Officials at SDIO headquarters are certainly saying the right words. The report has been sent to all contractors with a cover letter from SDIO director Lieutenant General James A. Abrahamson in which he calls battle management "the long pole in the tent," and adds that "The SDIO endorses the spirit and content of the report of the Eastport Study Group. It is found to be in harmony with the needs of the SDI program and its rapid implementation shall be pursued throughout the R&D effort."

The panel members themselves say they are quite pleased with the response. SDIO did not ask the panel for a yes-man report, says Seitz, and it certainly did not get one. "There was a very wide spectrum of political opinion on the panel," he says. "If anything, it leaned toward the liberal side. Furthermore, we felt very free to look at the whole problem, not just an isolated piece of it.

"Everything we've heard from SDIO suggests that they are listening," he adds. "In fact, they've threatened to take money away from contractors who don't listen."

Nonetheless, there is still plenty of room for skepticism. "The Eastport report calls for a profound cultural change in the way weapons contractors operate," says John Pike, a defense analyst for the Federation of American Scientists. But is that really happening? "To fully implement the Eastport recommendations," he says, "you would have to put all of SDIO's hardware projects and field demonstrations on hold for several years. Then you would concentrate your efforts on some very basic research into the fundamental concepts of ballistic missile defense, until you had the software problem completely worked.

"And yet," he says, "SDIO is still spending horrendous amounts of money on hardware. From a bureaucratic point of view you can see why they're doing it that way. Software isn't tangible, you can't show it to anybody. Hardware *is* tangible. But it means that inevitably you're going to get a situation a few years down the road when SDIO says, 'Hey, we've got all this neat hardware. Can you guys make it fit?"

For a long time, says Pike, there has been a big debate in the software community: Will battle management be workable in the 21st century? "Politically," he says, "one of the effects of the Eastport report may be to unite the software community behind the idea that SDIO is doing the wrong thing." ■ M. MITCHELL WALDROP

ADDITIONAL READING

Eastport Study Group, *Summer Study 1985: A Report to the Director of the Strategic Defense Initiative Organization*, December 1985.

R. J. Smith, "New doubts about Star Wars feasibility," *Science* **229**, 367 (1985).

Briefing:

Charge Density Waves Seen in Potassium

Because of their comparatively simple electronic structure, the alkali metals are sometimes considered a test-bed for understanding the behavior of electrons in solids. Concepts proven to be sound in such an uncluttered environment can then be extended to more complicated materials. A new neutron diffraction study of potassium, however, seems to support an old and controversial assertion that theorists have incorrectly treated some aspects of even the alkali metals. Physicists contacted by *Science* regard the finding as significant but would like to see it confirmed before calling the controversy settled.

The new study, reported by Tomasz Giebultowicz of the National Bureau of Standards (NBS), Albert Overhauser of Purdue University, and Samuel Werner of the University of Missouri at Columbia, provides direct evidence for the existence of charge density waves in potassium, thereby confirming a 1964 prediction by Overhauser, who also coined the term "charge density wave."

In brief, Overhauser had calculated that, when postassium is in its lowest energy or ground state, the free electrons responsible for potassium's metallic character do not remain uniformly distributed throughout the material, as the then current thinking held. Instead, the electron density varies sinusoidally with a characteristic wavelength (hence the name charge density wave) that is generally not an integral multiple of the crystal lattice constant.

The reason for the sinusoidal clumping of electrons is that it lowers their energy. In the jargon, the exchange and correlation energies are reduced. A consequence of the clumping is that the lattice undergoes a distortion in an attempt to reduce the huge electric fields generated by the separation between the positive charge of the potassium ions and the negative charge of the electrons.

Overhauser's ideas have never been well received, but in 1964 there were no experimental examples of charge density waves, so the question was somewhat academic. Some years later, researchers began finding a phenomenon like charge density waves in so-called layered materials, those in which the electrons effectively move in only two dimensions, and in linear conductors in which the motion is nominally one dimensional.

Instead of adopting Overhauser's explanation, however, solid-state physicists attributed the observations to another effect called the Peierls instability (after Rudolf Peierls of the University of Oxford), which automatically occurs in linear conductors, but they kept the name charge density waves. The Peierls instability also involves a lowering of electron energy and a lattice distortion but the mechanism, which depends on an interaction between the electrons and lattice vibrations, is different from that proposed by Overhauser.

In particular, both models allow for large effects in lower dimensional materials but the Peierls instability is thought not to occur in simple three-dimensional metals, such as potassium. The new neutron diffraction study is by far the most direct evidence for charge density waves in this material, although anomalies (see the Additional Reading for the most recent example) in several of its properties have raised the possibility of their existence. If confirmed, the finding means that theorists will need to modify their thinking about the complicated ways in which electrons behave in solids by incorporating Overhauser's ideas.

Neutron diffraction is so helpful because it is sensitive to the small displacements in the positions of the ions in the distorted crystal lattice. Near each Bragg diffraction spot there are much less intense satellite spots whose shape (intensity as a function of diffraction angle or, equivalently, momentum transfer) provides information about the distortions. In the case of potassium, not only are the satellite spots dim ($1/10^5$ as intense as the Bragg spot they are associated with) but they are so close to the Bragg spot that a very high resolution neutron spectrometer is needed to see them. In addition, a large, defect-free single crystal is needed, the growing of which is a major project in itself.

The difficulty of the experiment is the reason that it has taken so many years to come up with the evidence for charge density waves in potassium. The measurements, described as an experimental tour de force by one physicist, were done at the NBS neutron scattering center in Gaithersburg, Maryland. While there is little question about the data and although the most obvious alternatives to charge density waves seem inconsistent with the findings, physicists would like to see confirming evidence elsewhere. Other explantions may yet be found as well. "It's hard to rule out what hasn't been thought of yet," says Overhauser. ■ ARTHUR L ROBINSON

ADDITIONAL READING

T. M. Giebultowicz, A. W. Overhauser, S. A. Werner, *Phys. Rev. Lett.* **56**, 1485 (1986).

E. Jensen and E. W. Plummer, *ibid.* **55**, 1912 (1985).