A Quick Look at a Real-Time ATC Solution

This write-up is about Air Traffic control automation. The ATC environment is dependent on a real-time database. That database should contain the relevant data of the system updated to the latest second. Where is every aircraft (cooperative and **non-cooperative**), where is it going and at what speed? What flight plans exist, what are the current weather conditions, what is the minimum terrain, what flights are scheduled for arrival and departure at each terminal? Inconsistent data – like ***separate Flight Plan processing*** - must never be permitted. Trying to make separate parts of the real-time database converge into a whole has never been and never will be successful. The ATC database must be **completely coherent** at its start, and **performance must be completely predictable**.

With this predictable database such needs as route optimization, minimization of delays and cockpit display can be realized. Air to air conflicts and controlled flight into terrain can be detected and advisories issued to both IFR controllers and VFR traffic to correct problems as they are found. **NEXGEN** can become a reality - soon.

But – these capabilities are dependent on a simpler much more efficient computer capability than the multiprocessor in use today (or tomorrow). The multiprocessor has repeatedly, since 1963, been proven inadequate for the real-time ATC problem. Theorists declare ATC problems intractable when using the multiprocessor. Let's look at some examples of a ***different – simpler -*** technology that **is capable of managing our real-time ATM database problems today and tomorrow.** Especially ***note the instruction count.***

Example 1

ON TOP
By Richard Collins
"BACK TO THE FUTURE"
In "Flying" Magazine Dec. 1995 pg 16

"In November 1971, I flew to Knoxville, Tennessee, for a demonstration of a revolutionary new use of air traffic control computers. It was the first system to offer conflict alert plus the promise of low altitude alert. There was a potential additional benefit from the new equipment: automated VFR traffic advisories. You were given a transponder code that was identified with your aircraft. Then, in a computer-generated voice (not as good as they are today) the computer would automatically call traffic at five, three and one mile ranges. A VHF frequency was dedicated to this experimental service in the area. The information was based primarily on the Mode A transponder. Mode C (altitude reporting) was in its infancy at the time, but if both airplanes were so equipped the automated system would also give the altitude of the other aircraft. Once the threat had passed, the voice would let you know that the traffic was no longer a factor."

The system also provided direction to traffic "***traffic 3miles at ten o'clock***". Terrain avoidance was implemented in December 1971. It worked as specified. An aircraft was automatically advised: ***"terrain 2 miles at flight level 31***."

In addition to the functions mentioned in Collins' note, the AP was **automatically** initiating and tracking all primary and secondary radar targets, and was providing display data for all traffic. The AP was programmed with about three man-years of effort, and had less than 2,800 instructions. It was a predictable **single thread instruction stream** (**STIS**) machine.

I was project engineer on the Knoxville experiment, and I can state, unequivocally, that **what was done in Knoxville in 1971 cannot be done in any ATC system in our country today.**

Example 2

Based on the Knoxville experiment, Goodyear Aerospace, designed, fabricated and programmed an improved version of the Knoxville computer. This new machine, called the STARAN associative processor (**AP**), had much more capability and was programmed to function as a complete ATC system. It could **automatically** track 500 primary radar targets. Secondary radar was used for identification and altitude reporting. It contained all the functions of the Knoxville system plus flight plan and display processing.

Programming STARAN was started on Jan. 4, 1972 and six programmers wrote about 7,600 instructions before the hardware was delivered to Dulles Field on May 15th for the 1972 International Air Show. It used Suitland radar data for the demonstration. It performed all its design functions in less than 8% of available time, and contained simulation routines that demonstrated the very high-speed performance capabilities of the technology.

The real-time database management system at Knoxville and in STARAN used a **single thread instruction stream** architecture to achieve the performance demonstrated. The key is the simultaneity achieved. **One instruction--hundreds of simultaneous operations.**

Example 3:

Based on the success of the AP in '71 through '73, the U. S. Navy, in 1977, started a development program to design an AP for their airborne early warning command and control system in the E2C aircraft. Their goal was to be able to automatically track 2,000 aircraft based on 4,000 primary radar reports. The problem was predicted to require about 173.3 milliseconds in the AP. Grumman engineers programmed the correlation and tracking solution to "assure" equivalent performance. The measured time was 113.8 milliseconds. The AP (called ASPRO by the Navy) became the repository for much of the E2C real-time database.

Janes.com reported about the E2C

"The early 1980s saw the introduction of the Group 0 standard with the AN/APS-138 radar ………..entered US Navy service in 1988 as part of the E-2C Group I package. Other enhancements **included ASPRO adjunct processors to improve track management and display processing functionality,…"**

And Janes.com described **ASPRO**:

" Enhanced High Speed Processor - To handle the increased radar track file and required expansion of display symbol capacity, a high-speed parallel processor is incorporated into the mission computer which expands the active track file by 400% over Group 0. The enhanced high-speed processor equipped L-304 computer allows the E-2C the capability to process more than 2000 tracks."

These references were removed from Janes.com when ASPRO was replaced by an "off the shelf" system. As in FAA ATC, the tracking requirements for the E2C had to be changed. They were reduced by 333%, from 2,000 to 600 tracks.

ASPRO occupied a space of about 0.42 cu ft (including power supply and battery backup). More than 150 units were delivered to the Navy starting in 1983.

ASPRO could have easily satisfied the AAS requirements, thus eliminating the need for multiple ATC development programs. **Billions** of dollars would have been saved while achieving full functionality.

The aircraft tracking performance shown in ASPRO, using hardware designed in 1978 **cannot be realized in any ATC system in the Nation today!**

AP performance in the ATC problem is **predictable**. Multiprocessor performance for ATC **is not predictable**. All theoretical studies declare the multiprocessor solution intractable.

The capability of the AP is difficult to understand because it is so simple.
(*We all know computers are supposed to be complex.)*

The AP can predictably manage the real-time database in NEXTGEN. There is not a predictable multiprocessor ATC database management system available in the world at this time. Theorists state that such a system is unlikely.

The AP has been demonstrated repeatedly!

The AP can improve ATC performance starting very soon!

I'd like to discuss it with you. I can be reached by phone at 678-450-4413, by email: willcm@charter.net or by postal service: Will Meilander, APT 1110, 3801 Village View Dr. Gainesville, GA 30605.