Alaska's Capstone Program

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Capstone is a joint effort by the FAA Alaskan Region and the aviation industry in the state to improve aviation safety and efficiency, essentially by installing the latest in avionics technology in participating aircraft.

Phase one of Capstone is in the southwest Yukon-Kuskokwin delta region, a non-radar area limited to visual flight rules, has provided:

* Weather information directly to the cockpit in general aviation flights.

* Automated weather systems that enable commercial operators to make GPS approaches at certain airports.

* GPS non-precision instrument approach procedures for 10 additional remote village airports.

* A data link network allowing participating pilots to see surrounding air traffic on a cockpit display.

* An interface with existing radar tracking to provide "radar like" services to participating aircraft.

* Ground infrastructure deployment for weather observation, data link communications, surveillance, and flight information services.

Participating aircraft receive:

* An instrument flight rules (IFR)-certified GPS navigation receiver.

* An ADS-B transmitter/receiver.

* A multi-function color display with traffic/terrain advisories.

* Traffic Information Surface Broadcast (TIS-B) with radar traffic information.

* Terrain database

* Flight information data depicting airports and related flight safety information.

In phase two, which is already under way, Capstone is moving into the southeast Alaska around the capital, Juneau, which FAA says is "more environmentally challenged area of the state."

Source: FAA Alaskan Region

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Capstone: Heating Up in Alaska

David Jensen

With a new avionics package approved, an IFR infrastructure being established and a study indicating it delivers safety benefits, the Capstone program in Alaska appears to be on a fast track. Does it represent the FAA at its best?

"This is the FAA at its best," asserts Gordon Pratt, president of Chelton Flight Systems, commenting on the Federal Aviation Administration's Capstone program in Alaska. "It shows the agency as being progressive-oriented."

Pratt may be accused of being biased with his praise, having been awarded in February 2002 the FAA contract to provide the avionics package for Capstone Phase II. But the program's steady progress, plus the findings of a recently released study of Capstone's impact on air safety in Alaska, supports Pratt's view.

Capstone is a proving ground for such new technologies as satellite navigation, broadcast weather and flight information, required navigation performance (RNP), automatic dependent surveillance-broadcast (ADS-B) and on-board synthetic vision display, among others. It is being conducted appropriately in Alaska, where air transportation is essential, as less than 10 percent of the state is accessible by road. The venue also is appropriate because Alaska's mountainous landscape, unpredictable weather and dearth of ground-based navaids have contributed to a sorry air safety record. For example, one controlled flight into terrain (CFIT) accident occurs on average every nine days in the state. And, from 1992 to 1994, Alaska's crash rate for air taxi and general aviation aircraft was 2.5 times higher than the U.S. average, according to the *FAA Statistical Handbook of Aviation, 1997*.

However, an analysis titled "Capstone Phase I Interim Safety Study, 2000/2001," conducted by the University of Alaska Anchorage and Mitre Corp.'s Center for Advanced Aviation Systems Design (CAASD), indicates that progress is being made to make air travel in Alaska safer. (More on the study later.) Mitre CAASD has been working on Capstone since it began, establishing technical specifications, developing architecture for the program's infrastructure, and designing systems integration, as well as conducting tests and evaluations.

New Avionics

The Capstone program entered its first phase in 1998, in southwest Alaska's Yukon-Kuskokwim Delta region, where Bethel serves as an aviation center. The program's second phase, launched in 2001, is centered in Juneau and conducted in the southeast Alaska region.

In February the Chelton avionics package for Capstone Phase II was to be approved to provide three-dimensional navigation. The wide area augmentation system (WAAS)/GPS receiver achieved certification under the TSO 145/146 standard, and the display system was approved under various TSOs for a primary flight display (PFD). With the TSO 145/146 certified receiver (see sidebar, page 20), pilots in the Capstone program can use GPS as a sole means of navigation.

The avionics for Capstone Phase II operations comprise the following:

- Navigation and primary flight displays;
- AAS/GPS receiver;
- Attitude heading reference system (AHRS);
- Air data computer;
- Integrated master caution warning system, which monitors aircraft performance, altitude, airspeed, fuel, area traffic and terrain; and
- Terrain awareness warning system (TAWS).

The Chelton system can include one to four liquid crystal displays, according to Pratt. "Operators in Phase II don't have to take the full suite," adds Worth Kirkman, lead engineer with Mitre CAASD. "Many may take the navigation display, but not take the primary flight display."

The Chelton sytem can provide pilots with both synthetic vision, for a forward-looking 3-D image drawn from the TAWS data base, and highway-in-the-sky (HITS) imagery, using data from the WAAS/GPS receiver and air data computer. Both graphic features can be shown independently, or one can be overlaid on the other–a capability that may be particularly beneficial when a pilot negotiates an approach to an airport in a mountainous area.

The map display for Capstone Phase II avionics will show marked improvement over the one developed for the Phase I package, which is "a kind of moving map, with a relative notion of the aircraft's relationship to terrain," says Kirkman. The Phase II map provides a "shaded image of the terrain...comparable to a TAWS display," he adds.

The Chelton package was to be certified in perhaps the most advanced Cessna 172RG. The University of Alaska owns the aircraft, and Anchorage-based Northern Lights Avionics Inc. installed a Chelton system that includes two LCDs, a PFD and a navigation display. "The system was designed for cabin-class aircraft," says Pratt. "But the STC covers all aircraft, from Piper Cubs to Citation jets."

Chelton was to have made an initial delivery of 15 systems for the Capstone program by late January. About a half dozen operators each will equip initially one or two of their aircraft with the new avionics. Two Part 135 operators–LAB, in Juneau, and Harris Aviation, in Sitka–are to receive the first systems for installation.

Pratt claims the Capstone package is being delivered to other customers, as well. They include a Hillsboro, Ore., completion center for installation on a Raytheon Beech King Air; FR Aviation Ltd. in the UK, for installation in about 100 military helicopters; and the U.S. Air Force and U.S. Drug Enforcement Administration (DEA), for OV-10 Broncos assigned to carry out night crop spraying in the narcotics producing regions of Colombia. "We also have an agreement with Aero Commercial Aircraft Group to provide the system as a factory option," Pratt adds.

New Infrastructure

While Alaskan aircraft are being equipped for Capstone Phase II, FAA and Mitre CAASD are busy establishing a complementary instrument flight rule (IFR) infrastructure in southeast Alaska. Currently, the infrastructure includes a thin scattering of ground-based navaids, largely VORs and NDBs, which require line of sight to successfully transmit signals. In mountainous Alaska, this often means limiting route altitudes for IFR flight to as high as 9,000 feet. Communications, too, is limited in southeast Alaska.

However, FAA plans to add VHF ground stations in the region, according to Jim Cieplak, principal systems engineer with Mitre CAASD. "And we are going to take advantage of WAAS and GPS to define our route structure."

"We expect the new routes to be published by the end of March," says Cieplak.

Referring to Victor 440, an IFR route through southeast Alaska, Cieplak adds that "aircraft normally would have to fly at 9,000 feet, using two VORs located in Sitka and Yakutat. But with WAAS/GPS, they can fly as low as 2,000 feet."

Rather than receiving positioning data from the ground, Capstone Phase II-equipped aircraft will receive the data from GPS satellites, with corrections derived from a WAAS geostationary satellite positioned over the Pacific Ocean Region (POR). The WAAS satellite receives the corrections from the west coast WAAS master station in Palmdale, Calif., which processes data from three ground stations in Alaska–in Anchorage, Juneau and Cold Bay. Capstone officials plan to complete the initial low-level IFR route structure in May 2003.

Special FAR for GPS

A proposed Special FAR (federal aviation regulation) to permit IFR operations using GPS was issued for a 30-day public comment period, beginning in mid-January. The Special FAR"will allow us to use GPS for area navigation in Alaska," says Cieplak. "It will mean that aircraft operating in the region won't need a backup system to GPS. The commercial aircraft will be the exception in that they must have two GPS systems."

The Special FAR permits the use of GPS for lateral navigation (LNAV). "The WAAS/GPS receiver can provide both LNAV and VNAV [vertical navigation], but the TERPS [terminal instrument procedures] for GPS-VNAV haven't been finalized," Pratt reports. "We expect that to be done in 2004.

"When the TERPS are completed, the WAAS/GPS receiver will provide precision approach capability comparable to a [Category I] ILS," he adds. Pratt claims that WAAS/GPS receivers approved for both LNAV and VNAV will allow instrument approaches when conditions present a minimum 250-foot ceiling and half-mile visibility at unlighted airports and 250-foot ceiling and a quarter-mile visibility at lighted airports. "Initially, we will use baro [barometric] VNAV for non-precision approaches," says Pratt, of the Capstone Phase II-equipped aircraft.

In addition to the new low-level IFR routes, Capstone officials also plan to create special WAAS approach/departure procedures at three airports that now allow only VFR operations. These will be established for Haines, Gustavus and Hoonah, all common destinations for Part 135 operators flying from Juneau.

"These destinations are in rocky areas with a lot of weather and near glaciers, which produce fog," says Cieplak. "The minimums at the three airports will be in the range of 800 to 1,200 feet [ceiling] and two to five miles visibility."

At Juneau, Capstone officials plan to achieve 850-foot/two-mile minimums using WAAS/GPS, a considerable improvement over the current 2,120-foot ceiling and four-mile visibility minimums. This reduces the decision altitude at Juneau by more than 1,200 feet," says Cieplak. (Using RNP, Alaska Airlines has been able to reduce the minimums at Juneau to 724 feet and one mile.)

The Mitre CAASD engineer says the Capstone program "will move next to develop WAAS approaches in the Ketchikan/Petersburg area [south of Juneau] and then, eventually, will proceed throughout the state." Alaska has about 285 airports, and only 91 have published instrument approach procedures.

On top of on-board equipment and an IFR infrastructure, preparation for Capstone Phase II also requires considerable training. "All of these factors have to come together," says Cieplak.

He adds that the new Capstone Phase II equipment and procedures produce a large learning curve. "We're not just teaching the pilots, but we're also teaching FAA officials, so they can be up on the technology and specifications."

The Capstone office and University of Alaska are developing a training program for Capstone Phase II. A beta training class was being conducted early this year, and its approval for pilot instruction was expected this month.

Safety Study

FAA established the Capstone program to improve air travel safety in Alaska, and results from the University of Alaska-Mitre CAASD study give preliminary evidence that the agency is achieving its goal. Although it is too soon to say exactly how beneficial Capstone will be (the study is ongoing), the "Capstone Phase I Interim Safety Study, 2000/2001" indicates that the program contributes to an improved safety record.

To form a baseline, the University of Alaska Anchorage's Institute of Social and Economic Research (ISER) first analyzed the accidents in Yukon-Kuskokwim Delta region prior to the Capstone program, from 1990 to 1999. Researchers "looked at the accidents and found that if the new technology had been installed on all aircraft in the test region during the 1990s, it might have...prevented one in seven accidents and nearly 50 percent of the fatal accidents," according to the study.

ISER subsequently compiled the following preliminary results from Capstone's "phase-in period," 2000 to 2001:

- Capstone equipped aircraft operated by commuter and air-taxi operators were in seven accidents, while non-equipped aircraft were in 12 accidents. Researchers caution, however, that it is premature to "assess whether this is a systematic change that will continue, or just the result of chance variation."
- Of the seven Capstone-equipped aircraft that had accidents, "only one was of the type that the new technology should have prevented." It was a CFIT accident, and the National Transportation Safety Board (NTSB) "found that the pilot had disabled the avionics feature that might have helped him avoid the crash."
- Only one Capstone-equipped aircraft was in a fatal crash. The accident, which took place on takeoff in clear weather, was "not a type of accident that Capstone was designed to address."

While three of the accidents involving non-equipped aircraft resulted from poor runway conditions, no Capstone-equipped aircraft were in such accidents. Researchers admit they "did not anticipate that Capstone avionics could reduce runway-related accidents." Nevertheless, they discovered from interviews with pilots that, with Capstone avionics, the pilots could "identify other planes that have just landed at a particular airport and then get in touch with the pilots of those planes and find out runway conditions."

As the number of airports in southwest Alaska with instrument approaches increased from three to 13, the number of IFR-certified commercial aircraft operating in the area rose from eight to 22 "and will likely continue to increase."

Positive Feedback

From interviews with pilots and operators in the Yukon-Kuskokwim Valley region, researchers unearthed further positive feedback. They found that nearly half of the 106 pilots surveyed believed the Capstone Project made flying "much safer," and most of the remaining pilots said it "improved safety somewhat." And they found that operators who were reluctant to take part in the program in 1999 and 2000 have since asked to be included.

But problems also were reported. About 15 percent of the pilots complained of "more time spent using avionics instead of looking at where the plane is going and of more aircraft flying close together, because they are all using Capstone's GPS to fly in a straight line between villages." In addition, pilots noted that, in the winter, when wearing heavy gloves, they found it more difficult to operate the Capstone Phase I avionics' buttons and knobs.

The surveyed pilots also warned that the Capstone Phase I avionics require considerable training and that, so far, pilot training with the equipment lacks a quality standard. "Learning to use the GPS takes time," the study states.

"Also, the equipment has so many functions–weather, traffic, flight planning–that pilots can't master them all in one training session."

Still, ISER researchers recommend that the Capstone program continue and that Alaskan operators be encouraged to participate. "The Capstone program won't see its full benefits unless pilots and operators support it and use all its capabilities," ISER researchers state. For more on the ISER study, visit www.alaska.faa.gov/capstone/docs/docs/htm.

TSO 145/146 WAAS/GPS Receiver

What must a wide area augmentation system (WAAS)/GPS receiver do to achieve the TSO 145/146 standard? Jim Cieplak, Mitre CAASD's principal systems engineer, lists the receiver's performance requirements in four scenarios:

- Receive an instrument flight rule (IFR) WAAS signal.
- If the WAAS signal is not available, the system must automatically revert to a fault-detection and exclusion (FDE) mode (like an "advanced RAIM [receiver autonomous integrity monitoring] mode," according to Cieplak). This mode detects faulty GPS satellites and excludes them from the navigational solution.
- If not enough satellites are in view for FDE, the system must automatically enter normal RAIM mode and give the pilot a RAIM flag, if navigation is unsure.
- With no GPS signal, the system must automatically enter an automated VFR (visual flight rules) dead-reckoning mode, which, with the Chelton avionics package, is done with the attitude heading reference system (AHRS).

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