TechUpdate

Airplane factory staffed by robots is getting closer

Some elements on a computer-controlled robotized plant are already in place

By PAMELA WEINTRAUB

NEW YORK — There are skeptics — some of them in the aerospace industry itself — who doubt that a robot-operated factory will turn out airplanes by the year 2000.

But the Air Force and several aerospace companies are moving in just that direction, and at a rapid clip. They are investing millions of U.S. and company dollars in research that they say will make computer-directed, robot-operated aircraft factories economically and technically feasible.

The goal is a factory in which a master computer, at the apex of a hierarchy of lesser computers, orchestrates a workforce of seeing, moving robots in an automated manufacturing center that builds airframes from beginning to end.

According to the Air Force, robot development will advance in series of increasingly complex steps, each embodying a segment of the projected manufacturing center. When all the elements — including computer hardware and software, robot work cells and sensors that see and feel — have been developed, construction of a bona fide factory of the future can proceed.

Michael Moscynski, manager of robot efforts at the Air Force Materials Laboratory, said the biggest challenge will be the integration of the pieces. The robots, the sensors and the computers are more or less available, he said, but what's needed is a conceptual link to tie it all together.

The reason robots loom so large in the Air Force's effort to automate aircraft production is their flexibility. They can change jobs, producing one part and then another, up to six times a day, Moscynski said. This is critical in the aircraft industry — as it is in many other manufacturing businesses — where the number of units completed in a month can be counted by tens rather than by hundreds or thousands.

The robot effort is the most dramatic and visible part of a $75-million Integrated Computer Aided Manufacturing (ICAM) program directed from the Air Force Materials Laboratory at Wright-Patterson Air Force Base, Dayton, Ohio.

ICAM, nothing less than a microscopic examination of the manufacturing process, may result in the nation's first "unmanned aircraft factory" by the turn of the century. But the payback should begin almost immediately, as the bits and pieces come on stream.

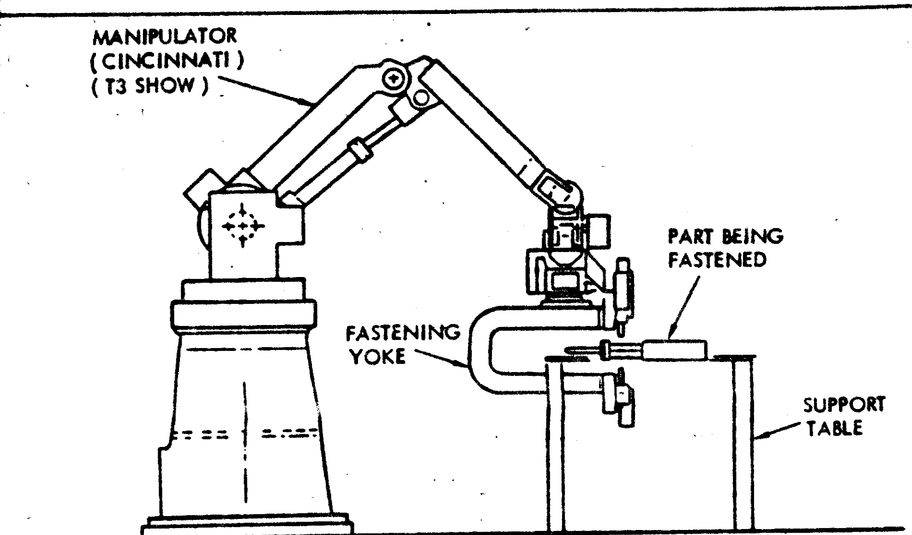
The Air Force predicts that within five years the broad program could reduce overall operating costs 25 percent. This includes a 40 percent improvement in machine utilization, a 35 percent reduction in needed floor space, a 50 percent reduction in shop floor labor, a 25 percent increase in throughput and a 50 percent increase in accuracy. If someone wanted to build a factory from scratch, Moscynski said, ICAM technology would reduce overall investment by 10 percent.

Robots, which get about three percent of the ICAM funding, should increase productivity by a factor of four where they're used.

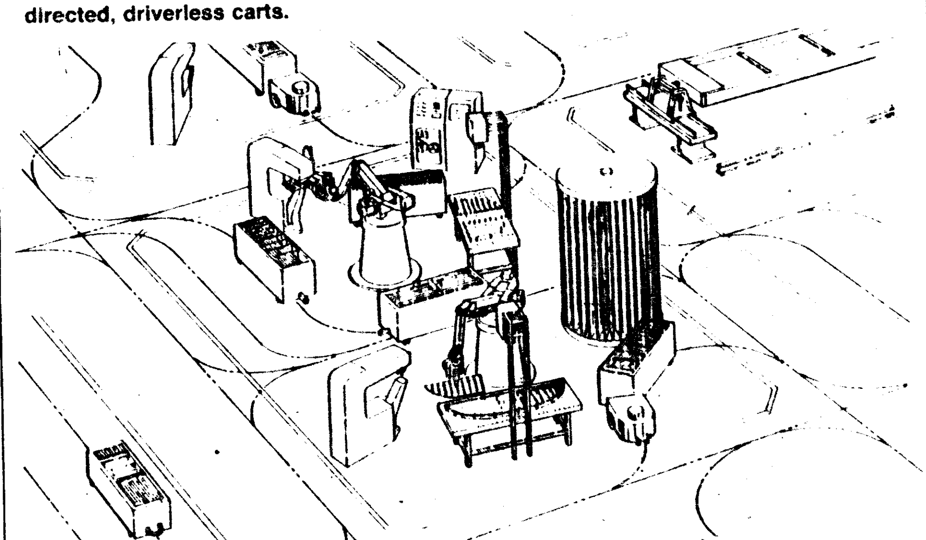
In the near term, General Dynamics Corp.'s Fort Worth, Tex., Aircraft division is working on a manufacturing center where robots will fabricate panels for the Air Force F-16 multi-role fighter aircraft. The center is to be completed by 1985.

More advanced projects are farther downstream. Lockheed Aircraft Corp.'s Lockheed-Georgia Co., Marietta, Ga., for example, is designing a robot cell that would assemble aircraft parts after they have been fabricated in an installation like the one taking shape at General Dynamics.

And the McDonnell Aircraft unit of



AUTOMATED ASSEMBLY — Lockheed-Georgia concept for automated assembly of aircraft components includes a robot-operated fastening system (above) with drill, riveter and camera system — used for both verifying position and for inspection of holes and rivets — mounted on a robot-held yoke. Below is one concept for an automated sheet metal work cell, with stock and workpieces transported by computer-directed, driverless carts.



McDonnell Douglas Corp. in St. Louis, Mo., will create a high-level computer language specifically for robots. Once it's developed, robots will use the language to speak with each other, machine tools and computers throughout the factory. This should culminate in an "Automated Sheet Metal Center" that binds each robot, machine and sensor into an entirely integrated factory where every action can be controlled and monitored.

When the three programs are finished, a technological synthesis will take place. At that point, the industry will know enough about the inner workings of its own manufacturing process to automate it almost entirely.

According to Gerald Ennis of McDonnell Aircraft, the projected robot-run manufacturing center is based on a concept called "distributive control."

That means, he said, that computers distribute instructions down through a series of increasingly simple computers which ultimately manage a workforce of "intelligent," microprocessor-controlled robots, machine tools and sensors.

The "workforce" in almost any manfuacturing center would be divided into work cells, each dedicated to a particular kind of task. The best example of this is probably the robot cell in operation at General Dynamics right now.

According to Dean Golden, director of that project, the company is using today's

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technolgoy with a few modifications. A single robot drills holes and trims edges on F-16 access door panels. The robot in use, a T-3 Cincinnati Milacron unit, can more or less emulate the human arm. It represents just one station in a mile-long manufacturing center that might include seven robots fabricationg 90 percent of the aircraft body parts by 1985, Golden said.

In addition, a second Milacron T-3 at Fort Worth is drilling about 550 holes in the graphite-reinforced plastic vertical tail fin for the F-16. It does the job in about two hours. Doing the same work manually takes three men eight hours.

But that robot not, part of the ICAM program, belongs to a joint Air Force-company plant modernization program administered through the Air Force's F-16 program office (AMM/MN, Jan. 21).

In the ICAM program, two more robots are to go into action in a few months, Golden said, and three others are currently being adapted and refined at General Dynamics' laboratories. After that, the company may acquire two to four additional robots that would fabricate parts for F-16 wings. And, robots that paint finished parts would be next on the agenda.

The aircraft panels to be fabricated will be divided into groups or "families" in accordance with the concept of "group technology," Golden said. In that manufacturing system, each part family — determined by similarities in shape, size or machining steps — will go to a specific cell with a specific robot programmed to deal with the general group "type." Because robots can move through endless variations, seven of them will theoretically produce hundreds of shapes.

But in reality, there are still a few problems. For one thing, robots aren't manufactured with end effector tools accurate enough for use in aerospace, where two thousandths of an inch can be crucial. So, Golden said, General Dynamics has developed its own robot tools,including drills with "limit.

switches" that signal the computer when a hole is completed.

Even more important, microprocessors in today's robots can't hold all the data points needed to drill thousands of holes, change tools for each operation and sense tool wear.

General Dynamics is supplementing the system with its own miroprocessor right now, Golden said, but the sharp nose dive in the cost of computing power may lead robot manufacturers to solve the problem for good in a few years.

Another kink emerges when production must be stopped for up to 20 hours while robots are manually "taught" a new task step by step. But, according to Gerald Ennis of McDonnell, this difficulty can be worked out with more computing power as well.

"Once we have the robot language," he said, "we'll develop programs on a mainstream computer and send instructions down through a series of processors to the robot." It will still take hours for a programmer to come up with the sequence of instructions, but at least the robot itself will stay in commission, while the program is written off-line.

In the initial McDonnell scheme, scheduled for completion this October, robots receive instructions from a computer also connected to a video system, a rotating table and automatic riveting machine.

After "searching" for the exact piece required, the visual sensor would "tell" the table to turn so that the robot could pick up a specific part and bring it to the riveter. Additional cameras would check to make sure that rivets were installed accurately to within a few thousandths of an inch.

According to the Air Force, the next step is development of yet another cell connected to the first by a still larger computer that coordinates the whole thing.

The upshot will probably resemble this scenario, proposed by Lockheed: Metal sheets stored in a major manufacturing center would travel -- by computer-directed driverless cart — to work stations where robots would use a variety of machines and tools to bend and cut material into shape. These "fabricated" sheets would then head toward assembly cells "manned" by mobile robots that rivet the sections together, using three-dimensional visual sensors for accuracy. The pieces would move on to still other assembly cells, where robots would fasten them to other, larger sheets. Computer-controlled cranes might eventually

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carry about 10 finished sections to a final assembly cell. where the entire airplane body would be put together — with the help of robots.

The Lockheed program is "the most future-thinking project of all." Moscynski said. because it addresses the role that robots can play in assembly.

According to Moscynski. Lockheed is just working up a paper study for ICAM. but the company has also begun to apply some of its ideas with three robots in a proprietary in-house program.

Lockheed said robots that do assembly in accordance with the above scenario would load and unload parts in storage. bring them to a holding fixture and then clamp them into place with the help of a camera on the robot "wrist."

The robots would drill holes. countersink rivets. install nuts. apply a sealant or weld while moving from spot to spot through the work cell on tracks. Simultaneously. the sensor — which measures the three-dimensional location of hundreds of thousands of points on the surface of an object in seconds — would check for accuracy.

So far. robots can pick up a panel and move it across an automatic riveter which installs fasteners. A near term goal would be assembly of C-130 cargo plane bulkheads. each with 38 detailed parts and about 160 fasteners. If robots can assemble that. Lockheed said. they can probably assembly anything.