September 3, 1998

The Honorable Tom Daschle
Democratic Leader
United States Senate
Washington, DC 20510

Dear Mr. Leader:

In response to your request of September 17, 1997, the Congressional Budget Office is examining the budgetary and security consequences of a wide range of nontraditional cooperative arms control measures that might improve nuclear security between the United States and Russia. As you requested, we are providing the interim results of the analysis. The enclosed document examines the security and budgetary implications of improving Russia's access to early-warning data to reduce the chances that Russia will launch a nuclear strike on the basis of erroneous information.

The full scope of your request will be addressed in a forthcoming CBO study. Other measures examined in that analysis will include de-alerting nuclear forces, ensuring that Russian nuclear materials do not leave the country and that Russian scientists do not aid rogue nations, and enhancing the transparency of nuclear stockpiles and warhead dismantlement.

If you wish further details on these results, we will be pleased to provide them. The CBO contacts are Geoff Forden for policy issues and Raymond Hall for costs.

Sincerely,

June E. O'Neill

Enclosure

cc: The Honorable Trent Lott
Majority Leader
United States Senate

The Honorable Strom Thurmond
Chairman
Senate Committee on Armed Services

The Honorable Carl Levin
Ranking Minority Member
Senate Committee on Armed Services

The Honorable Jesse Helms
Chairman
Senate Committee on Foreign Relations

The Honorable Joseph R. Biden, Jr.
Ranking Minority Member
Senate Committee on Foreign Relations

IMPROVING RUSSIA'S ACCESS TO EARLY-WARNING INFORMATION: PRELIMINARY RESULTS

At dawn on January 25, 1995, researchers from the National Aeronautics and Space Administration (NASA) launched a Black Brant XII missile skyward from an island off the coast of Norway, hoping to learn more about the Northern Lights. As the rocket climbed, it was picked up by a Russian radar installation 470 miles away at Olenegursk, Russia. To the Russians, the trajectory could have been that of a Trident missile launched from a U.S. submarine. Such a single missile launch might be intended to blind Russia's early-warning radars to a massive first strike, which even then could have been just below the Earth's horizon and minutes away from disabling Russia's Strategic Rocket Forces. Within minutes, Russia's nuclear command and control system was placed on a higher level of alert, and President Yeltsin activated his "nuclear briefcase" in order to be able to issue launch orders if necessary. During that time, the fate of the United States depended on the Russian president's making the right decision even though he could not be certain that Russia was not under a surprise attack.

What if this event had occurred during a moment of political crisis, when Russian and U.S. forces were already at a high level of alert? Could nuclear war have been triggered through a faulty interpretation of incomplete data? What can the United States do to lessen the chance of an unintentional nuclear attack? At the request of Senator Tom Daschle, the Democratic Leader of the Senate, the Congressional Budget Office (CBO) has examined ways that the United States and Russia can reduce the dangers associated with nuclear weapons outside the framework of the Strategic Arms Reduction Treaty (START). Specifically, CBO has looked at measures that reduce the likelihood of an unintended nuclear attack—a possibility that has received considerable interest recently as information about Russia's aging nuclear command and control system becomes available.

CBO is examining two very different approaches to reducing the chance of an inadvertent nuclear war. The approach discussed in these preliminary results—simply because the data were more quickly assembled—strives to improve Russia's confidence that it is not under attack by providing Russia with a global awareness of missile launches. CBO has explored various ways of lending technical assistance to Russia to eliminate these shortcomings.

The other method, which has received considerable attention in the press and among academics, involves a series of steps the United States and Russia could take by reducing the alert status of their nuclear forces. That process has become known as "de-alerting" and will be examined in the final CBO study on nontraditional approaches to increasing nuclear security.

The United States solved the technical problems of detecting missiles from space almost 30 years ago. The resulting systems used sophisticated sensors capable of scanning the Earth's surface and detecting the infrared radiation—light invisible to the human eye but given off by heated objects—emitted by a missile's hot exhaust. The systems also used advanced data processors to help them distinguish a missile from the natural backgrounds, such as bright sunlight reflected by high clouds, that obscure the view of the missile. Russia appears to lack the technologies needed to make such sophisticated detector systems that are capable of operating in space.

Various methods have been proposed for improving Russia's early-warning system. Concerned that the Year 2000 problem will seriously affect Russia's early-warning computer system, Deputy Secretary of Defense John Hamre has suggested that the United States send Russia information from U.S. early-warning satellites. In fact, Presidents Bill Clinton and Boris Yeltsin signed an agreement on September 2, 1998, to do just that. Others have emphasized the importance of Russia having its own highly capable system. Those proposals have centered on lending some form of technical assistance to improve Russia's satellite-based system.[1] Measures aimed at improving its ground-based radar system would not instill the same levels of confidence. Ground-based systems within a country's border are inherently limited in coverage regardless of any improvements. A space-based system would enable the Russians to know whether an attack has been launched.

CBO has examined five options for improving Russia's access to early-warning information. The options differ in the amount of autonomy Russia is given to improve its early-warning system and in how rapidly the improvements can be made. In general, the solutions that can be implemented more rapidly give Russia less control over the resulting system and therefore less confidence in the system's reliability. That is an important consideration, since increasing Russia's confidence is the goal of these efforts.

Because early-warning systems are critical for protecting the United States, any effort to assist Russia must include special precautions to ensure that the security of those systems is not compromised. If not done carefully, sharing data or technology might reveal vulnerabilities, if they exist, of U.S. early-warning systems. At least in theory, Russia could exploit those weaknesses to launch a surprise attack. In addition, Russia might be able to use the shared technology to improve its military capabilities in other, unintended areas. CBO has tried to indicate the areas of concern for each approach. Those concerns must be balanced against any benefits the United States receives from decreasing the chance of an accidental nuclear war.

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1. One proposal for providing technical assistance to the Russians was developed by Theodore Postol of the Massachusetts Institute of Technology. In a 1998 briefing to CBO staff, Postol advocated lending technical support to help Russia develop its own system.

HOW DOES IMPROVING RUSSIA'S EARLY-WARNING CAPABILITIES BENEFIT THE UNITED STATES?

Shortcomings in Russia's early-warning system can have a direct effect on the security of the United States. After the collapse of the Soviet Union, the United States became increasingly worried about the Russian military's ability to manage its nuclear command and control system. The Congress discussed the possibility that a renegade Russian unit might initiate an unauthorized nuclear strike. More recently, attention has turned to an even more catastrophic threat: an authorized strike mistakenly launched by Russia's leaders in response to a false alarm.

The United States has long been aware of the dangers posed by false alarms. For example, several incidents in 1979 and 1980 precipitated increased levels of alert in U.S. nuclear forces and air defenses.[2] The most serious of those incidents were ultimately judged to be false alarms—caused by either human or mechanical errors—when the U.S. national command authority checked the raw data from its global early-warning sensors. Russia's early-warning system may have been at least as vulnerable to false alarms as the U.S. system was during the Cold War. Some analysts feel that Russia's economic difficulties and the concurrent degradation of its early-warning system make such false alarms even more probable today than during the Cold War.

Experts disagree, however, about the implications of the Norwegian rocket incident. Many analysts in the United States worry that if a similar incident occurred during a time of political crisis, a Russian leader might order a "retaliatory" strike. Conversely, some Russian analysts have argued that the incident proves that their command and control system works, since they did not launch a nuclear strike.

An analysis of tracking data supplied by NASA reveals a number of similarities between the trajectory of the NASA rocket that Russian radars would have detected and a hypothetical U.S. Trident missile launched to blind Russia's early-warning radar system. The perceived threat was presumably not that the missile's warhead would destroy Russian radars or command centers, since the rocket and all its discarded stages were moving away from Russian territory. Rather, the Russians probably believed that the missile, if it was nuclear tipped, would detonate high in the atmosphere. The resulting nuclear cloud would have obscured the Russian radars' view of any more incoming missiles.

Nevertheless, Russia's early-warning system should have shown a number of inconsistencies with that interpretation. The similarities were clearly enough to

2. U. S. Senate, *Recent False Alerts from the Nation's Missile Attack Warning System*, Report of Senator Gary Hart and Senator Barry Goldwater to the Senate Committee on Armed Services (October 9, 1980).

cause concern at Russia's early-warning center, but it is not clear whether the inconsistencies would have been sufficiently apparent to reassure Russian leaders during an international crisis, even though they were apparent in January 1995.

Having a capable space-based early-warning component in their command and control system would have reassured the Russians that they were not under the threat of a surprise attack. It would also have reassured them that even if the NASA rocket was designed to black out local ground-based radars, Russian leaders would still not have been blinded. As discussed below, however, Russia's current early-warning satellite systems may not be capable of such global coverage.

WOULD U.S. TECHNICAL ASSISTANCE HELP RUSSIA'S EARLY-WARNING CAPABILITIES?

The open literature identifies a number of deficiencies in Russia's ground- and satellite-based early-warning systems. The breakup of the Soviet Union left several of Russia's radar installations on what is now foreign soil (in Latvia and Kazakhstan, for example). According to an agreement between Russia and Latvia, the Russian-operated radar station in Latvia is scheduled to begin shutting down on September 1, 1998. Even if Russia's other radar stations are still operational, Russia's early-warning radars will not detect all missile attacks, especially missiles launched on shallow trajectories from submarines.

Russia's satellite-based early-warning system also has shortcomings. One of its two deployed satellite systems is dedicated to watching for missiles launched from the continental United States. Those satellites are in highly elliptical orbits that allow the use of less sophisticated sensors—by positioning the satellite to view missiles against the black background of space—but even under ideal conditions, they provide, on average, a view over U.S. missile fields for only a quarter of each satellite's orbit. At present, the fleet of satellites does not give complete 24-hour coverage.

Russia has six of those satellites in its fleet today: five were launched between 1993 and 1995, and the sixth was launched this year. Using orbital parameters supplied by NASA, CBO has estimated that this fleet currently provides coverage of the U.S. missile fields for less than 17 hours per day. Thus, Russia cannot depend on its fleet to detect a U.S. missile launch.

The coverage could be significantly less. CBO's estimate of 17-hour coverage assumes that all satellites perform optimally. However, most of the older satellites have stopped maneuvering to maintain their position and have drifted far from their original orbits. As the satellites drift, their viewing time is greatly

reduced. The fact that the Russians have allowed them to drift so far might indicate that the satellites' sensors are not working.

The other component of Russia's space-based early-warning system is in geostationary orbit—an orbit so high it takes 24 hours to complete one circuit around the Earth and, hence, the satellites appear fixed over the same spot. Those satellites have, at best, a very restricted view of the Earth's surface because their sensors are small. Furthermore, because of the locations chosen for those satellites, they cannot detect ballistic missiles launched from large areas of the Earth's oceans—areas where the missiles carried by Trident submarines are within striking range of Russian targets.

The area of the Earth's surface that a sensor can view is directly related to the number of detector segments—or pixels—that can be formed along its length. Russian émigrés to the United States who worked on the initial development of Russia's early-warning satellite system have reported that as late as 1978, Russian sensor arrays were one-hundredth the size of U.S. early-warning sensors.[3] The Soviet Union appears to have made steady technological progress through the 1980s. Western studies of Soviet scientific publications have identified improvements in the quality of sensor materials used in research. By 1992, Russian reports indicated that Russian scientists were producing sensors comparable in size with sensors the United States flew in outer space during the late 1970s.[4] However, neither the extent to which the largest sensors had moved from research labs to the production line nor the sensor's ability to withstand the rigors of outer space is clear from those reports. In interviews with several U.S. space scientists collaborating with Russian colleagues, CBO learned that the industrial base needed for the production of large, reliable, space-qualified sensors in Russia still lags far behind that of the West.

WHAT ARE THE CONCERNS IN AIDING RUSSIA'S EARLY-WARNING SYSTEM?

Sharing early-warning data or technology with Russia raises several important concerns. If not done carefully, such arrangements might reveal vulnerabilities in U.S. systems. Russia might also use the shared technology to improve military capabilities in other areas. The nature of the concerns will depend on the details of the assistance. CBO considered three instances in which Russia might use any knowledge or technology transferred in unintended applications: using information

3. See, for example, Boris Kagan, *Soviet ABM Early Warning System (Satellite-Based Project M)* (Falls Church, Va.: Delphic Associates, 1991), pp. 88-90.

4. Vladimir Khryapov and others, "Optical Sensors," *Optical Engineering,* vol. 31, no. 4 (1992), pp. 678-684.

gained to circumvent current or future U.S. early-warning satellites, using a capable Russian early-warning satellite system as part of a missile defense network, and using the information gained to improve air-to-air missiles. The technical aspects of those issues are discussed below, as are some non-security-related objections to sharing early-warning technology.

The United States has always considered data related to its early-warning satellites to be extremely sensitive. Armed with enough knowledge about the U.S. system, another country might exploit the system's limitations to plan a nuclear attack. Any option based on existing U.S. early-warning satellites (currently DSP, for Defense Support Program, satellites) would need to protect such information. However, the United States already has procedures in place to share early-warning information generated by DSP satellites with some allies. Those procedures are designed to protect sensitive information. Since the United States tailors the information it shares today, it could do the same with information given to the Russians.

Sensors used today have evolved considerably since the first DSP deployments. Modern sensors use different materials and have different properties, such as greater sensitivity, than do sensors used in the 1970s. But the United States found those old detectors acceptable. Thus, options that permit Russia to buy certain sensors could give it sufficient detection capabilities without revealing sensitive information about current U.S. systems.

Some analysts worry that a complete early-warning satellite system similar to the one the United States deployed in the 1970s could be used, at a very primitive level, in an antiballistic missile system. Such a warning system would not have the accuracy needed to direct interceptor missiles to an incoming warhead, but it could be used to cue air defense radars where to look—much as the United States plans to use cueing with its Patriot missile batteries. Since Russia's existing ground-based early-warning radars already probably provide better cueing information, improving Russia's early-warning satellites could have a minimal effect on its ability to actively defend against ballistic missiles.

Other Russian military systems also use infrared. Such systems could, in principle, benefit from knowledge gained from the sensors and data processors that might be transferred—inadvertently improving Russia's short-range air-to-air missiles, for example. Russia's short-range air-to-air missiles, however, already match, or perhaps even exceed, the capability of U.S. short-range missiles. The technology the United States would transfer from the older space-based early-warning system might represent no improvement over current Russian missile technology.

Russia might be better able to use improved data processor technology to help the capabilities of its air-to-air missiles. But whether that knowledge could be applicable to an air-to-air missile trying to distinguish between an aircraft and multiple decoy flares is not clear. Today, on-board computers are predominant factors in determining an air-to-air missile's capabilities, including how well it can overcome countermeasures. An early-warning satellite's on-board data processor is highly specialized: it performs the same simple task a large number of times in a very short period.

In any case, Russian scientists and engineers are aware of the technologies used in both sensors and data processors. What Russia appears to lack, as discussed above, is the technological infrastructure to manufacture them. Allowing Russia to purchase individual components could therefore have a very small effect on other military applications.

A study of actual accidents involving nuclear weapons suggests that adding more warning systems does not necessarily increase safety.[5] Indeed, the greater complexity of additional sensors could, according to that analysis, add more avenues for failure. Some of the analysts who share that view believe that reducing the number of nuclear weapons is the only way to decrease the chances of inadvertent nuclear war. CBO will examine those issues and how they relate to de-alerting in more detail in the forthcoming study.

Other analysts have concerns not related to security. Some disagree with the need to help Russia with its early-warning system. They claim Russian leaders have already decided how much an early-warning system is worth to their security and are funding it at what they consider to be the appropriate level. Others maintain that assistance to Russia should be judged in terms of how much it improves the security of the United States.

HOW COULD THE UNITED STATES TRANSFER THE REQUIRED INFORMATION OR TECHNOLOGY?

CBO has constructed five alternatives intended to illustrate ways to help Russia improve its access to early-warning information. When constructing options to transfer technology, CBO has assumed that Russia lacks the industrial base needed to produce large, space-qualified infrared detectors and signal-processing computers. Space-qualified electronics are highly reliable and can stand the harsh environments encountered both during launch and in high Earth orbit. Those components are not

5. Scott D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, N.J.: Princeton University Press, 1993).

"off-the-shelf" items, but they can be bought commercially from firms both in the United States and in Europe.

At the same time, the increased access to Russia's space complex since the demise of the Soviet Union has made it clear that Russia's space and rocket scientists can develop some systems that equal or exceed the technical sophistication of U.S. systems. CBO has therefore assumed that Russian space institutes are fully capable of integrating Western sensors and data processors into Russian satellites. In its options that involve technology transfers, however, CBO has included U.S. experts to advise Russian scientists. Those experts could facilitate and accelerate Russia's use of Western technology. Such assistance might also serve to build Russia's confidence that the United States was not contemplating aggression, much like similar contacts between U.S. and Russian nuclear weapons scientists have accomplished in Department of Energy programs.[6]

Russia's government and space institutes may not have the resources to take advantage of Western technology in a timely fashion. CBO has therefore developed several options that illustrate the spectrum of financial assistance the United States might provide to Russia. That assistance ranges from paying the salaries of scientists and engineers who are working on developing those satellites at space institutes to purchasing hardware and Russian launch services. Both the Department of Energy and the Cooperative Threat Reduction programs within the Department of Defense have developed methods of accounting for such support by requiring status reports and other "deliverables" before payments are made.

The options developed by CBO are roughly ordered by the increasing autonomy that Russia would have in developing its satellites. Options 2, 3, and 4—in which Russia buys sensors and signal processors from the West—are about equally intrusive. They differ, however, in the level of funding the United States provides Russia's space institutes. The order of the options also roughly reflects the time needed to improve Russia's access to early-warning information. Options that can quickly provide Russia with that type of information offer less autonomy, and options that allow Russia to develop its own satellites take longer to implement.

Option 1: Share Early-Warning Data

The United States can quickly and inexpensively provide data from U.S. early-warning satellites. The data can be filtered and slightly time-delayed so that sensitive information is not revealed.

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6. These contacts are often referred to as lab-to-lab contacts and have been chiefly undertaken to improve the safety and security of Russia's fissile material.

As Deputy Secretary of Defense Hamre has suggested, the United States could consider sharing that information with Russia at least for a limited time. But since the data first pass through U.S. ground facilities, Russian leaders could still have doubts about whether the United States would actually warn them of a U.S. attack. This option can be put in place very quickly—in roughly a year—because the United States already has similar agreements with several of its allies and much of the infrastructure is already in place. Indeed, Presidents Clinton and Yeltsin agreed on September 2, 1998, to share early-warning data about launches of ballistic missiles and space launches around the world, an approach that could be similar to the one illustrated in this option. Based on data provided by the Department of Defense, which has experience with other data-sharing agreements, CBO estimates that giving Russia information from U.S. early-warning satellites could cost roughly $5 million over five years and, after that, have a recurring cost of about $200,000 a year (see Table 1).

TABLE 1. COSTS OF IMPROVING RUSSIA'S ACCESS TO EARLY-WARNING INFORMATION (In millions of dollars)

Option		Total Cost[a] (1999 to 2003)
1	Provide data from U.S. early-warning satellites.	5
2	Waive U.S. export controls and allow the sale of sensor and data processor equipment to Russia.	1
3	Implement Option 2 and also fund the salaries for personnel at Russian space institutes that develop and fabricate the early-warning satellites.	60
4	Fund development, hardware, and other costs, including launch services using Russian space launch vehicles.	1,340
5	Fully fund a joint research venture between the United States and Russia to explore the technology needed for the next generation of satellites.	190

SOURCE: Congressional Budget Office.

a. Option 1 would incur annual costs beyond 2003 of about $200,000. Since Russia is assumed to pay operating costs for an indigenous system, the other options incur no costs beyond 2003.

Option 2: Transfer Technology

The United States could waive export restrictions to allow the sale of specific space-certified detector and on-board data processing technologies. Direct lab-to-lab contacts would help Russian scientists use the technologies.

This option allows the United States to control the level of technology transferred to Russia. Furthermore, Russia would assemble the satellites and do extensive tests of any components purchased from the West to verify the components' reliability. Based on how long it took the Soviet Union to develop its first early-warning satellite system, this option could provide Russia with a working satellite system within five years. CBO estimates that this option could cost $1 million over five years, mainly to support the lab-to-lab contacts.

Russian space institutes may not receive the financial backing from the Russian government to take advantage of this assistance in a timely fashion. Instead, those institutes might devote a higher priority to the Western commercial interests that are already providing them with much-needed hard currency. Recent examples of this problem are the two modules that Russia is building for the international space station. The module financed by Western firms appears to be on schedule, but the one financed by the Russian government is not, apparently because of financial difficulties. The next two options address this problem by increasing the extent of financial assistance.

Option 3: Pay Russian Scientists

In addition to Option 2, Russian institutes could receive U.S. funding for personnel to develop and fabricate more capable early-warning satellites themselves. Direct lab-to-lab contacts would be made to help transfer the knowledge needed for developing the technologies.

Russian space research institutes have been adversely affected by the economic troubles the whole country has suffered in recent years.[7] As a result, projects funded by the West appear to receive a higher priority at those laboratories than even Russian military projects. For instance, a Russian newspaper recently blamed the failure of a geostationary early-warning satellite—launched April 29, 1998—on the diversion of resources to non-Russian projects.[8] The article reportedly

7. Maxim V. Tarasenko, "Current Status of the Russian Space Programme," *Space Policy*, vol. 12, no. 1 (1996), pp. 19-28.

8. "Russia Loses New Early-Warning Satellite," *Aerospace Daily*, July 20, 1998, p. 104. The article cites reports on July 15, 1998, in the *Kommersant Daily*.

mentioned a Japanese project involving the landing of a statue of Buddha on the moon. Having the United States fund the salaries of Russian scientists and engineers involved in developing their own early-warning systems would allow the institutes to devote the requisite time and resources. It could provide Russia with a working satellite system within five years. Using the costs associated with the contracts Russian scientists and engineers have with the Department of Energy, CBO estimates that this option could cost roughly $60 million over five years.

Option 4: Fully Fund Russian Project

The United States could accelerate Russia's acquisition of early-warning satellites by fully funding their development, construction, and deployment (using Russian space launch vehicles) in Russia.

Russia would be able to purchase the sensors and other components from Western firms. Russian scientists would still test and assemble the satellites from the components. The costs of satellite systems make this option substantially more expensive than the previous options, but complete U.S. funding would ensure that the system was developed and deployed as quickly and effectively as possible. CBO estimates that this option could cost $1,340 million over five years. That estimate reflects the costs of the hardware the United States uses in its DSP satellites; it also reflects the cost of using Russian launch vehicles, which are much less expensive than Western launch vehicles.

Option 5: Fund Russian Research into Next-Generation Technology

The United States can help Russia develop an indigenous next-generation early-warning satellite by funding Russian research. Russian and U.S. scientists have already established a joint venture, known as the Russian American Observation Satellite (RAMOS) program, to explore the backgrounds likely to be encountered by the next generation of early-warning satellites. The United States could fund 100 percent of that research, including Russia's half, thereby accelerating the completion of this project.

In contrast to the previous options, this assistance would help Russia develop its own sensors and data processors. Such assistance would represent a minimal level of intrusion into Russia's early-warning system. It would also present a very low risk of revealing sensitive information about the U.S. early-warning system. Since it is unlikely that Russia could develop a next-generation satellite from this information within the next 10 years, however, this option does not immediately solve the problem of Russia's decaying early-warning system.

Nonetheless, a 10-year delay increases the likelihood that Russia will improve its technological infrastructure to the point where it can produce the needed components. In the meantime, this option could foster trust between the two countries' early-warning establishments by increasing contact and cooperation while working to meet a common future threat—regional ballistic missiles. CBO estimates that completing the RAMOS project could cost $190 million over five years.

In summary, Russia's early-warning system is incomplete and does not provide the level of assurance that the United States has demanded from its own system for many years. The shortcomings in Russia's early-warning capability could be dangerous for the United States; a partially blinded Russia could mistake some benign event as an attack and launch a nuclear strike against the United States. CBO has explored a variety of different approaches to improving Russia's early-warning capabilities. Some could be done quickly and inexpensively but would give Russia less confidence than those that enhance Russia's ability to construct its own system. Options that provide more confidence are more expensive and will take longer to improve Russia's early-warning system. More than one of the options could be pursued simultaneously. For example, combining Option 1 with Options 2, 3, or 4 would quickly improve Russia's early-warning system and would increase Russia's confidence in the medium term by helping it to develop its own system. Adding Option 5 would help ensure that Russia's early-warning system continues to be effective in the long run. At the same time, any assistance raises important security issues that must be addressed in order to ensure that the U.S. early-warning system is not compromised.