

Air Force gets new, economy Buic

Third version of the backup interceptor control system has about double the air defense capabilities of predecessor network, costs but \$35 million

By James Brinton

Boston bureau manager

U.S. air defenses will get a lift later this fall when the Aerospace Defense Command takes delivery of the first of 15 improved Buic—backup interceptor control—systems at North Truro on Cape Cod, Mass. The price of Buic 3 is comparatively modest by the standards of military procurement—around \$35 million. But the system, which has considerably greater capabilities than its predecessors, is considered good enough to rate as a potential successor to the Sage—semiautomatic ground environment—air defense system, which will be phased out in the 1970's. Buic 3's technical excellence is all the more welcome in light of the fact that Pentagon planners have continually sliced funds from the program since it was first set up during the early 1960's.

Too close for comfort. Sage centers, which began going operational in 1958, were originally intended for defense against manned bombers and air-breathing missiles, and are located in or near the areas they're supposed to protect. With the development of intercontinental ballistic missiles carrying nuclear payloads, it became apparent that an enemy could wipe out with a single shot not only a key target area but its air defense system as well.

Accordingly, the Air Force began casting about for alternatives. Eventually, the service went for the Buic program, which locates control centers at long-range-radar sites located well away from important targets.

The first Buic system, deployed in 33 locations, was an interim, manual setup. But Buic 2, which was developed under the management of the Air Force Electronics

Systems division (ESD) at Hanscom Field in Bedford, Mass., was designed to be an austere replica of the sophisticated Sage.

Facilities

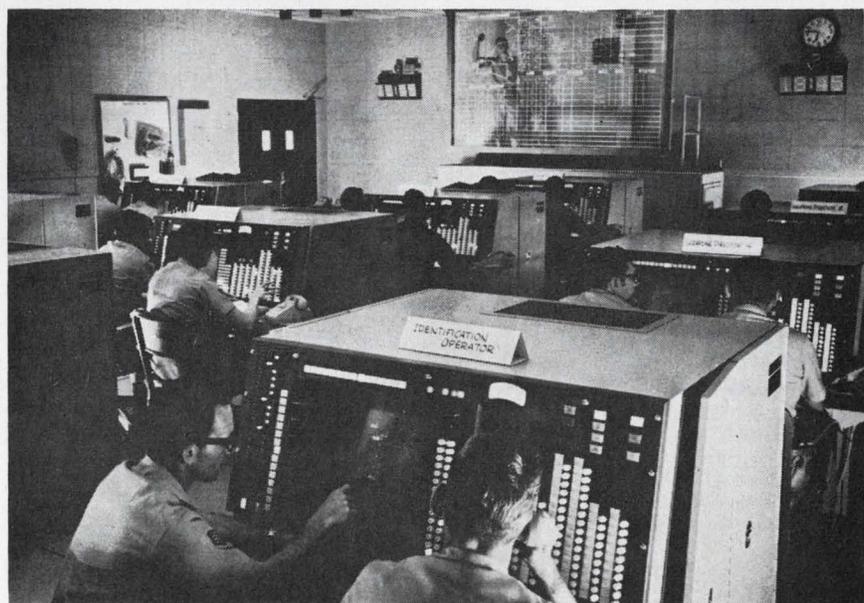
A Buic 2 center uses Sage radars, but it has its own solid state data processing equipment, built around the Burroughs Corp.'s D-825 general-purpose military computer. Five operator consoles with fast cathode-ray-tube displays are linked to the computer by communications lines.

Each center can manage an air battle over an adjacent Sage sector, as well as above its own terrain. Operators get a visual display of data stored by the computer, along with a continuous flow of new information from farflung airborne, shipboard, or ground-based sensors. The consoles are push-button controlled and of modular construc-

tion to facilitate interchanges in case of breakdowns. Each unit is fully capable of air surveillance, weapons control, direction of air battles, and simulated training exercises.

Scramble. When Sage radars pick up a target, the Buic 2 center accepts the inputs from the sensors, generates tracking information, and displays the data on the operator consoles. The system can check regional weapons availability and determine whether interception is possible. Once prelaunch and firing commands have been issued, the system can calculate and transmit guidance data to interceptors, whether aircraft or missiles.

Though a technical success, Buic 2 got caught in the switches of a Pentagon economy drive. So, after \$140 million had been invested in hardware, the number of installations was frozen at 13. However,



Overview. In a dry run, console operators scan Buic 3's tv-like displays for track and intercept data, as well as the status of retaliatory forces.



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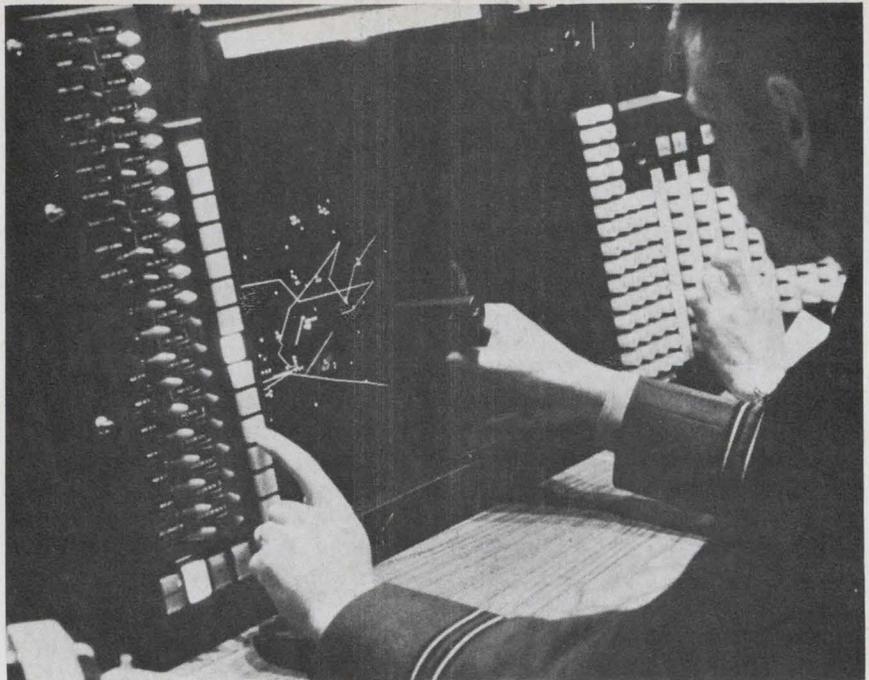
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Test case. An officer practices air-defense routines at display console of Air Force's Buic 3 system; first facility goes operational this year.

during 1964 and 1965, before the first Buic 2 site had been activated, the whole program got a thorough going-over. Eventually, defense officials sent ESD and the Mitre Corp., which was doing the systems engineering work, back to their drawing boards to get more mileage out of the hardware that had been bought. As a result, a lot of engineers were wearing two hats, performing acceptance tests on Buic 2 and drawing up design specifications for a follow-on system.

Added attractions

When Mitre and ESD finished their specifications on Buic 3—amid a crescendo of groans from project managers over further cutbacks and a lack of manpower, sympathy, and the like—a number of additions had been made. There are, for example, more operator consoles (making a total of 11 at some sites, 10 at others), another message processor, another tape unit, eight core memories instead of six and an additional drum memory.

"With more memory, more consoles, and a greater capacity to communicate, Buic 3 can handle two or more times the number of tracks, as well as manage twice as much weaponry," says Capt. Joseph F. Elefritz, ESD's project manager.

James C. Naylor, Mitre's Buic 3

project leader, believes the console changes are more significant than those made in the data processing gear. "At least they took more effort and resulted in a noticeable enlargement of the system's capabilities," he says.

Wider choice. Almost all of the logic in the consoles has been modified in some way, according to David B. Fleury, an assistant site engineer from Burroughs. But probably the most important change is the use of 49 categories of incoming information rather than 15, as in Buic 2 units. Operators can now call up more information on displayed features or geographical references, targets, and the like.

Information written on a drum for relay consoles is tagged with a nine-bit identification code. Throwing the console's category selector switches filters some data out and passes some through to the display. Some information is sent to a console with a specific mission, say, weapons director, because of the computer program, but category switches give the operator some discretion as to what he observes. There's an "only" position for each category that keeps all other data off the screen.

In addition, says Fleury, there are new console address switches that can send information to a display that isn't programed for it.

Two group switches make it possible to select large numbers of categories at will.

Enhancement. The display is refreshed by repeated reading of the continuously spinning drum memory. Only a few delay lines are used to prevent jitter or other visible defects. "There isn't any memory capability to speak of in the consoles," says Naylor. "And because we serve 11 consoles from our drums, we refresh less often than in Buic 2. Thus our display flickers a little."

This flicker problem was a thorny one for a while, Naylor explains, because Buic 3 uses a light sensor gun to discriminate among various displayed features and to help initiate action against a "hostile." The pulse code used to distinguish the various types of data is transmitted to the gun by flashing phosphor.

"So we were stuck," Naylor says. "On the one hand, we needed a phosphor with long persistence for low flicker, and on the other, we wanted a fast rise time to get the code pulses on the screen clearly enough for the logic behind the light gun to decipher them. Eventually we came up with a mixture of P-12 phosphor, for persistence, and P-16, for rise time. We still get a little flicker, but the data codes come through clearly."

Gun shy. Naylor notes that only certain information can be handled with a light gun—a situation that tends to cut the number of operator

errors. For example, if an operator tries to dispatch an interceptor to shoot down a geographical boundary, rather than a hostile aircraft, the computer refuses to transmit the order and informs the operator of his error on a small cathode-ray tube to the right of the large display.

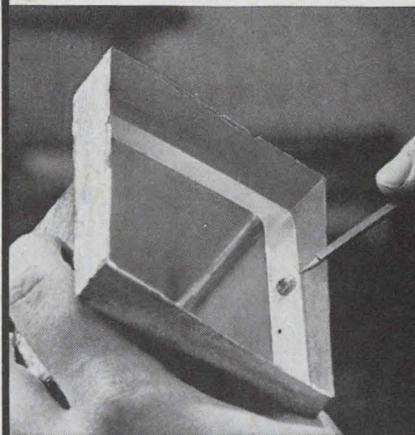
In addition, the computer can reject such goofs as committing weapons to a track (target) already being shot down by another operator. The machine can also tell the operator if the interceptor has too little fuel or lacks the speed to reach the target, or if the target is actually a friendly airplane. All this information appears in flashing letters on the message crt, along with instructions about how to rectify errors.

Naylor points out that Buic 3 consoles have feature selection switches that put track data on the display crt in alphanumeric form. This information includes the course, speed, and altitude of a target, notice of the dispatch of weapons to deal with the track, and symbols indicating when track is about to become the responsibility of an adjacent center. Buic 2 lacked this latter feature.

Next best

Outside the operator consoles, Naylor feels that the status display console in the data processing section is the most important new feature of the Buic 3. In the Buic 2,

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In the budget message and five-year program, presented to the Senate Armed Services Committee last January, Robert McNamara, then Defense Secretary, forecast that much of the U.S. air surveillance, warning, and control network could be phased out during the 1970's when Awacs (airborne warning and control system) and over-the-horizon radar become available. On the "to-go" list would be all but one of the Sage combat centers, all of the Sage direction centers and about half the search radars, all of the gap-filler and DEW (distant early warning) line radars, and all of the AEW/ALRI (airborne early warning/airborne long-range input) aircraft. Retained would be the Norad (North American Air Defense Command) combat operations center, a manually operated combat center in Alaska, 10 Buic stations, and some of the search radars and fire-control centers at Nike-Hercules batteries.

When Buic 3, which has twice the data processing, tracking, and display capacity of its predecessor system, got a green light in 1966, McNamara recommended that Sage be all but eliminated. Under the original plans, two Buic 3 systems would have been deployed in each of eight Sage sectors along U.S. borders; in addition, three other Sage sectors were to get one Buic system apiece. Subsequently, however, the total number of Buic sites was cut back to 15.

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Check point. Status display console rides herd on communications and data processing portions of the Buic 3; system serves as maintenance monitor.

information on how the computer was running and what was going wrong came to the facility maintenance monitor via Flexowriter. Now there's a board full of lighted buttons that not only indicates the status of the equipment at a glance but also allows the site personnel to conduct tests and simulate defense operations without having to use punched cards or keyboard instructions.

The new setup will speed repairs, Naylor observes. "The use of a utility computer program with simplified trouble printouts on the status display console helps the men find an error to within 13 to 15 circuit cards that can be pulled en masse and replaced," he says. "While all this is going on, the computer will switch over to some of the redundant components in the system."

But Buic 3 isn't home free so far as maintenance, Naylor feels. "It uses the relatively new and untried concept of error detection and recovery; this might be a big chunk of technology to digest immediately," he says. "I'm sure a computer expert could quickly learn how to work with the system, but the airmen have only 19 weeks of training in maintenance."

Progress report

Naylor maintains that the programs used with the D-825 are the

best possible for such a processor. There were software problems, though, growing out of the fact that the computer is a transistorized second-generation machine. In addition, the computer has to service more consoles, record and relay more data, and perform more data analyses, than it had had to in Buic 2 operations. The exact nature of the new software developed by the Systems Development Corp. is classified, but Naylor does state that "SDC solved a problem that there was no money left to solve, and in doing so pushed the D-825 to the limit of its capabilities."

Overcoming adversity. If Buic 3 had been properly funded, says Naylor returning to a favorite theme, the programing problem could have been solved more easily. Withal, the program's shortage of men and money forced two other innovations, he says. The first was an adaptation of existing Bell System modems that permits the transmission of double the amount of data per second than was previously possible. Since the extra speed really isn't as important as money in this case, the Aerospace Defense Command is switching some of its communications links from duplex to simplex lines. Naylor believes that when the change over is finished, the ADC will be saving approximately \$6 million a year.

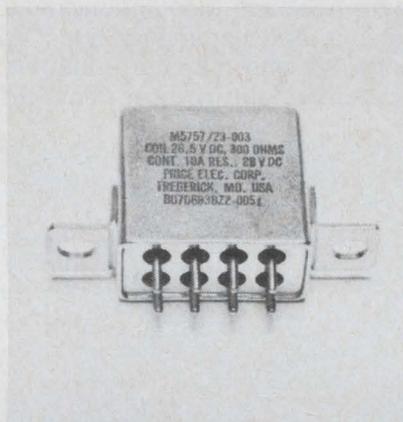
The other innovation is the application of systems engineering management techniques to the procurement of computer programs. Says Naylor: "In the late 1950's, software producers weren't required to meet performance standards. Now with SEM spec 3751 and ESD's Exhibit EST-1, software makers must show and tell just like the hardware people."

EST-1 includes a statement of test procedures and makes some tests the responsibility of the contractor, Naylor continues. "It's no longer a case of the software contractor writing a program and letting the buyer debug it; with EST-1 documentation, there are fewer bugs in the first place, and test instructions are included as a further protection to the customer." In reference to Buic 3, he says that "the use of EST-1 helped us escape several problems long before the scheme went into operation."

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