CISAC…

• is a standing committee of the NAS
• was established in 1980, with the initial purpose of conducting off-the-record bilateral dialogues with a counterpart group in the Soviet Academy of Sciences;

• is a mixture of
  – senior academic analysts of international security & arms control,
  – individuals of long experience in the national nuclear weapons labs & the defense industry, and
  – retired leaders from the military, government, and arms-control diplomacy

About half are members of the National Academy of Sciences, the National Academy of Engineering, or the Institute of Medicine.
<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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<tbody>
<tr>
<td>John P. Holdren ¹²</td>
<td>Chair</td>
</tr>
<tr>
<td>Catherine M. Kelleher</td>
<td>Vice Chair</td>
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<tr>
<td>John D. Steinbruner</td>
<td>Vice Chair</td>
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<tr>
<td>Wolfgang Panofsky ¹</td>
<td>Chair Emeritus</td>
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<td>Gen William F. Burns</td>
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<td>Christopher Chyba</td>
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<td>Stephen Cohen</td>
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<td>Susan Eisenhower</td>
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<td>Steve Fetter</td>
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<td>Alexander H. Flax ²</td>
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<tr>
<td>Richard L. Garwin ¹²³</td>
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<td>Rose Gottemoeller</td>
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<td>Margaret A. Hamburg ³</td>
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<td>Raymond Jeanloz ¹</td>
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<td>Spurgeon M. Keeny, Jr.</td>
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<td>Joshua Lederberg ¹³</td>
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<td>Matthew Meselson ¹³</td>
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<td>Albert Narath ²</td>
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<td>C. Kumar N. Patel ¹²</td>
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<td>Jonathan D. Pollack</td>
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<tr>
<td>Michael Clegg ¹ (ex officio)</td>
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<tr>
<td>Jo L. Husbands (Staff Director)</td>
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<tr>
<td>Patricia Wrightson (Sr Staff)</td>
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<td>Chris Eldridge (Staff)</td>
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<td>La’Faye Lewis-Oliver (Staff)</td>
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<tr>
<td>Ben Rusek (Research Associate)</td>
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</tbody>
</table>

* as of December 31, 2004

¹ = NAS, ² = NAE, ³ = IOM
CISAC ACTIVITIES

• DIALOGUES WITH COUNTERPART GROUPS
  Soviet Union / Russia, China, India

• MAJOR STUDIES BY THE FULL COMMITTEE
  Management & Disposition of Excess Weapons Plutonium (1994)

• MAJOR STUDIES BY “SPINOFF” COMMITTEES

• BIOLOGICAL WEAPONS WORKING GROUP
• OTHER SUBGROUP ACTIVITIES
  “mini-meetings” and workshops on selected topics
• SESSIONS AT NAS ANNUAL MEETINGS
Motivation for the study

• Previous CISAC studies underlined key role of transparency, monitoring, and verification, both for
  – future of arms limitation among the nuclear-weapon states
  – keeping NEM from proliferation-prone states & terrorists

• In 2000, DOE requested that CISAC study potential for more comprehensive approach to nuclear-arms control

• Focus evolved to emphasize monitoring because
  – world events & new administration increased salience of nonproliferation & counter-terrorism relative to “arms control”
  – transparency and monitoring are central to all 3 agendas
CISAC: Monitoring Nuclear Weapons and Nuclear Explosive Materials

Scope of the study

- Study explored “extent to which current & foreseeable approaches to transparency & monitoring can support verification for all categories of nuclear weapons – strategic & non-strategic, deployed & nondeployed – as well as for the nuclear explosive components & materials that are their essential ingredients.”

“We believe that increasing the categories of items subject to transparency & monitoring would be valuable – and may ultimately be essential – as the United States and the world attempt to address the urgent & interrelated goals of reducing the dangers from existing nuclear arsenals, minimizing the spread of nuclear weaponry to additional states, and preventing the acquisition of nuclear weapons by terrorists.”
Scope of the study (continued)

• “The study has addressed the technical and institutional approaches & capabilities in transparency & monitoring that could be applied to any or all of these purposes.”

• “It has not tried to analyze or make recommendations about the choices in U.S. nuclear-weapon and nonproliferation policies & priorities that will continue to shape the context within which such approaches and capabilities might be applied.”
Magnitude of the monitoring challenge

• 30,000 nuclear weapons remain in the world
  – ~95 percent possessed by Russia & the USA
  – remainder by UK, France, China, Israel, India, Pakistan, possibly North Korea

• Moscow Treaty commits USA & Russia to reduce operationally deployed strategic offensive nuclear weapons to 1700-2200 each by end of 2012
  – doesn’t include nonstrategic weapons or non-deployed strategic weapons
  – no transparency or monitoring provisions
    (declarations & monitoring under START expire 12-09)
  – doesn’t apply to countries other than USA, Russia
The monitoring challenge (continued)

• Stocks of nuclear-explosive materials (NEM) – HEU and plutonium – pose risks
  – increasing number of weapons in nuclear-weapon states
  – acquisition of nuclear weapons by states that don’t yet have them but do have NEM
  – illicit transfer to or theft by other states or subnational groups intending to make nuclear weapons.

• HEU and Pu are difficult to produce. Access to them is the limiting technical ingredient for acquisition of nuclear weapons.
The monitoring challenge (continued)

- Quantities of NEM are immense

<table>
<thead>
<tr>
<th></th>
<th>Military</th>
<th>Civil</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEU</td>
<td>1840</td>
<td>60</td>
<td>1900</td>
</tr>
<tr>
<td>Pu (unirradiated)</td>
<td>260</td>
<td>230</td>
<td>490</td>
</tr>
</tbody>
</table>

These are metric tons (thousands of kilograms). IAEA definition of a “Significant Quantity” (SQ) – enough for a weapon – is 25 kg HEU, 8 kg Pu. Global NEM stocks > 100,000 SQ
The monitoring challenge (continued)

Qualitative aspects of the challenge

- Tensions between sharing information about stockpiles of nuclear weapons & NEM and maintaining the security of these stockpiles against attack, sabotage, and theft.

- Characteristics of NEM and nuclear weapons place limits on the capabilities of any system of transparency & monitoring.

- Tension about extent to which transparency & monitoring measures should be enshrined in formal agreements: negotiation of agreements may be difficult & protracted, but may be needed for the most stringent measures & for assurance of sustainability.
CISAC: Monitoring Nuclear Weapons and Nuclear Explosive Materials

Weapons and Components

- Elements of a transparency & monitoring regime:
  - comprehensive declarations
  - measures to confirm declarations of weapon inventories
  - measures to confirm declarations of weapon dismantling, manufacture
  - measures to confirm destruction, manufacture of weapon components (pits, CSAs)
Weapons: Declarations

- Declarations can be made at various levels of detail:
  - aggregate inventories (total number of weapons)
  - by weapon type, status
  - by facility
  - itemized
- Comparable historical data would help build confidence
- “Secure declarations” can allow exchange of detailed data while retaining control over its release
  - encryption (separate key for each record)
  - message digests (secure hash for each record)
Weapons: Inspections

- Declarations can be confirmed with inspections of deployed and storage warheads
- Sampling greatly decreases number of inspections needed to gain confidence declaration is accurate
- START defined procedures for missile warheads; all other warheads in storage
- Two approaches for identifying weapons
  - templates: confirm that characteristics of object match those of a known weapon
  - attributes: confirm that characteristics of object are consistent with a nuclear weapon
CISAC: Monitoring Nuclear Weapons and Nuclear Explosive Materials

**Weapons: Template Identification**

- Measure radiation signature
**Weapons: Templates Identification**

<table>
<thead>
<tr>
<th>Object</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warhead Type A, #1</td>
<td>0.8</td>
<td>92</td>
<td>32</td>
<td>7.7</td>
<td>42</td>
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<tr>
<td>Warhead Type A, #2</td>
<td>0.9</td>
<td>90</td>
<td>31</td>
<td>8.2</td>
<td>45</td>
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<tr>
<td>Warhead Type A, #3</td>
<td>0.8</td>
<td>91</td>
<td>32</td>
<td>8.5</td>
<td>45</td>
</tr>
<tr>
<td>Warhead Type B</td>
<td>496</td>
<td>0.8</td>
<td>140</td>
<td>336</td>
<td>491</td>
</tr>
<tr>
<td>Warhead Type C</td>
<td>63</td>
<td>43</td>
<td>0.9</td>
<td>34</td>
<td>128</td>
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<tr>
<td>Warhead Type D</td>
<td>11</td>
<td>102</td>
<td>26</td>
<td>0.6</td>
<td>46</td>
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<tr>
<td>Warhead Type E</td>
<td>55</td>
<td>174</td>
<td>86</td>
<td>31</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Compare with known templates**

**Protect data; indicate “match” or “no match”**

Diagram: Detector System → Computer Hardware and Software → Data Barrier → Unclassified Display

Information Barrier → Classified Information → Template → Detector System
Weapons: Tags and Seals

- Tags uniquely identify objects
- Seals indicate tampering
Weapons: Monitored Storage

- Real-time monitoring of storage weapons, weapon components
Nuclear Explosive Materials (NEM)

- Basic structure of transparency & monitoring for NEM can be parallel to that for weapons & components:
  - comprehensive declarations of quantities & locations, plus info on chemical forms & isotopic composition
  - declarations of inventories of NEM surplus to military & civilian needs
  - provision for inspection of all declared facilities as well as of any undeclared suspicious activities
Nuclear Explosive Materials

- Transparency & monitoring can be made easier by reducing stocks & flows of NEM
  - accelerated down-blending of excess HEU for use as reactor fuel;
  - replacement of HEU fuels in research reactors
  - disposition of excess Pu by conversion to mixed-oxide fuel for civil reactors or immobilization with radioactive waste;
  - negotiated cutoff of production of NEM for weapons;
  - nuclear fuel cycles for civil reactors that minimize or eliminate vulnerability of NEM;
  - centralization under international control of all facilities capable of enriching uranium or separating Pu.
Nuclear Explosive Materials

- Related measures that would assist international efforts to increase transparency & monitoring for NEM are:
  - Continued substantial improvements in national systems of MPC&A
  - Continued strengthening of the IAEA safeguards regime, including universal applicability of the Additional Protocol and increased IAEA manpower & funding

- Improved management & decreased inventories of NEM would become increasingly crucial if lower limits were agreed on total warhead stocks.

- While technologies exist to achieve greatly improved monitoring for NEM, a strengthened international consensus on the value of doing this will be needed to solve cooperatively the problems involved.
Clandestine Stocks and Production

• Undeclared weapons can be obtained by:
  – clandestine retention of existing weapons
  – manufacture of new weapons
  • clandestine retention of existing NEM
  • clandestine production of NEM
  – transfer of weapons or NEM from another state
Clandestine Stocks

- Tools for detecting clandestine stocks:
  - National Technical Means (NTM)
  - Human sources
  - Audits of records
  - Physical evidence ("nuclear archaeology")
    - overall uncertainty ~2% for Pu
    - state might confidently hide enough NEM for tens (China) to hundreds (Russia) of weapons
Clandestine Production

• Tools for detecting clandestine production:
  – National Technical Means (NTM)
  – Human sources
  – Environmental sampling

• In general, production of NEM difficult to hide

• US intelligence has detected every program, and identified production facilities, before significant quantities of NEM were produced
  – Soviet Union, China, Israel, India, Pakistan, South Africa, Iraq, North Korea, Iran