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New Verification Technologies for Arms Control and Disarmament

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Revision 4x

Outline

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Verification Challenges for Existing and Next-generation Arms Control Treaties

Comprehensive Test Ban Treaty

Fissile Material Cutoff Treaty

Next-generation Nuclear Disarmament Treaties

PART II

Emerging Technologies

Real-time video from space

Crowdsourcing

Verification Challenges for Existing and Next-generation Arms Control Treaties

Nuclear Arms Control Treaties

(and their Verification)

Comprehensive Test Ban Treaty (CTBT)

Bans all nuclear explosions in all environments
and would be verified by extensive verification mechanisms

Fissile Material Cutoff Treaty (FMCT)

At a minimum, treaty would ban fissile material production for weapons purposes
(Verification could use many tools/approaches developed for the NPT)

Next-generation Nuclear Disarmament

Agreements that place limit on total number of nuclear warheads in arsenal
would pose qualitatively new verification challenges

Verifying the Comprehensive Test Ban Treaty

INTERNATIONAL MONITORING SYSTEM

All Facilities

CERTIFIED	INSTALLED	UNDER CONSTRUCTION	PLANNED	TOTAL
274	20	21	22	337

- Primary Seismic
- Auxiliary Seismic
- Infrasound
- Hydroacoustic
- Radionuclide
- Radionuclide with Noble Gas *
- Radionuclide Laboratories

Arctic Ocean
Arctic Ocean
Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Ukraine
France
Italy
Spain
Turkey
Kazakhstan
Mongolia
China
South Korea
Afghanistan
Pakistan
India
Thailand
Indonesia
Papua New Guinea
Australia
New Zealand
Iraq
Iran
Algeria
Libya
Egypt
Saudi Arabia
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
South Africa
Madagascar
Canada
United States
Mexico
Venezuela
Colombia
Brazil
Peru
Bolivia
Chile
Argentina
North Pacific Ocean
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Southern Ocean
Southern Ocean
Southern Ocean

Source: www.ctbto.org/map, retrieved in March 2013

The IMS Has Already Proven More Powerful Than Originally Anticipated

At the time of signature, it was assumed that the IMS would achieve a detection probability of 90% for a 1-kiloton (well-coupled) test

In the early 2000s, detection limit revised to about 0.1-kilotons

Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty
Committee on International Security and Arms Control, National Academy of Sciences, Washington, DC, 2002

Three North Korean tests confirmed the performance of the International Monitoring System

9 October 2006, 0.6–0.9 kt, detected by 22 IMS stations

25 May 2009, 2.5–4.6 kt, detected by 61 IMS stations

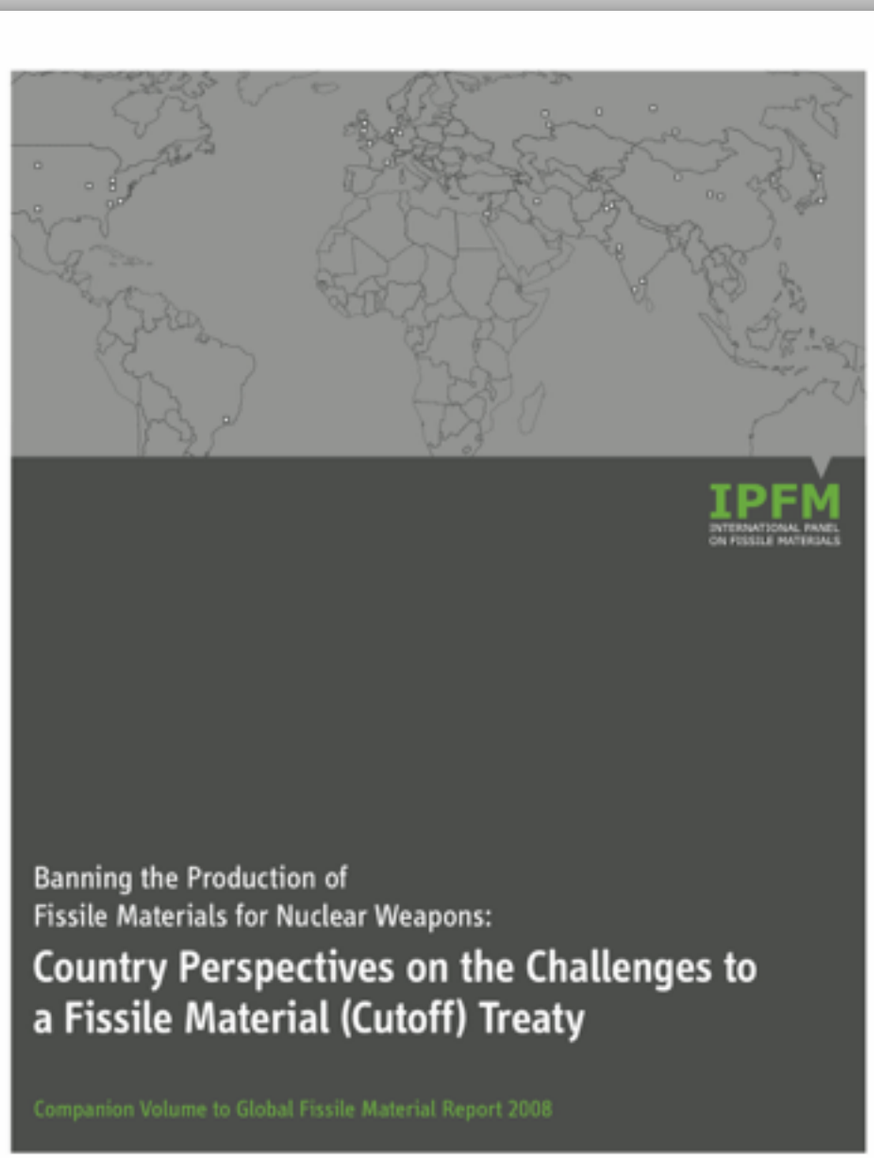
12 February 2013, 6.0–8.0 kt, detected by 94 (seismic) IMS stations

O. Dahlman, J. Mackby, S. Mykkeltveit, and H. Haak
Detect and Deter: Can Countries Verify the Nuclear Test Ban?, Springer, 2011

Verifying the Fissile Material Cutoff Treaty

Global Fissile Material Report 2008

www.ipfmlibrary.org/gfmr08.pdf and www.ipfmlibrary.org/gfmr08cv.pdf



Verification Challenges

1. Shutdown facilities
2. Operational enrichment plants
3. Operational reprocessing plants
4. Challenge inspections at military nuclear sites

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depending on scope of FMCT

5. Naval-reactor fuel cycle
6. Weapon-origin fissile material

Precedents for verification exist in NPT safeguards
in non-weapon states, but some (important) differences

Verifying Nuclear Disarmament

Going “Beyond New-START”

“While the new START treaty is an important step forward, it is just one step on a longer journey. As I said last year in Prague, this treaty will set the stage for further cuts. And going forward, we hope to pursue discussions with Russia on reducing both our strategic and tactical weapons, including non-deployed weapons.”

U.S. President Obama, upon signing the New START Treaty, April 2010

Thousands of Nuclear Weapons Are No Longer Deployed and Currently In Storage

W87/Mk-21 Reentry Vehicles in storage, Warren Air Force Base, Cheyenne, Wyoming

Photo courtesy of Paul Shambroom, www.paulshambroom.com

What Are We Worried About?

(The Challenges of Nuclear Disarmament Verification)

Main Cheating Scenarios and Associated Verification Challenges

Verification Challenge 1

Party offers hoax or tampered devices instead of authentic treaty accountable items (TAI) so that real warheads, warhead components, or fissile material can be "diverted" to a secret stockpile of nuclear weapons

⇝ Verifying the dismantlement of nuclear warheads

Verification Challenge 2

Party provides incomplete baseline declarations so that some treaty accountable items (e.g. warheads) are never part of the verification regime

⇝ Verifying the completeness of declarations

Verified Warhead Dismantlement

Warhead Dismantlement Verification

Some Precedents Exist and Future Work Can Build on Them

Inspection System developed as part of the 1996–2002 Trilateral Initiative during a demonstration at Sarov
Source: Tom Shea

Visual contact with a mockup nuclear weapon during a UK-Norway Initiative Dismantlement Exercise
Source: UK Norway Initiative, David Keir

Rationale behind verifying warhead dismantlement is to provide confidence that actual warheads are destroyed and that the fissile material they contained is recovered and accounted for

Many Challenges for Verified Warhead Dismantlement Remain

Development and Demonstration of Practical Inspection Systems

that assure the inspecting party that instrument works as described
and assure the host state that sensitive information is not leaked during the inspection

Trilateral Initiative developed focused only on plutonium

Demonstrate Viability of Cooperation Between Nuclear and Non-nuclear Weapon States

UK Norway Initiative has broken new ground in this area

but secrecy issues tend to make research and development outside the weapons labs difficult

Verifying the Completeness of Declarations

(skipping)

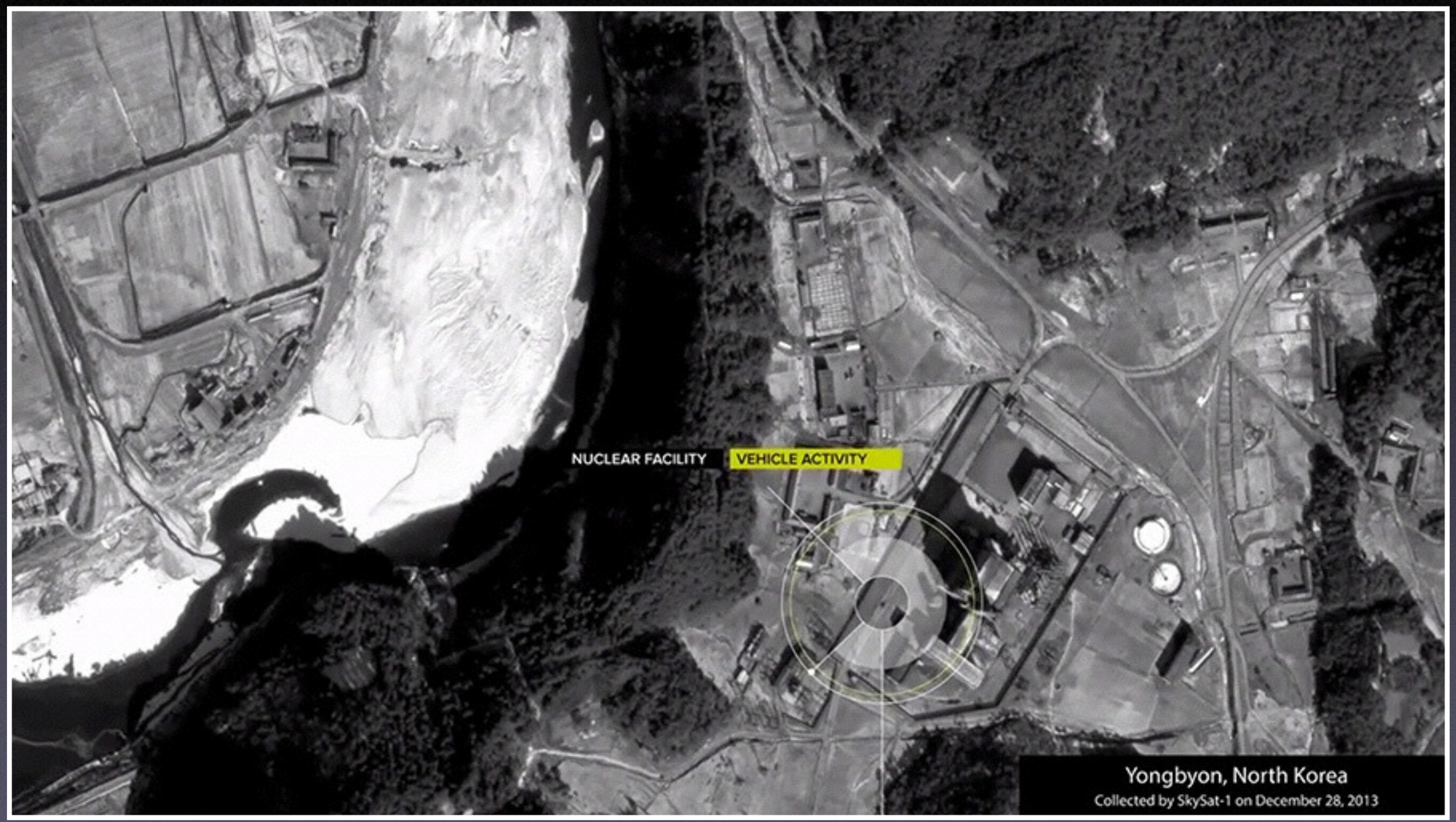
Emerging Technologies

Real-time Video from Space

Example 1

March 14, 2011 - DigitalGlobe

HD Real-time Video from Space



Posted in February 2014, www.youtube.com/watch?v=BsW6IGc4tt0 see also www.skyboximaging.com

Is There a Role for Real-time Video for Verification Purposes?

Characteristics and Constraints

Satellites can "stare" at selected site for about 60–80 seconds at a time

Revisit time for an arbitrary point on earth on the order of 1–3 times per day
(assuming appropriate satellite constellation)

Several applications (going beyond standard satellite imagery) imaginable

Preparations for a nuclear test; shipping activities; plumes from operating reactor

Challenges

Costs: Will international organizations (IAEA/CTBTO) be able to afford such a tool?

Countermeasures: How relevant and effective?

Crowdsourcing

Example 2

The 2009 DARPA Red Balloon Challenge

(The Classic Example)

December 2009, ten numbered eight-foot weather balloons
were deployed at public locations across the continental United States

Challenge: Find and submit the coordinates of all ten balloons as quickly as possible

Reward: $40,000 – Winning team identified all locations in just under 9 hours

Crowdsourcing Typology

There are fundamentally different types of crowdsourcing

Basis for all types: the crowd is connected, i.e., ability to reach out to crowd effectively

Mobilizing the crowd: Recruiting team members to join effort and encouraging them to recruit additional team members

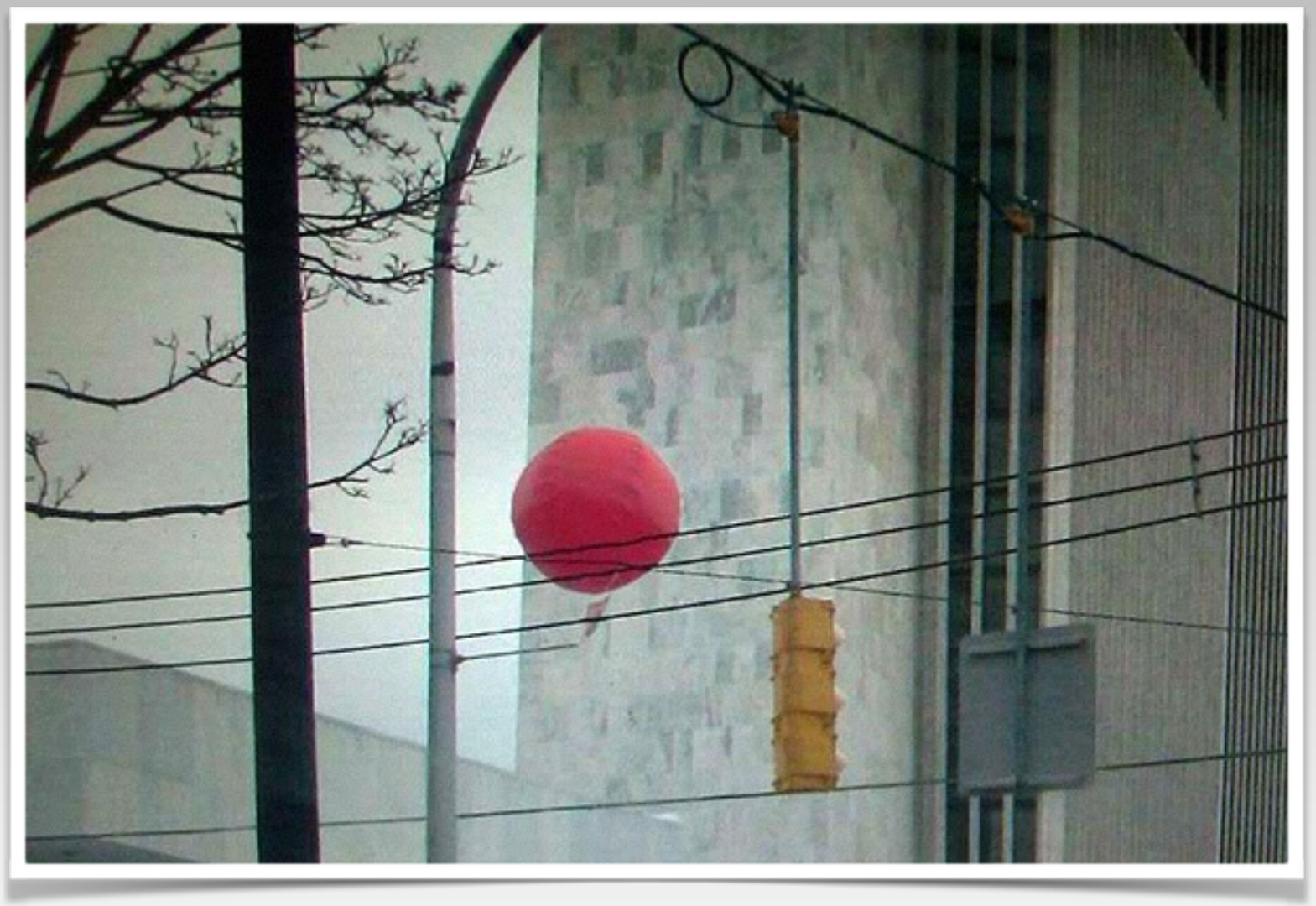
Probing the crowd: Sending request to crowd (pre-selected or not)
Takes advantage of "ubiquitous detectors" (e.g. smart phones)

Listening to the crowd: Open-source intelligence, data mining, big data
No one specifically signs up for (or is even aware of) the effort

Even for the same task, different crowdsourcing techniques can be leveraged

Categories adapted from K. L. Hartigan and C. Hinderstein
The Opportunities and Limits of Societal Verification, 54th Annual INMM Meeting, Palm Desert, CA, July 2013

Sabotage is Often Easy and Effective



Fabricated picture posted during the challenge showing balloon in Albany, NY, www.twitpic.com/s9kun

J. C. Tang et al., "Reflecting on the DARPA Red Balloon Challenge, *Communications of the ACM*, 54 (4), April 2011, pp. 78–85

Is There a Role for Crowdsourcing for Verification Purposes?

Successful precedents for emergency response, humanitarian relief, disease control
BUT deception efforts and sabotage are largely irrelevant in these cases

Experience so far with more relevant cases is mixed: false reports dominate

<u>Example: Red Balloon Challenge</u>

MIT team recruited 5,000 participants, 200 submissions, fewer than 40 accurate

Validation of crowdsourced data is (very) costly

V. Naroditskiy, I. Rahwan, M. Cebrian, N. R. Jennings, "Verification in Referral-Based Crowdsourcing," *PLOS ONE*, 7 (10), October 2012, 1–7

Where Does This Leave Us?

Verification Technologies for Disarmament

Requirements for Existing or Next-generation Arms Control Treaties

Technology gaps for CTBT/FMCT verification small

BUT: Nuclear disarmament verification requires new approaches and techniques

Important opportunities to initiate new development and demonstration projects

Emerging Technologies

Real-time video: Costs, equal-opportunity access, robustness against countermeasures

Crowdsourcing: many different concepts; potential not well understood

Hard to define formal verification mechanisms and procedures; better for “ad-hoc” applications?

Fine line between national intelligence gathering versus equal-access/equal-opportunity crowdsourcing