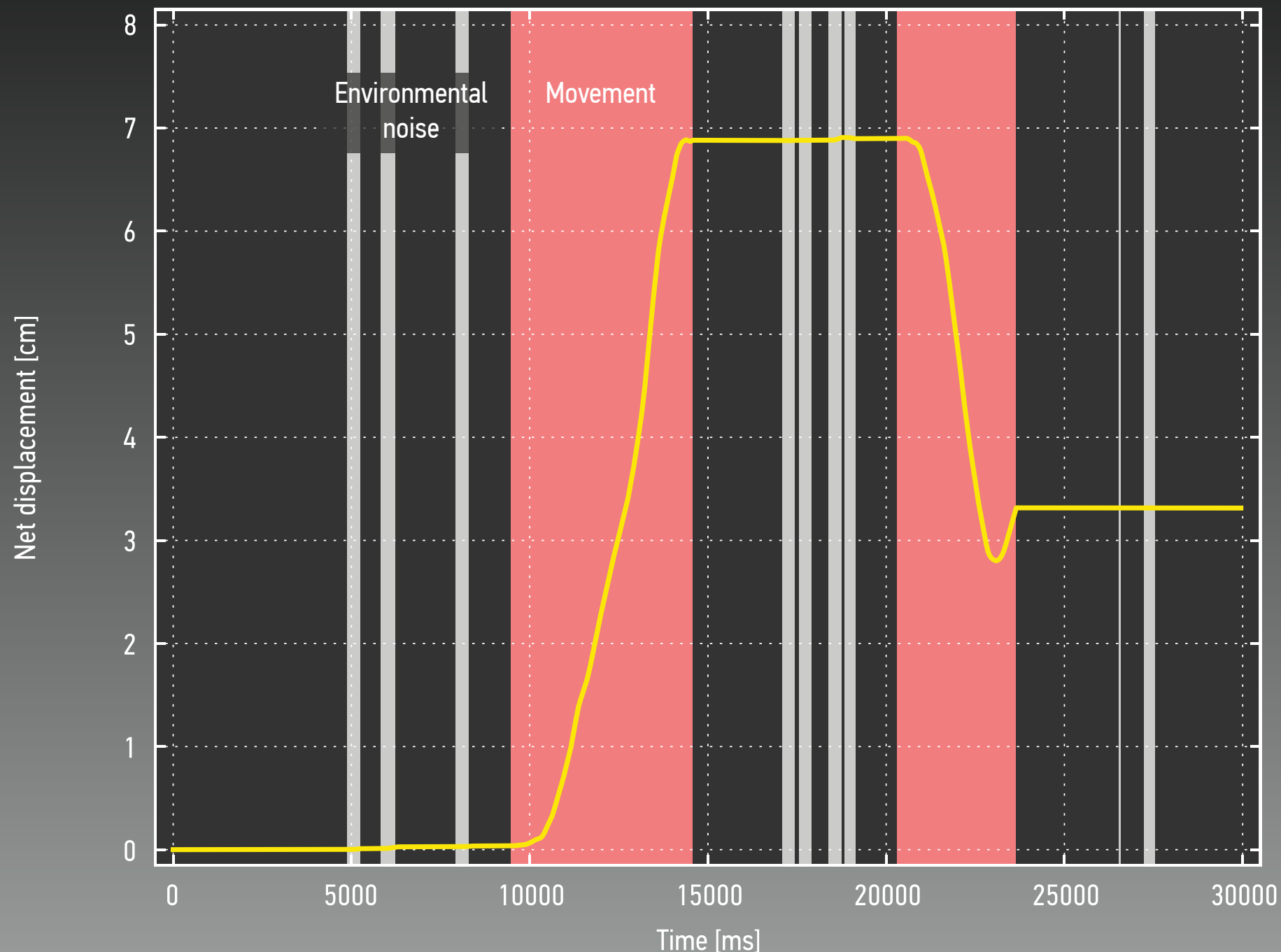
TAG "WAKES UP" IF ACCELERATIONS EXCEED THRESHOLD VALUE



(Data acquired and analyzed with preliminary methods and algorithms)

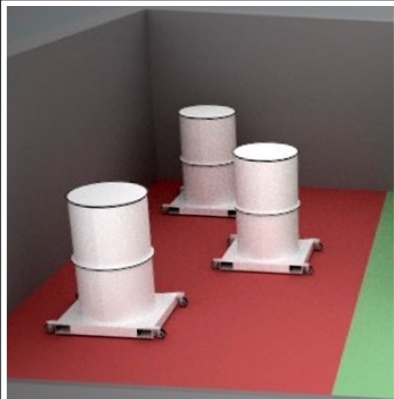
SAMPLE DATA SET AND BUDDY TAG'S RESPONSE

IN TRACKING MODE, ALGORITHM IDENTIFIES TRANSLATIONS



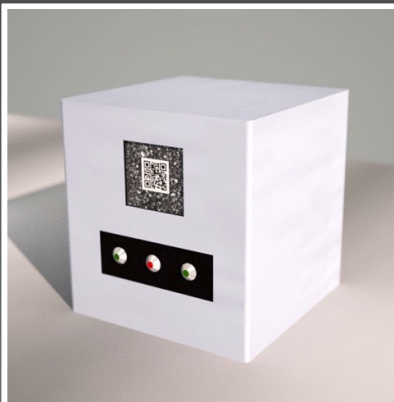
(Data acquired and analyzed with preliminary methods and algorithms)

SUMMARY AND NEXT STEPS



VERIFYING NUMERICAL LIMITS

Buddy Tag provides a method to non-intrusively verify numerical limits on sensitive items (by separating the tag from the item) with opportunities for gradual enhancements



NEXT STEPS: REVIEWING THE CONCEPT

Joint construction of a number of full-up prototypes for review by independent experts to assess selected features and potential vulnerabilities



BUDDY TAG AS A PLATFORM FOR TECHNOLOGY DEMONSTRATION

Relevant technologies include unique identifiers, tamper indicating enclosures, secure electronics, secure software, and advanced algorithms

Source: U.S. Department of State, twitter.com/StateAVC/status/666731747674058753 (bottom)

ACKNOWLEDGEMENTS



Bureau of Arms Control, Verification and Compliance (AVC)
U.S. Department of State

Consortium for Verification Technology
National Nuclear Security Administration
U.S. Department of Energy

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