



Photograph: Copyright Paul Shambroom

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

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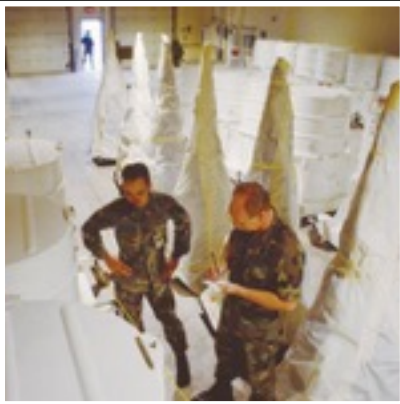
Revision 2

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: Paul Shambroom (top), U.S. Department of Energy (middle), and Google Earth (bottom)

VERIFYING NUMERICAL LIMITS

TAGGING

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

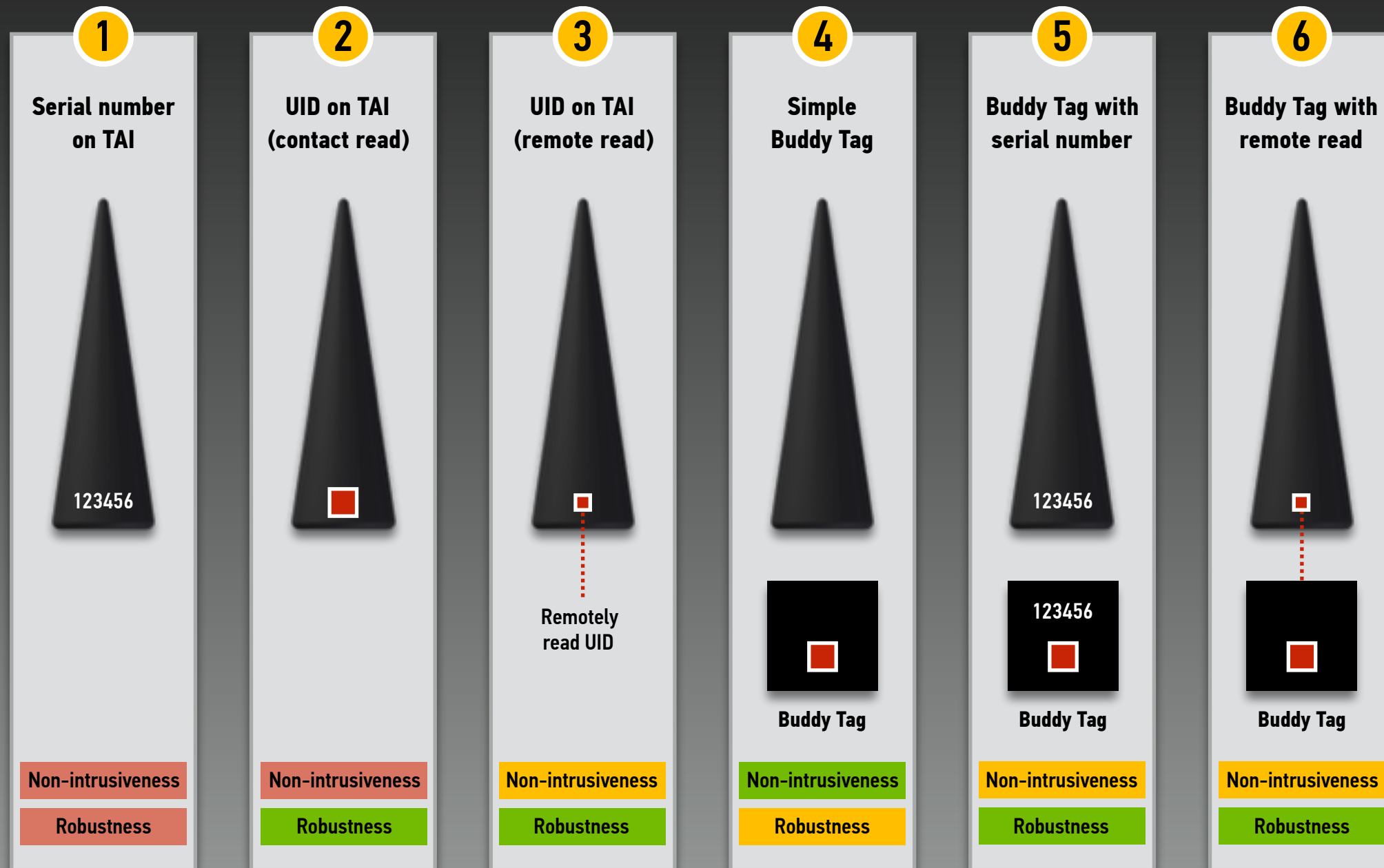


Source: www.automoblog.net

*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

The image is a composite of two advertisements. On the left is a Tile advertisement showing a woman in a kitchen with the text "Find your phone, keys, anything." and a "BUY TILE FOR \$25" button. On the right is a My Buddy Tag advertisement. It features a video player showing a smartphone with the app interface and a list of features: "Out-of-Range Alert", "Water Safety Alert", "Panic Button", and "Last-Seen Location". To the right of the video player is a yellow box with the text "A Lost Child is a Parent's Worst Nightmare", the My Buddy Tag logo, "Keep Kids Safe", and a "Shop Now" button.

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

OPTION FOR A MINIMALLY INTRUSIVE ONSITE INSPECTION

USING BUDDY TAGS WITHOUT DIRECT ACCESS TO TREATY ACCOUNTABLE ITEMS

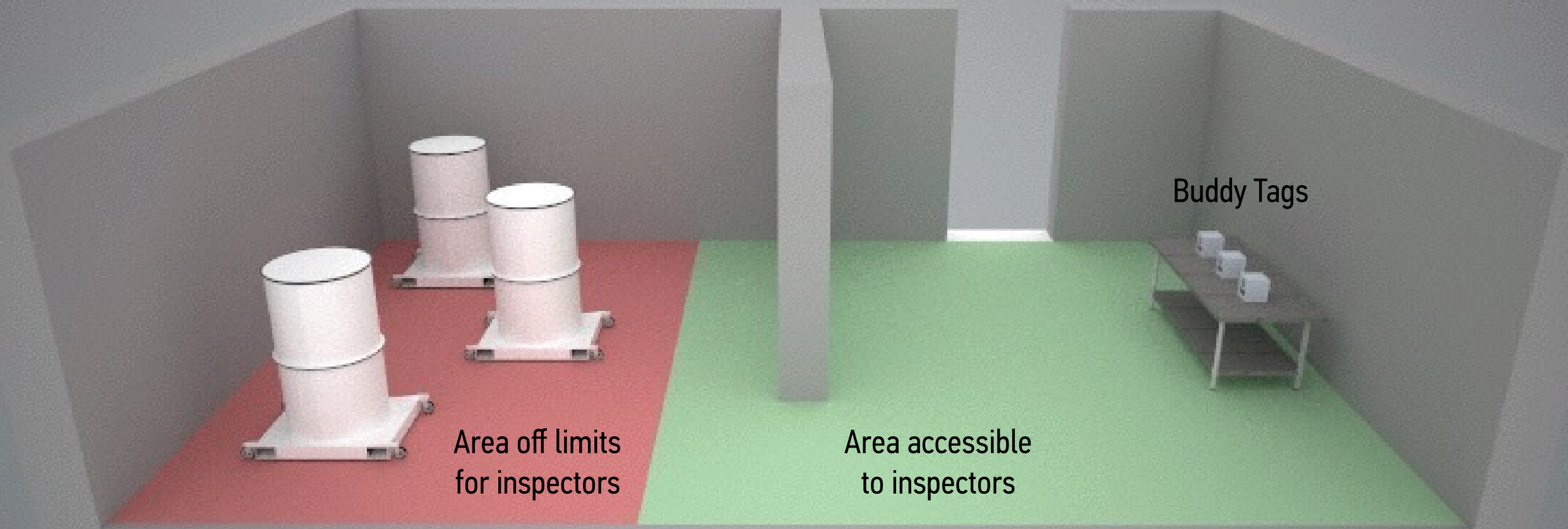


Image: Tamara Patton

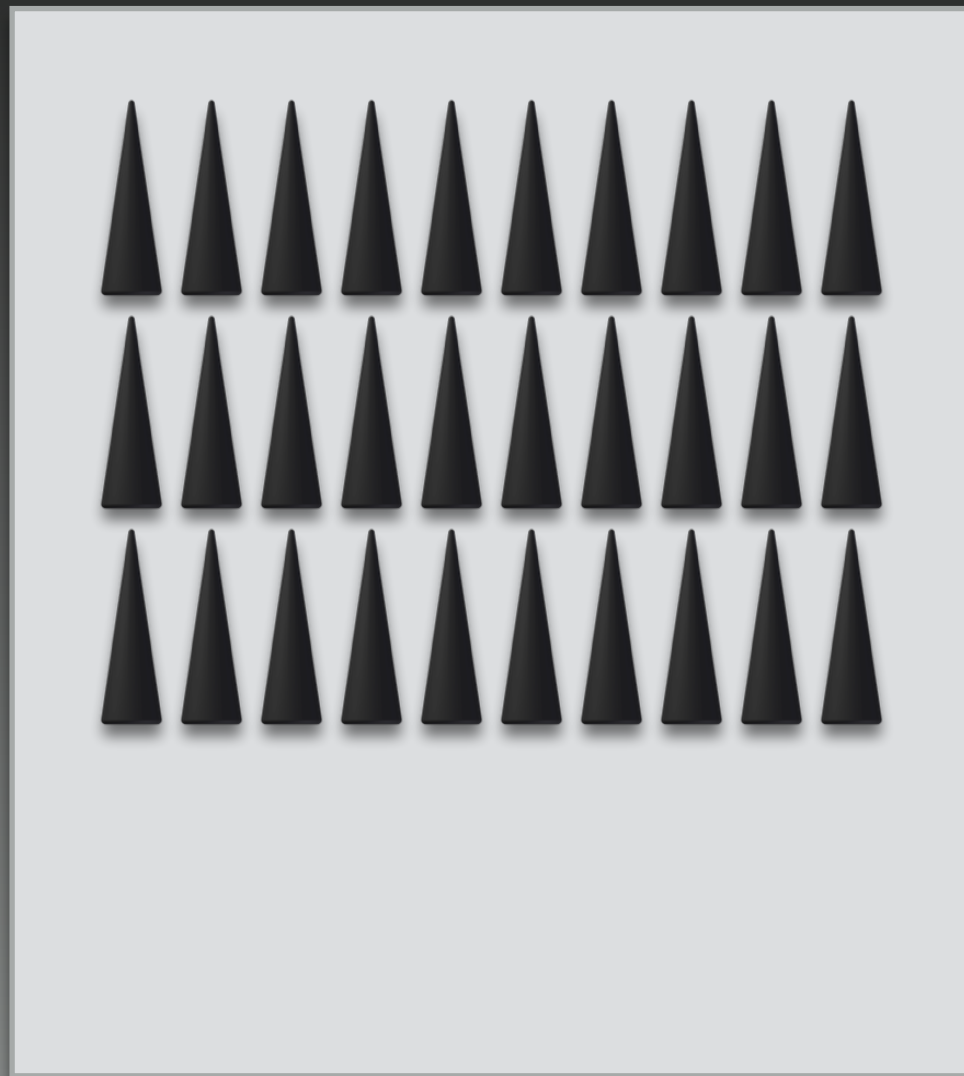
SCENARIO 1

(“DISHONEST HOST”)

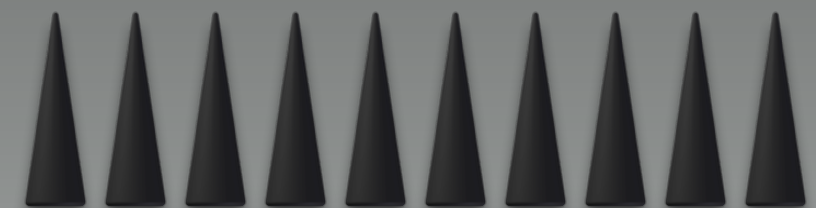
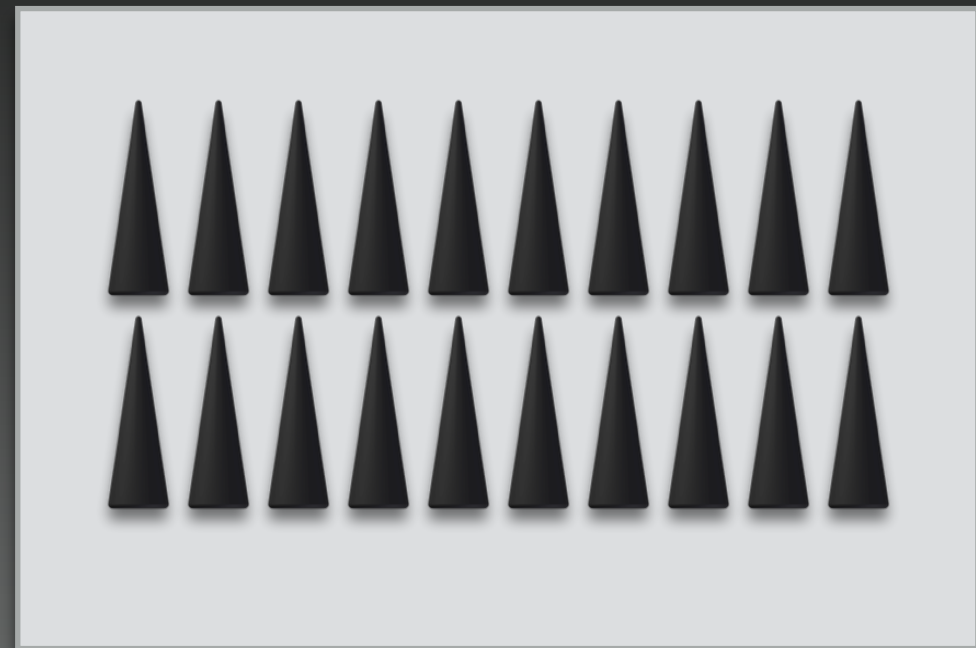
SCENARIO 1

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

SITE A



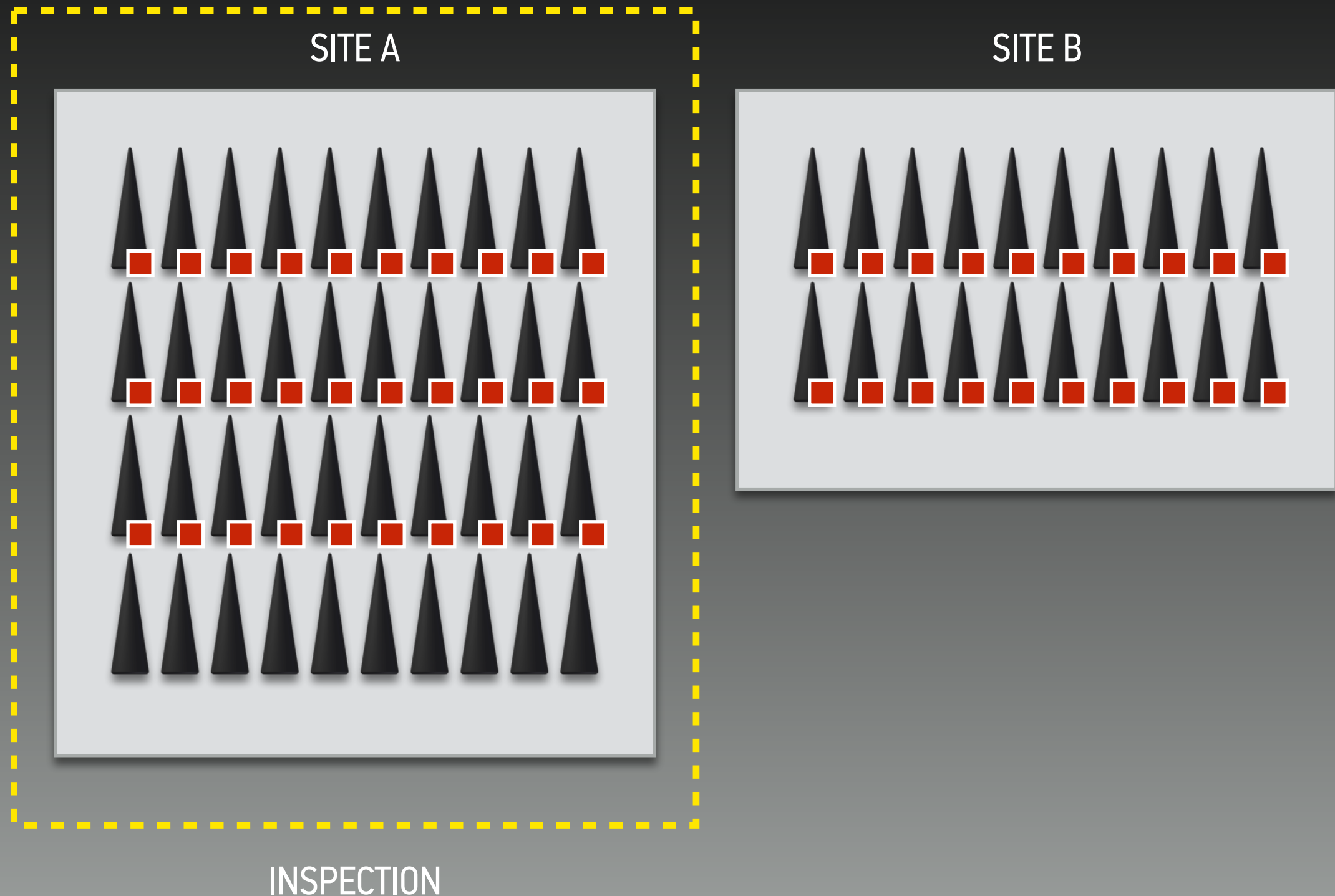
SITE B



In reality, there are 60 warheads

SCENARIO 1

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



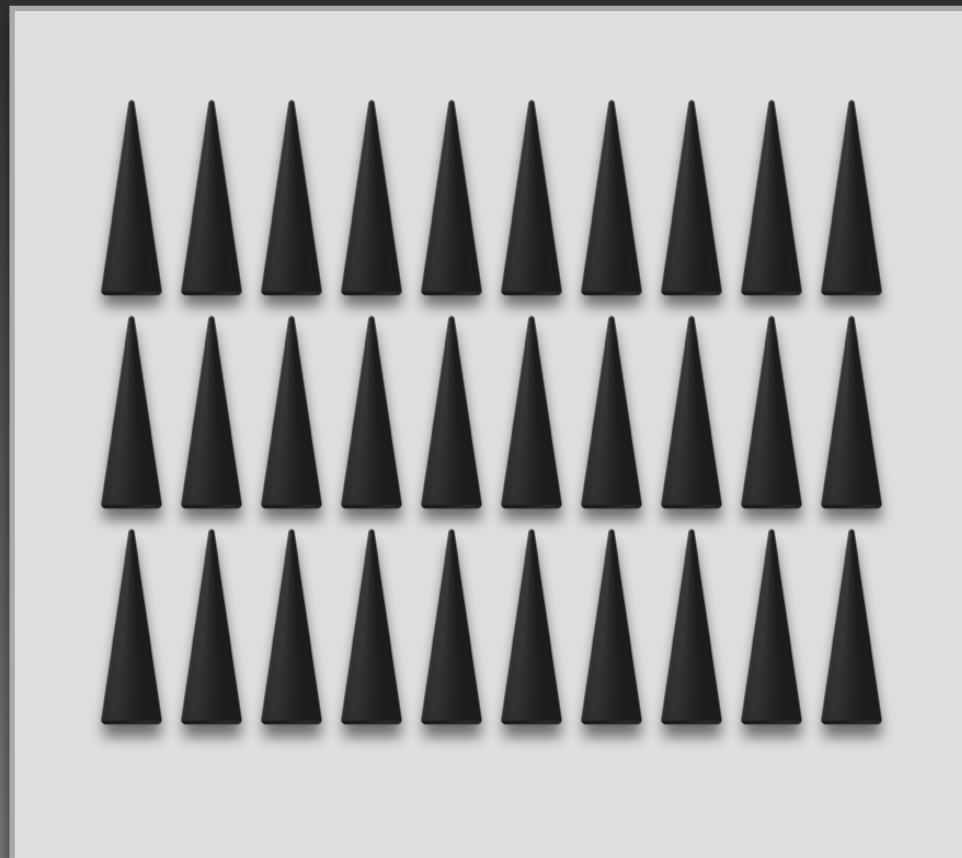
SCENARIO 2

("HONEST HOST")

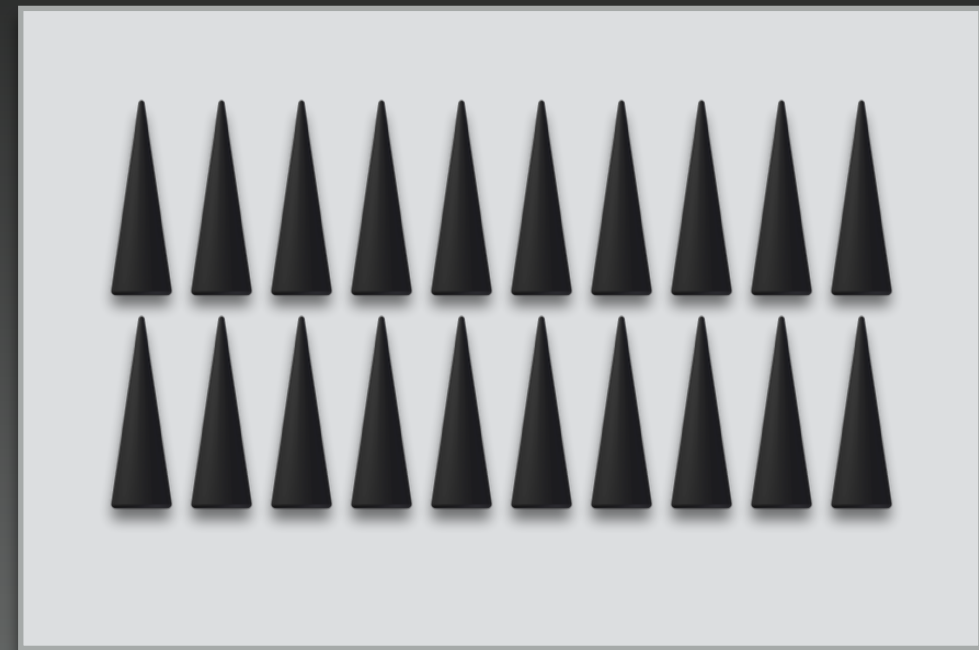
SCENARIO 2

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

SITE A



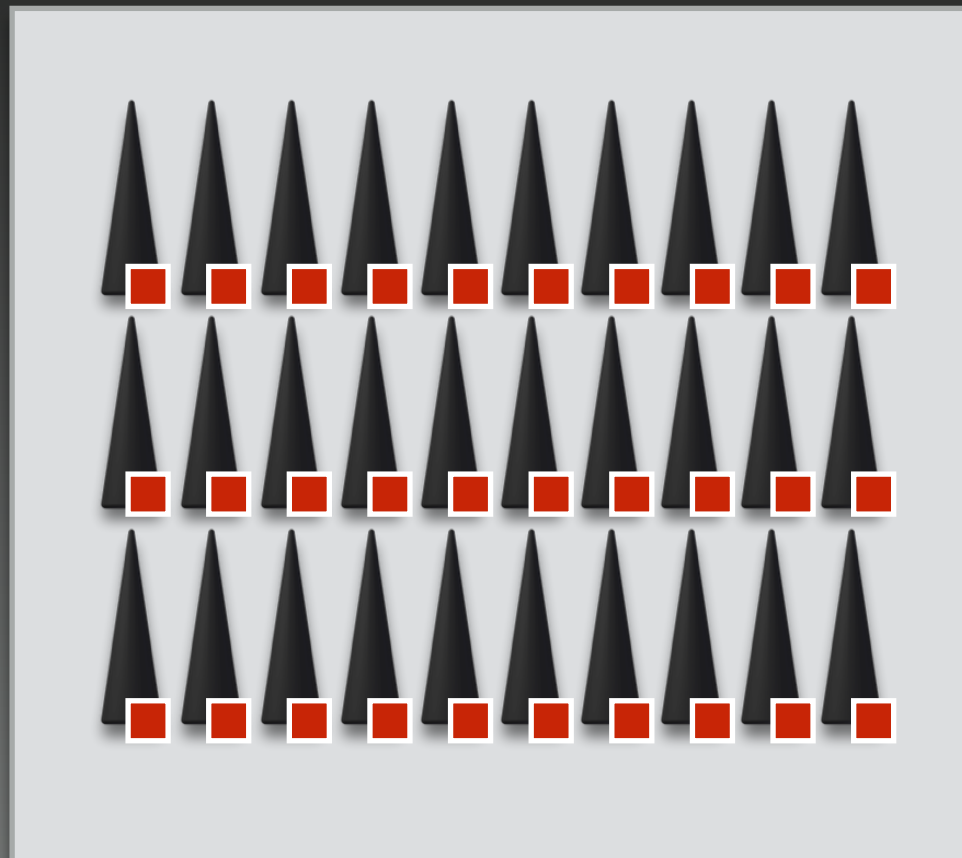
SITE B



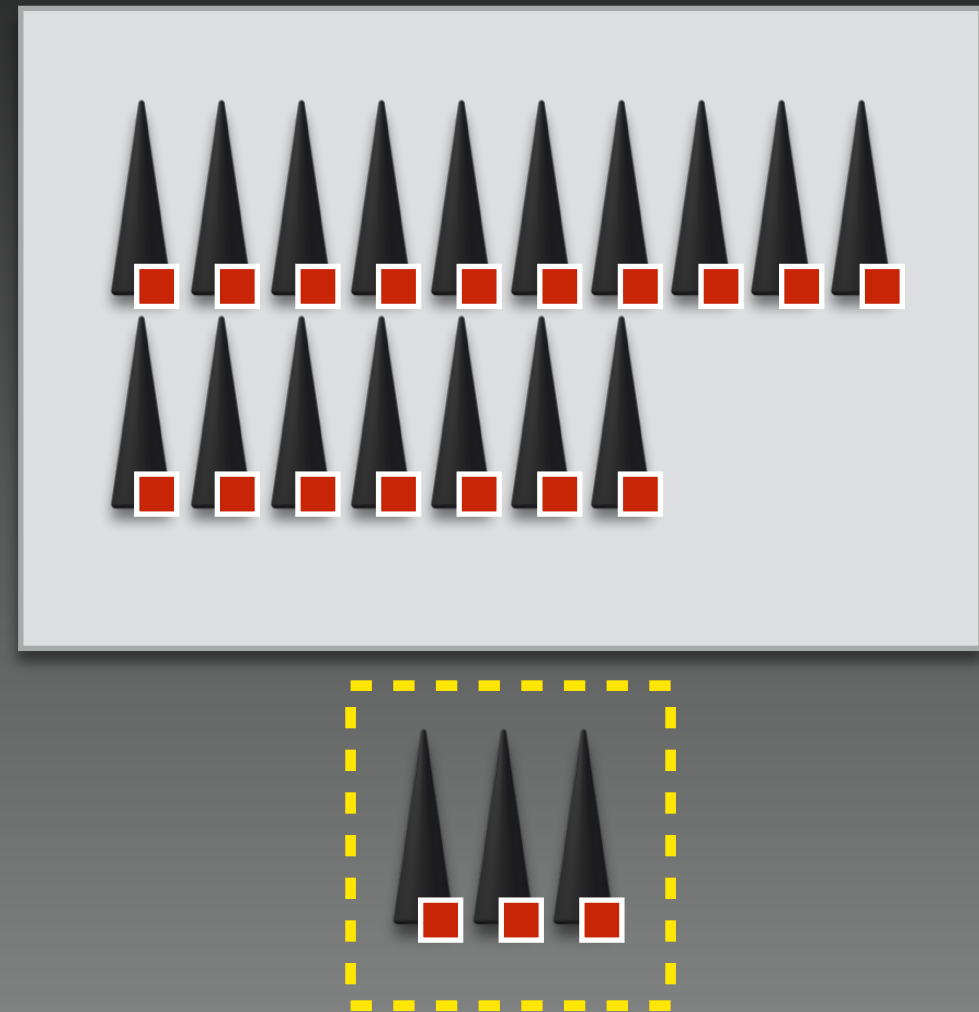
SCENARIO 2

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

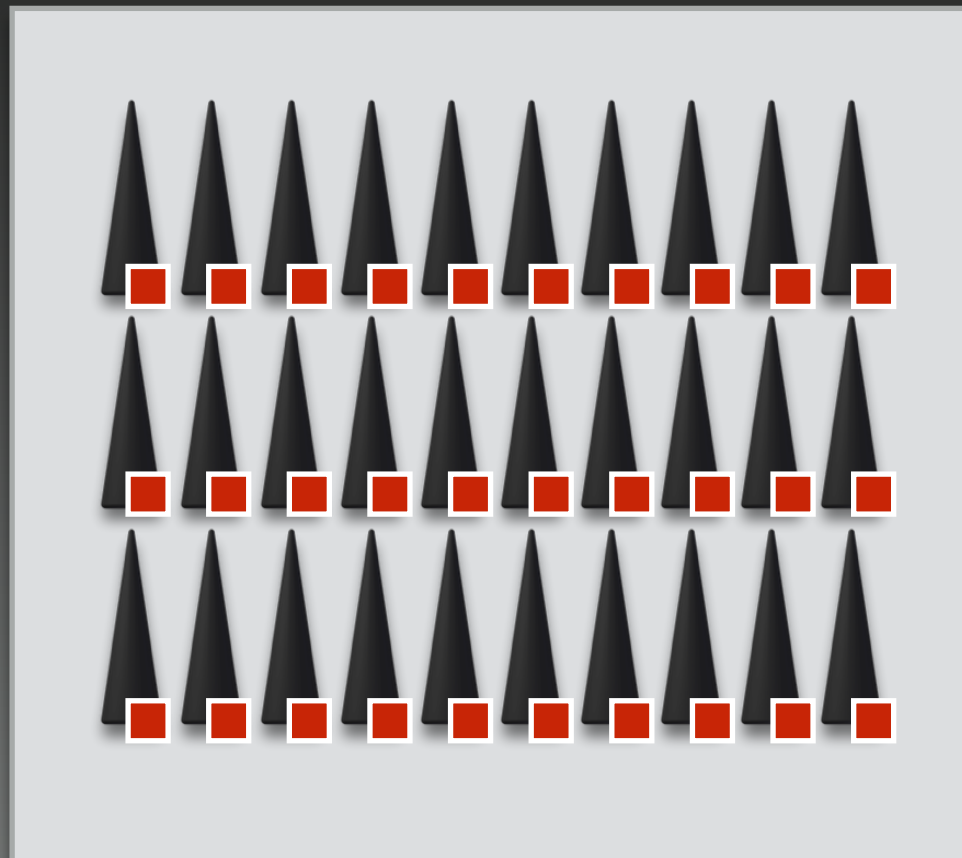
SCENARIO 3

("DISHONEST HOST REVISITED")

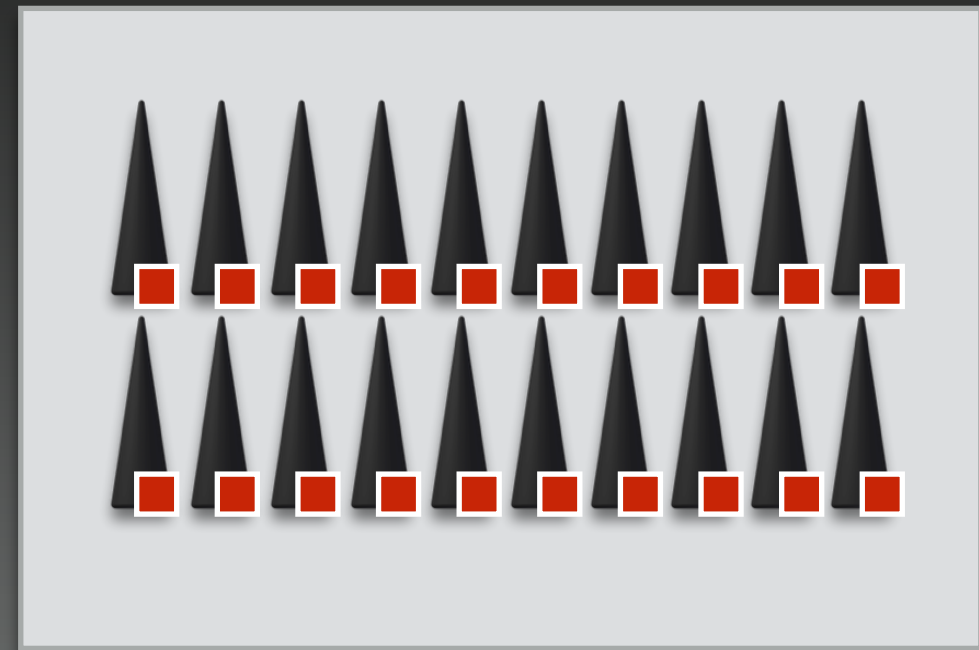
SCENARIO 3

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

SITE A



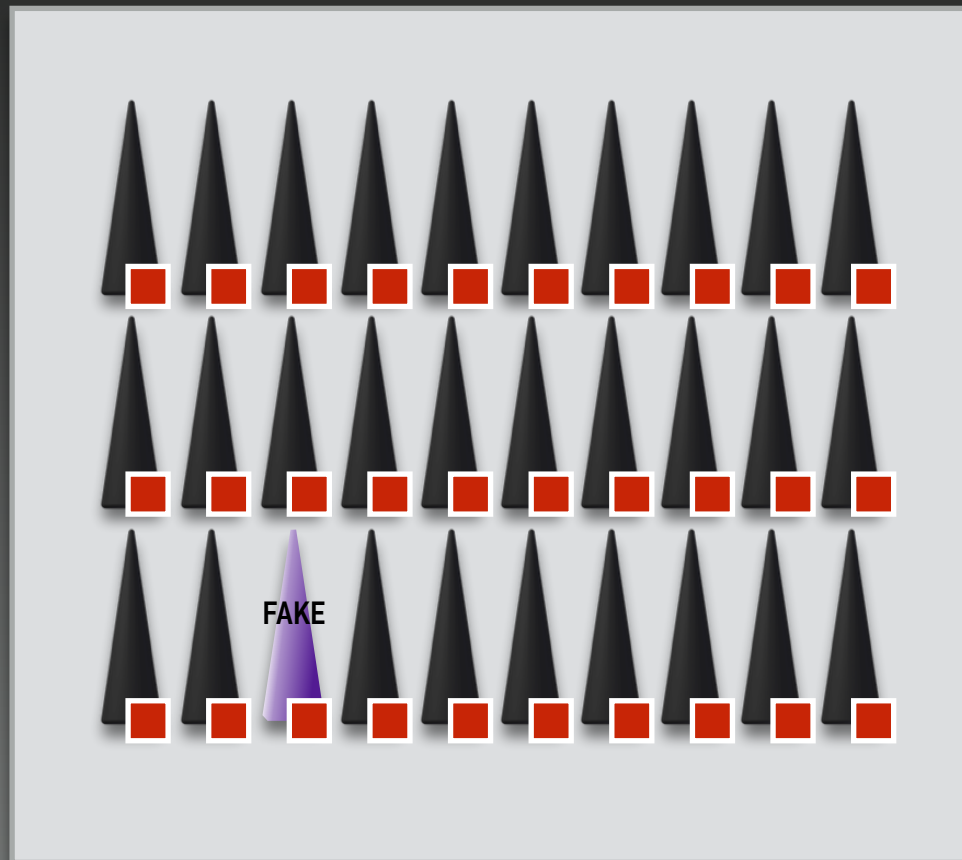
SITE B



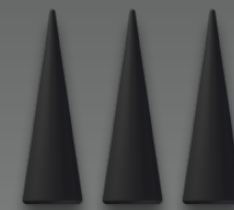
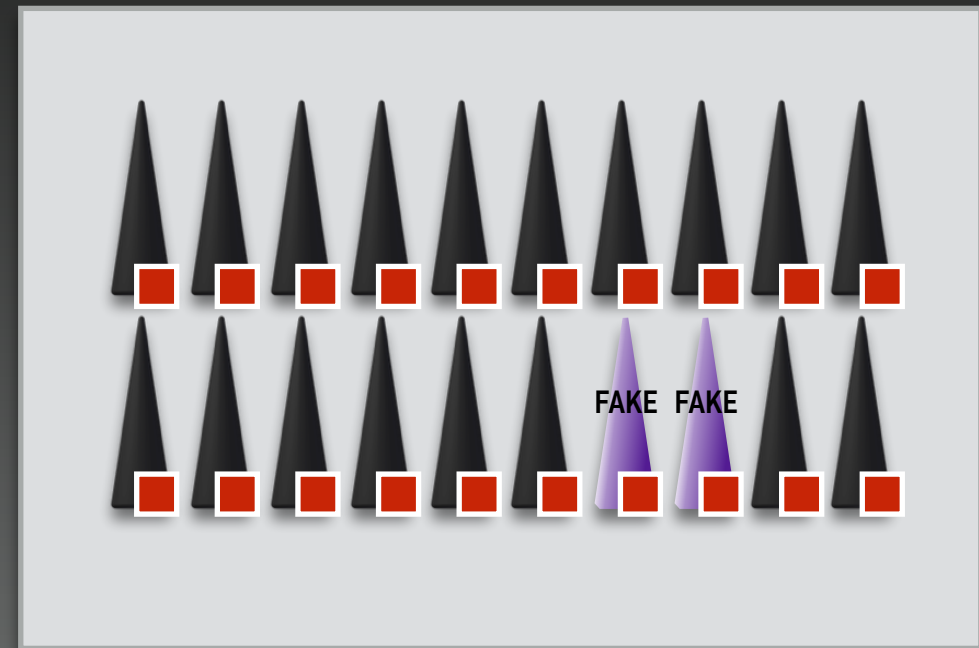
SCENARIO 3

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)

HOW DOES A BUDDY TAG LOOK LIKE?

ELEMENTS OF THE BUDDY TAG

Tamper Indicating Enclosure

Unique Identifier

LED Display

State of health
Movement detected
Battery status

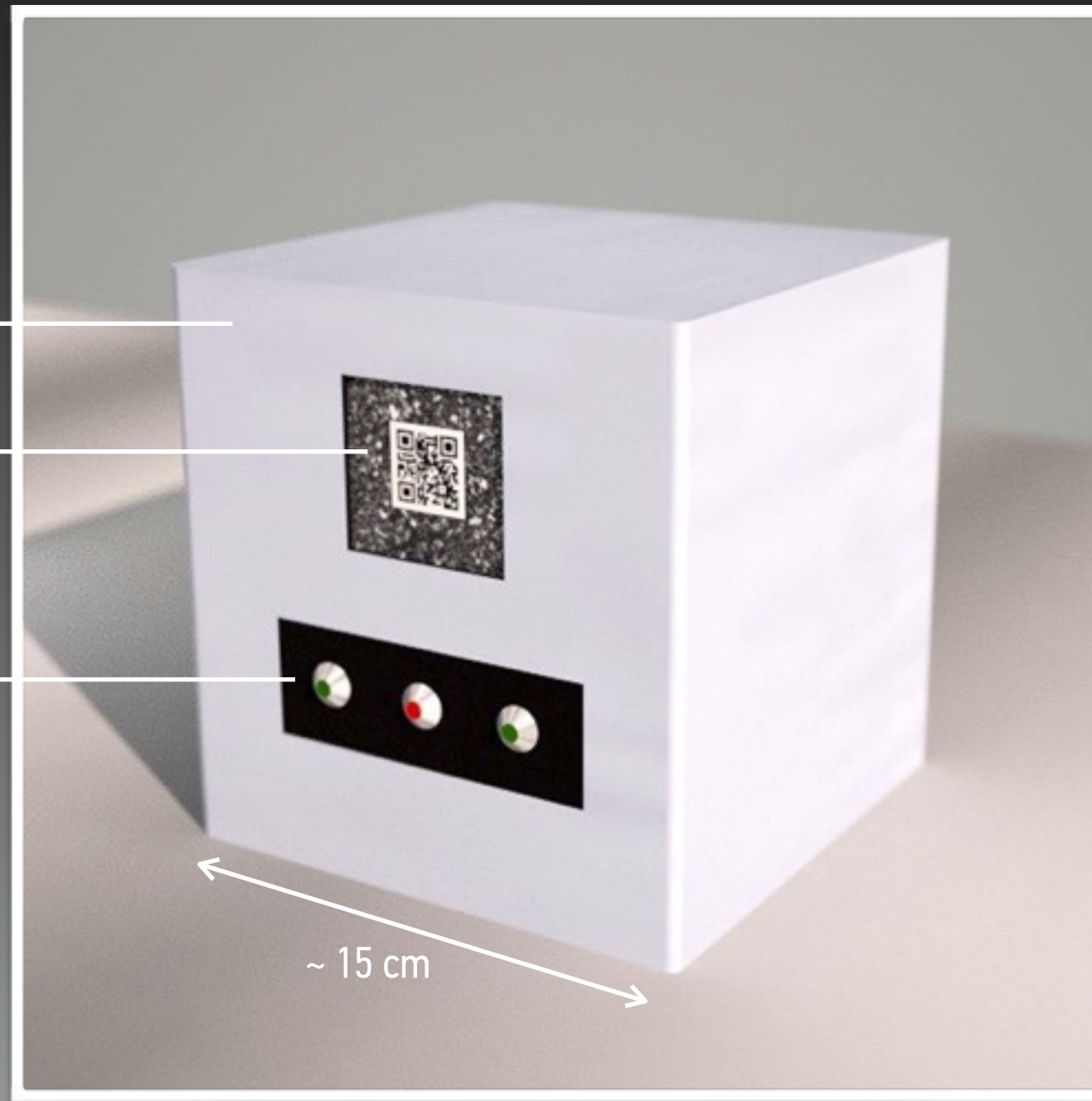


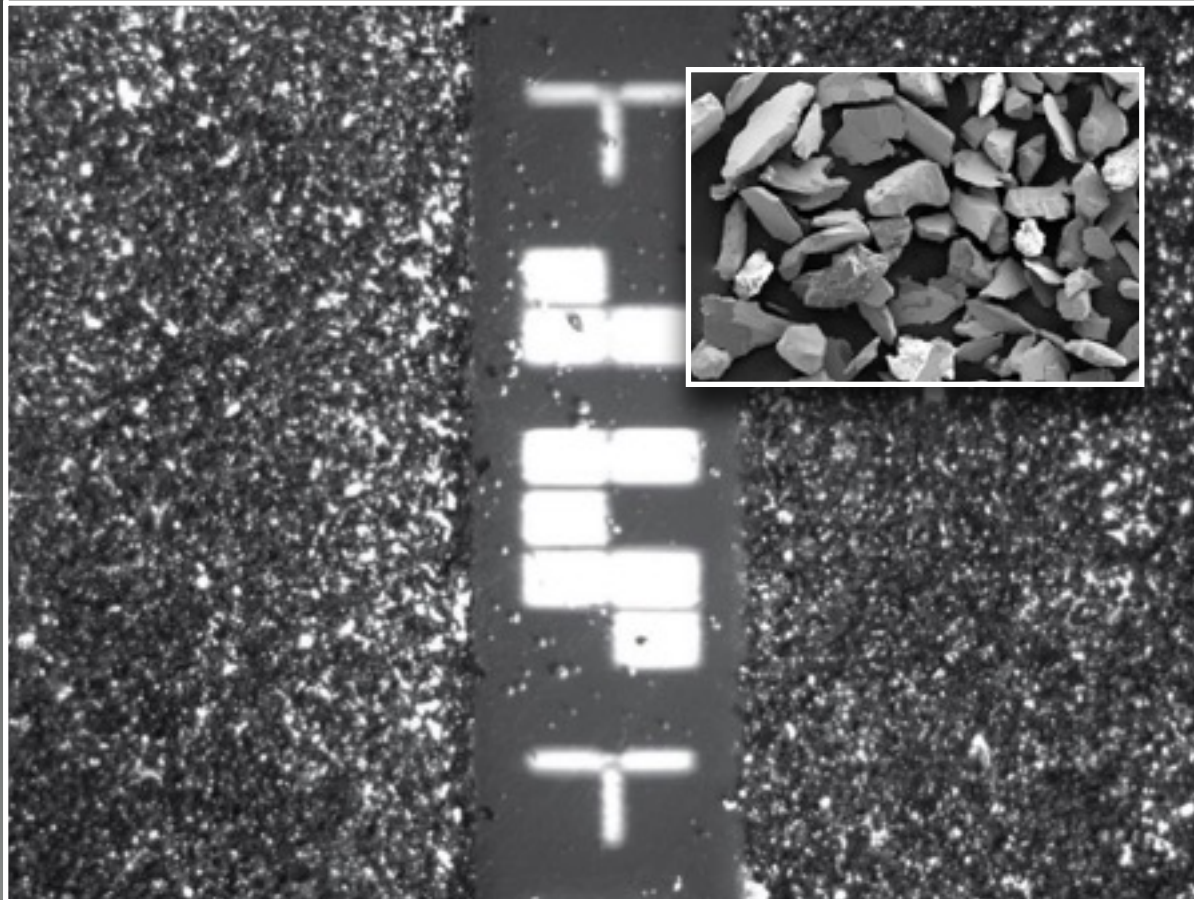
Image: Tamara Patton

TAGGING THE TAG

TREATY ACCOUNTABLE ITEMS WITH UNIQUE IDENTIFIERS

UNIQUE TAGS

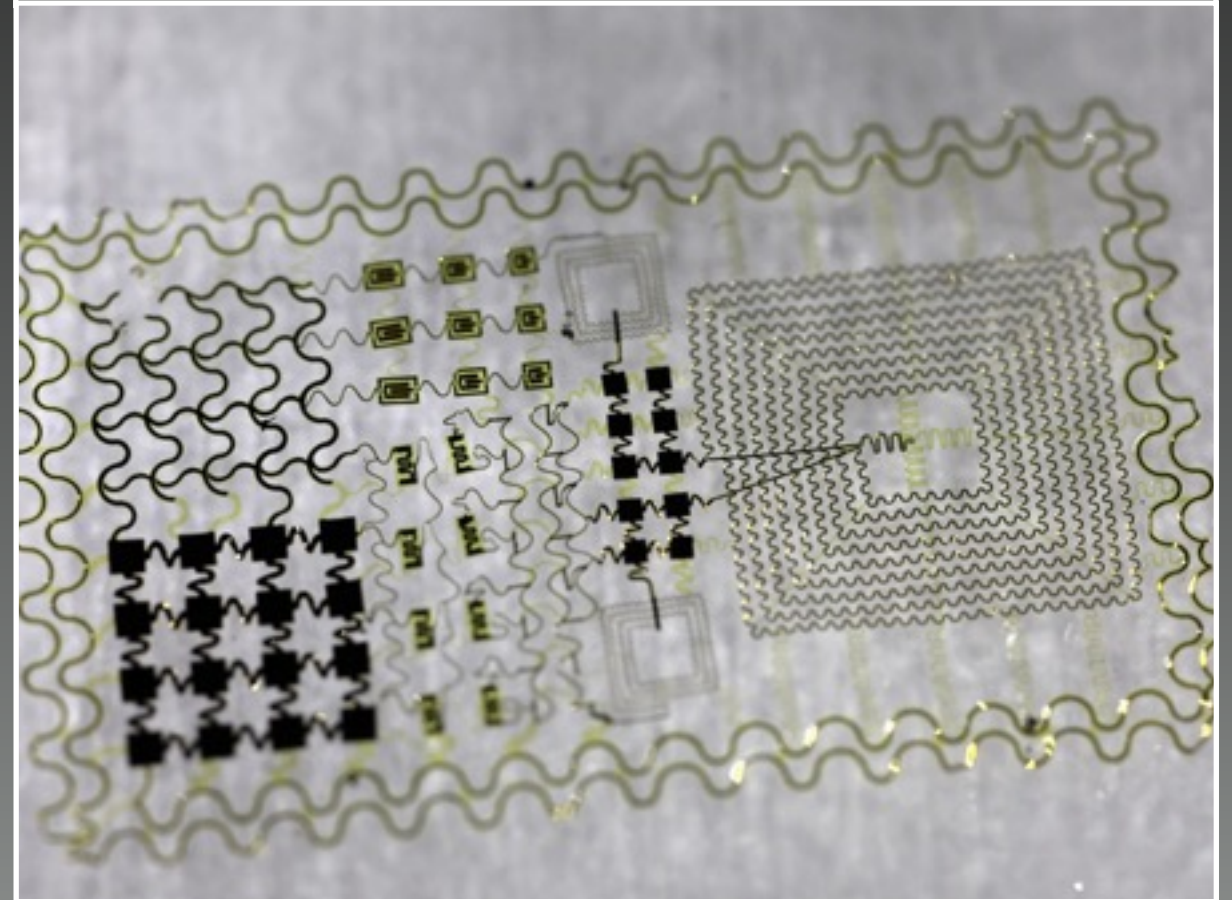
Physically unique, i.e., very hard to duplicate



Reflective Particle Tag
using microscopic particles randomly suspended in matrix
Source: Sandia National Laboratory

IDENTICAL TAGS

Physically non-unique, but input/output unique



Electronic Tattoo
using printed circuits, miniature sensors, and solar collectors
Source: John Rogers, University of Illinois

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

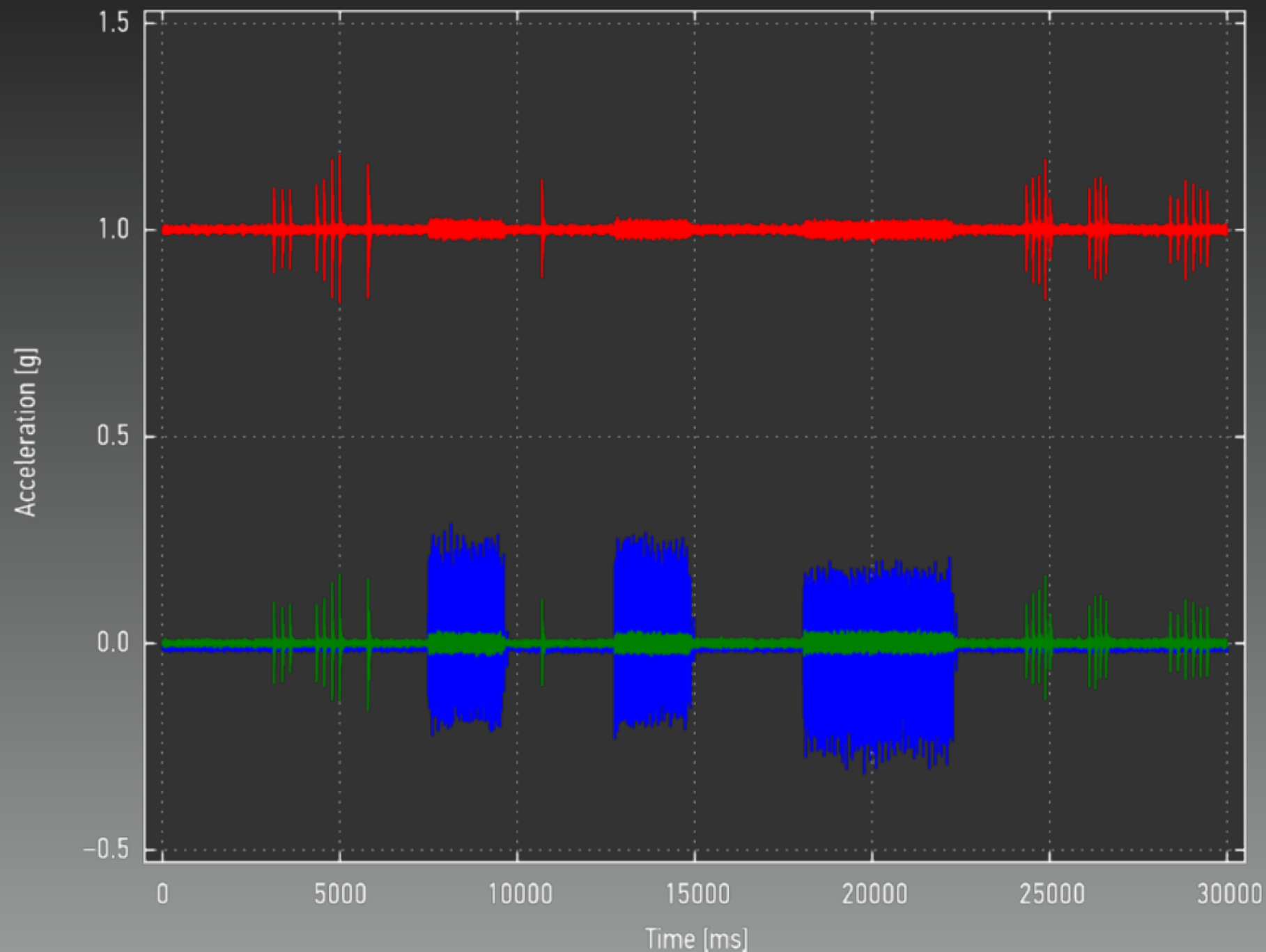
Source: Sensoror

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

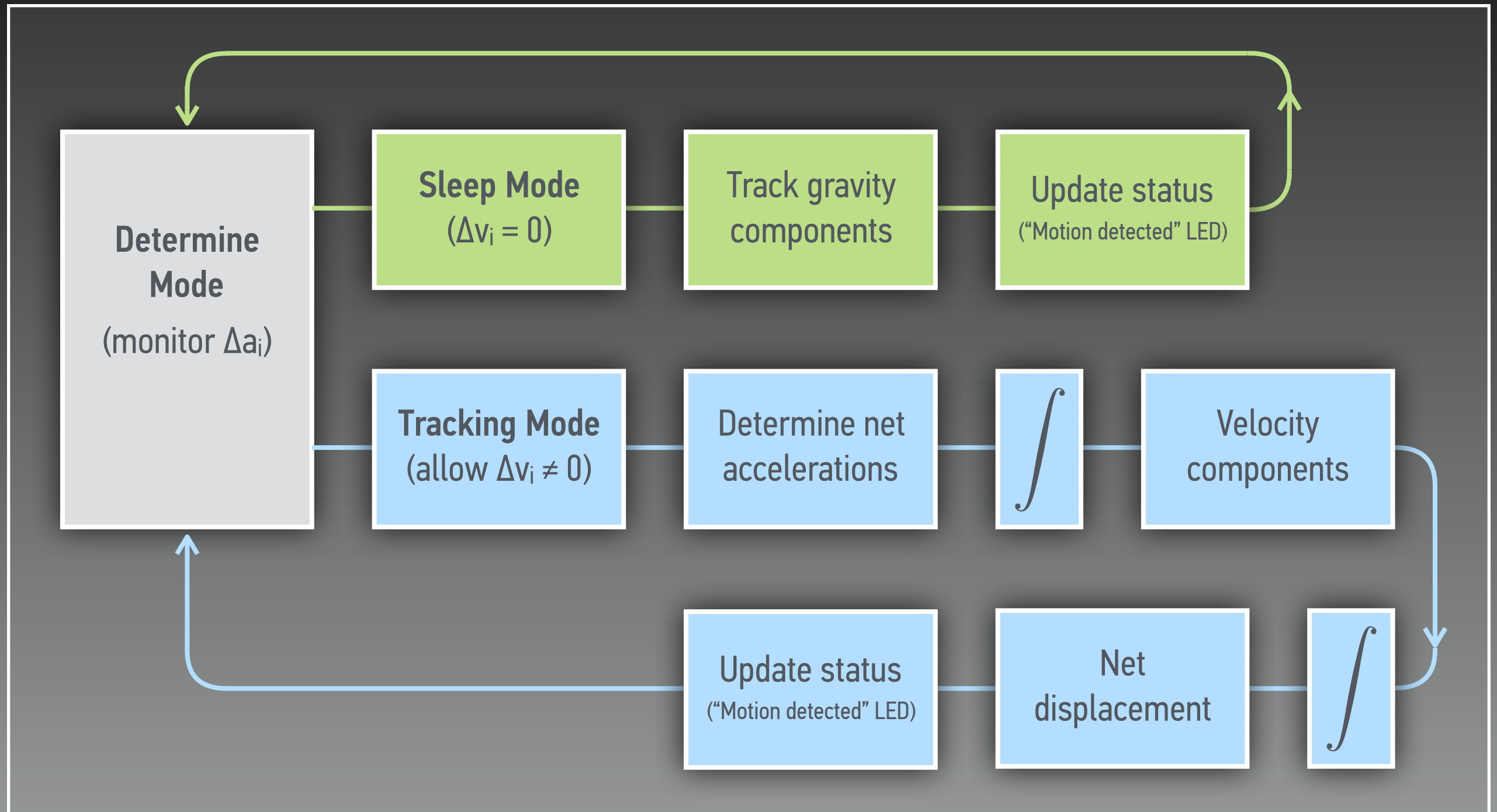
See damien.douxchamps.net/research/imu for a list of currently available units

STIM300 RAW DATA

6000 DATA POINTS PER SECOND FROM ACCELEROMETERS AND GYROSCOPES

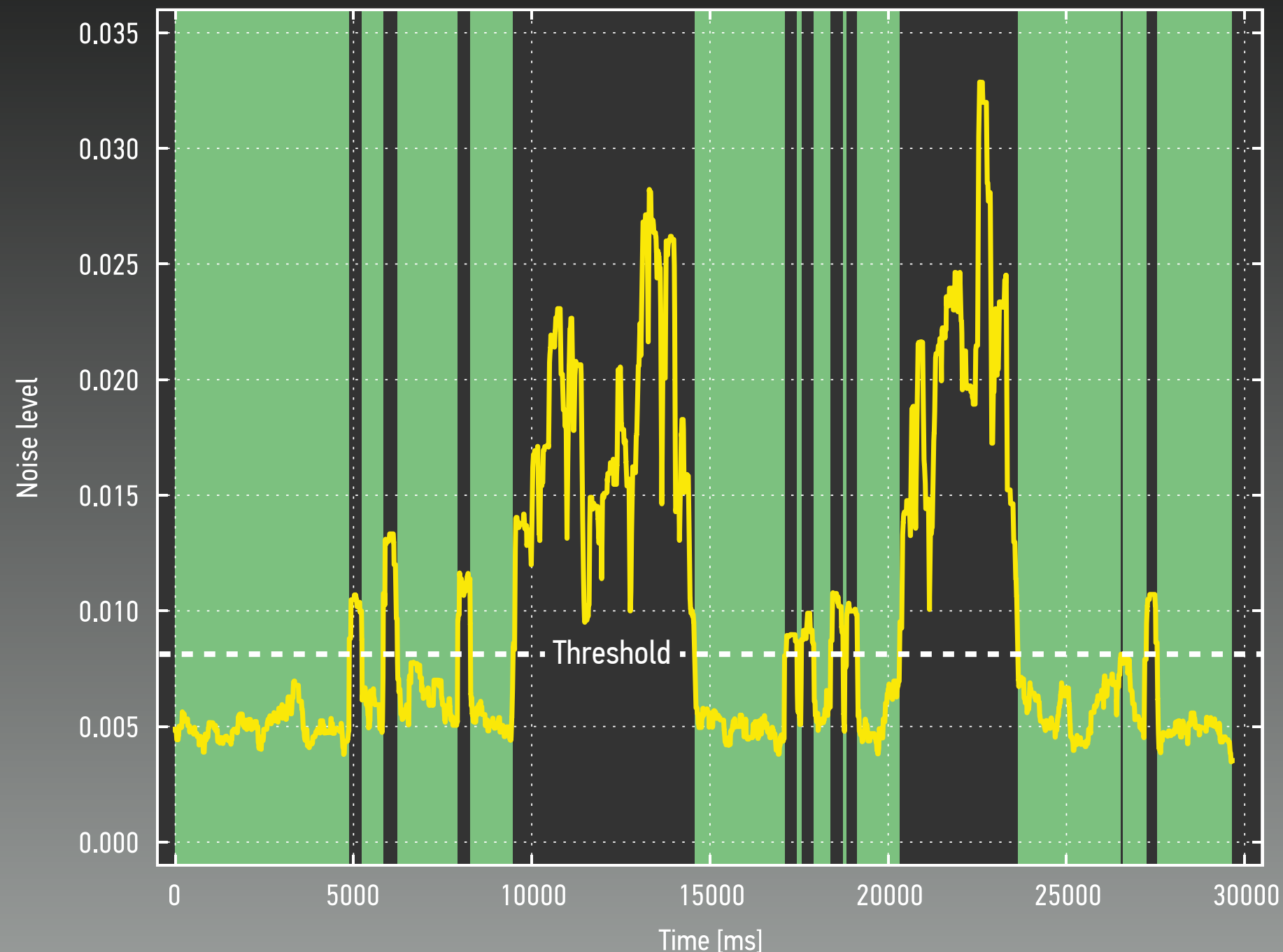


MODE OF OPERATION



SAMPLE DATA SET AND BUDDY TAG'S RESPONSE

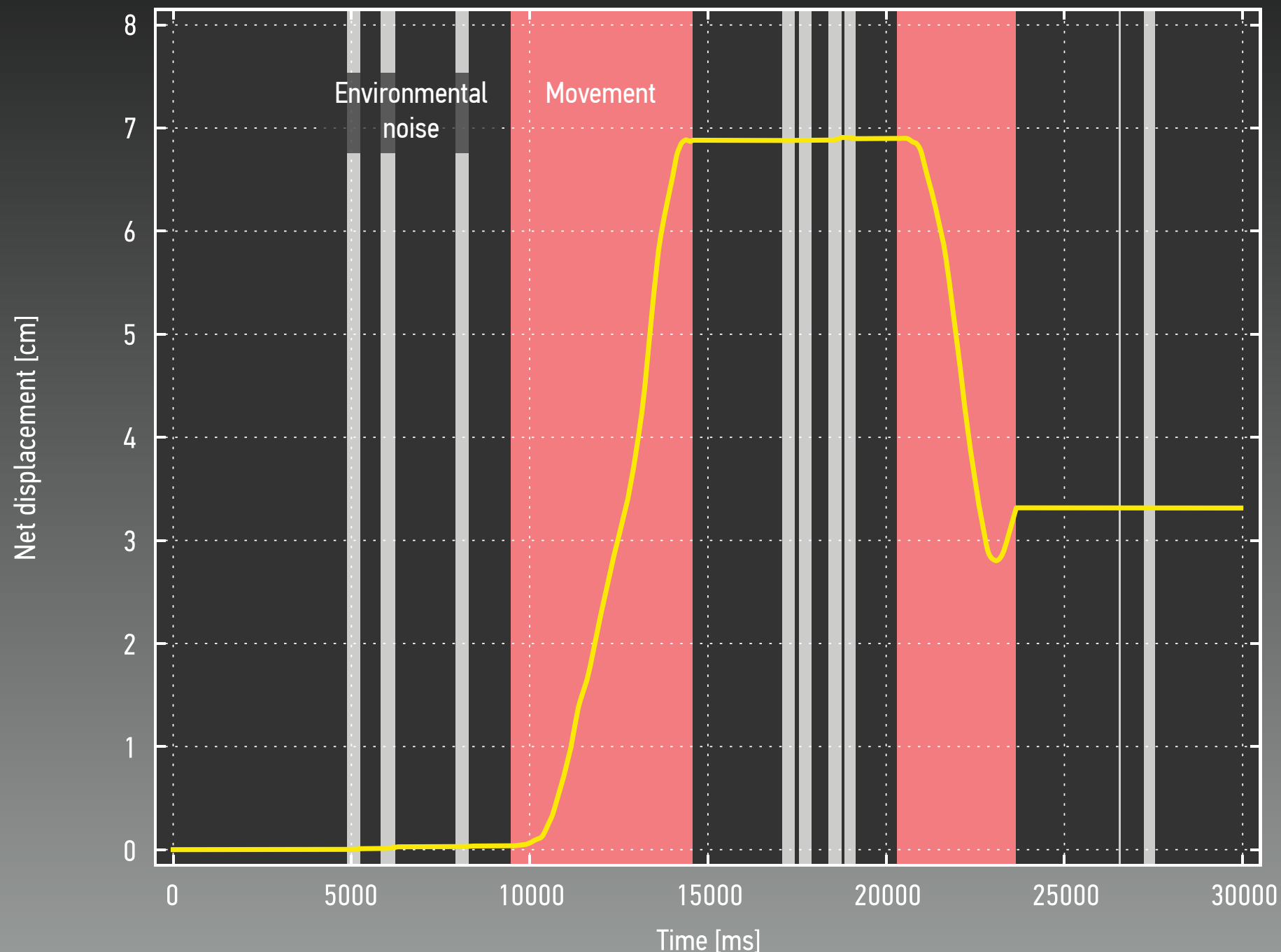
TAG "WAKES UP" IF ACCELERATIONS EXCEED THRESHOLD VALUE



(Data acquired and analyzed with preliminary methods and algorithms)

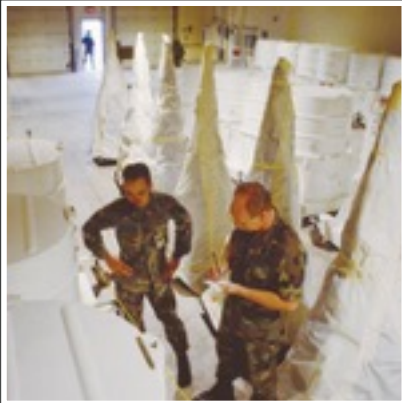
SAMPLE DATA SET AND BUDDY TAG'S RESPONSE

IN TRACKING MODE, ALGORITHM IDENTIFIES TRANSLATIONS



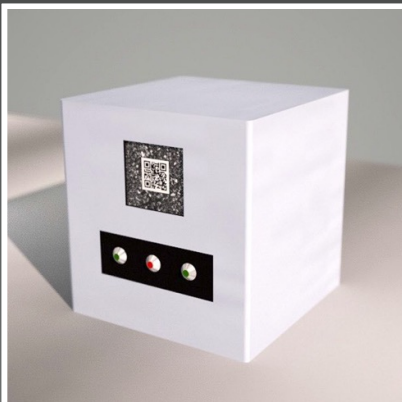
(Data acquired and analyzed with preliminary methods and algorithms)

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: Paul Shambroom (top) and U.S. Department of Energy (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