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HIGH-RESOLUTION COMMERCIAL IMAGERY AND OPEN-SOURCE INFORMATION: IMPLICATIONS FOR ARMS CONTROL[1]

Advancements in imaging and information-handling technologies worldwide constitute both a blessing and a curse to arms control which was never easy in terms of getting opposing sides to trust and verify. High-resolution commercial satellite imagery will offer views of virtually any location on Earth with resolutions from one to five meters, either as finished photographic prints or as data for soft-copy displays. An expanding wealth of open-source information is being published in both commercial and public data bases, as hard-copy or online through computer networks. Interested parties may acquire the imagery and open-source information through direct purchase or indirectly through research services. These new sources of information will allow more identifications of targets and activities worldwide than ever before and will thereby apply in varying degrees to arms control agreements. Government and civil groups around the world may use this new range of analysis either to support or to challenge verification and compliance procedures.

INTRODUCTION

Two maturing and expanding technologies of the information age offer both great promise and great complications for arms control. Satellite imagery that was once the exclusive domain of governmental intelligence agencies is about to become widely available to anyone who wants to spend the money. Imagery, data, and opinions from far-away places are now just an Internet connection away. The users of this knowledge and their purposes for using it will be varied.

This paper focuses on arms control treaties, but much the same open-source information challenge exists for the military, civil, and economic requirements of the U.S. Government. Military applications may involve activations of strategic offensive and defensive systems, deployments of conventional forces in-country or out-of-country, logistics movements, arms transfers, and general support to military operations. Civil applications could include resource monitoring and management, pollution and waste monitoring, natural disasters, environmental treaty compliance, and other long-term global trends. Economic requirements could include non-military production, energy resources and technology, agricultural assessments, and transportation analysis. Open-source information already has much to offer in these areas, and satellite imagery showing more details would be another welcome addition.

HIGH-RESOLUTION COMMERCIAL SATELLITE IMAGERY

High-resolution commercial satellite imagery (HRCSI) will offer much more detailed information than is currently

available from the Landsat and Spot Image systems. HRCSI will include resolutions from five meters down to one meter, with the one-meter imagery having the most interest for potential customers. The advent of HRCSI was the subject of a conference recently held in the Washington area.[2] More than 40 organizations advertised their products and services related to commercial imagery in general, but only a few companies were preparing to market HRCSI (table 1).

The new imagery will yield much more information from space than the public is used to seeing. Compared to Landsat's 30-meter resolution, one-meter imagery will offer 900 times more data for forming a visible image (fig. 1). Compared to the 20- and 10-meter resolutions of imagery provided by Spot Image, Inc., one-meter imagery will offer 400 and 100 times more data (figs. 2, 3, and 4).

Increased data from HRCSI will allow the analysis of commercial imagery to move beyond the mere general identification and location of large facilities to more detailed descriptions of buildings and physical layouts. More accurate measurements will be available for the length, width, and height of buildings and other objects of interest. For the first time, the general public will be able to detect the presence and/or absence of military vehicles (in garrisons, depots, or field deployments), detect the differences in length and width among really large items like naval vessels, certain jet aircraft, and mobile missile launchers. Table 2 provides a sampling of military targets and the resolution ranges that enable detection, identification, and description.

Table 1. Firms offering high-resolution commercial imagery.

Company	Satellite--Imagery Resolution	Anticipated launch Date
Israel Aircraft Industries	EROS-1 -- 1.8 meter	late-1995
	EROS-2 -- 1 and 1.5 meters	1997
Earth Watch (U.S.)	Earlybird -- 3 meters	early 1996
	Quickbird -- 1 and 4 meters	mid-1997
Orbital Imaging (U.S.)	Orb view -- 1 and 2 meters	mid-1997
Space Imaging	SIS-1 -- 1 and 4 meters	mid- to late-1997

In Table 2, it is interesting to note the range of resolutions versus target types and their relationship to the advent of HRCSI. Of the 80 resolution values, only ten were satisfied by the currently available low-resolution commercial satellite imagery and those satisfactions were confined to the concepts of detection and general identification for really large objects only. HRCSI adds 35, or more, satisfactions (highlighted in red), extending capabilities into the previously unavailable ranges of precise identification and description. After HRCSI becomes a reality, only identification and description of the more esoteric target types and detailed technical analysis of all target types will remain the exclusive domain of the "national technical means" operated by the U.S. Intelligence Community. While there is nothing inherently surprising in this trend, the rise in resolution satisfactions dramatically shows the loss of "privately held" information that the U.S. Intelligence Community will suffer because of HRCSI--information that could be applied to tasks like arms control. With more primary players in the information game, pressure will increase to be the first to use imagery-derived data, or at least do something with it. This then pressures secondary players to do more than they perhaps had planned.

The companies listed above have focused only on engineering and imagery science. The engineers build and operate the satellites that acquire the imagery data. Imagery scientists use mathematics and computer processing to produce visible images either as hard-copy photographic prints or as soft-copy displays on computer monitors. These companies are relying completely on other "value-added" companies or the customers themselves to perform the analysis of the imagery--extracting information from the imagery and converting the story into words. This continues the same data-versus-analysis standoff that has persisted over almost 25 years of low resolution commercial imagery from the Landsat and Spot Image series of satellites.

Table 2. Imagery resolutions (in meters) necessary for different levels of analysis on targets of interest to arms control.

TARGET	Detection[a]	General ID[b]	Precise ID [c]	Description [d]	Technical Analysis [e]
Bridges	6	4.5	1.5	1	0.3
Radar and Radio Sites	3	1-1.5	0.3	0.15	0.015
Supply Depots	1.5-3	0.6	0.3	0.03	0.03
Airfield Facilities	6	4.5	3	0.3	0.15
Rockets and Artillery	1	0.6	0.15	0.05	0.045
Aircraft	4.5	1.5	1	0.15	0.045
Missile Sites (offensive and defensive)	3	1.5	0.6	0.3	0.045
Surface Ships and Submarines	10-30	4.5-6	0.6-1.5	0.3-1	0.3-0.045
Nuclear Weapons Components	2.5	1.5	0.3	0.03	0.0015
Vehicles	1.5	0.6	0.3	0.06	0.0045
Minefields	3-9	6	1	0.03	n/a
Ports and Harbors	30	15	6	3	0.3
Railroad Yards and Shops	15-30	15	6	1.5	0.4
Roads	10-20	5	1	0.6	0.4
Urban Areas	60	30	3-5	1	0.75
Terrain	90+	30-90	4.5	1.5	0.75

Resolutions shown in Blue already available from the low-resolution commercial satellite imagery operations such as the American Landsat and the French Spot-Image systems.
Resolutions shown if would be available from the proposed high-resolution commercial satellite imagery systems that are the subject of this paper. [a] Location of a class of units, objects, or activity of military interest.

[b] Determination of general target type.

[c] Discrimination within general target type.

[d] Size/dimension, configuration/layout, components construction, equipment count, etc.

[e] Detailed analysis of specific equipment.
Table generally developed from references 1, 2, and 3.

The remote sensing industry put much technological effort into acquiring and processing the data from the early low-resolution remote sensing systems yet comparatively little into "interpretation" and dissemination of this imagery. The result was that the industry failed both to develop the broadest consumer base possible and to foster a generic appreciation of the potential of such imagery in the mind of the average citizen. To this day, only a comparatively small number of imagery professionals request and work the imagery data owing to the still-high cost of buying and processing data, the small number of imagery professionals currently working, and the limited usefulness of current low-resolution imagery systems. The rest of the potential U.S. and international customer base still seems to believe that space imagery is some sort of magic.

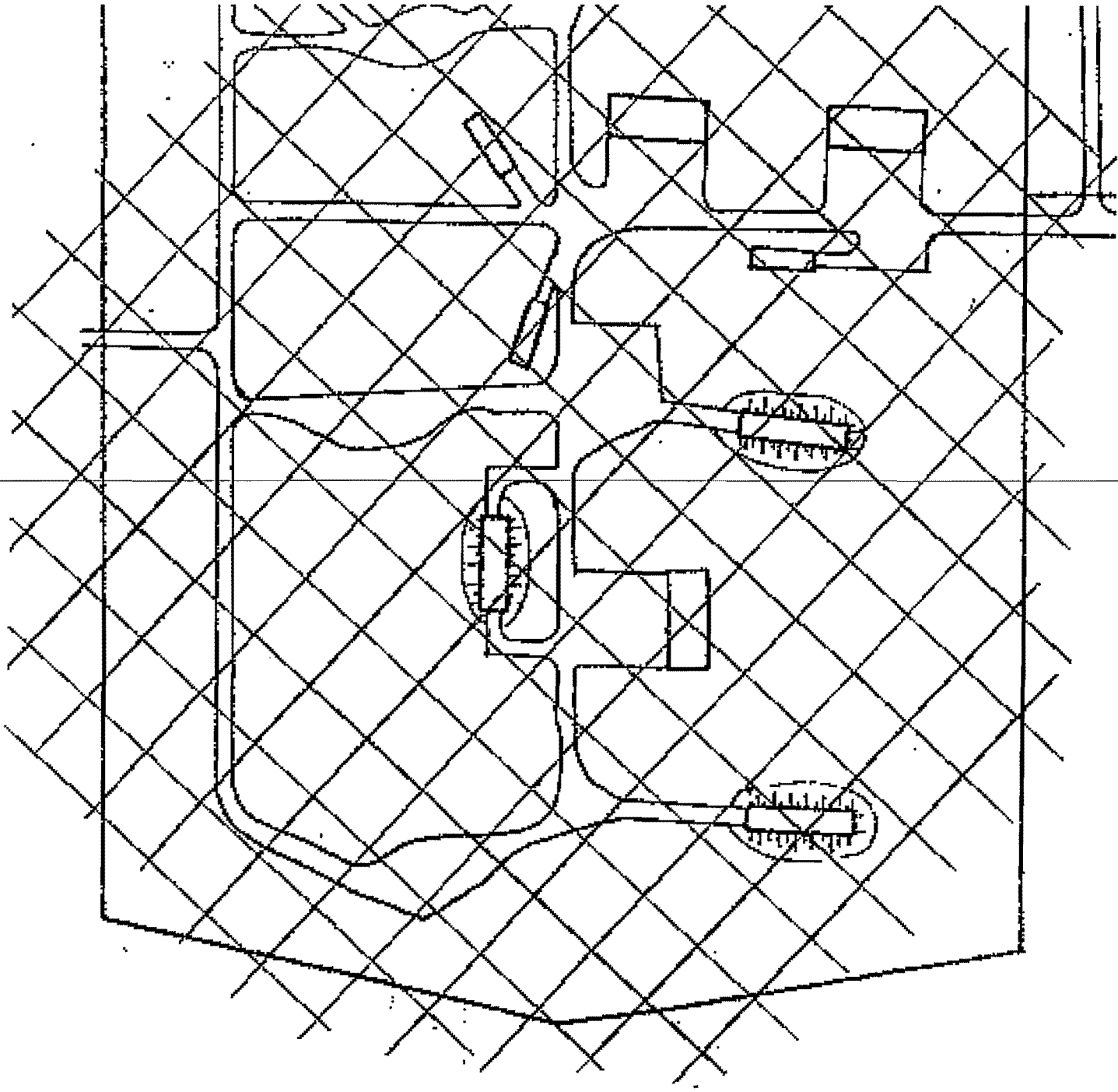


Figure 1. A portion of a Russian missile base with the 30-meter grid of the Landsat imaging system overlaid upon it showing the coarseness of the resultant imagery. The missile base diagram was one of the drawings made public with the Intermediate-Range Nuclear Forces Treaty.

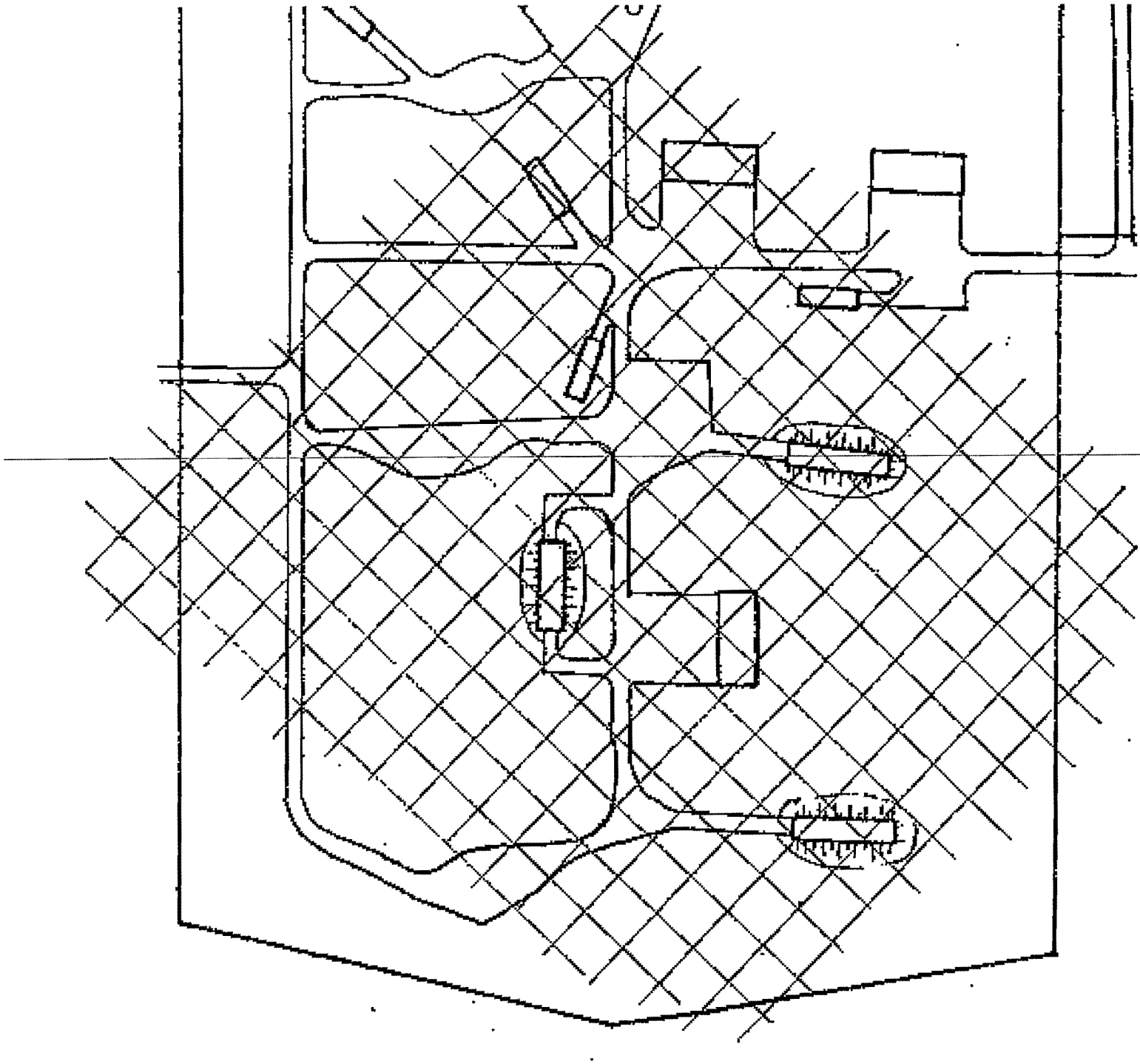


Figure 2. A portion of a Russian missile base with the 20-meter grid of the SpotImage system overlaid upon it, showing a better image that the Landsat resolution of fig. 1, but still a relatively coarse pattern.

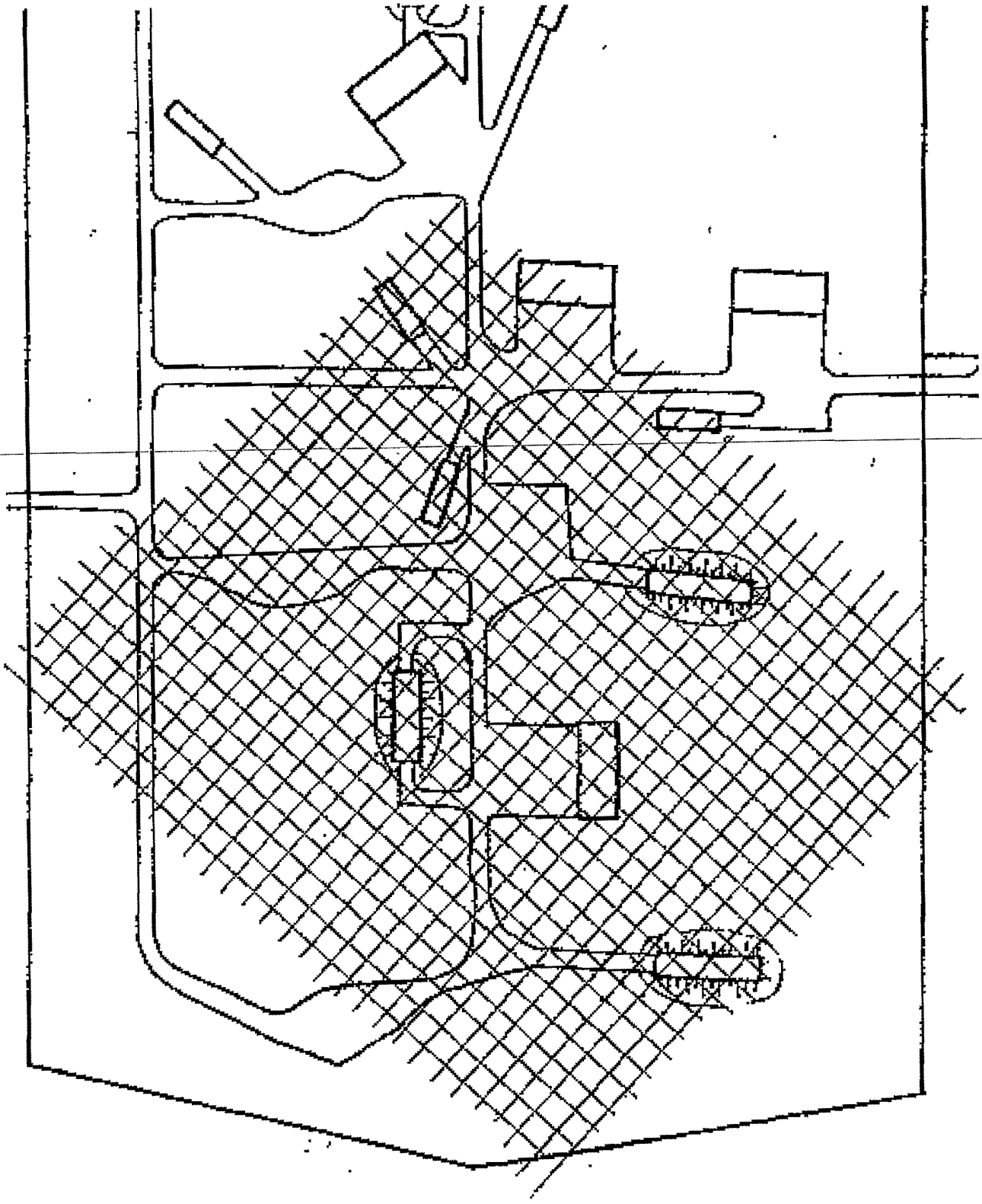


Figure 3. A portion of a Russian missile base with the 10-meter grid pattern of the SpotImage system overlaid upon it, showing yet a better image that in either figs. 1 or 2, but still a somewhat coarse image.

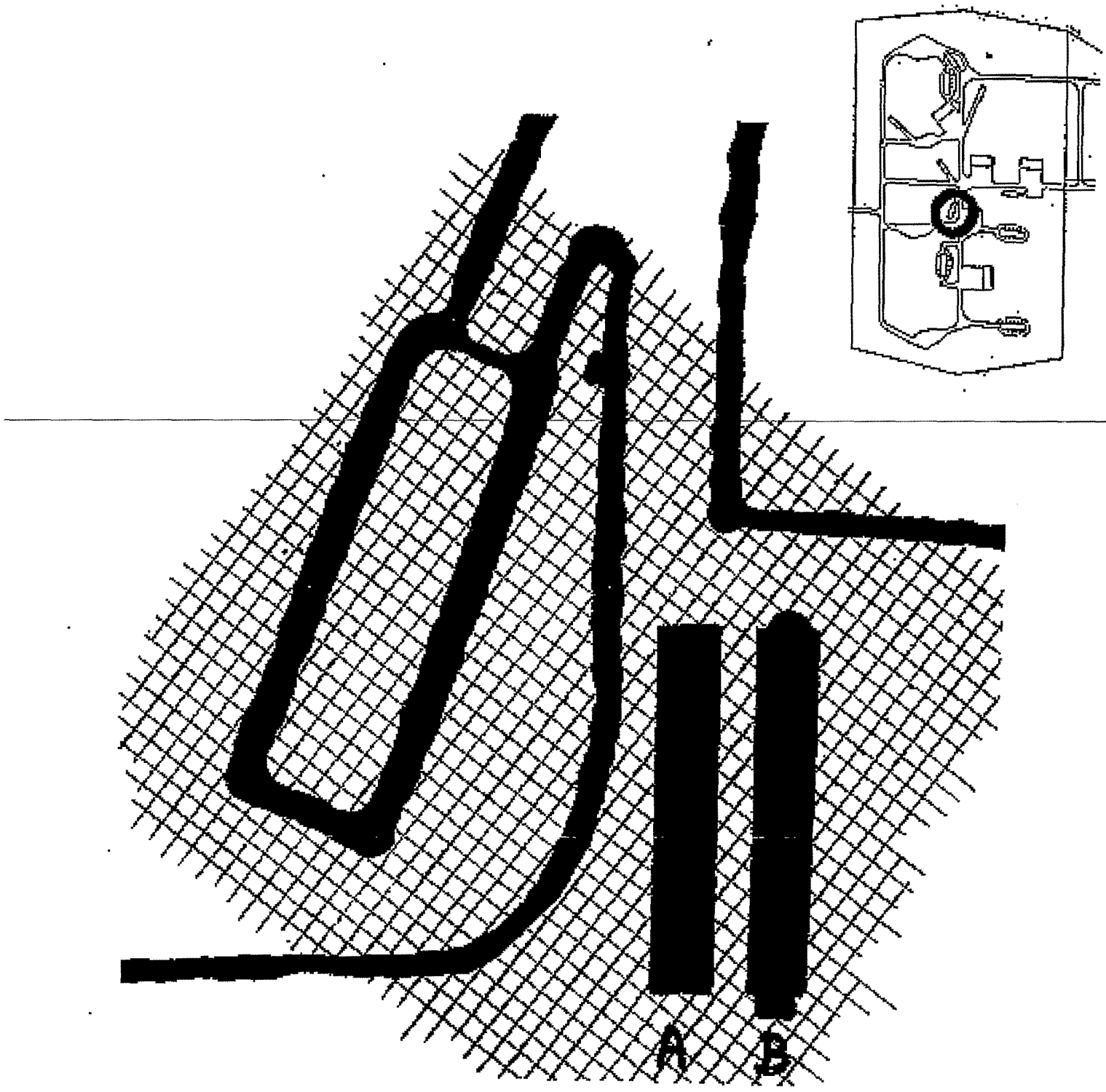
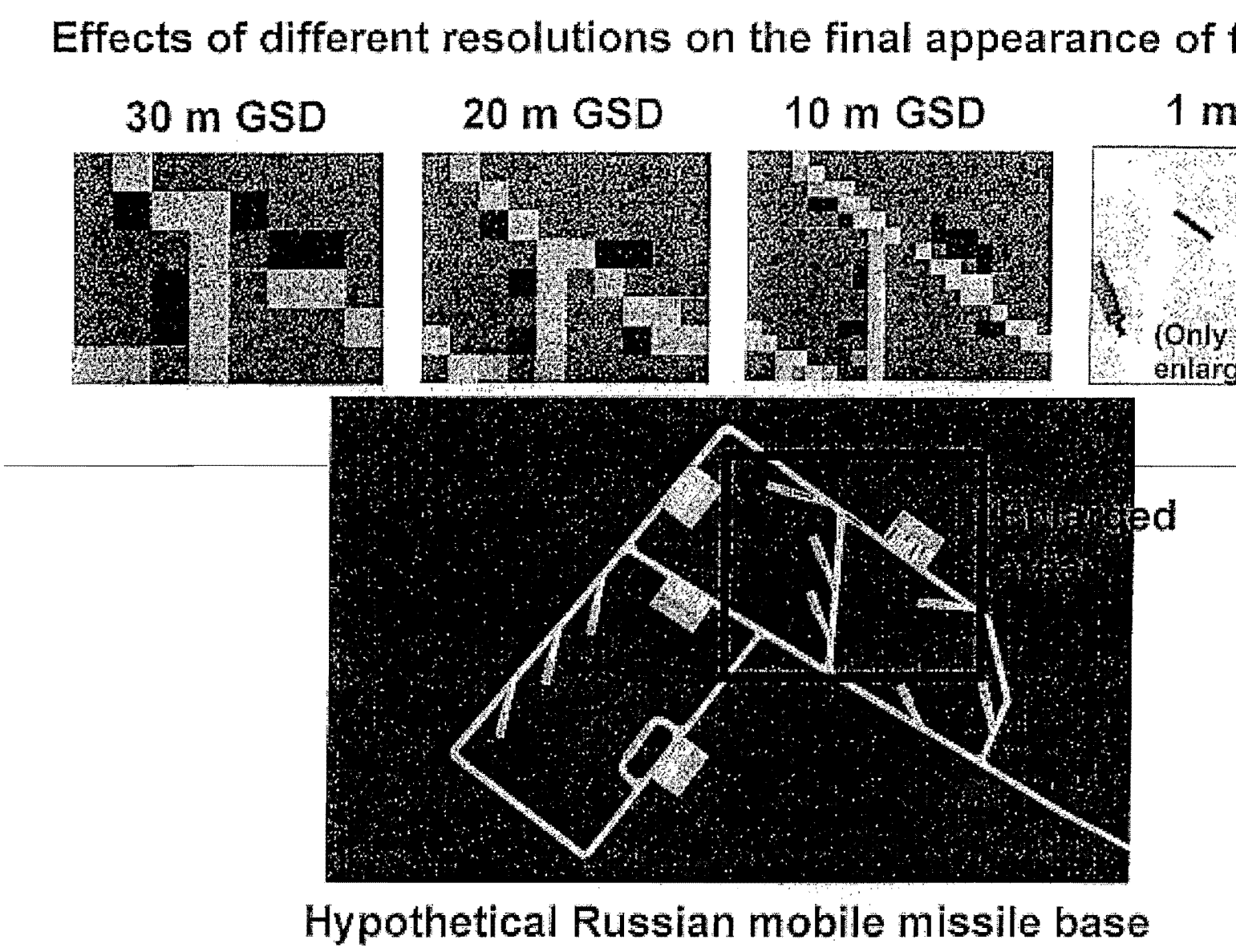


Figure 4. An enlarged view of a portion of the same Russian missile base shown in all earlier figures, this time with a one-meter grid pattern overlaid upon it. This approximates the level of detail that HRCSI would show. Item A is an SS-25 mobile missile launcher drawn to approximate scale, without its launch canister. Item B is the same launcher with the launch canister. The inset map shows the area of enlargement.



OPEN-SOURCE INFORMATION

Open-source information on the international level is merely an expansion of the relatively greater amount of information that Americans have always had available and generally taken for granted. A recent conference in the Washington, D.C., area highlighted the continuing expansion of international open-source information via hard-copy publications, CD-ROM packages, and online through the Worldwide Web and other computer networks[3] Thirty organizations advertised their products and services. Only one was a U.S. governmental organization; 22 were private contractors and organizations offering access to scores of databases, most of them their own in-house creations. Seven of the organizations offered personal computer hardware and software to facilitate queries, retrievals, and information integration.

The databases and products collectively contain numerous citations about equally numerous topics. Arms control, military equipment and issues, aeronautical and aerospace developments, and basic science and technology are examples of topics most important to this paper. One example from this group would be the Teal Group databases and publications on world military and civil aircraft, world missiles, military electronics, U.S. defense and aerospace companies and agencies, U.S. defense business, and the U.S. defense budget. Of interest to arms control are databases on politics, regional issues, commerce and economics, finance, leadership analysis, and medical data.

One open-source publication publicized at the conference was a hard-copy newsletter entitled the *Risk Report.* It is

published ten times a year by the Wisconsin Project on Nuclear Arms Control and specializes in tracking weapons of mass destruction. For example, the May 1995 issue focused on China as a missile market place, emphasizing the technical capability of China's main missile systems and their threat potential. The same issue also featured information on China's rocket and missile factories, China's nuclear proliferation to Islamic countries, and China's sales of poison gas ingredients to Iran.

Another publication featured at the conference was OSS Notices, the monthly newsletter of Open Source Solutions, the sponsor of the conference. A 31 January 1996 issue of the newsletter provided three pages of short summaries of relevant national and international events or opinions, 15 pages of announcements of new databases and services, and 11 pages of references and services. The newsletter also advertised forthcoming meetings and conferences. For example, the 31 January issue featured 32 announcements of open source-related meeting across the United States and Europe during the rest of 1996.

For too long and in too many ways the United States and its Intelligence Community have relied on the false notion that no one else can "know and understand as much as us." Three unrelated media reports, before and after the open-source symposium, highlight the folly of this notion and demonstrate the breadth and speed of open-source information and its relevance to worldwide considerations about arms control:

--A U. S. embassy report from Moscow described a Worldnet interactive satellite television interview on 5 February 1996, concerning prospects for ratification of Start-II by the Duma of the Russian Federation. At least eleven Russian arms control experts, including Ambassador Yuriy Nazarkin who negotiated the Start treaties, and two American experts shared views that were broadcast live around the world.

--An article in a Washington newspaper described the gist of a recent U.S. National Intelligence Estimate (NIE) on the ballistic missile threat to the United States during the next 15 years. The classified information was provided by a U. S. congressman who chose to disregard the security implications of the NIE because he disagreed with its contents and wanted to publicize what he called its "outrageous politicization"-making public what was tightly held just a short time before.

--A short article in a leading technology magazine emphasized the speed with which Russian computer users were able to master western programs. The significance of that report was the ability of certain Russian engineers to adapt to the computer applications without training. The further implication is how easy it will be for the rest of the world to do the same with modern computer and communications technologies.

IMPLICATIONS FOR ARMS CONTROL

With the potential to upset the balance between information held by government and the private sector, HRCSI and open-source information have two basic implications for verification and compliance of arms control treaties. We judge the new range of public information will affect some treaties a great deal (helping or interfering) and will have little effect on others.

We believe the treaties most likely to be affected include:
--Intermediate-Range Nuclear Forces (INF)
--START-I
--START-II
--Conventional Forces Europe (CFE)
--Anti-Ballistic Missile (ABM).

At present, the INF Treaty is the only arms control agreement that resulted in the release of the full range of weapons systems-related data to the public domain. This included--for both the United States and Russia--equipment photographs, base diagrams and locations, and technical details of all treaty-related missile systems. These data were released to the public because all INF-related systems were to be eliminated.

In contrast, detailed locations of treaty-related weapons systems were not made public for START-I, CFE, and ABM. These treaties emphasize control rather than elimination of weapons systems, and the United States and Russia did not want all information freely available to other countries, particularly China. However, the U.S. government published a generalized map for at least the START-I treaty. It would not take much concerted effort to use low-resolution imagery to delineate the locations of the bases and other complexes shown on the general maps, a follow-up research effort with HRCSI would yield descriptions of the bases and some equipment counts not previously available to the public. This new information would enable foreign governments and non-governmental organizations to begin to

compete with the United States and Russia in terms of access to detailed knowledge of the disposition of treaty-related weapons systems.

HRCSI and open-source information will likely have little effect on arms control treaties like the Biological Weapons Convention (BWC), Chemical Weapons Convention (CWC), Comprehensive Test Ban Treaty (CTBT), and Fissile Materials Cutoff Treaty (FMCT). These treaties involve facilities that could be imaged, but their names and locations are not often in the public domain. Beyond that, these four treaties are meant to monitor military-scale processes that involve equipment too small to be identified adequately on HRCSI. Furthermore, every production line or storage facility related to these materials is under some sort of roof, whether in a known, suspected, or totally clandestine facility. Open-source information, even if it were available and accurate, probably would have little more than transient, uncertain value. If some aspect of a country's illegal operations were compromised, the offending country would either relocate the work (if that were possible) or clamp down on physical and communications security and deny any accusations. For these treaties, the information-gathering capability of the U.S. Intelligence Community is likely to survive any serious challenge for supremacy for years to come, keeping the balance of the information in governmental vice public hands.

SCENARIOS

We will consider three scenarios we believe likely for the use of HRCSI and open-source information relative to verification and compliance for arms control treaties:

Best Case --Information that corroborates the U. S. position
Middle Case -- Information that neither corroborates nor refutes U. S. position
Worst Case -- Information that refutes the U.S. position.

In the best case, either the HRCSI or the open-source information or both would provide more material for traditional major players like the United States and Russia. Their intelligence professionals could use the publicly available information to show the facilities, equipment, processes, shipments, and other activities that confirm the U.S. position--pro or con--on some aspect of arms control verification and compliance. The activity in question may be a treaty-legal process taking place as required or scheduled, such as the close-out of a missile base or the destruction of treaty-limited equipment. The activity might be a violation that was unknown or perhaps suspected, such as the construction of an illegal missile base, other prohibited activity at a missile base or nuclear test site, or expansion of a biological/chemical facility not explained by commercial needs or previous announcements. The audiences for this information could include U.S. officials and agencies, foreign governments, the United Nations, and any of the international arms control monitoring groups--like the Organization for the Prevention of Chemical Weapons, the Standing Consultative Commission, the Joint Compliance and Inspection Commission, and the Special Verification Commission.

In the middle case, both the HRCSI and open-source information yield information that is less than conclusive, neither confirming nor denying a U.S. position. Some activity may be seen, but it may not be identifiable or repeated enough to establish any meaningful pattern. Some other information may be heard or passed along, but it is circumstantial by itself and has little or no chance of being proven one way or another. Ambiguity persists and rumors abound.

In the worst case, HRCSI and open-source information provide clues or a whole story that contradicts a U.S. position. The United States may claim a violation of some aspect of an arms control agreement without declassifying the information necessary for substantiation. Information that clearly refutes the U.S. position may come from an international news organization, a graduate school, a think tank, or any other special-interest group. Whether the publicly held information is correct or complete will be beside the point; the open story says there is no problem, and the U. S. position says there is a problem.

And the worst of all worst cases would be an official U.S. position that states that something has not taken place or could not happen when publicly available evidence shows clearly that it has happened. The publicity will reveal that the U.S. position was based on less than full evidence, calling into question the quality of Intelligence Community analysis and the billions of dollars invested in its technical collection of data.

Two additional factors are at work in these scenarios, one in opposition and one in favor. The factor in opposition is the expense of building and maintaining the organization that orders, processes, and analyzes the HRCSI and open-source information. It is true that imagery and image-processing costs are less than they once were and the

capacity of electronic data-handling is vastly more than before, but the reality is that the expense is still high. The hardware, software, AND data still cost upwards of a million dollars to acquire for an initial setup and as much as a few hundreds of thousands of dollars annually for a decent level of operational capability. And the human factor in this open-source analysis costs more thousands of dollars. Bits and pieces of information may be easily affordable to some individuals, but a whole story, and its sustaining infrastructure, has costs. These are only to be borne likely by customers with very deep pockets, such as corporations or heavily funded foundations that could sustain such a non-profit venture.

The factor in favor is the pressure that HRCSI and open-source information can bring to bear on the normally lengthy process of intelligence analysis. For analysis to be done correctly, the best information must be patiently gathered, sorted, and written up so as to make the reporting as solid as possible. Since World War II, the Intelligence Community has had a relative edge on treaty-relevant information--having weeks, months, or years to work the data, as fast or as slowly as its analysts and managers saw fit. As HRCSI and open-source information become available in a profit-oriented market (read speed-oriented market), their mere presence creates a previously unknown form of competition for the Intelligence Community. While analysts can always write any sort of story faster, the issue of the accuracy of WHAT they write looms larger and larger. At some point, the middle and worst case scenarios would begin to predominate, and then the Intelligence Community begins to lose some of its hard-won credibility.

OUTLOOK

HRCSI and open-source information are two maturing technologies whose time is almost at hand. The quantity and quality of the information those two sources may yield relevant to verification and compliance of arms control treaties will vary widely. In any form they will represent the most significant challenge that the U.S. Intelligence Community has faced to date in terms of competitive analysis by foreign governments and non-governmental organizations. There is little doubt that the classified information provided by the "national technical means" of the U.S. Intelligence Community will continue to give it the final edge on most determinations of treaty-related activities, but competition is beginning to grow.

The "business as usual" approach long applied by U.S. intelligence analysts in their information-rich isolation will be a thing of the past. Federal budgetary reductions will force a smaller corps of government analysts to try to maintain some semblance of their corporate capability in the face of the increasing mass of open-source information. Intelligence Community supremacy in the realm of information availability and handling will be challenged as never before.

Endnotes:

[1] This note was written by Graham T. Richardson and Robert N. Merz of IVI/ITA in response to a request from Sallie Mullen, Director of IWITA. The subject matter was derived from unclassified sources. Questions should be directed to Mr. Richardson at 202-736-4457 or Mr. Melz at 202-736-4702.

[2] *Land Satellite Information in the Next Decade,* 25 - 28 September 1995, held at the Tyson's Corner Sheraton Premiere, Vienna, Virginia, and sponsored by the American Society for Photogrammetry and Remote Sensing, the National Aeronautics and Space Administration, the U. S. Geological Survey, and the National Oceanic and Atmospheric Administration.

[3] *"Global Security & Global Competitiveness: Open Source Solutions, "* 4th International Symposium, 7 - 9 November 1995, Washington, D.C., sponsored in part by Open Source Solutions, Inc.

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1. US Senate. 1978. Senate Committee on Commerce, Science, and Transportation, NASA Authorization for fiscal year 1978, pp. 1642-1643.

2. McDonnell-Douglas Corporation. 1982. *Reconnaissance Handbook,* p. 125.

3. Florini, Anne M. 1988. "The Opening Skies: Third-Party Imaging Satellites and US Security," in *International Security,* Vol. 13, No. 2 (Fall 1988), pp. 91-123.

4. Gupta, Vipin. 1995. "New Satellite Images for Sale," in *International Security,* Vol. 20, No.1 (Summer 1995),

pp. 94-125.

5. US Central Imagery Office. 1995. Presentation at conference, *Land Satellite Information in the Next Decade,* September 25-28, 1995.

6. Miscellaneous information garnered by the authors from the two conferences cited earlier in this paper.