Capstone Phase I
Interim Safety Study, 2000/2001

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Executive Summary

Alaska relies on aviation more than any other state does. It is 615,230[1] square miles—representing 16 percent of the total U.S.—but it has only 13,628 miles of public roads.[2] Less than 10 percent of the state is accessible by road. Rivers are frozen for most of the year. But because Alaska is huge, has fewer than 650,000 people, and is divided by mountain ranges, the infrastructure and services that support aviation in most other states are lacking in many areas of Alaska.

What is the Capstone Program?

To help improve aviation safety, the Federal Aviation Administration (FAA), in cooperation with industry, began testing new technology in the Yukon-Kuskokwim (Y-K) Delta region of southwest Alaska in 1999. The FAA contracted with the University of Alaska Anchorage's Institute of Social and Economic Research (ISER) and Aviation Technology Division (ATD) to evaluate the benefits of the new safety program—known as Capstone. The program involves:

1) Equipping commuter airlines, air taxis and selected part 91 operators[3] with avionics that shows pilots their location and information about nearby terrain, other aircraft, and weather.
2) Building ground stations that broadcast weather and flight information and that can provide radar-like surveillance of planes equipped with the new avionics.
3) Installing weather observation stations and creating and publishing instrument approaches, in order to provide more weather information and enable pilots to land at isolated airports in poor weather.

This technology is most likely to help prevent mid-air collisions and controlled-flight-into-terrain (CFIT) accidents, which make up only a small part of the small-plane accidents in southwest Alaska but are the most likely to cause deaths. Aside from helping prevent accidents, the technology is designed to make it easier for pilots to fly—by making it easier to navigate, by providing more current weather information, and by making instrument landings possible when weather deteriorates.

Why Test in Southwest Alaska?

Communities in southwest Alaska are far from highways and depend heavily on aviation to transport people and cargo. The Capstone program focuses on the Y-K Delta's primary transportation hub of Bethel, the smaller hubs of Aniak and St. Marys, and the villages those hubs serve (Figure ES-1, next page). More than 20 air taxi and

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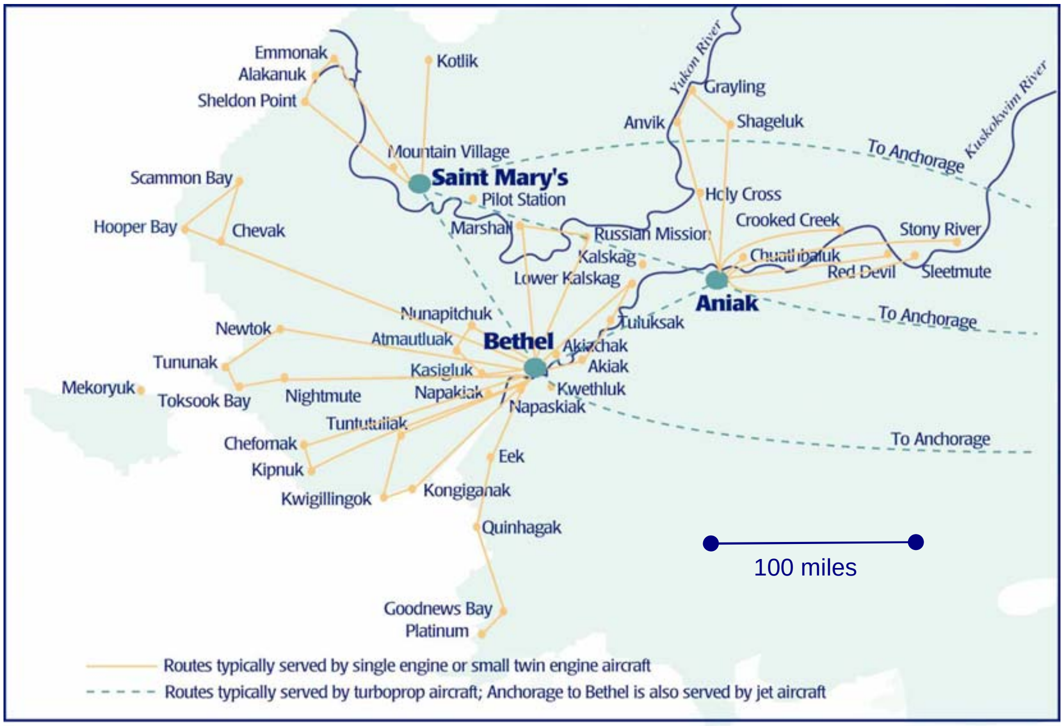
[1] Statistical Abstract of the United States, 2001, Table 343.
[2] Alaska DOT&PF, www.dot.state.ak.us/stwdplng/highwaydata/pub/cprm/2001cprm.pdf, Certified Public Road Mileage as of December 21, 2001. Excludes Marine Highway miles.
[3] In 2000 and 2001, most of these were government agencies such as the State Troopers or USFWS that operate fleets of aircraft under part 91.

commuter airlines serve these places, mainly with aircraft seating fewer than 10 passengers.

Figure ES-1. Y-K Delta Communities and Selected Air Routes



Like the rest of Alaska, the Y-K Delta has an accident rate considerably above the U.S. average. Pilots routinely face rapidly changing weather, flat-light and white-out conditions, fog, and ice fog. Also, weather information is limited. Before the Capstone program started, the Y-K Delta had only seven locations with regularly available weather information. Only Bethel, the major hub, has a manned weather station.

Weather stations were 100 miles or more apart, before the Capstone program began, meaning that local weather information was often unavailable to pilots flying into many communities. Finally, pilots in this region often have to land with few navigational aids, at airports with short, unpaved runways; 90 percent of the airports in the region have gravel or dirt runways,[4] and two thirds are less than 3,000 feet long.

What's the Status of Capstone So Far?

As of December 2001, the FAA had equipped 140 aircraft in the Y-K Delta with Capstone avionics. That included about 85 percent of air taxi and commuter planes operating in the Y-K Delta. The FAA had also installed automated weather stations (AWOS) at nine airports and published non-precision instrument approaches—landing instructions—for ten airports. Six of the planned 11 ground stations that transmit

[4] FAA 5010 database

weather, traffic, and other information to aircraft in flight were also operating by the end of 2001, although at somewhat less than their final planned capabilities. In mid-2002, the FAA was continuing to install the new avionics in planes and build ground stations.

What is ISER Evaluating?

ISER's evaluation began in 1999 and will continue through 2005. We are primarily evaluating how well the Capstone program is meeting its central goal of improving aviation safety.

What Did the Baseline Study Find?

ISER first analyzed data for the period 1990-1999, before the Capstone program started. We quantified the scarcity of navigation aids and weather information for pilots flying in the Y-K Delta (as described earlier). We then looked at 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 about 1 in 7 of all accidents and nearly 1 in 2 fatal accidents, by mitigating all causes of the accidents.
- Helped pilots avoid more than half of all accidents and fatalities, by mitigating some but not all of the causes of the accidents.

How Has Capstone Affected Safety?

We can't expect to see the full safety effects of the Capstone program yet, because the program was still being phased in during the period we evaluated. By mid-2002, almost all air taxi and commuter planes in the Y-K Delta had been equipped with Capstone avionics—but averaged over 2000 and 2001, only about half had the avionics.

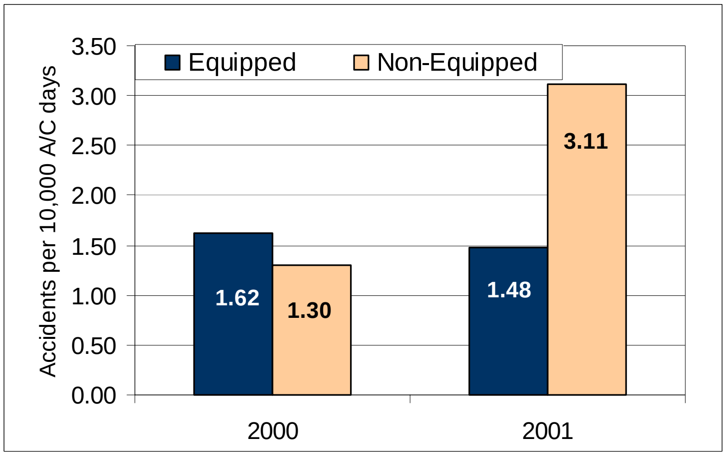
Also, as of mid-2002 the Bethel air control tower still lacked the equipment it needed to efficiently manage Capstone-equipped planes. Finally, as of mid-2002, the new weather reporting stations—while helpful—had not yet been tied in to the ground stations that send information to the Capstone-equipped planes. That means pilots could only get the weather information by telephone before they took off, or once they were within radio range.

With that level of implementation, we would expect the Capstone equipment to have prevented only one in four controlled flight into terrain (CFIT) crashes and one in ten mid-air collisions. In an average year, there might be no such accidents.

Still, we do have some preliminary results from this phase-in period:

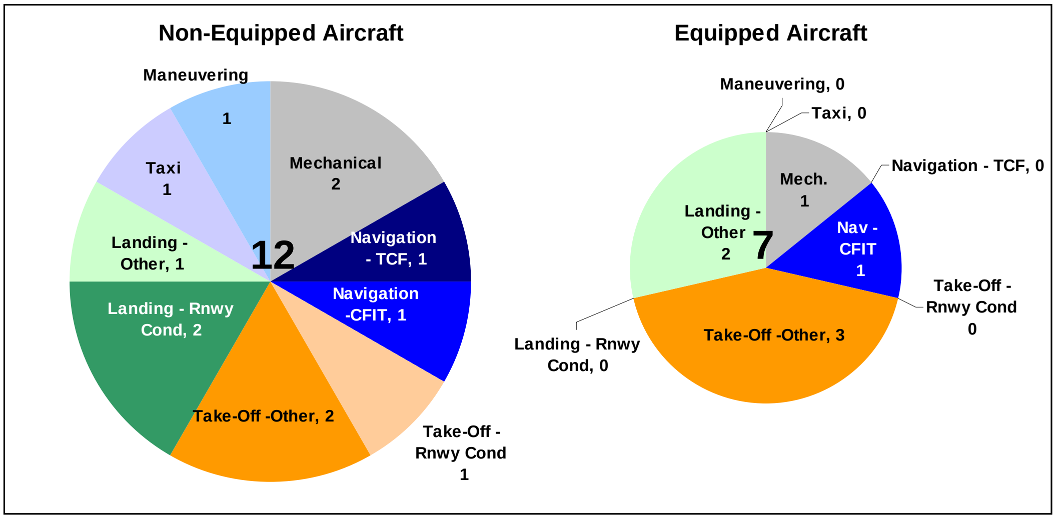
- Aircraft equipped with Capstone avionics had fewer accidents in 2001 than similar aircraft not equipped with the new avionics (Figure ES-2, next page). Commuters and air-taxi operators in the Y-K Delta had 7 accidents with Capstone-equipped planes and 12 accidents with planes that did not have the new avionics. However, it's still too early to assess whether this is a systematic change that will continue, or just the result of chance variation.

Figure ES-2. Accident Rates for Capstone Equipped and Non-Equipped Aircraft, Y-K Delta Part-135 Operators



- The only fatal accident with a Capstone-equipped plane during 2000-2001 took place in Dillingham, which is outside the Y-K Delta. That plane crashed on take-off in clear weather, not a type of accident that Capstone was designed to address. The NTSB investigation was not complete in mid-2002, but there is no evidence that the Capstone avionics could have prevented that crash.
- Pilots flying aircraft equipped with Capstone avionics had no accidents that were the result of poor runway conditions in 2000 and 2001. But 3 of the 12 accidents with planes lacking the new avionics–two landing and one take-off– did result from poor runway conditions (Figure ES-3, next page). We did not anticipate that Capstone avionics could reduce runway-related accidents. But pilots have told us that because they have Capstone equipment, they can 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.
- Of the seven Capstone-equipped planes that had accidents in the Y-K Delta in 2000 and 2001, only one was of the type that the new technology should have prevented. That was a controlled-flight-into-terrain (CFIT) accident. But the National Transportation Safety Board (NTSB) found that the pilot had disabled the avionics feature that might have helped him avoid the crash (NTSB Final Report ANC01LA046). Other accidents were five minor ones where pilots misjudged take-offs or landings and one in which the propeller came off during flight, but the pilot successfully landed.
- Additional weather stations and GPS approaches have encouraged Y-K Delta operators to pursue certification for instrument flight rules operations. As the number of Y-K Delta airports with instrument approaches increased from 3 to 13, the number of IFR-certified commercial aircraft operating in the area rose from 8 to 22 and will likely continue to increase.

Figure ES-3. Y-K Delta Commuter and Air Taxi Accidents, 2000 – 2001 Among Equipped and Non-Equipped Aircraft



Accident categories are explained in detail on page 20, figures 2-5 and 2-6. TCF=terrain clearance floor; CFIT=controlled flight into terrain

We also surveyed pilots and operators in the Y-K Delta to ask their opinions about Capstone's effectiveness and worked with the FAA when it surveyed and observed pilots and operators to find out how easy the equipment is to use. Those surveys found:

- Nearly half the 106 pilots ISER surveyed believe the program has made flying in the test area much safer. Most of the rest said it had improved safety somewhat.
- Operators who were reluctant to take part in the Capstone program in 1999 and 2000 have now asked to be included. As of mid-2002, all small commercial operators based in or operating out of Bethel had agreed to participate.
- Pilots especially liked Capstone's ability to warn them about terrain hazards and nearby traffic. They also liked having additional weather information.
- Capstone's GPS, along with the published landing approaches at nine additional airports, have encouraged several operators to upgrade their capacity to fly under instrument flight rules (IFR). Being able to fly IFR means operators can fly safely under worse weather conditions.
- Pilots also noted potential problems with using Capstone: more time spent using avionics instead of looking at where the plane is going and more aircraft flying close together, because they are all using Capstone's GPS to fly in a straight line between villages. But only about 15 percent saw these as major problems.
- Pilots reported that in the winter, when they're wearing heavy gloves, they find it more difficult to push the buttons and turn the knobs on Capstone equipment.
- Pilots need thorough and repeated training as well as practice to use this equipment effectively. Learning to use the GPS takes time. Also, the equipment has so many functions—weather, traffic, flight planning—that pilots can't master them all in one training session.

- Operators provide pilot training, and the quality of that training varies—so some pilots are trying to use the Capstone equipment with only minimal training.
- The Capstone program is one of several attempts to improve aviation safety in Alaska. In the Y-K Delta these include improved maintenance facilities, increased management oversight, and increased pilot training. Capstone has played a significant role, by providing additional weather stations, GPS approaches, avionics, and training. We know other changes have also improved safety, but we can't identify how much each is contributing.

What Are Initial Recommendations?

Capstone Phase I has not yet been fully implemented. To fully realize Capstone's potential benefits, the FAA must finish equipping the fleet as planned and building the ground infrastructure to support the system's capabilities. Operators must continue to provide training and support for pilots to use the equipment effectively. Our preliminary recommendations include:

- *Continue the Capstone program.* Only when all the Capstone equipment is in place and pilots have been well-trained—and have used the equipment for a longer period—can we expect to see the full safety benefits.

- *Market program to operators and pilots.* The Capstone program won't see its full benefits unless pilots and operators support it and use all its capabilities. The FAA needs to continue to market the program to pilots and Flight Standards District Offices (FSDOs) need to assure pilots and operators that the technology won't be used for enforcement.

- *Ensure adequate pilot training.* Operators need to allocate time and money for thorough initial and continuing training. FAA oversight could help to ensure this. Simulators with Capstone avionics would be a valuable addition to the pilot training.

- *Expand GBT coverage.* To get the most benefit out of data-link weather and other relevant information the Capstone program potentially makes available in the cockpit, pilots need to be able to access this information wherever they fly, and not just in a part of the Y-K Delta. It's important to increase the number of ground-based transceiver stations so they cover at least the full Y-K Delta.

- *Provide radar-like approach control services.* To fully realize the potential benefits of radar-like services, the FAA should work to provide approach-control services for Bethel airport using Capstone's capabilities.

- *Require more operator feedback.* The FAA should require future Capstone participants to provide more information on how often and where they fly, what training they provide, who their pilots are, and what their qualifications are. Lack of such information in the Y-K Delta hampers our ability to estimate safety benefits. Operators in Phase I of the program weren't required to provide this information when they received the Capstone equipment.

1 Introduction

Alaska relies on aviation more than any other state does. It is 615,230[5] square miles—representing 16 percent of the total U.S. —but it has only 13,628 miles of public roads[6]. Less than 10 percent of the state is accessible by road. Rivers are frozen for most of the year. But because Alaska is huge, has fewer than 650,000 people, and is divided by mountain ranges, the infrastructure and services that support aviation in most other states are lacking in many areas of Alaska.

The FAA Alaska Region's Capstone program is a joint initiative with industry to improve aviation safety and efficiency in Alaska, by using new tools and technology to provide infrastructure and services. The first phase of Capstone is in southwest Alaska, primarily in the Yukon-Kuskokwim Delta (Y-K Delta). The program involves:

- Equipping commuter airlines, air taxis and selected part 91 operators[7] with avionics that shows pilots their location and information about nearby terrain, other aircraft, and weather.
- Building ground stations that broadcast weather and flight information and that can provide radar-like surveillance of planes equipped with the new avionics.
- Installing weather observation stations and creating and publishing instrument approaches, in order to provide more weather information and enable pilots to land at isolated airports in poor weather.

This technology is most likely to help prevent mid-air collisions and controlled-flight-into-terrain (CFIT) accidents, which make up only a small part of the small-plane accidents in southwest Alaska but are the most likely to cause deaths. Aside from helping prevent accidents, the technology is designed to make it easier for pilots to fly—by making it easier to navigate, by providing more current weather information, and by making instrument landings possible when weather deteriorates.

To learn the benefits and limitations of these new tools and technologies, the Capstone program contracted with the University of Alaska Anchorage's Institute of Social and Economic Research and the Aviation Technology Division to evaluate aviation safety changes in the Capstone area. This *Capstone Interim Safety Report* describes those changes through the end of 2001.

1.1 The Yukon Kuskokwim Delta Region of the Capstone Area

The Capstone Phase I area is a geographic region from 58° to 64° north latitude and 155° to 167° west longitude (Figure 1-1, next page). Nearly all the Capstone ground systems and avionics are in the Yukon-Kuskokwim Delta. Bethel is the aviation center

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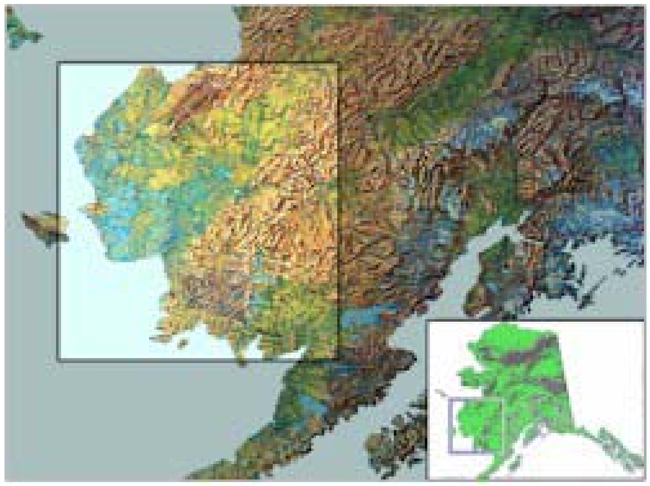
[5] Statistical Abstract of the United States, 2001, Table 343.
[6] Alaska DOT&PF, www.dot.state.ak.us/stwdplng/highwaydata/pub/cprm/2001cprm.pdf, Certified Public Road Mileage as of December 21, 2001. Excludes Marine Highway miles.
[7] In 2000 and 2001, these were typically government agencies such as the State Troopers or USFWS that operate fleets of aircraft under part 91.

of the delta (see Figure 1-2). It is also the largest community in the Y-K Delta and the economic, governmental and cultural center of the region. Aniak to the northeast and St. Marys to the northwest are also economic and mail distribution hubs for the delta.

Figure 1-1. The Capstone Area in Southwest Alaska



Aviation activities are concentrated in Bethel, Aniak, and St. Marys, as shown in Figure 1-2, next page. The hubs receive daily scheduled service from passenger and cargo carriers. The mainline passenger and cargo flights to Bethel originate in Anchorage, the largest hub airport in Alaska. These flights are on Boeing 737 and Beech 1900 passenger aircraft and DC-6, Boeing 727, and EMB 120 Brasilia cargo craft.

Since air is the only transportation system that can operate year-round, essentially all passengers and 95 percent of all cargo arrive via scheduled air service. Bethel, Aniak, and St. Marys are mail hubs for 52 smaller communities in the delta. Single-engine and light twin-engine aircraft such as Cessna 207, Cessna 208 Caravan, Cessna 172 and Twin Otter carry passengers and cargo to those smaller communities.

An example of a typical flight would be a Boeing 737 combi (passengers and freight combined) operated by Alaska Airlines from Anchorage to Bethel, with 16,000 to 20,000 pounds of freight and mail and about 50 passengers[8]. In Bethel, passengers, freight and mail headed for other communities would be transferred to the local carriers. A typical flight out of Bethel might be a Cessna 207 with 4 passengers and 300 pounds of mail going to Hooper Bay, Scammon Bay, and Chevak and then returning to Bethel.

[8] Personal communication, J.D. Hill, Anchorage Operations Office, Alaska Airlines., November 2002.

Figure 1-2. Air Routes in the Yukon-Kuskokwim Delta

The economic, social, political, cultural, and regulatory factors affecting aviation safety in the Y-K Delta—and the Capstone-equipped aircraft flying there—are the focus of this report. The Capstone area includes communities outside the Y-K Delta—Iliamna, Unalakleet, Dillingham, King Salmon and McGrath— but the focus of Capstone activity is aircraft and flight activity based in Bethel, Aniak and St. Marys.

Pilots in the Y-K Delta routinely face weather hazards: rapidly changing weather, flat light and white-out conditions, fog, and ice fog.[9] These hazards are made worse by incomplete or unavailable weather information. Only Bethel has a manned weather observation station; the rest of the information routinely available to pilots is from automated stations. While this information is useful, the distance between observation stations—and the relative lack of local forecasts that combine information from multiple stations over time—mean that pilots routinely encounter unexpected bad weather.

And besides those hazards, pilots with no low-altitude ATC radar coverage must fly with relatively few navigation aids, to airports with unpaved runways (90 percent are gravel or dirt). These runways are often short (one third are less than 2,000 feet; two-thirds are less than 3,000 feet), and half have no lighting. Most flights between Bethel and the surrounding villages are single-pilot flights, leaving the pilot to meet these varied challenges without help.

Accident rates in the Y-K Delta area are similar to Alaska's statewide rates, which are higher than national averages. Alaska's aircraft crash rate (crashes per 100,000 flight hours) for air taxi and general aviation flights during 1992-94 was 2.5 times higher than the U.S. average (FAA Statistical Handbook of Aviation, 1997). From 1990 through

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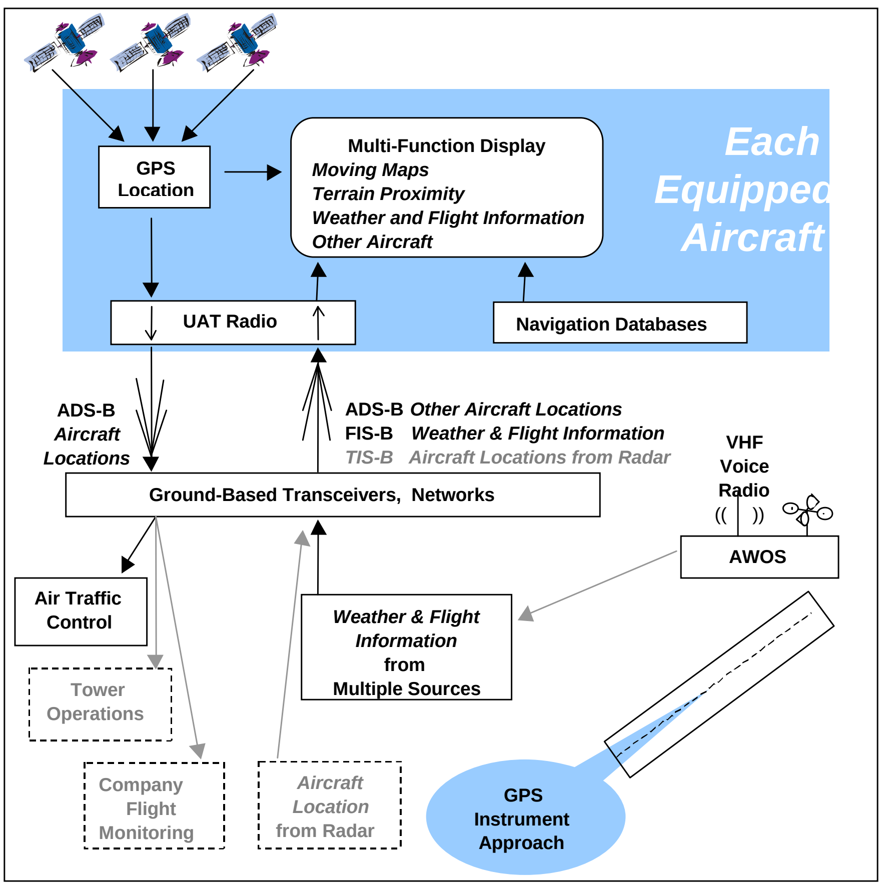
[9] These are described more completely in the Capstone Baseline Report, Chapter 7.

1999, commercial operators in the Capstone area had 204 accidents. About one tenth of those accidents (20) were fatal accidents, accounting for 31 deaths.

1.2 Capstone Program

As we noted earlier, Capstone Phase I is equipping aircraft in the Y-K Delta with a new type of avionics that shows pilots their location, nearby terrain, other aircraft, and weather and flight information. Another part of the program is installing ground stations that broadcast weather and flight information and receive GPS-location messages (sent by aircraft), allowing radar-like surveillance and providing company managers with the ability to follow flights. Capstone is also installing weather observation stations at isolated village airports and creating non-precision instrument approaches that enable instrument flight rules (IFR) operations when weather conditions are inadequate for visual flight rules (VFR) operations. Figure 1-3 illustrates these systems.

Figure 1-3. Capstone Systems



The Capstone avionics and ground systems are designed to help prevent many of the accidents that occur in rural Alaska and to use new technologies to help compensate for remote location and limited infrastructure. The Capstone avionics has a GPS location sensor, on-board databases with digital maps that include information on navigation and terrain elevation, and a display on which pilots are able to see their location centered on a moving map and thus be alerted to dangerously close terrain. A universal access transceiver (UAT) broadcasts the aircraft's location to the ground and to other Capstone-equipped aircraft. The UAT receives location information from other Capstone aircraft and displays that information, to warn pilots before there is a possibility of collision. The UAT can also receive messages from ground systems about locations of non-Capstone aircraft that are visible to radar, as well as weather maps and other flight information that are displayed to pilots to warn them about hazardous conditions and to aid in-flight planning.

Capstone ground systems are designed to work with the avionics to help pilots manage and control aircraft more effectively. Ground systems relay the locations of Capstone aircraft for air traffic controllers to use where radar coverage is not available; for tower operators to use for more rapidly locating planes; and for the companies that operate the aircraft to use in following the progress of their flights.

Capstone is installing automatic weather observation systems (AWOS)[10] at remote airports to tell pilots the conditions at possible destinations. These AWOS also help meet the safety and regulatory requirements for instrument operations, which can safely continue in poorer weather. Capstone makes this possible by allowing for publication of FAA-approved, non-precision GPS approaches at these locations.

The Capstone program was funded in October 1998, and the first avionics were installed in November 1999. Phase I is scheduled to continue equipping aircraft through 2002 and to continue ground infrastructure improvements and data collection through 2004.

1.3 Safety Evaluations

This report assesses changes in aviation safety in the Capstone area from January 2000 through December 2001 and provides a preliminary estimate of the safety benefits of Capstone. Equally important—since Capstone is an ongoing program and adjustments can be made—this report estimates whether individual elements of Capstone have or have not improved safety so far.

This report builds on a previous report, *Air Safety in Southwest Alaska – Capstone Baseline Safety Report* (baseline report).[11] The baseline report described aviation in the Capstone area from 1990-1999. It characterized commercial operations (employees and training levels, aircraft and avionics) and facilities and services. The report estimated a rough "best-case scenario" for Capstone's potential safety benefit by dividing historical accidents into broad categories of causes that Capstone might

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[10] Automated Weather Observing System (AWOS) stations measure, collect and disseminate current weather information. They do not forecast weather. They provide airport identifier, Zulu time, and current information on sky conditions, visibility, wind speed, wind direction, temperature, dew point, altimeter setting, density altitude, and wind gusts to pilots, usually by VHF radio. Hourly AWOS data is available by telephone.

[11] The Baseline report is available at http://www.alaska.faa.gov/capstone/docs/baseline.pdf

address. It also reported pilots' initial assessments of how they expected the Capstone technology to affect operations and safety.

Additional background on aviation safety in Alaska is available in the reports listed below.

> Mitchell (American Airlines Training Corporation); *Final Report on Definition of Alaskan Aviation Training Requirements*; (1982).
>
> National Transportation Safety Board (NTSB); *Aviation Safety in Alaska;* (1995).
>
> Garrett et al; "Epidemiology of Work-Related Aviation Fatalities in Alaska 1990-94," in *Aviation, Space and Environmental Medicine* Vol. 69, No. 12; (1998).
>
> FAA; *Joint Interagency/Industry Study of Alaskan Passenger and Freight Pilots;* (1999).
>
> Thomas, Timothy K., et al; "Controlled Flight into Terrain Accidents Among Commuter and Air Taxi Operators in Alaska", *Aviation Space and Environmental Medicine*, Vol. 71, No. 11; (2000).

1.4 Organization of This Report

Section 2, Evaluation of the Capstone Baseline, re-examines some of the data and findings discussed in the *Capstone Baseline Report* for the period 1990-1999. This establishes a basis for projecting the potential safety effects of Capstone. First, we repeat the baseline analysis, looking only at Y-K Delta part-135 operators. That group of air carriers is Capstone Phase I's target population. Section 2.2 then compares accident causes for the components of Capstone area operations, including all Capstone area operations, Capstone part-135 operations, and Y-K Delta part-135 operations.

Section 2.3 attributes 1990-1999 accidents to a detailed set of causes that help us to assess Capstone's expected safety effects. Sections 2.4 and 2.5 consider the extent to which Capstone could have indirect safety benefits in two areas–increased IFR operations and improvements in operator and pilot safety attitudes and practices. Section 2.6 discusses the limitations of available baseline data that constrain our analysis.

Section 3, Evaluation of 2000/2001 Safety Factors, identifies relevant aviation safety data from 2000 and 2001. Section 3.1 discusses implementation of Capstone Phase I ground infrastructure and services. Section 3.2 looks at Capstone avionics–installation, pilot training, and usability. Section 3.3 assesses changes in the level of aviation operations in the Capstone area. Section 3.4 identifies changes in pilot and operator safety attitudes and practices. Section 3.5 discusses the limitations of our ongoing data collection.

Section 4, Changes in Safety, estimates the overall safety benefits of Capstone for the Y-K Delta and for the Capstone area. Section 5 states conclusions of the study team. Appendixes include data tabulations, details of data collection, and analysis methods.

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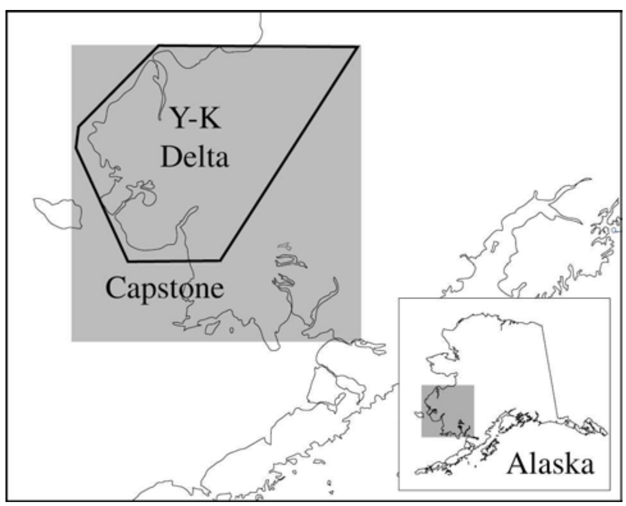
2 Evaluation of the Capstone Baseline

Understanding how the Capstone program is affecting safety begins with understanding the situation *before* the program began. The earlier baseline report describes operations and accidents in the Capstone area from 1990-1999 and assesses how the Capstone program might have improved safety, if it had existed during that period.

The causes and rates of accidents from 1990 to 1999 differ significantly by location, FAR part, and accident severity. The baseline report assessed how Capstone might have affected all flights in the Capstone area. Here we review our baseline analysis and focus it on the operations and accidents among part-135 operators in the Y-K Delta (Figure 2-1). Capstone is equipping aircraft belonging to these operators, and accident causes and rates in this group are most directly comparable to accidents among aircraft that are now Capstone-equipped. Sections 2.1 and 2.2 compare all accidents in the Capstone area from 1990-1999 with accidents in the same period for just the Y-K Delta part-135 operators. As the Capstone program was implemented over the last two years, these part-135 operators–who received the majority of the avionics–provide us with an opportunity to measure safety benefits among a limited group of operators who face similar aviation and economic challenges.

Figure 2-1. Alaska, Capstone Area, and Y-K Delta



The baseline report assessed potentially preventable accidents among other air carriers, agencies, and individuals flying in the Capstone area; that analysis is helpful for understanding the potential benefits to that broader group, where the data available for the analysis is much more limited.

Section 2.3 examines which of the accidents in the baseline period could potentially have been prevented by Capstone Phase I and explains how we made those determinations. Section 2.4 discusses why there was limited capacity for IFR operations in the Capstone area during the baseline period. This baseline information is necessary for the later discussion, in Section 3, of the potential for additional IFR operations in the Y-K Delta.[12] Section 2.5 briefly reviews the safety posture information in the baseline report, and Section 2.6 discusses the limitations we have encountered in collecting and analyzing data for the baseline period.

2.1 Baseline Populations

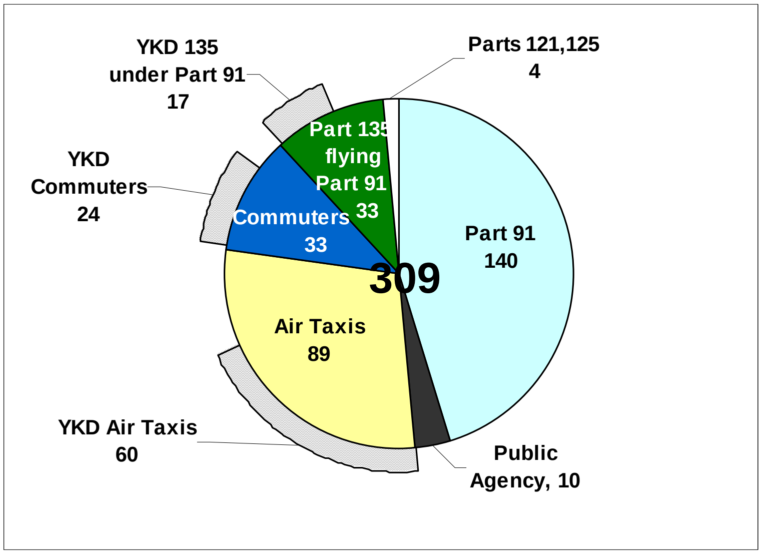
Data collected for the Capstone Phase I baseline and analyzed in the baseline report correspond to the formal scope adopted by the Capstone program. That includes general aviation aircraft flying under Federal Aviation Regulations (FAR) part 91 (referred to as part-91 operations); scheduled and unscheduled commercial service by small aircraft flying under part-135;[13] larger passenger and cargo transport aircraft under part 121; and aircraft flown by or for governments for public use. Geographically this includes the Y-K Delta plus other hubs and villages within the Capstone area.

Phase I of Capstone will of course have the most effects on air operations using aircraft with the new avionics and flying where new infrastructure and services are provided. Through December 2001, almost all the infrastructure and services provided by Capstone have been located within the Y-K Delta, and new avionics have been installed almost exclusively into part-135 aircraft based there. This group is the most directly affected, and is the focus of this report.

Accidents among all the groups from 1990 to 1999 are shown in Figure 2-2 (next page). The inner pie chart shows the distribution of accidents by FAR part for the Capstone area, 1990-1999, including the break-out of sub-groups in part-135. The striped extensions show the subsets of these accidents by Y-K Delta part-135.

[12] As the potential for additional IFR operations is an unanticipated effect of Capstone, it was not discussed in the baseline report.
[13] Operations in Alaska also include "part-135 flying as 91." In this report these aircraft are included with scheduled and unscheduled part-135 aircraft.

Figure 2-2. Capstone Area and Y-K Delta Part-135 Accidents by FAR Part Number of the Flight, 1990-1999

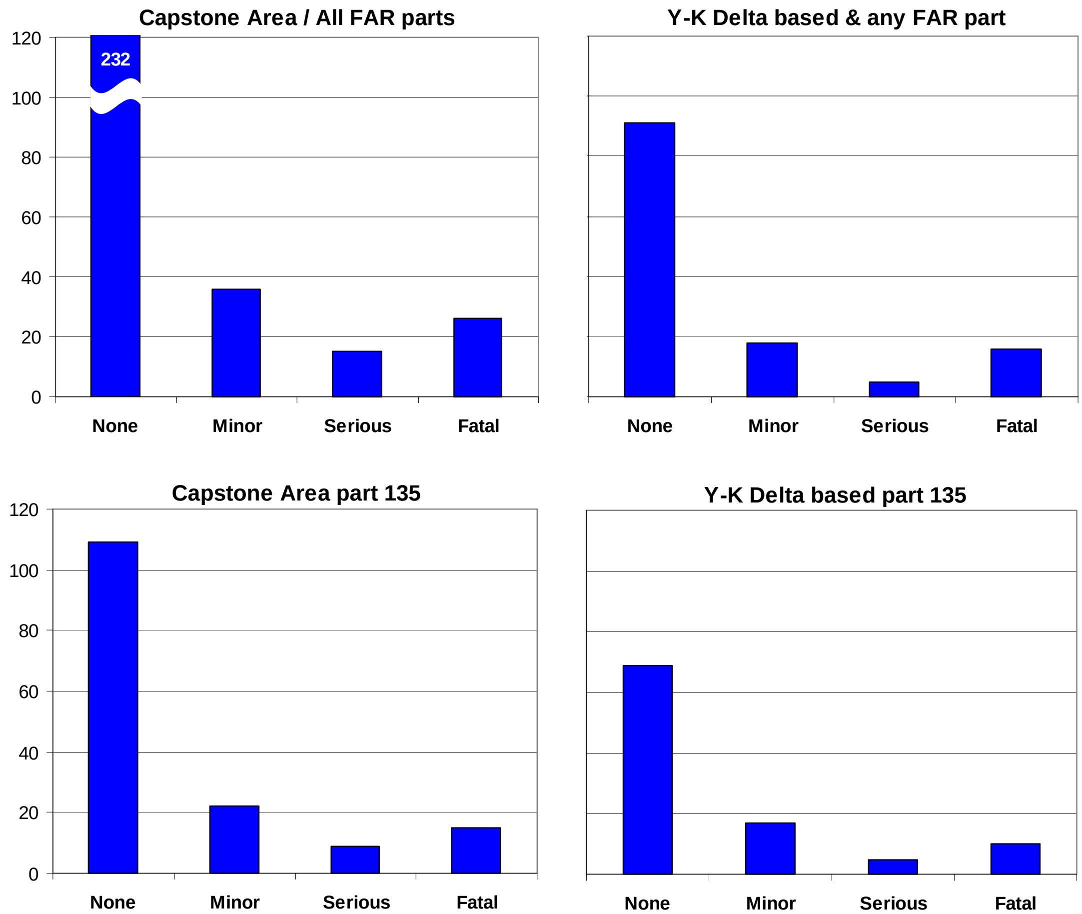


There were 309 accidents in the Capstone area of southwest Alaska from 1990 to 1999 (pie) of which 101 were aircraft operated by Y-K Delta Part-135 operators that are a main focus of Capstone Phase 1 (gray outer wedges). The categories "part 135 flying under 91" and "YKD 135 under Part 91" refers to those flights that commercial operators may make under the less restrictive general aviation regulations (part 91). These are non-revenue producing flights, such as return flights from a one-way charter or flights to and from a maintenance location.

2.2 Causes and Severity of Accidents Among Capstone Area Aircraft

During the baseline period, accidents among all Capstone area aircraft, Capstone area part-135 aircraft, and Y-K Delta part-135 aircraft have similar injury rates, as shown in Figure 2-3 (next page). Each accident is categorized by the worst injury it caused. Most accidents–typically around 70 percent–result in no injuries. In the Capstone area, the 38 accidents that caused only minor injuries hurt a total of 62 people; the 26 fatal accidents resulted in 50 fatalities.

Figure 2-3. Capstone Area and Y-K Delta Accidents, 1990- 1999 by FAR Part and Injury Severity



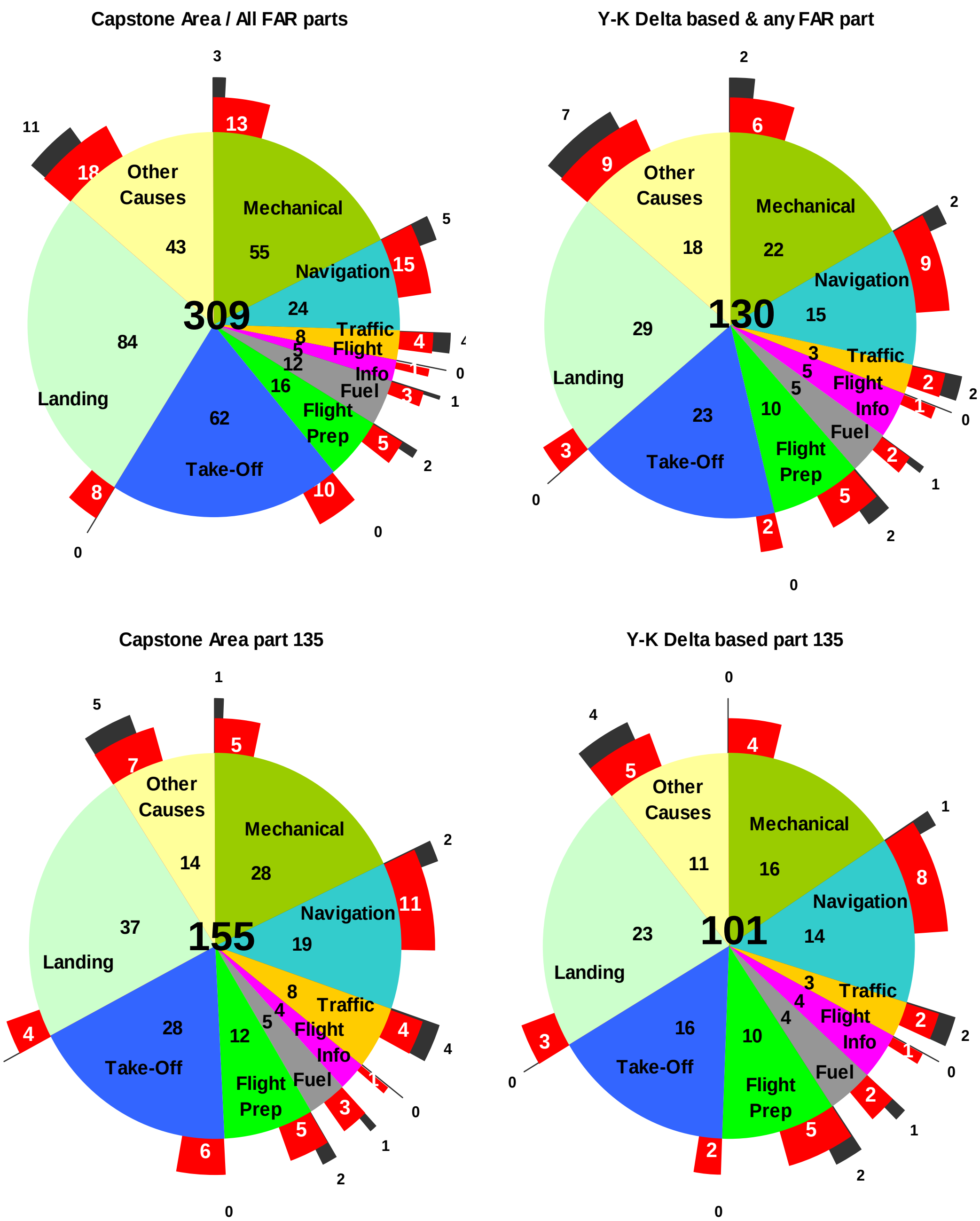
Causes of accidents among these aircraft groups are also similar. Figure 2-4 (page 14) divides the same accidents shown in Figure 2-3 into nine basic cause categories. The inner pie shows all accidents. The red extension shows only accidents that caused injury. The black outer-most extension shows only fatal accidents. The causes are grouped as follows:

Mechanical Failure Engine failure, inoperable control surfaces, failed landing gear, propeller or shaft failure. (There were no fatal accidents in this category among part-135 aircraft based in the Y-K Delta during the 1990s. In the Lower 48, 10 percent of mechanical accidents are fatal.)

Navigation Controlled Flight into Terrain (CFIT) while en route is often associated with reduced visibility and small navigational errors. In the Y-K Delta, CFIT accidents also occur in VFR when flat light on snow-covered ground prevents pilots from recognizing terrain. Terrain Clearance Floor (TCF) warnings are planned for Capstone Phase II; this function would address the 20 to 30 percent of CFIT accidents that occur on approach or departure. Phase I avionics aren't designed to directly deal with such accidents. Rarely, CFIT accidents are due to pilots being far from their intended path; GPS-map displays can help reduce those accidents.

Traffic	Usually mid-air collisions between aircraft. Also accidents from last-moment avoidance of other aircraft and from jet blast on airport surface.
Flight Information	Usually accidents that result from inadequate weather information and are often caused by icing and sometimes poor visibility but rarely convective weather. (Surface winds contributing to take-off or landing accidents have been included under take-off or landing rather than here.) Occasionally, lack of information on changes in procedures or facility status also contributes to accidents.
Fuel Mis-Managemnt	Typically accidents caused by running out of fuel. Sometimes, pilots fail to switch fuel tanks.
Flight Preparation	Accidents caused by a variety of poor flight preparation measures, including failure to insure that cargo is tied down and within the aircraft's weight and balance limits and failure to check whether fuel has been contaminated by water. Rare in the Lower 48 but significant in the Y-K Delta are accidents caused when pilots or others fail to remove ice or snow from the aircraft; these are often serious or fatal accidents.
Take-off and Landing (two causes)	Accidents during take-off or landing from various causes, including accidents when pilots fail to maintain control (especially in wind), maintain improper airspeed, or don't take adequate care near vehicles or obstacles. In the Y-K Delta, an unusually high number of such accidents results from poor runway conditions or from hazards at off-runway sites such as beaches and gravel bars; float planes sometimes hit obstacles in water.
Other	Includes a variety of accidents from unusual causes such as hitting birds or colliding with ground vehicles.

Figure 2-4. Capstone Area and Y-K Delta Accidents, 1990- 1999 by Cause and Injury Severity



Each pie above is actually three nested charts. The inner, multi-colored pies show all accidents by accident cause; the red wedges show accidents with a minor or serious injury by accident cause, and the outer black wedges, fatal accidents by cause.

The causes of *fatal* accidents are markedly different from those of all accidents. For example, although accidents during landings or take-offs are the two most frequent types of accidents, they caused no fatalities in the Capstone area from 1990-1999. This finding is consistent with recent accident studies[14] in the Lower 48. Accidents from other causes—like navigation errors or mid-air collisions—are much more likely to be fatal. The percentage of fatal accidents due to navigation errors in the Y-K Delta during the baseline period was comparable to the percentage of such accidents in the Lower 48—but the percentage due to traffic problems (like mid-air collisions) is dramatically higher in the Y-K Delta.

2.3 Potential and Expected Prevention

The baseline analysis of Capstone's potential to prevent accidents grouped accidents into three categories where Capstone would address:

- All identified causes (the "yes" category)
- Some but not all identified causes (the "maybe" category)
- None of the identified causes (the "no" category")

This report builds on that baseline analysis by focusing on Y-K Delta part-135 accidents, using more detailed cause categories, and attempting to quantify the likelihood that Capstone—as implemented in 2000 and 2001—could have prevented each type of accident. The analysis methods are compared in detail in Appendix A. Figure 1-3 (page 4) shows how Capstone works:

- Capstone addresses accidents associated with ***navigation*** by showing pilots their location on a moving map on a multi-function display (MFD). Capstone derives the location of the aircraft from GPS, and stores the map as part of an onboard navigation database.
- Capstone can reduce ***en route CFIT accidents*** by telling pilots their location relative to high ground. The system compares nearby terrain to the aircraft's altitude and GPS location and then color-codes the information on the MFD — terrain 500 feet or less below the plane is displayed in yellow; terrain level with the aircraft or higher is displayed in red. The GPS unit also has programmable functions to aid en route flight planning and may reduce pilot navigation workload.
- Capstone addresses accidents associated with aircraft ***traffic*** through ATC radar-like services (discussed below) and by showing pilots the locations of other Capstone-equipped aircraft. Each equipped aircraft broadcasts its location to other Capstone equipped aircraft within line-of-sight[15]. This helps keep pilots aware of other aircraft in their vicinity and helps them coordinate with other nearby pilots. In the future, locations of aircraft that are not Capstone-equipped

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[14] *2001 Nall Report – General Aviation Accident Trends and Factors for 2000*, AOPA Air Safety Foundation

[15] The Capstone avionics also transmits the location to GBTs, which in turn provide that information to air traffic controllers, to aircraft within line-of-sight of the GBTs, and through an internet service to companies wishing to flight follow their aircraft.

but that are visible to ATC radar might be provided by traffic information service broadcast (TIS-B) from the network of ground-based transceivers (GBTs).

- Capstone provides ***improved weather and flight information*** through new AWOS installations at remote airports and by broadcasting text and graphical weather information to the cockpit. The pilot can display the broadcast information on the multi-function display.
- Capstone supports increased IFR operation. The program installed new AWOS equipment at remote airfields, and published GPS instrument approaches for those airfields. For qualified aircraft and pilots, this allows safe IFR operations in low visibility conditions that unsafe for VFR operations. Capstone also improves and expands IFR operations by allowing air traffic controllers to use automatic dependent surveillance-broadcast (ADS-B) to support radar-like services. ADS-B takes an aircraft's location from GPS[16] and transmits it to ground-based transceivers, which forward it to ATC computers—where the aircraft locations are displayed much like aircraft locations from radar. This capability allows controllers to provide flight-following and surveillance-based separation services in airspace that is not visible to radar.
- Tower operators at Bethel airport in 2002 use a "BRITE" display of ADS-B targets to help them locate aircraft, better coordinate arrival and departure sequencing, and monitor surface operations. However, they did not have this display during the interim study period.
- Managers in companies that operate Capstone-equipped aircraft in 2002 will be able to monitor their flight locations on PCs connected to the Internet. This capability has the potential to significantly improve managers' awareness of risks and help improve safety posture. The companies did not have this capability in 2000 and 2001.

Accidents in each category have distinguishing features (found by reviewing the detailed narratives) that allow us to assign them to detailed cause sub-categories that are or are not directly addressable by Capstone.[17] For those directly addressed by Capstone, narratives also provide insights into the likelihood that a perfectly implemented Capstone program would have prevented the accident. Based on this narrative and expert opinion, we have estimated a best-expected prevention likelihood for each Capstone area accident from 1990 through 1999.[18]

Capstone's success at preventing each type of accident also depends on the proportion of aircraft that are equipped, levels of pilot training, and geographic coverage of Capstone services, all of which gradually change as Capstone is implemented. How these factors affect Capstone's ability to prevent accidents is described for each of the

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[16] Capstone Phase I avionics determines the aircraft altitude from the aircraft's barometric encoder, and not from satellite positioning. Latitude and longitude information is derived from the GPS.

[17] We have chosen the accident cause categories in this report to facilitate analysis of the potential impact of Capstone capabilities. Therefore, they differ from categories used in other reports such as *Nall*.

[18] The full list of accidents, estimated percent of causes addressed and best expected prevention is included in appendix B.

accident categories below. Bold portions of headings correspond to the labels on Figure 2-5; underlined ones are a direct focus of Capstone for which we can make quantitative projections of impact.

Fuel Mismanagement — Not a direct focus of Capstone, but these accidents are very dependent on safety posture of pilots and their companies. Safety posture is influenced by Capstone as well as other safety initiatives.

Mechanical Failure — Not a direct focus of Capstone. Some influence by company safety postures or improvements in maintenance facilities.

Flight Information — No impact in 2000-2001, but in-flight accidents in this category are a direct focus of Capstone. We believe that accidents due to icing would have been preventable, if pilots had access to icing information. When available, weather products that display icing information on maps will be particularly helpful. NEXRAD[19] graphics, METARS, TAFs and AWOS information (as well as NOTAMs, PIREPs, and AWOS data over FIS-B[20], when implemented) will contribute to safer operations, but we cannot assess the fraction of 1990-1999 accidents they would have prevented.

Preventing accidents depends on the geographic coverage of FIS-B, the availability of broadcast service, the availability of specific products (such as icing information), equipage of aircraft, the effectiveness of pilot training in accessing and interpreting weather information, and safety posture, including pilot attitudes.

Navigation — We estimate (best possible case) that 90 percent of en-route CFIT accidents could be prevented if all aircraft were equipped with Capstone avionics and all pilots trained to use the equipment perfectly. About 10 percent of en route CFIT accidents would occur regardless of these factors, because the pilots can't always respond effectively to terrain warnings in low visibility, flat light, or white-out conditions. In these cases, the pilot's responses induce spatial disorientation and the pilot loses control of the aircraft.[21]

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[19] NEXRAD is the weather service's "Next Generation Radar", which uses Doppler radar to show areas of active precipitation and software improvements to make better use of the radar information.

[20] Because the new AWOS stations installed by Capstone are not connected to the weather service's system, information from those stations is not yet available over Capstone avionics. Information from older AWOS stations is available over Capstone.

[21] *Broadcast Services Evolution Path: Preventing Fatal GA Accidents by Market or FAA Services*; Kirkman, Stock, Peed; MITRE Corporation, 2002. This analysis estimated a 25% residual for fatal CFIT accidents by General Aviation pilots provided with terrain awareness capability. Our assessment of accidents by YK Delta commercial pilots resulted in a smaller percentage because the pilots have higher experience levels, and experience many fewer spatial disorientation accidents than general aviation pilots.

(Navigation, cont'd)

For the other 90 percent of cases, the fraction of en route CFIT accidents and mistaken location accidents that Capstone might actually prevent depends on to the percent of aircraft equipped and the actual training level of pilots. Assuming the effects are proportional, we express this mathematically as:

$$\begin{matrix}\textit{\% Accidents}\\ \textit{Prevented}\end{matrix} = 90\% \bullet \begin{matrix}\textit{\% from}\\ \textit{en route CFIT}\end{matrix} \bullet \begin{matrix}\textit{Fraction}\\ \textit{Equipped}\end{matrix} \bullet \begin{matrix}\textit{Training}\\ \textit{Effectiveness}\end{matrix}$$

CFIT during approach and departure (TCF violations) is not directly addressed by the Phase I Capstone avionics, so we don't estimate any prevention. All types of navigation accidents could be influenced by changes in the pilot's workload due to Capstone avionics and by changes in safety posture, but we do not have a basis for assessing this quantitatively.

Traffic

We estimate that Capstone could be 100 percent effective in preventing mid-air collisions by helping pilots be aware of aircraft around them, if both aircraft are equipped and both pilots trained to use the equipment perfectly. Most collisions occur in good visual conditions with many safe ways for pilots to avoid a collision. So the percent of accidents prevented depends on the likelihood that the first aircraft is equipped, the likelihood that the second aircraft is equipped, and the training levels of the two pilots. Again assuming the effects are proportional, we express this as:

$$\begin{matrix}\textit{\% Accidents}\\ \textit{Prevented}\end{matrix} = \begin{matrix}\textit{Fraction}\\ \textit{Equipped}\end{matrix} \bullet \begin{matrix}\textit{Fraction of } \textbf{\textit{Other}}\\ \textit{Aircraft Equipped}\end{matrix} \bullet \begin{matrix}\textit{Training}\\ \textit{Effectiveness}\end{matrix}$$

Other aircraft include not only part-135 but also part-91, part-121, and public use aircraft with which a Y–K Delta part-135 aircraft might collide.[22] We include the training effectiveness only for the pilot of the first aircraft in the equation, since typically if one aircraft takes evasive action the other aircraft does not need to.[23]

Flight Preparation

Not a direct focus of Capstone. Accidents in this category reflect lapses in safety procedures by pilots and their companies. Improved safety practices may be influenced by Capstone and other safety initiatives.

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[22] We calculate the effectiveness for 2000/01 by first multiplying the function describing the increase over time of the equipped portion of the Y-K Delta fleet times the function describing the increasing portion of all aircraft in the area that are equipped. We then average the resulting function over the 2001/02 period.

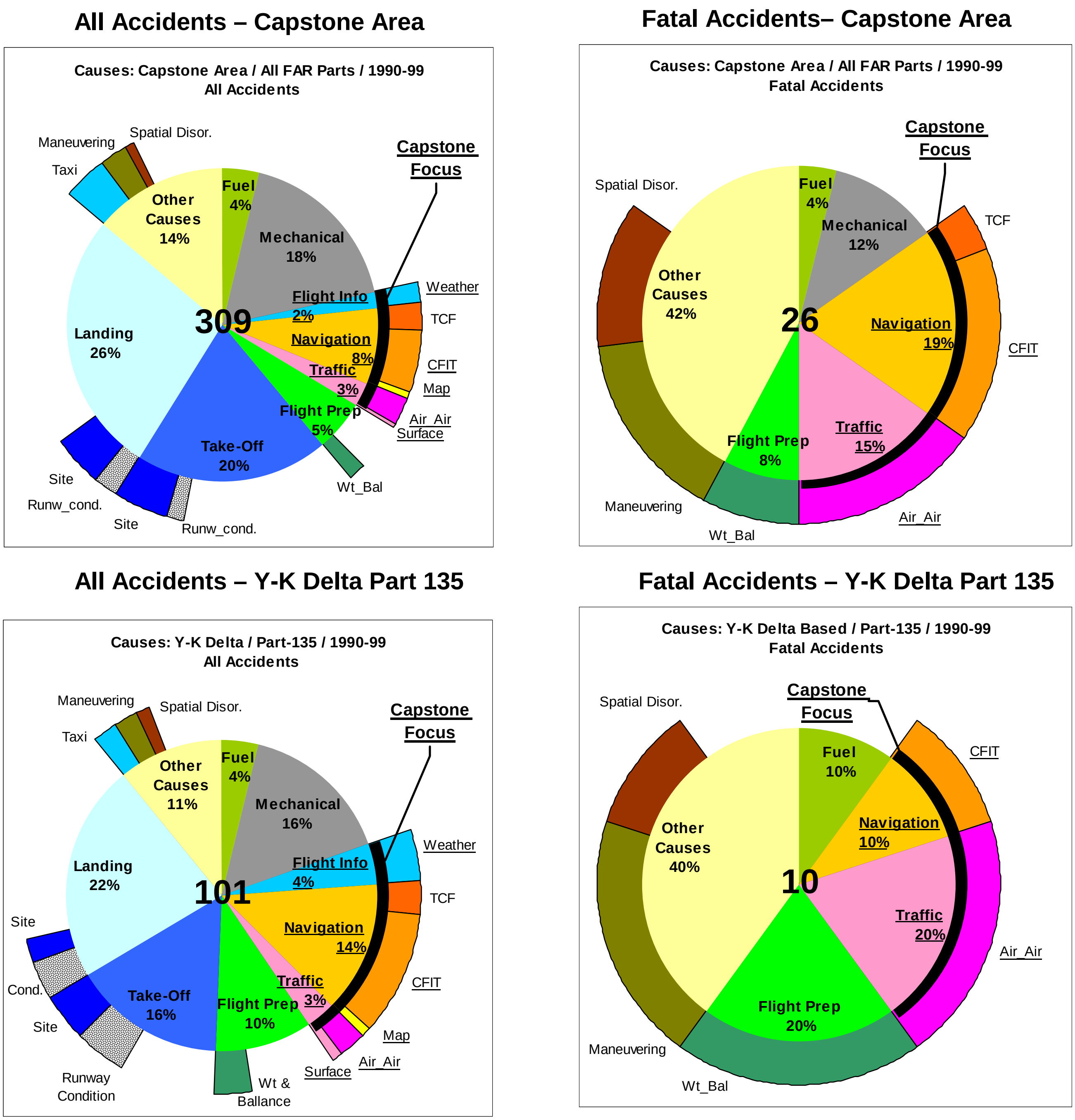
[23] Because the pilot of either Capstone equipped aircraft could take action to avoid collision, we could refine this equation by replacing Training Effectiveness (TE) with 1-(1-TE)(1-TE). In this report, the difference between the two equations is about 1/20th of one accident.

Take-off and **Landing**	Not a direct focus of Capstone. Likely influenced by skill and experience levels of pilots and the quality of runway maintenance. Wind information from AWOS or FIS-B may contribute to safer operations, but this could not be quantified from accident histories.
Other	Not a direct focus of Capstone. Some accidents clearly could have been avoided with better pilot training and improved safety.

The figures on the next page illustrate our analysis. The upper two charts in Figure 2-5 (next page) show all Capstone area accidents from 1990–1999 (the inner pie of Figure 2-4, upper left chart) and Capstone area fatal accidents 1990–1999 (outer ring of the same chart). The outer rings in Figure 2-5 show selected detailed cause categories, highlighting those causes that Capstone could potentially prevent. The lower two charts show the same information for Y-K Delta part-135 operators. Note that the Capstone Area charts in Figure 2-5 expand on the information in the upper left chart of Figure 2-4; the Y-K Delta Part-135 pies expand on the information in the lower right chart from Figure 2-4. Definitions of the detailed causes in Figure 2-5 are provided in Figure 2-6, page 21.

There is little difference between the causes of all accidents and of fatal accidents for part-135 operations in the Y-K Delta and in the Capstone area as a whole—although Y-K Delta part-135 operations have somewhat higher fractions of accidents caused by navigation and flight preparation errors. Visual differences between the fatal accident pies in Figures 2-5 are misleading. With a total of only ten Y-K Delta part-135 fatal accidents, random differences resulting from a single accident appear large.

Figure 2-5. Accidents and Fatal Accidents in the Capstone Area and of Y-K Delta Part 135 Operators, 1990-1999, by Detailed Cause



Inner Pies show accidents by 9 major causes
Black arcs indicates accident causes that are a focus of Capstone
Outer rings breaks down selected causes into detailed causes
Detailed cause definitions in box on following page

Figure 2-6. Definitions of Detailed Cause Categories

Flight Info:

Weather= Accidents where the availability of weather information was a factor.

Navigation:

TCF = CFIT accidents that occur on approach or departure

CFIT: Controlled Flight into Terrain accidents

Map = pilot did not know aircraft's location

Traffic:

Air_Air = mid-air collisions; occasionally, collisions between moving aircraft on the ground

Surface: collisions on the ground

Flight Prep:

Wt_Bal = aircraft not loaded within weight and balance restrictions

Take-off and Landing:

Runw_cond= accidents related to runway conditions such as potholes, debris on the runway, etc

Site= unisiual hazards of off-runway sites;

Other:

Taxi=collisions with objects (not a/c) while taxiing

Maneuvering=typically, stalling the aircraft while maneuvering

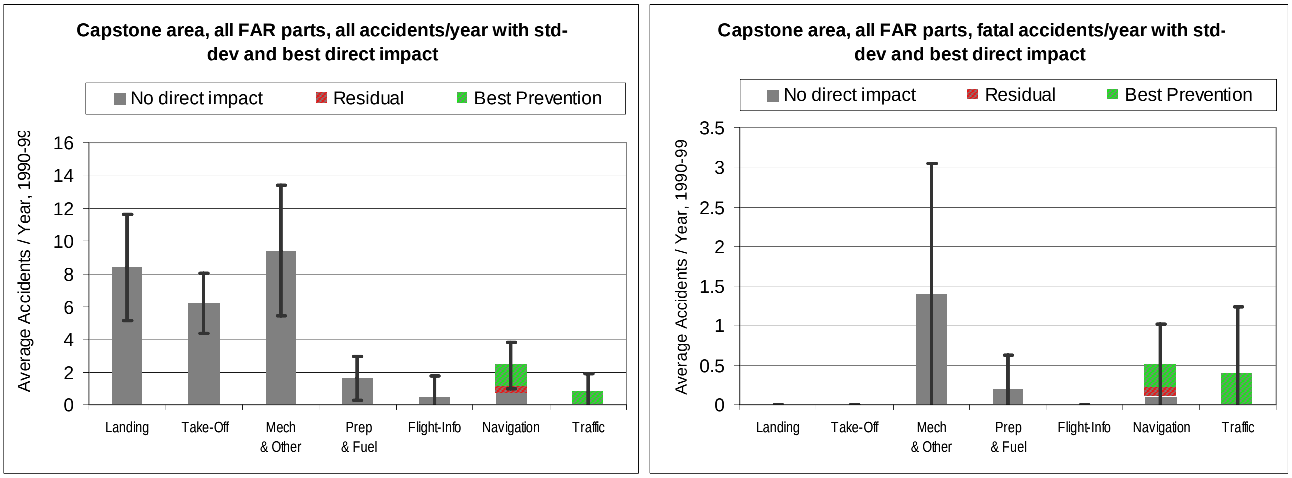
Spatial Disor.=loss of control due to pilot disorientation

In Figures 2-7 and 2-8 (next page) we take the nine broad cause categories in Figure 2-5 and combine them into seven, combining mechanical causes with other and flight preparation causes with fuel. Figure 2-5 showed total accidents from 1990 through 1999; Figures 2-7 and 2-8 show those accidents in annual averages rather than decade-long totals. The standard deviation of the ten-year series for each type shows how much the number of accidents varies from year to year.

The fraction of accidents that would be eliminated by a best-expected prevention (estimated as described above) is shown in green. The residual (best expected being less than 100 percent) is shown in red. Cause categories and sub-categories that new Capstone technologies don't directly address are shown in gray.

Fatal accidents average less than one per year; those small numbers, combined with a wide variation in the number of accidents from year to year, mean that it will be several years before a statistically significant change could be observed. Accidents from navigation problems are the category most likely to provide statistically significant changes in the number of accidents. Other categories of accident may also be affected by Capstone, though we cannot make a projection from data in the baseline period. We discuss several such possibilities in the cause subsections.

Figure 2-7. Average Annual Accidents, Fatal Accidents, and Best Expected Prevention, by Cause, in the Capstone Area, 1990-1999



The gray "no direct impact" bars represent accidents with causes that Capstone does not address. This includes the lower gray portion of the navigation bars. The green "best prevention" areas show the number of accidents that we estimate Capstone might have prevented if fully implemented in the baseline period. The red "residual" area shows the number of potentially Capstone-preventable accidents we estimate would have occurred even with Capstone. The "I" lines centered on the top of each bar show one standard deviation of the ten-year series–and give an indication of how the number of accidents varies from year to year. Typically, two-thirds of the annual counts fall within one standard deviation of the mean.

Figure 2-8. Average Annual Accidents, Fatal Accidents, and Best Expected Prevention, by Cause, Y-K Delta Part-135 Operators, 1990-1999

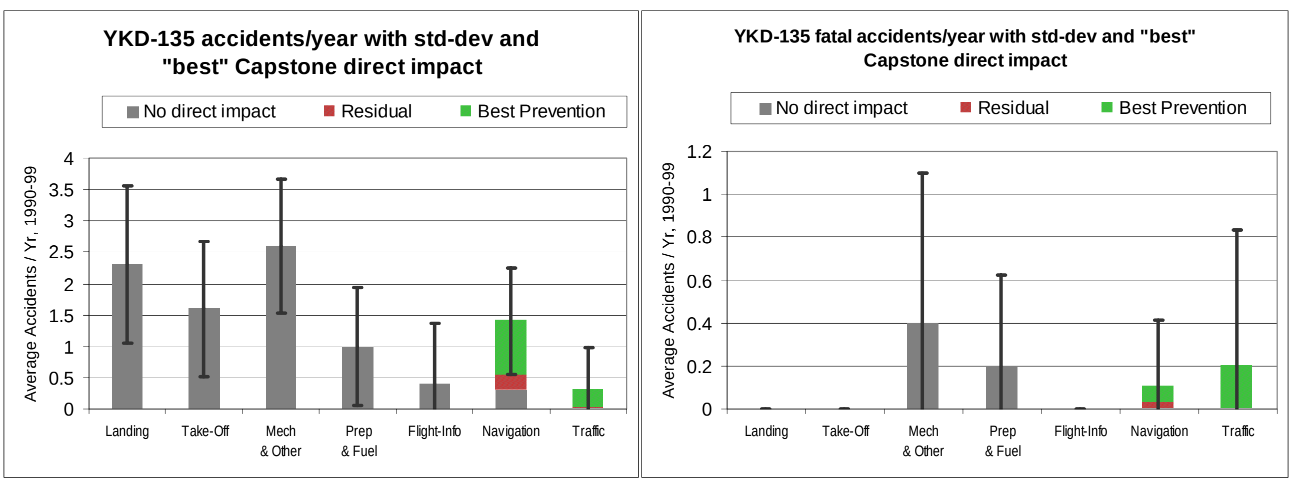


Figure 2-7 showed all accidents for the Capstone area; this figure looks only at accidents of Y-K Delta Part-135 operators. The gray "no direct impact" bars represent accidents with causes that Capstone does not address. This includes the lower gray portion of the navigation bars. The green "best prevention" areas show the number of accidents that we estimate Capstone might have prevented if fully implemented in the baseline period. The red "residual" area shows the number of potentially Capstone-preventable accidents we estimate would have occurred even with Capstone. The "I" lines centered on the top of each bar show one standard deviation of the ten-year series–and give an indication of how the number of accidents varies from year to year. Typically, two-thirds of the annual counts fall within one standard deviation of the mean.

For the Capstone area, our best-expected prevention estimate is that average annual accidents from navigation problems would have been about 1.3 accidents per year lower than observed in the baseline period; traffic accidents would have been about 0.8 accidents per year lower. Fatal navigation accidents would have been about 0.3 accidents per year lower and fatal traffic accidents about 0.4 accidents per year lower (Figure 2-7).

We would only have seen those reductions if all aircraft in the Capstone area had been equipped with new avionics, and if the ground infrastructure had served the entire area. The best-expected reduction for the operations and area actually affected by Capstone Phase I is lower, as Figure 2-8 shows. Y-K Delta part-135 operators would have had 0.9 fewer navigation and 0.3 fewer traffic-caused accidents per year; fatal accident averages in those categories would have declined by just 0.08 and 0.2 accidents per year.

2.4 IFR Capability

In the baseline period, the potential for IFR operations in the Y-K Delta was limited. In the Capstone area, there were only seven airports equipped with instrument approaches. Of the Y-K Delta airports that account for most of the traffic among our Capstone operators, there were only three airports with instrument approaches: Bethel, Aniak, and St. Marys. Therefore, even if aircraft and operators were IFR-equipped and certified—and pilots certified and current—they were still restricted to VFR operations for most of their flights, since there was no way to make an IFR approach and landing if destination weather was below VFR minimums. Of the 27 Capstone area operators identified in the baseline report, 14 had VFR-only certificates.

2.5 Safety Posture

Training, maintenance, flight preparation, decision-making, and oversight are all indicators of the safety attitudes and practices of Capstone operators. Economic factors such as insurance and customer choices also affect safety posture.

2.5.1 Training

Initial and recurrent pilot training is central to safe flying. Beyond basic piloting skills, pilots need to know the particular aircraft they are flying, and how it responds to the loads they carry. They need to be knowledgeable about a great variety of local conditions, including terrain, navigation and communication aids, airport facilities, and weather hazards. They need to be thoroughly familiar with both FAA and company regulations governing their operations. They need to understand how to function successfully in the local business environment as well. Some of this knowledge comes through formal training, but much is mastered only through experience.

In the baseline period, some of the Capstone operators were large enough to have extensive written training programs; others were small one-pilot operations with little or no capacity to provide training internal to the company. Critical safety issues in the

Capstone area that operators would typically address in formal training would be taking off and landing on short, gravel runways and dealing with the weather hazards of the area (see Section 1 of this report and Chapters 3 and 7 of the baseline report).

Pilots reported a mean of 53 hours of ground training and 34 hours of flight training in a wide variety of categories in the previous 14 months (see baseline report, Chapter 8). The importance of experience in addition to formal training was clear when pilots reported their greatest safety concern in the Y-K Delta: “Pilots not experienced in Alaska conditions” (baseline report, p. 46).

2.5.2 Maintenance

Well-maintained aircraft are another component of safe operations. As with training, Capstone operators in the baseline period ranged from those large enough to have extensive in-house maintenance down to one-pilot companies which took their aircraft to a local licensed A&P mechanic for required maintenance. Nevertheless, the baseline analysis makes it clear that mechanical failures have not been a major source of accidents and especially not of serious accidents. Of 155 accidents from 1990 through 1999, only 28 included mechanical failure among their causes, and 23 of those resulted in no injuries (Figure 2-4).

2.5.3 Oversight

Federal aviation regulations are designed to ensure that aircraft have adequate maintenance, pilots have more than adequate rest and training, and operators provide more than adequate oversight of their operations. Regulatory oversight contributes to safety by balancing the economic incentive operators have to try to do more with less.

Chapters 5 and 6 in the baseline report discuss regulatory requirements, safety programs, and FAA oversight of Capstone operators. Four of the larger operators fell completely or partially under FAR part 121; the rest flew exclusively under FAR part-135. The smallest part-135 operators had only minimal manual and personnel requirements. We found that FAA inspectors met most frequently with operators whose headquarters were in Anchorage or Fairbanks. Operators and pilots reported that Bethel facilities receive fewer visits, although inspectors do travel to Bethel as their time permits. Therefore, small operators headquartered in Bethel received less oversight than those with facilities in Anchorage and Fairbanks. Inspectors that we talked to rarely flew beyond Bethel to the smaller communities. Many of those villages are served only by smaller aircraft, with only one to five potentially paying seats. It would be a significant financial burden for the companies to transport non-paying inspectors in such small aircraft.

2.5.4 Economics

The economics of air carrier operations in the Y-K Delta are unforgiving. As described in the introduction, companies use very small aircraft to serve many scattered destinations. The number of passengers traveling to any one destination (other than Bethel) is typically too low to support frequent service without some form of subsidy.

One way the federal government has chosen to provide that subsidy is the “bypass mail” program—under which shippers, rather than the U.S. Postal Service, deliver mail directly to the air carrier. Shippers pay a subsidized rate to the Postal Service, which in turn pays carriers enough to cover their calculated cost of delivering the mail. This program is designed to enable participating air carriers to sell passenger tickets at the marginal—rather than the average—cost of transport. By covering many of the fixed costs, air carriers can potentially keep passenger fares affordable.

In the baseline period, operating costs in the Y-K Delta were pushed higher by rising insurance rates. Alaska’s high accident rates and small insurance market combined to make participation less attractive to insurers. As a result, only a few companies offered insurance to air carriers here, and they charged high rates. Some air carriers chose to cease carrying passengers in order to reduce insurance costs.

Taken together, these factors provided air carriers in the 1990s with economic incentives to cancel as few flights as possible, get as many flights out of each pilot and each aircraft as possible, and load aircraft as full as possible.

2.6 Limitations of Baseline Data

Data on air operations within the Capstone area are quite limited. As discussed in section 2.3 of the baseline study, departure and enplanement data collected by the U.S. Bureau of Transportation Statistics (BTS) record only scheduled passenger and cargo flights. The only systematic data available for the Capstone area during the baseline period come from the APO Terminal Forecast Survey Summary Report from the FAA’s Aviation Policy and Plans Office. The APO compiles historical traffic counts from FAA Form 5010, the airport master record. In Bethel, the air traffic controllers report the number of aircraft cleared for take-off or landing. At all other airports in the Capstone area, airport managers provide estimates of annual traffic counts; published data for Capstone airports are only available for 1999. We estimated annual departures by dividing the traffic counts by two. This method undercounts unscheduled air taxi and general aviation departures to and from off-airport locations.

As described in section 4.6 of the Capstone baseline report, as of 1999 there were 22 locations in the Capstone area with some level of weather reporting. Bethel was the only staffed full-time weather station in the area that provided continuous weather observations. All the remaining sites that continuously reported weather were automated stations. There are several reasons why weather information available to pilots and for our baseline analysis was less complete than in most areas of the U.S.

- Distance between stations. The 22 locations were widely separated, typically at least 60 miles apart and often more than 100 miles. In a region characterized by changing weather, widely separated stations can’t observe many localized conditions.

- Lack of corroboration. In much of the continental U.S., automated observations are supplemented by other weather information, such as from Doppler radar and manned observations. In the Capstone area in the 1990s there was often no other source of information to help reconstruct local weather conditions when reported data for weather factors such as wind speed or visibility were missing or obviously invalid.

- Lack of interpretation. Current weather information, while useful, is greatly improved by interpretation in the context of how the weather is changing over time—that is, by local forecasts. In large, sparsely populated regions like the Capstone area, the National Weather Service makes a single forecast for a large area, characterizing general conditions but without the specifics needed to determine exactly where it is safe or dangerous to fly.

3 Evaluation of 2001 Safety Factors

This section describes progress in implementing Capstone to date and Capstone's effects on safety in the study area through 2001. Other factors besides Capstone also affect safety, and also consequently affect the risk of aircraft accidents from the various causes we analyzed in Section 2. So we also describe these other factors and discuss how we might distinguish their effects from those of the Capstone program.

3.1 Infrastructure and Services

Capstone has provided new infrastructure and services that support IFR and improve VFR operations in the Y-K Delta. These include AWOS installations, improved navigation, data-linked weather, and radar-like services in this non-radar environment. A "Brite" display for tower operators, flight following for operator management, and traffic information broadcast had not yet been implemented at the end of 2001.

3.1.1 AWOS Stations and GPS Approaches

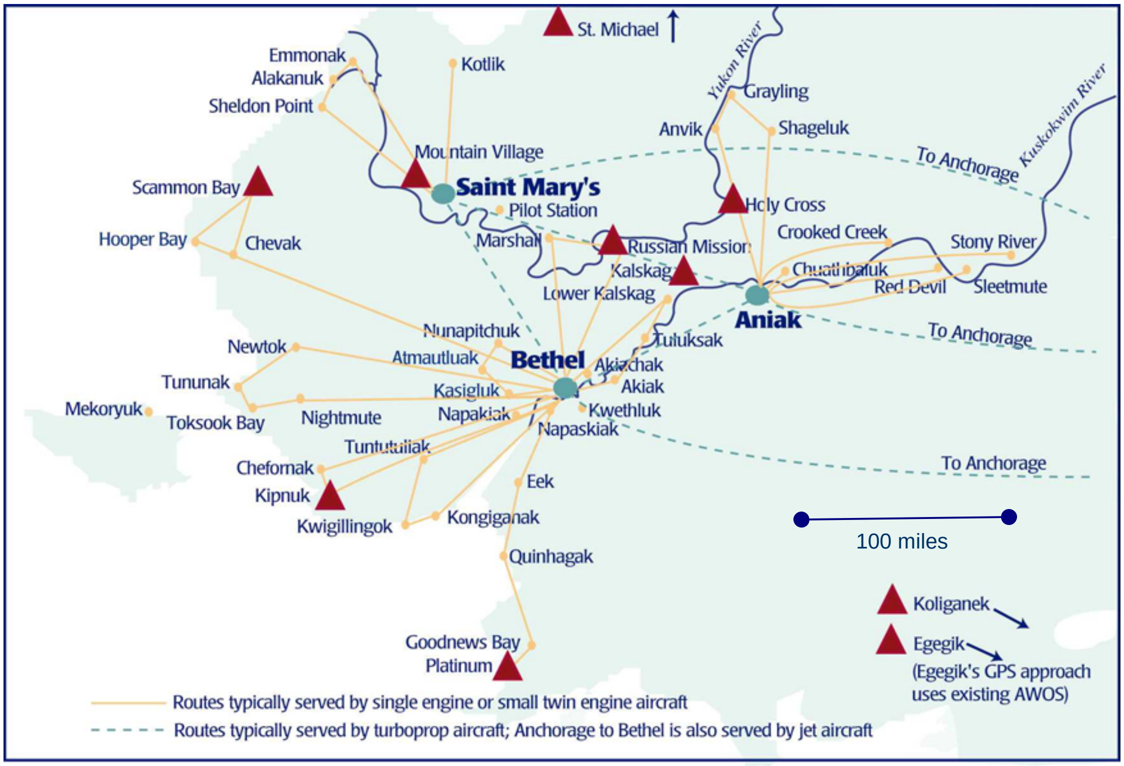
As part of the Capstone program, nine airports have received AWOS weather reporting stations and associated GPS non-precision instrument approaches. Eight of the AWOS stations and one GPS approach were added during 2001. One additional airport is scheduled for improvements in 2002. Table 3-1 summarizes these changes; Figure 3-1 (next page) shows the locations of the new facilities in the Y-K Delta.

Table 3-1. Weather Stations and GPS Approaches Added in 2000 and 2001

Airport	AWOS	GPS Approach
Egegik	Baseline	2001
Holy Cross	2001	2000
Kalskag	2001	2000
Kipnuk	2001	2000
Koliganek	2001	2000
Mountain Village	2000	1999
Pilot Point	Planned	Planned
Platinum	2001	1999
Russian Mission	2001	2000
Scammon Bay	2001	2000
St. Michael	2001	1999

Source: FAA Capstone program, http://www.alaska.faa.gov/capstone/status.htm

Figure 3-1. New AWOS Stations and GPS Approaches in the Y-K Delta



The AWOS stations and GPS approaches are most useful to instrument operations, but they also provide helpful services to VFR flights. Pilots flying between Bethel and airports with weather information and GPS approaches are less likely to encounter unexpected bad weather and more likely to be able to land safely if they do. Even without the GPS approaches, the additional AWOS stations represent a real improvement in the weather data available to all Y-K Delta flight operations.

In the baseline period, only eight weather stations in the Y-K Delta provided pilots with continuous weather information.[24] The closest were about 60 miles apart; in many areas pilots would have to fly over 100 miles between weather stations. As discussed in Chapter 7 of the baseline report, the Y-K Delta is a transition area between continental and maritime climates; the weather often changes rapidly as pilots travel toward the coast. The eight new weather reporting stations added under Capstone double the number of Y-K Delta reporting locations, and the distance between weather reporting stations along most typical flight routes is now less than 50 miles.

Besides improving the available weather information, increasing the number of destinations to which IFR flights are possible also increases the potential return to operators if they develop IFR-capability. It is expensive to equip aircraft and keep pilot

[24] The baseline report lists 22 weather reporting stations (page 33). Of these, ten are outside the Y-K Delta, and four operate only to support military or large commercial flights, and thus are often unavailable. Bethel has a 24-hour National Weather Service office, and the remaining seven are AWOS or ASOS installations.

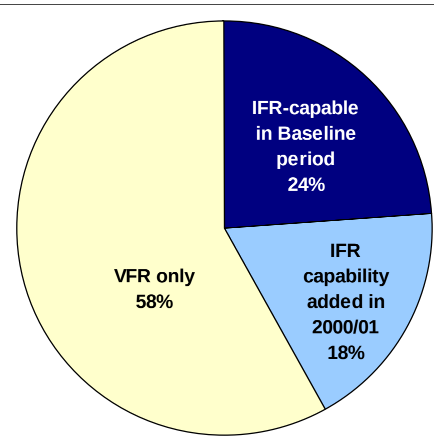
IFR training current; operators will make that investment only if they can recover those expenses through fewer cancelled flights (and so, more revenue). Once operators make that investment, pilots flying VFR, rather than guess about deteriorating weather, can file and fly under IFR.

To assess how much this new infrastructure contributes to safety in the Y-K Delta, we looked at how many more operations were served by the new equipment, compared to operations served by weather reporting and instrument approaches in the baseline period. Bethel is often the origin or destination of operations; we excluded Bethel operations numbers so we could focus on operations served by weather reporting and instrument approaches at the non-Bethel end.

We analyzed several sources of data: enplanements from 1995 through 1999; APO data from 1999 (the baseline operations data—airport managers' estimates of traffic at their airports); and T-1 origin-destination passenger counts from 1995 and 1996 (which include scheduled service only). None of these data provide an exact count of total flights into and out of the Y-K Delta; however, they all produced similar results. The number of operations into IFR-capable airports (excluding Bethel) increased by more than 75 percent as a result of the added AWOS stations and GPS approaches. Figure 3-2 shows the percent of air taxi and commuter operations at Y-K Delta airports (excluding Bethel) with IFR capability in the baseline period; where IFR capability was added in 2000 and 2001, and where all operations are still VFR only.

About 40 percent of flights to small Y-K Delta communities could benefit from the IFR capabilities of the destination airports. Since not all aircraft are equipped or certified to fly IFR, fewer than that could actually fly IFR. But because aircraft in the IFR fleet carry on average more passengers per flight than VFR-only aircraft, about 45 percent of the available seats to airports with IFR infrastructure are on IFR-capable aircraft.

Figure 3-2. Estimated Air Taxi and Commuter Operations to Y-K Delta Airports Excluding Bethel by IFR Capability of Airport



Source: APO operations data,
Air Taxi Operations Estimates by Airport, 1999

3.1.2 Data-link weather

The flight information system–broadcast (FIS-B) function of the Capstone system is intended to provide aircraft with current weather information and forecasts. During 2000 and 2001, this capability increased greatly, but this feature of Capstone Phase I was still not completely implemented at the end of 2001. Pilots' access to up-link weather data is limited by the existence of few ground-based transceiver stations (GBTs). But even in areas served by GBT's, pilots' access to information is still affected by several factors: whether the GBTs are operating or are temporarily shut down for maintenance; if they are operating, whether the pilot is within radio line-of-sight of a station; and what weather products exist and are linked to the GBTs.

In early 2000, there were no GBTs in the Y-K Delta; by July 2000, there were three, and by May 2001, there were five (as well as one in the Anchorage area). Figures 3-3 (below) and 3-4 (next page) show the areas within which pilots flying at 1000' (yellow) and 3,000' (yellow plus red) were in radio line-of-sight of GBTs in July 2000 and May 2001, and thus were able to access data-link weather.

Figure 3-3. Ground Based Transceiver Coverage, July 2000

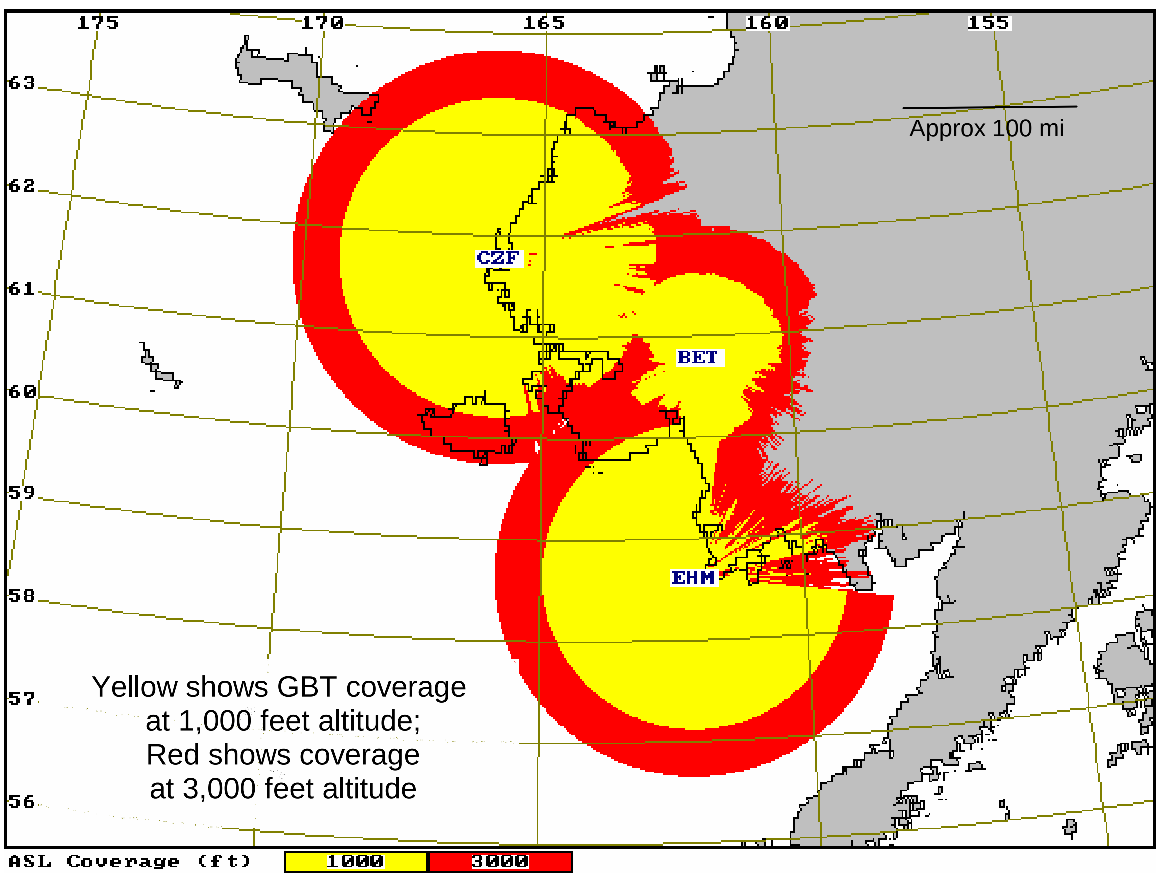
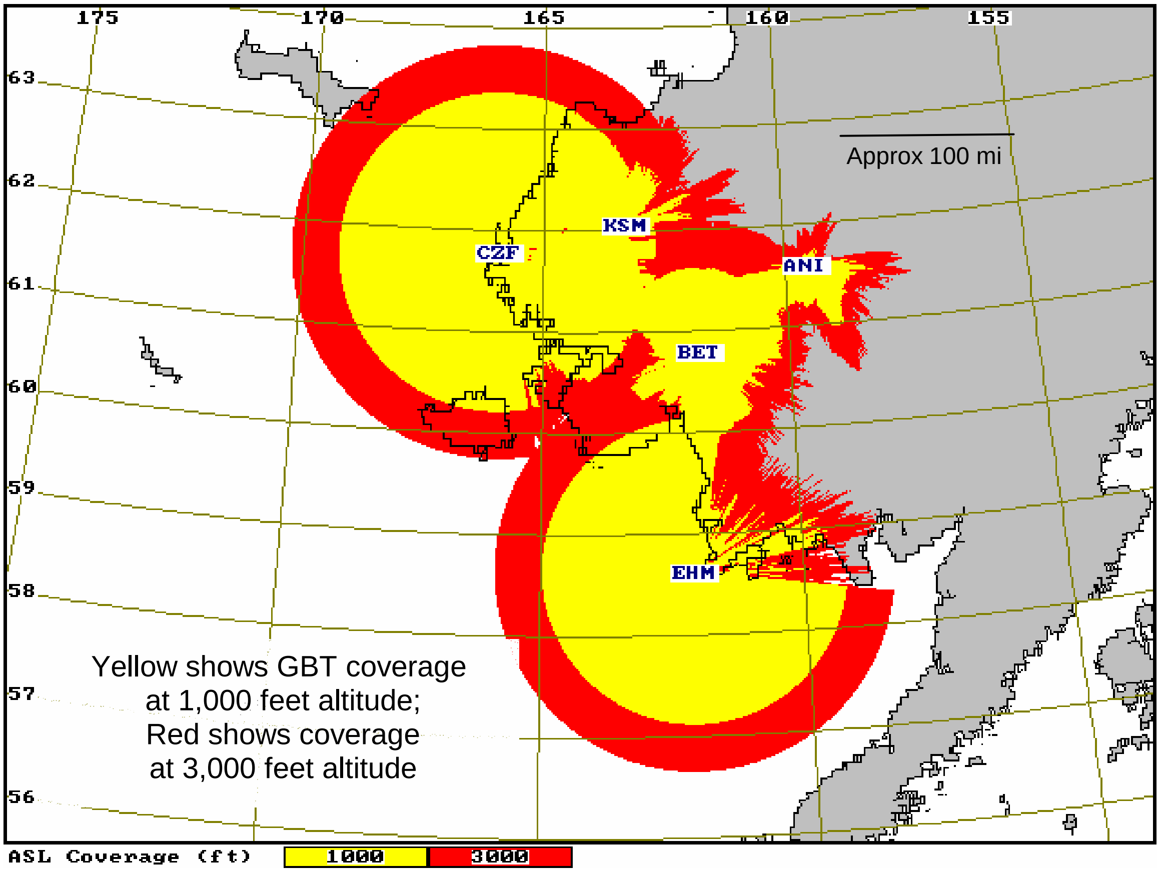


Figure 3-4. Ground Based Transceiver Coverage, May 2001



By mid-2001 there were GBTs in Bethel, Cape Newenham, Cape Romanzof, Aniak and St Marys, as well as at Site Summit outside Anchorage. Additional installations are planned for Dillingham, King Salmon, Sparrevohn, Tatalina, and Unalakleet.

Text weather (METAR and TAF) is available through the GBTs; graphic weather from Bethel weather radar (NEXRAD) was usually available by late 2001. One of the implementation difficulties was establishing a robust data connection from NOAA (which produces the NEXRAD data) to the GBTs for broadcast to aircraft. The Bethel airport radar covers most of the Y-K Delta. However, because there is only one radar installation covering an area from several different directions—rather than the multiple installations typical for NEXRAD products in other states—bad weather may be obscured from the radar's view, if there is precipitation directly between the area of bad weather and Bethel. To interpret Bethel's NEXRAD graphics, pilots have to do more analysis than they would with similar weather products elsewhere.

The pilots and operators using the flight information system (FIS) report the following limitations and concerns.

- FIS does not yet have weather for the new AWOS III stations that were added as part of Capstone. Pilots can only get those weather data over the telephone before they take off, or by radio when the aircraft is near the AWOS. When all the AWOS data becomes available en route, through FIS, pilots will be better able to use such data to decide what to do in changing weather conditions.

- FIS is only available when flights are in line-of-sight range of the Bethel GBT. When all the GBTs are brought on line this concern should be eliminated.

3.1.3 Radar-like Services

As mentioned above, flight below 6,000 feet in the Y-K Delta is in a non-radar environment. The only radar coverage in the area is high-altitude coverage for long-range jets, controlled from Anchorage Center. Capstone's traffic awareness function, which lets anyone with an ADS-B receiver see the locations and altitudes of Capstone-equipped aircraft, brings the potential of "radar-like" services to the Y-K Delta. Controllers in Anchorage could use Capstone's ADS-B feature to guide Capstone-equipped aircraft just as they now use radar to guide aircraft over 6,000 feet. This idea was successfully tested in January 2001.

Few operators have used radar-like services since they became available. Capstone operators are accustomed to operating without air traffic control and have little motivation to change at this time. The greatest potential benefit of radar-like services for most Capstone operators would be to provide approach control to the Bethel airport—and that service is not yet available.

As more Y-K Delta part-135 operators upgrade their operations to become IFR-capable (see section 3.3.2), radar-like services for both en-route operations (currently available) and approach control (not yet implemented) will be more useful to them. During the study period, both operator development and Capstone program implementation limited the use of radar-like services to only a few flights. Until we see how Capstone operators use this capability, it's impossible to estimate even the potential safety benefit.

3.1.4 Tower Services and Approach Control

Tower services are similar to radar-like services, except that the controllers are in the Bethel tower, rather than at the Anchorage Center. Using a BRITE display, controllers can more easily acquire and track VFR and SVFR aircraft. Approach control, if implemented at Bethel, could potentially allow air traffic controllers[25] to use Capstone technology to space and sequence IFR or SVFR aircraft landing at Bethel. During times of special visual flight rules (SVFR) operations, controllers are both spacing the IFR aircraft and closing the Bethel airport Class D airspace to all VFR (including SVFR) traffic for the approach and departure of IFR flights. While the average SVFR operational time[26] is less than 10 minutes, the times vary from none to over an hour.

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[25] Approach Controllers would not necessarily be located at the Bethel tower, but could be at Anchorage Center, Fairbanks, or some other location.

[26] "Operational time" in this context is the time from a pilot's request for SVFR clearance to his time of landing.

Over 10 percent of SVFR traffic waits 20 minutes or more. When Capstone is fully implemented, air traffic controllers will be able to see both (1) traffic on radar and (2) ADS-B broadcasting traffic. They will not need to close the Class D airspace for as long a period as they now do for arriving IFR flights, and could potentially space SVFR flights more efficiently. Both of these could shorten operational times. These services, therefore, can improve efficiency for operators and provide the potential safety benefits described in Section 2.3.3, Traffic. These services were not implemented in 2001, and the average SVFR operational times did not change from the baseline through 2001.

In interviews, some smaller operators said they were concerned that if many larger operators move to IFR operations (see next section) before the Bethel tower is able to manage IFR and Capstone-equipped SVFR together, then the SVFR delays will increase. That's because there would then be more IFR operations, which take precedence over SVFR operations into Bethel airport.

3.1.5 Flight Monitoring

The Capstone system potentially provides a way for Capstone operators to track their aircraft over the Internet, using PC software that would allow them to access ADS-B information at their operations base. All operators we talked to would like to use that capability to improve management oversight of flight activities—but such flight monitoring was not yet implemented in 2001.

3.1.6 TIS-B

Traffic information system-broadcast (TIS-B) will send location data into the Capstone avionics for aircraft that are visible on radar. The multi-function display (MFD) will then display aircraft visible on radar, as well as the ADS-B equipped traffic. One of the potential drawbacks of Capstone's traffic display is that pilots may rely on the MFD to show all other aircraft, forgetting that some are not visible. TIS-B will make one category of invisible aircraft—those on radar—visible, this improving the effectiveness of Capstone's traffic awareness functions. However, TIS-B was not yet operating at the end of 2001.

3.2 Avionics

Figure 3-5. Capstone Avionics

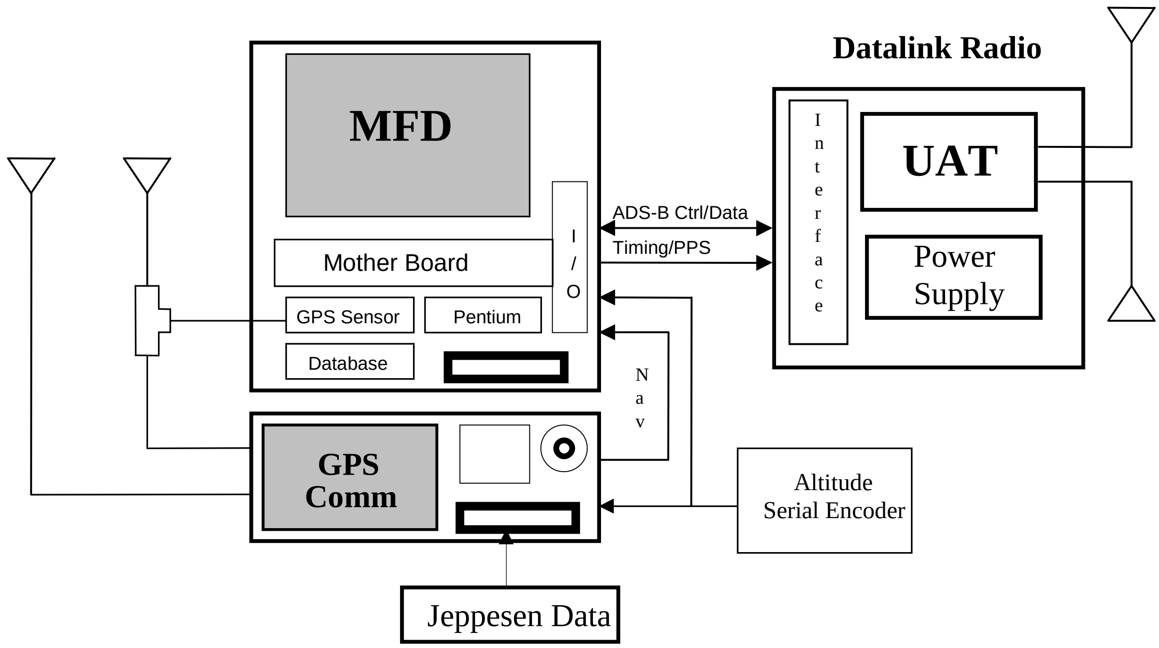

Figure 3-5 shows the primary components of the airborne avionics system in Capstone Phase I:

1. *A GX50/60 GPS navigator*: The system is a non-precision IFR approach certified GPS receiver. The GX50/60 provides navigation in areas that are not served with traditional navigation aids such as VOR and NDB and provides route information, distance, and time remaining. The unit includes extensive information on routes, navaids, and airports; the GX50/60 also includes a 720-channel communications radio.
2. *The MX20 Multi-Function Display (MFD*), with:
    a. *Terrain alerting and awareness* provides a color-coded display of hazardous terrain in the area of the aircraft.
    b. *Traffic alerting* currently tells pilots the locations of other Capstone-equipped aircraft relative to their aircraft. When the TIS-B feature is implemented, it will also display the locations of aircraft visible to radar.
    c. *Custom map* provides a sectional-like display that can be customized to show route lines, airports, navaids and geographic features.
    d. *Flight Information System* displays METAR and TAF text weather.
    e. *Weather* displays NEXRAD weather radar.
    f. *Flight plan* allows the pilot to display and edit the active flight plan and also displays information such as runway diagrams and CTAF frequencies.

3. *The UAT "box" or universal access transceiver*. This is the transmitter/receiver that communicates the ADS-B data link information between aircraft and from the aircraft to ground stations. It also receives flight information and weather services from the ground stations and will receive TIS-B information when that feature is implemented. This 50-watt UHF transmitter reports the aircraft data at one-second intervals.

3.2.1 Equipped Aircraft and Operations

Capstone's effectiveness depends on what fraction of flights take place in equipped aircraft. This is especially true for the traffic functions, where both aircraft need to be equipped to "see" each other. From January 2000 through the end of December 2001, the Capstone program equipped 138 aircraft, bringing the total equipped from 2 to 140. The blue line in figure 3-6 (next page) shows the percent aircraft being used in the Y-K Delta by part-135 operators that were Capstone equipped, by month[27]. We estimate that by December, 2001, this was about 85 percent. On average over the study period, about 45 percent of aircraft operated by part-135 operators in the Y-K Delta were equipped with Capstone avionics. This percentage is not necessarily the same as the percentage of aircraft operations flown with an equipped aircraft. Capstone-equipped aircraft might have been used proportionally more (or less) than other aircraft.

Data from the Bethel tower about SVFR operations are currently our best source of equipped vs. non-equipped operations data for Y-K Delta part-135 operators, and we believe these ratios are a good estimate for those companies' non-SVFR operations as well. The data is less accurate for estimating the fraction of all operations that are Capstone-equipped. Our data show that Y-K Delta part-135 operators accounted for 90 percent of SVFR operations in 2000 and 2001–4,877 of 5,408 total tower strips. However, part-91 operations normally have greater flexibility and are much more likely to choose not to fly in marginal weather. So SVFR data may under-represent the fraction of all operations that is flying under part 91, and over-estimate the fraction flying under part 135.

We estimate the percent of SVFR flights that were Capstone-equipped from the aircraft identifier that controllers include on the "tower strip" that they create for each SVFR flight. Sometimes this is a company name and flight number, but often it is an N-number—which allows us to identify whether the aircraft was Capstone-equipped on that date.[28]

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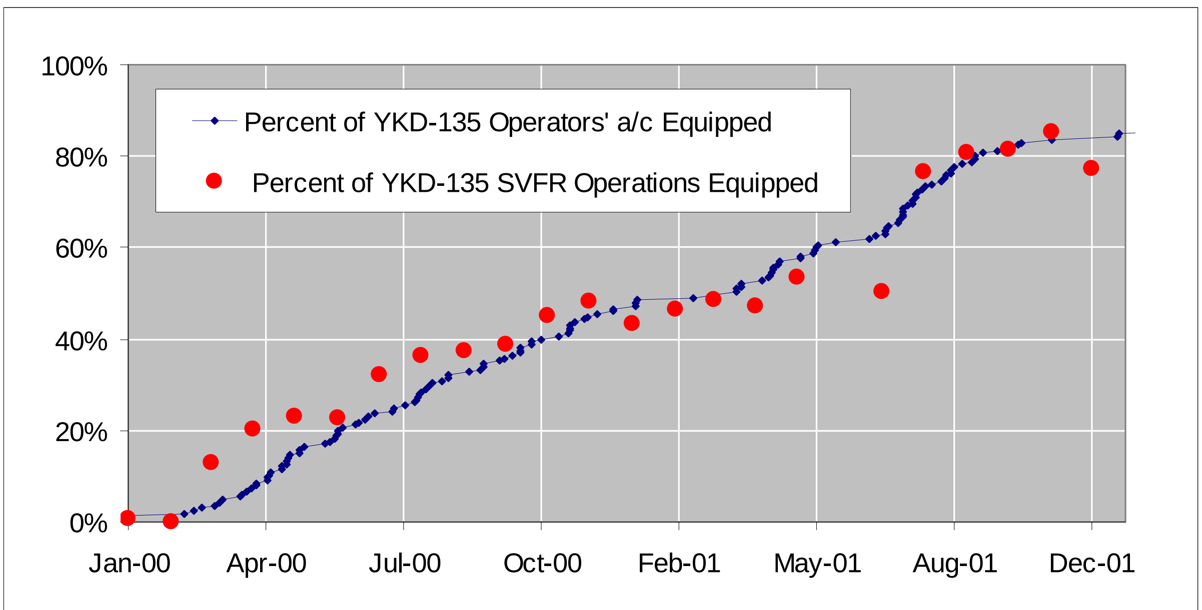
[27] Four equipped aircraft belonged to public agencies, and nine more belonged to operators outside our target group of Y-K Delta part-135 operators. It's difficult to specify exactly the number of aircraft the Y-K Delta part-135 operators are actually using over time; however, even after accounting for these 13 aircraft, between 80 and 85 percent of the Y-K Delta part-135 fleet was Capstone-equipped by December 2001.

[28] This plot omits information from two dates. The tower strips provided for 5/5/01 and 7/11/01 were actually strips from multiple dates over more than one month; the identified date was merely the beginning date of the group. Grouping such large numbers of operations (402 and 509, respectively) at the earliest date would have skewed the data towards earlier implementation than was the case.

The percentage of operations with equipped aircraft starts near zero (which makes sense, since only two aircraft were equipped in January 2000) and is about 80 percent in November and December 2001. Through most of 2000, when relatively few aircraft were Capstone-equipped, SVFR operations show a consistently higher share of equipped aircraft than do the fleet numbers. We have anecdotal evidence that pilots preferred to fly Capstone-equipped aircraft; this, combined with the SVFR operations data, indicates that when equipped aircraft were a relatively small share of the fleet they may have been flown more than non-equipped aircraft.

However, in late 2000 and all of 2001, the equipped share of SVFR operations is sometimes higher and sometimes lower that the equipped share of the fleet. Once equipped aircraft were common, they don't appear to have been used more or less than non-equipped aircraft. By December 2001, when over 80 percent of the part-135 fleet had been equipped with the new avionics, the overall use in SVFR operations should also have been just over 80 percent.

Figure 3-6. Percent of Y-K Delta Part-135 Operators' Aircraft that were Capstone Equipped, and Percent of their SVFR Operations Flown with Capstone-Equipped Aircraft January 2000–December 2001



Sources: SVFR data – Bethel tower strips
Number of Aircraft equipped: FAA Capstone Program Office
Fleet Size: participating Capstone operators

Section 3.3 assesses operation levels by FAR part in the Y-K Delta. Part-91 operations make up about 30 percent of overall Y-K Delta operations. Almost no part-91 aircraft were Capstone-equipped in the interim evaluation period. Assuming that Y-K Delta part-135 operations accounted for just under 70 percent of all Y-K Delta operations, then the fraction of total operations comprised by equipped aircraft rose from zero to about 60 percent from January 2000 to December 2001, and averaged about 35 percent.

3.2.2 Training on Capstone Avionics

Under contract with the FAA, the University of Alaska Anchorage's Aviation Technology Division conducted train-the-trainer classes on Capstone avionics for participating operators. Those classes were designed to provide an instructor cadre and give Capstone operators the capability to provide "in-house" training for their pilots on the equipment. These classes were largely conducted in 2000.

In 2001, the division contracted with Capstone operators (at their expense) to provide the Capstone portions of those carriers' initial and refresher training programs. In 2001, air carriers hired the division to provide initial training for 127 pilots. In addition, the air carriers themselves have conducted numerous in house classes, including initial, recurrent and re-qualification training for their pilots. To provide additional support to carriers for their in-house training, the aviation technology division produced and distributed to Capstone participants a series of eight video training tapes that work with other training materials.

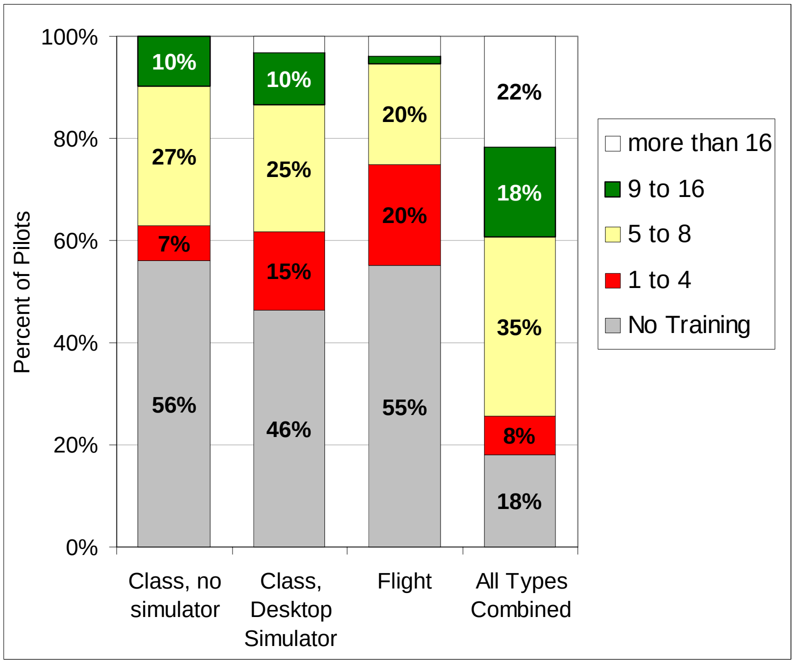
The division also scheduled the use of Capstone simulators that air carriers can check out to conduct their in-house Capstone training. In 2001, the division documented that demand exceeded the four available simulators—so the FAA acquired two additional simulators to meet training needs. The six simulators now available (four VFR, and two IFR/VFR) meet the air carriers' current training demands.

Training is a key element in the effective use of Capstone equipment. Some operators and pilots in the Capstone area are concerned that (1) not all pilots receive adequate training to use the equipment, and (2) not all trained pilots apply their training to flight operations.

Operators and pilots we surveyed generally agreed that Capstone training should include both initial and recurrent training; should include classroom, desktop simulator, and flight training; and should include flight checking. We asked Capstone pilots in the NIOSH survey how many hours of classroom training, classroom with desktop-simulator training, and flight training they had received. The answers to those questions for pilots in Y-K Delta Part 135 operations are summarized in Figure 3-7 (next page).

We interviewed 106 pilots who flew Capstone-equipped aircraft. Of those, 101 flew for Y-K Delta Part-135 operators. Pilots were drawn in two samples: a random sample of 40 pilots selected as part of the NIOSH survey, and 61 in a sample of convenience—that is, all the Capstone operator pilots we could contact during a set period, including many contacted during training. Because we contacted many of the pilots at Capstone training sessions, were concerned about a potential bias towards pilots with Capstone training. So we compared the random sample pilots with those in the convenience sample. The convenience sample did report significantly more classroom and classroom/simulator training than did pilots in the random sample; however, pilots in the random sample reported significantly more hours of flight training than those in the convenience sample. There was no significant difference when we looked at total training hours. Therefore, we believe that our total sample of 106 pilots accurately represents overall Capstone training among all pilots flying Capstone-equipped aircraft.

Figure 3-7 Type and Hours of Training on Capstone Avionics Reported by Y-K Delta Part-135 Pilots



Over half of all pilots answering our survey reported no hours of classroom-only training; many of those did have classroom –with-simulator training. When we add each pilots' hours of different types of training together, 18 percent reported no formal training of any type; another 8 percent had 4 hours or less of training; 40 percent had 9 or more hours of training.

Training levels ranged from none up to several days of classroom/simulator training supplemented by one-half to one day of flight training. We summarized the training levels of Capstone pilots employed by YK Delta part-135 operators by sorting them into five training levels and estimating an effectiveness rating for each of the levels. A 100 percent effectiveness would mean that the pilot would always use the equipment perfectly, in every instance where it could be useful. Fifty percent effectiveness would mean that over time, we expect that the pilot would avoid 50 percent of the accidents and incidents where Capstone avionics could theoretically be useful. Zero percent effectiveness would be the same as leaving the avionics turned off.[29] Table 3-2 (next page) shows the definitions of each training level and the effectiveness assigned to each.

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[29] Leonard Kirk estimated effectiveness levels based on classroom assessments, self-reports, and observations and interviews in the field. These assessments draw on models of learning and effectiveness in *Human Factors in Flight*, Chapter 9; Frank H. Hawkins; Ashgate Publishing Limited; 1993, and in the FAA's advisory circular AC 60-14; *Aviation Instructors Handbook;* U.S. Government Printing Office, Washington D.C.

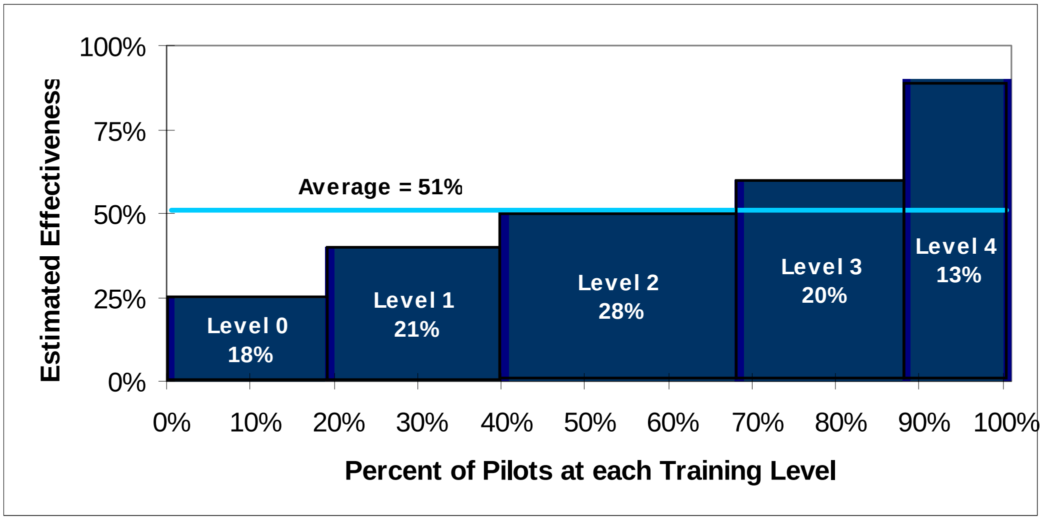
Table 3-2 Training Levels and Their Estimated Effectiveness

Level	Description	Effectiveness
0	No formal Capstone training	25%
1	Up to 12 hours of classroom training but less than 4 hrs of classroom/simulator training; up to than 1 hr of flight training	40%
2	More than 4 hours classroom or classroom/simulator training and up to 1 hr flight training	50%
3	More than 1 hr flight training but less than 4 hours classroom or classroom/simulator training	60%
4	More than 1 hr flight training and more than 4 hours classroom or classroom/simulator training	90%

Ninety percent effectiveness means that when a highly trained pilot encounters a situation in which the Capstone avionics could potentially help avoid an accident, nine out of ten times the pilot will use the equipment effectively to avoid the accident. Twenty-five percent effectiveness means that an untrained pilot using Capstone might be able to avoid an accident in one of four situations where Capstone avionics could potentially help avoid an accident.

Figure 3-8 (next page) shows the distribution of YK Delta Part-135 pilots by training level, the estimated effectiveness of each training level, and an estimated average effectiveness for Capstone pilots. The width of each bar is the percentage of pilots reporting each training level (for example, 18 percent of pilots reported no training; 13 percent of pilots reported training level 4). The height is the estimated effectiveness of their Capstone use, given the training they received; the average line represents the average effectiveness of Capstone pilots taken as a group. As we discussed above, our sample may be biased towards trained pilots, and so this average may be somewhat high. However, using the sub-sample of pilots who were chosen through random sampling gives a slightly different training distribution, but the aggregate estimate is within one percentage point of the 51 percent that we derive with the full sample.

Figure 3-8. Percent of Surveyed Y-K Delta Part 135 Pilots at Each Training Effectiveness Level, January 2002



The height of each bar is drawn from Table 3-2; the width (specified in the bars) shows the percent of pilots whose reported types and hours of training indicated that they were at each training level. The 51 percent line is the weighted average training level across all surveyed pilots.

3.2.3 Usability of Capstone Avionics

"Usability" measures how easily pilots can use the equipment to accomplish the tasks it was designed for and to evaluate the equipment's effect on cockpit workload. Usability of the Capstone equipment is critical: a piece of equipment that is difficult to use may not deliver the safety benefits it was designed for. Further, a piece of equipment that becomes a distraction or causes too much heads-down time in the cockpit could actually decrease safety.

We assessed the usability of Capstone avionics through surveys, observation flights, and simulator demonstrations. Two surveys administered by UAA (the pilot baseline survey in the fall of 1999 and the Capstone module of the NIOSH operator and pilot surveys in the winter of 2001/02) included usability questions. These two surveys were supplemented with key informant interviews, some of which covered usability issues. In 2000 and 2001, two additional surveys, focused primarily on usability, were developed and administered by the FAA's Civil Aerospace Medical Institute (CAMI), Wichita Certification Office, and VOLPE Transportation Systems. Some pilots participating in usability surveys also took researchers on observation flights or had them observe simulator training to demonstrate the equipment in use. These surveys, interviews, and observations took place primarily in Bethel.

Many users reported initial difficulties with some Capstone features, especially flight planning. However, with training and experience they reported becoming proficient—at least with the functions they use regularly. In actual flights and simulators, pilots were able to display traffic and terrain information without difficulty or excessive heads-down time. But even with functions they used frequently, pilots wanted fewer required button pushes—for example, they wanted to move between the terrain and the custom map modes, or the traffic page and map pages, with only one push of a button. Pilots with ground and flight training followed by 20 or more hours of operating experience demonstrated little difficulty using the equipment, although both surveys and interviews indicate that the flight planning function is difficult to use, even for IFR flight and two-pilot operations.

Pilots with less training or experience tended to use the equipment in much more limited ways. For example, many pilots, especially those with limited training, simply circumvent the flight planning function by using either the “nearest” or “direct-to” capability of the GX-60.

In summary, Capstone avionics is certainly usable enough to provide safety benefits but many pilots would prefer it be easier to learn and use. And to get the full safety benefit, pilots must have adequate training—including ground training using a simulator and flight training in a Capstone-equipped aircraft.

3.3 Operations

We made a major effort in 2001 to explore and develop different ways of establishing the denominator information we need—that is, the amount of flying in the Capstone area.

In the baseline report, we used the APO Terminal Forecast Survey Summary Report from the FAA’s Aviation Policy and Plans Office. This report uses historical data on traffic counts from FAA Form 5010, the airport master record. These counts are the only systematic data available for the Capstone area; however, in rural Alaska they represent estimates from airport managers rather than systematically collected data. In addition, airport managers have incentives to overestimate airport activity—in order to qualify for more state funding. UAA is not satisfied that these data represent a reliable count of aviation activity.

The FAA’s General Aviation and Air Taxi Activity and Avionics Survey (GA Survey) annually collects detailed information on the activities of a sample of aircraft in Alaska. If it were possible to identify which aircraft in the survey belong to Capstone operators, the survey could provide a measure of scheduled and unscheduled aircraft use to compare with the form 5010 data. Our review of the usefulness of this information included exploring ways of potentially identifying Capstone aircraft and a review of the sampling and survey procedures.

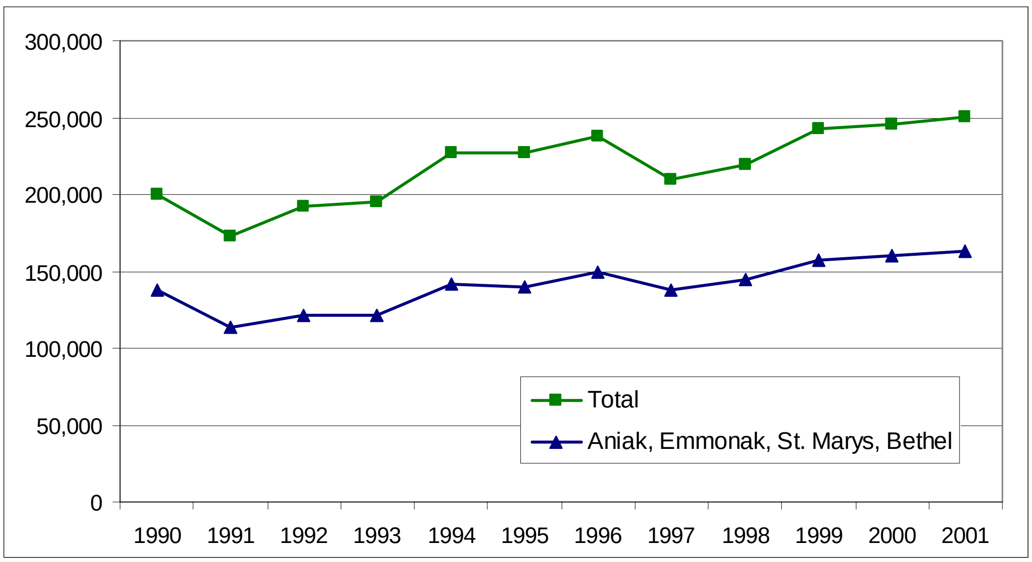
Accidents and accident rates provide one measure of aviation safety; there are many other factors we can measure that indicate levels of safety in Alaska. So a simple comparison of accident rates will not accurately measure Capstone’s effect on aviation safety. Certain types of accidents—those on take-off and those caused by mechanical failures—will be unaffected Capstone improvements. Others—primarily landing accidents—might be reduced by Capstone’s better weather reporting and new GPS approaches. But any reduction might also be the result of other factors unaffected by

Capstone's infrastructure improvements. Capstone should have its greatest direct effects on controlled-flight-into-terrain accidents and mid-air collisions.

3.3.1 Operations Levels

Figure 3-9 shows enplanement data for the Y-K Delta from 1990 to 2000 and a projection for 2001[30]. These data cover part-135 operators based in the Y-K Delta. Air taxis are likely to be undercounted, because reporting is voluntary for air taxi operators. We regard the enplanements data as the most reliable and accurate measure of part-135 activity. We projected 2001 levels in the Y-K Delta based on increased enplanements in Aniak, Emmonak, St. Marys, and Bethel and on by-pass mail data for Bethel.

Figure 3-9. Enplanements of Y-K Delta Part-135 Operators 1990–2000 and 2001 (projected)



Notes: "Total 2001 enplanements" is an estimate based on change in four regional hubs.
Source: FAA, data from form 28C

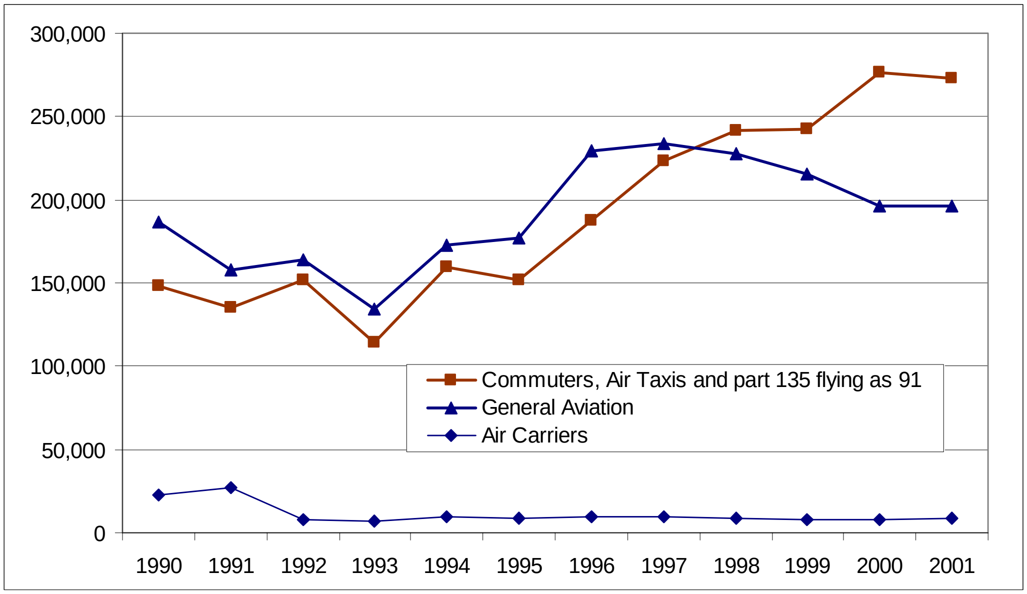
Because there are no general aviation data equivalent to part-121 operations' enplanements data, we don't have complete enplanement information for the Capstone area. We used data from the APO Terminal Area Forecast to estimate part 121 and general aviation and for area-wide activity of part-135 operators. These data are less reliable than the enplanements data.[31] Figure 3-10 (next page) presents operations levels in the Capstone area based on these data. The 2001 numbers are projections.

[30] Enplanement data from FAA Airport Planning, at http://www2.faa.gov/arp/planning/stats/

[31] For airports with control towers, controllers report the number of aircraft cleared for takeoff or landing. For airports without towers, which include all the airports in the Capstone area except Bethel, airport managers estimate the annual traffic counts. The numbers for non-tower airports are clearly estimates and don't change from year to year. These data are not very accurate.

We estimate that annual average part-135 operations in the Capstone area were 35 percent greater in 2000–2001 than the average of operations from 1990 to 1999. We estimate all operations (part-135 and other) increased 17 percent.

Figure 3-10. Air Operations in the Capstone Area, 1990–2001

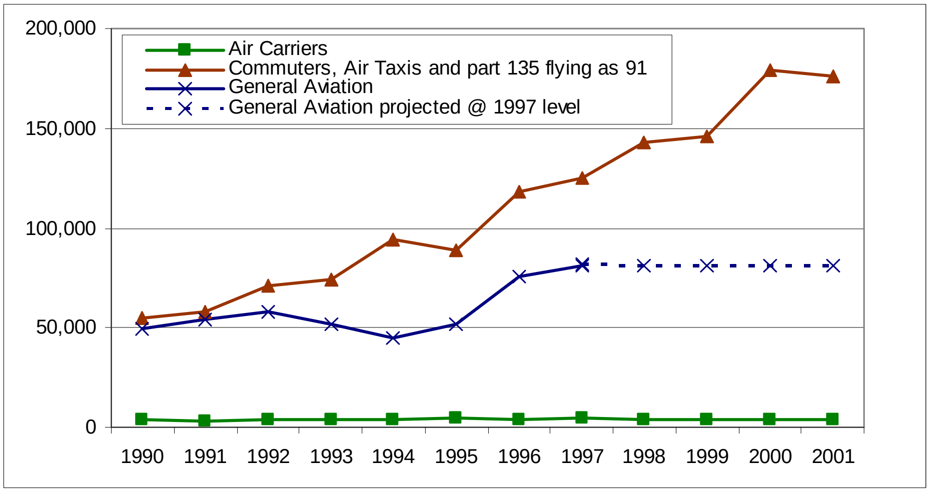


Source: FAA TAF data from form 5010

Figure 3-11 (next page) shows operations in the Y-K Delta from 1990 through 2001. Again, the data is from the APO Terminal Area Forecast estimates made by airport managers. The raw data indicates declining part-91 operations, driven by a reported 87 percent drop in part-91 operations at Bethel–which is inconsistent with all our other sources of data, including part-91 SVFR operations at Bethel and part-91 operations at other nearby Y-K Delta airports.

Therefore, for our analysis we have projected Y-K Delta part-91 operations as level since 1997 (shown as the dotted line in Figure 3-11) and adjusted figures that include part-91 operations accordingly. Part-135 operations have risen by an average of eight percent annually since 1996. Part-121 operations have risen by less than one percent annually. We estimate that part-135 operations in just the Y-K Delta were 40 percent higher in 2000-01 than the average from 1990-99.

Figure 3-11. Air Operations in the Y-K Delta, 1990–2001



Source: FAA (2002) Terminal Area Forecast (TAF) http://www.apo.data.faa.gov (7/12/02) and author estimates

3.3.2 IFR Capable Operations

Three components of the Capstone program make IFR operations easier for Capstone area operators. First, the GX50/60 avionics installed in the aircraft can be used as part of an IFR instrumentation system. Second, the program has installed AWOS III weather stations and published associated GPS non-precision approaches at nine airports in the Capstone area. The FAA selected these airports for weather stations and approaches based on input from the Capstone user group; they are among the busiest in the Y-K Delta. Third, the FAA is working toward using the Capstone avionics' ADS-B component to provide "radar-like" services for aircraft throughout the Capstone area.

These improvements are changing the mix of part-135 aircraft and how they are being operated in the Bethel area. A number of Capstone operators are in the process of obtaining IFR authority. Table 3-3 (next page) shows estimated growth in the number of aircraft that have become IFR legal as a result of Capstone Phase I. The number increased from 8 at the start of 2001 to 22 by the end of the year; we project the number will grow to 41 by the end of 2002. These aircraft meet four criteria. They are: (1) of a type that can be IFR certified; (2) equipped with Capstone avionics that can be used as part of the aircraft's IFR instrumentation; (3) belong to an IFR-certified air operator; and (4) fly in and out of Bethel. These are the aircraft that are most likely to use radar-like services, and the growth in the number of these aircraft parallels the growth of IFR-capable aircraft overall in the Y-K Delta.

The 41 aircraft represent a total of 90 scheduled arrivals per day at Bethel from Tuesday through Saturday and 20 flights per day on Sunday and Monday.[32] By June 1, 2002 there could be as many as 490 flights per week with the potential to use ADS-B radar-like services.

[32] Sunday and Monday schedules are limited due to mail distribution.

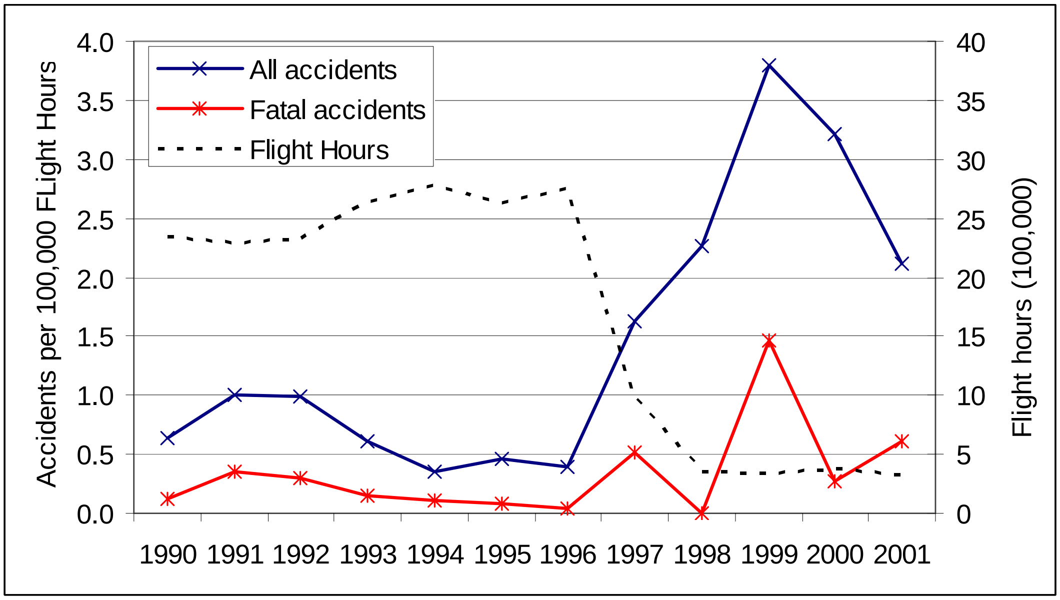
Table 3-3. Current and Projected Number of ADS-B IFR Legal Aircraft for FAR 121 or 135 operations at Bethel Airport

	Bethel Based*	Bethel Scheduled Operations**	Total
Status during 2001			
January 01, 2001	2	6	8
November 28, 2001	12	8	20
December 31, 2001	14	8	22
Forecast			
June 01, 2002	31	10	41

* Aircraft remains overnight in Bethel and Bethel is its primary base of operations
** Aircraft flies to Bethel daily or weekly as part of Capstone operations

The ability to operate under IFR in most of the Y-K Delta is very new. There are no data that would allow us to assess the historical safety differences between IFR and VFR operations in the delta. One possible approach is to look at the change in part-135 accident rates nationwide when new regulations changed the characteristics of the part-135 fleet. In 1997, new rules published under 14 CFR part 119 took effect, moving many of the more sophisticated part-135 operations with larger IFR-capable aircraft into part-121. Figure 3-12 (next page) shows the U.S. accident rates for part-135 commuter operations from 1990 through 2001. With the 1997 shift of many operators from part-135 to part-121, the number of part-135 commuter (scheduled service) hours dropped by 80 percent and the accident rate climbed. While the rate varies by year, it has consistently been much higher than before 1997. Since the regulations governing the operations that remained in part-135 had not changed significantly, the higher accident rates may indicate that the smaller VFR-only aircraft remaining in part-135 had higher accident rates all along—but those higher rates were obscured before 1997 by averaging them with accident rates among the larger, safer aircraft that subsequently moved into part-121.

Figure 3-12. Flight Hours and Accidents per 100,000 Flight Hours for All U.S. Commuter Air Carriers, 1990–2001



Source: NTSB; www.ntsb.gov/aviation/Stats.htm, Table 8.

Applying these national rates to the Capstone area is problematic, because there are many differences between the aircraft and operations affected by part-119 and the Y-K Delta aircraft that are moving toward IFR capability. Not only are accident rates different, but aviation operations and accident causes in southwest Alaska also differ from national averages. However, these NTSB data at least indicate that more capable and more sophisticated equipment may result in fewer accidents and fatalities.

3.4 Safety Posture

As we're defining the term here, "safety posture" for flights in the Y-K Delta is the total environment affecting aviation safety—including not only practices of pilots and operators, but also public policies and market forces. Some of the factors contributing to that environment are human factors, pilot training, aircraft maintenance, FAA oversight, operator management, economics, and industry initiatives. All these are part of an inter-related system, affecting and being affected by the Capstone program.

Operators set the bounds and provide the motivation for pilots to conduct safe flights, within the context of both regulatory oversight (which pressures them to improve safety) and economic factors (which pressure them to get the job done at the least cost). Economic pressures are varied, including all sources of revenue (mail, passengers, and freight) and costs (aircraft, training, maintenance, and insurance). Pilots can feel economic pressure on their operators, and that can make them feel pressured to take larger risks.

We need to track and (insofar as possible) quantify changes in safety posture for two reasons. First, changes unrelated to Capstone may cause accident rates to increase or decrease. We don't want to mistakenly attribute to Capstone changes that are actually caused by other factors. Second, the Capstone program may affect safety posture and indirectly affect accident rates (again, rates may increase or decrease). We want to identify and if possible quantify any indirect safety effects of the Capstone program.

We measured the safety posture in the Capstone area by interviewing pilots and operators, examining relevant data, and making ground and in-flight observations of facilities, equipment, and personnel. Operators and pilots—the primary source of Capstone assessments—have increasingly cooperated with our efforts to collect data on human factors that affect safety. This increased cooperation provides us with an opportunity not only to measure opinions and attitudes, but also to identify safety issues and possible solutions and to evaluate Capstone's effectiveness more broadly than we could by just relying on the aircraft accident rate as an indicator.

3.4.1 Human Factors

Air travel, like other means of transportation, involves inherent risks; safe flight involves risk management. Of the many factors involved in aviation safety, human factors ultimately determine whether a flight ends safely or results in an accident. Figure 3-13 (next page) illustrates the relationship among the various factors affecting whether the pilot avoids a preventable accident.

The pilot—who is ultimately responsible for risk management—uses the information and resources available to respond to the situation, making decisions and taking actions that are based on the perceived risk. The pilot brings to the situation knowledge and skills (gained through training and experience) as well as judgment—all of which are affected by the pilot's attitude toward risk. Carlton E. Melton, a human factors consultant, points out that, "risk taking can overrule the basic instinct for survival ... the best pilots know that the essence of safety in flight is ... in taking no unnecessary chances."[33]

This axiom has not changed, and it defines the two extremes of pilot attitude toward risk: pilots who are inclined to avoid unnecessary risks and prepare for and manage the necessary risks; and pilots who see "necessary risks" as whatever it takes to get the job done on schedule. Capstone equipment may help the first group reduce accident risk—but it could also help the second group push the envelope and ultimately increase risk.

While safety can't be installed in the instrument panel or mandated, pilots can use accurate, current, and integrated information (such as that provided by Capstone avionics) to support more informed decisions in managing risk. As discussed in Section 2, Capstone equipment helps pilots make decisions through improved terrain and traffic awareness, more accurate navigation, and other flight information. However, other human factors may limit Capstone's helpfulness.

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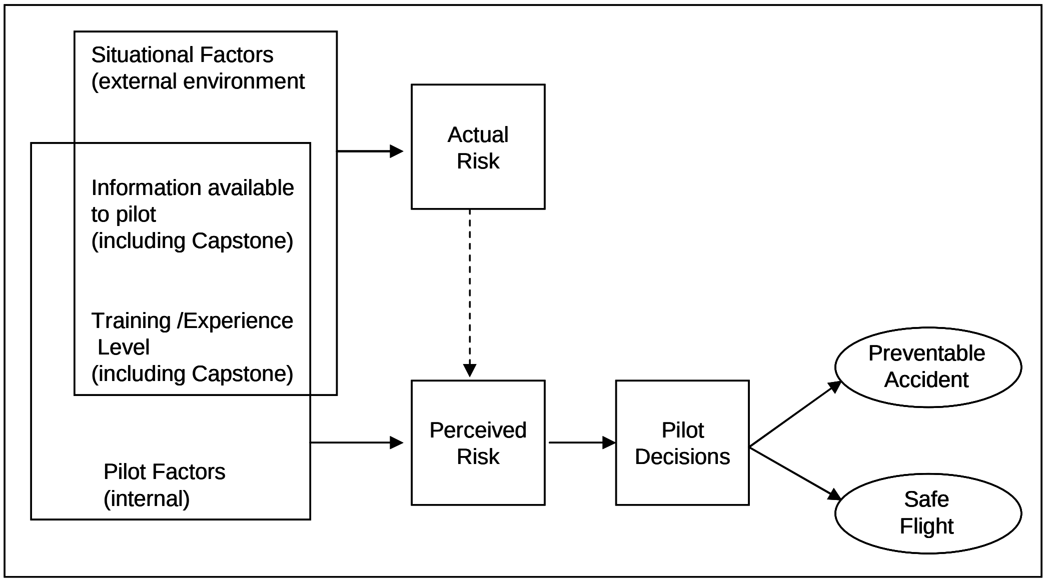
[33] Melton, Carlton E., "Can Human Error be Eliminated," *FAA General Aviation News,* July-August 1987.

Figure 3-13. Overview of Human Factors in Safe Flight



Situational Factors	**Information**	**Training/ Experience**	**Pilot Factors**
Weather	Weather reports	Capstone training	Attitude towards risk taking
Runway Conditions	Communications	Other training	Decision making skills
Navaids	Dispatch/flight following	Flight Experience	Judgment
Terrain	ARTC	Alaska experience	Opinions
Traffic	Terrain Awareness		Confidence level
	Traffic displays		Stress level
			Fatigue

This model was adapted from human factors models developed by Dr. Judith Orisano and Dr. Jon Holbrook, 2002, NASA Ames Research Center, Moffett Field, CA.

NTSB investigations have concluded that "pilot error" either causes or contributes to approximately 75 percent of aircraft accidents. Pilot error refers to one or more of 15 factors the NTSB has identified:[34]

- Excessive workload (task overload)
- Improper decision
- Improper use of equipment/aircraft
- Improper use of procedure
- Physiological condition
- Correcting lenses not worn
- Fatigue
- Incapacitation
- Physical impairment
- Physical strength overload
- Spatial disorientation
- Visual/aural detection
- Use of unapproved medication/drug
- Psychological condition
- Qualification

[34] NTSB, *Aviation Coding Manual*, 1998

All these factors can reduce (or negate) Capstone's usefulness and contribute directly or indirectly to accidents. For example, in investigating the April 2001 CFIT crash of a Capstone-equipped aircraft, the National Transportation Safety Board concluded that the pilot prevented the avionics from accurately relating the aircraft's altitude relative to terrain. That action, along with other errors, resulted in a CFIT accident.

Also, some pilots use personal identification names or disable the ADS-B to avoid being identifiable on other Capstone displays, on companies' flight monitoring displays, or by the FAA. This reflects some pilots' continuing concerns that Capstone information could be used as a basis for issuing violations.

Respondents to the Capstone module of NIOSH safety survey were asked why pilots might choose not to use the capabilities of Capstone avionics. Comments from 61 pilots are summarized below.

1. Monitoring too closely by:		
a. FAA enforcement	38	(62%)
b. Company	8	(13%)
c. Other aircraft	2	(3%)
2. Lack of knowledge or training	3	(5%)
3. Shifting between Capstone and non-Capstone aircraft	3	(5%)
4. Equipment design and reliability	2	(3%)
5. Instrument panel location	1	(2%)
6. Resistance to change	1	(2%)
7. Cost to maintain after test period	1	(2%)
8. Don't need it	1	(2%)

3.4.2 Training

Training—critical to the proper use of any equipment—is an essential part of flight safety posture. Proper training includes training in all aspects of flight operations and in the use of tools like those provided by Capstone.

Training pilots to make safe decisions needs to include both the use of the tools and the interpretation of the information those tools provide. In the Capstone area, some operators have expanded their training to include making weather and airport go, no-go decisions. Other operators have kept their training at the FAA-required minimum.

3.4.3 Maintenance

Since January 2000, four Bethel operators have expanded their existing facilities or constructed new facilities to accommodate indoor aircraft maintenance. In the past, hangar space was limited, and often so much mail was stored in hangars that there was no room to park aircraft or do maintenance. It's much easier to do pre-flight checks on aircraft parked inside and potential problems are easier to spot. Maintenance is more likely to be thorough and unhurried—especially compared with maintenance done outside in sub-zero, windy weather. These improvements potentially affect about 50 aircraft, or about 33 percent of the part-135 aircraft fleet in the Y-K Delta. The improved maintenance and appearance of the aircraft and facilities could also contribute to a more professional pilot attitude; we will look for evidence of this in our continuing human factors research.

3.4.4 FAA Oversight

FAA oversight helps pilots and operators resist economic or other pressures to shortcut regulations; it also helps keep them up-to-date about regulatory changes and to understand exactly what is required. Our surveys and interviews have not revealed any evidence that the level of oversight has changed since the baseline period—or, at least, operators don't perceive any change. Operators who in the baseline period expressed the belief that inconsistent or lax oversight allowed their competitors to operate unsafely have repeated those assertions in more recent interviews. They maintain that some operators fly in conditions not permitted by their operations specifications or the FARs. Specifically, they assert that some operators fly in weather conditions below VFR minimums, enabling them to deliver mail more quickly than operators who keep to the regulations. This gives unsafe operators a market advantage with the U.S. Postal Service, which is the largest single customer in the region. Several operators in the Capstone area have expressed a desire for increased FAA enforcement of visual flight rules that would "level the playing field" and contribute to safer operations.

The FAA could also contribute to improved safety through training oversight. Training levels are inconsistent from operator to operator. Pilots and operators we interviewed expressed concerns about inadequate training in the use of Capstone, in instrument proficiency, and in weather interpretation.

3.4.5 Operator Management

Management oversight has increased in the Capstone area. Four of the largest Capstone operators we surveyed reported that they have implemented formal risk management tools for their release decisions. These typically include a structured decision chain, starting with the pilot and including others such as the dispatcher, chief pilot, and senior management, depending on the conditions of the specific flight.

Two other management improvements that may affect safety are (1) use of FAA-certificated aircraft dispatchers in the decision-making role for part-135 operations and (2) operational-control training for management teams. Finally, operators reported in both open-ended survey responses and in interviews that they believe the addition of flight-monitoring capability using Capstone's ADS-B will improve their management oversight.

3.4.6 Economics

As discussed in Section 2, economic pressures can increase or decrease safety. The two most important economic factors in rural Alaska (and not just the Capstone area) are the U.S. Postal Service and insurance rates. There have been no changes in postal rules since the baseline period, although Congress is currently considering new rules.

Insurance rates, however, have increased. Alaska's high accident rate and generous claims settlements have led many underwriters to avoid the Alaska market. Those who do write insurance for Alaska carriers charge especially high rates to those who carry passengers, so some operators have stopped carrying passengers and instead carry mail and cargo only. Other operators have moved toward twin-engine and turbine-power aircraft, which cost more to operate but less to insure. Of the 155 operators we surveyed (statewide), 107 reported that their insurance rates had increased since early 2000. The increases ranged from 1 to 350 percent, with an average of 23 percent. Some operators see Capstone as part of a process that, together with training and other efforts to improve safety, will help reduce their insurance costs. Insurers vary their rates due to perceived risk (passenger, type of aircraft, pilot qualifications and accident history).

Passenger choices may also improve Y-K Delta safety, if passengers are willing to pay more for to fly with safer operators. According to Capstone pilots we interviewed, passengers are selecting airplanes with the "Capstone" logo on the side. The passengers like the airplanes with the "TV" and perceive they are in an aircraft that is safer. (More data is needed to determine the magnitude of this trend, which would tend to give an advantage to carriers with Capstone-equipped aircraft.)

In addition (as described by travel planners for larger organizations), some travelers are willing to pay a higher fare to ride on safer aircraft. Some corporate travel offices put their passengers in the Y-K Delta on twin-turbine aircraft with two-pilot crews to gain a safety benefit, even though fares for this class of aircraft are higher. All these twin-turbine, two-pilot aircraft are now Capstone equipped. One Y-K Delta air carrier will not carry passengers on single-engine aircraft.

3.4.7 Industry Initiatives

The Alaska Air Carriers Association has initiated a comprehensive, voluntary program that is intended to raise the standard of operational safety for commercial carriers throughout the state. That program is based on safety-risk assessment programs of individual companies and other operator initiatives. It will be administered by a new entity, the Medallion Foundation. The foundation's director, Jerry Dennis, has said "We will be advocating for a safety culture, working with other fine programs like the FAA's Capstone Program. The chief purpose will be to create an industry program which will establish high standards for safety and lower accident rates."

Under the Medallion program, carriers will be evaluated by the foundation's safety personnel in five areas and will receive a star for each area they complete. They will receive a Medallion award when they complete all five steps.

Of the 16 air carrier applicants for entry into the Medallion Program at the end of 2001, 8 are Capstone operators. The Medallion Foundation received funding in 2002 to assemble a staff and begin evaluating carriers. This process is to be ongoing; those carriers that meet the standard for stars may receive them within a few months.

3.5 Limitations of Ongoing Data Collection

This section briefly discusses limitations of four critical types of data that we use to evaluate 2000-2001 safety improvements in this report. These are weather, accident reporting, and air operations data, as well as data from operator and pilot surveys.

3.5.1 Weather Data

Section 2.6 discusses limitations of weather data during the baseline period. More recent weather data is subject to the same limitations. While the Capstone program installed nine new weather reporting stations in the region, the weather data recorded at these new stations is not being archived at the National Climate Data Center or Alaska state climate centers. This means that the data collected at these new stations were not available for analysis in this safety study.

3.5.2 Accident Reporting

Often there is a significant delay between when an aircraft accident occurs and when the National Transportation Safety Board (NTSB) completes its investigation of the cause. For serious accidents, especially ones involving fatalities, the NTSB may take more than a year to reach its final determination. For some accidents occurring in 2001, our analysis is based on preliminary assessments that could change.

Often the NTSB determines that multiple factors played a part in a given accident. This may complicate the task of projecting whether Capstone program components might have been able to prevent a particular accident. In accidents with multiple causes, one which is Capstone-related and others which are not, we must use professional judgment to determine the relevance of Capstone—and such determinations are inevitably somewhat arbitrary.

3.5.3 Operations Data

Operations data are critical to assessing whether the pattern of accidents over time measures a change in accident rates or hazards or whether it simply follows a change in scale of operations. Section 2.6 discusses limitations of operations data and weather data during the baseline period. These limitations apply as well during the evaluation period. In particular, we note that the Bethel tower data provide the only systematic information—a traffic count—on total activity over time. We note in section 3.3.1 that the APO traffic data from the Bethel tower over the period 1999-2001 appears inconsistent with other sources of related data[35]. There is no way to reconcile these conflicting data sources, and we cannot explain the discrepancies. In the end, we must make a judgment call on the balance of the evidence.

3.5.4 Survey Data

The data on operator and pilot characteristics, as well as information on pilot experience with Capstone avionics, are drawn from interviews with a sample of operators and pilots. Survey data of this kind contain four potential sources of error: sampling error, sample selection bias, response bias, and non-response to certain questions. Sampling error describes the potential discrepancy between the survey estimates and true values, based on the fact that only a portion of the population was interviewed. Appendix F describes the survey sampling procedure and sampling errors for operators and pilots. Sample selection bias occurs when some survey respondents are systematically more likely than others to be included in the sample. The operator and general pilot surveys were stratified random samples, so they do not have a selection bias. However, the Capstone usability survey employed a different sampling protocol, with additional pilots being interviewed in person at the Bethel airport—so pilots of some Capstone operators may be more likely to be included in the survey than those of other operators.

Response bias occurs if some types of operators or pilots are systematically more likely than others to respond to the survey. Survey responses rates, as described in Appendix F, were quite high—over 70 percent—so there is relatively little room for response bias to affect the results of these surveys. Finally, missing or invalid survey responses to individual questions show up as missing values in the survey data. For most questions, missing values represented only a small fraction of the responses—no more than five to ten percent of total responses.

[35] See page 42. To make our estimates of departures we reconciled data from several sources. For example, while the Bethel tower data report a substantial decline in total traffic between 2000 and 2001 total enplanements show a slight (0.7 percent) increase. We did not find evidence that airlines were using larger capacity aircraft. We did hear from several sources that the Bethel tower implemented a new method to track take-offs and landings.

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4 Changes in Safety

This section assesses the possible safety effects of Capstone in two ways: (1) changes in aviation accidents from the 1990-1999 baseline period to the 2000-2001 interim evaluation period; and (2) differences in accident rates between Capstone-equipped and non-equipped commercial aircraft based in the Yukon-Kuskokwim Delta. The section then summarizes the opinions of pilots and company managers about Capstone's safety effects. Finally, we conclude by summarizing our assessment of Capstone's effects on safety so far.

4.1 Changes in Accidents from the Baseline Period

To assess how Capstone might have improved safety, we first we use Capstone's implementation so far to make realistic projections of the number of targeted accidents Capstone *might* have been expected to prevent (and not prevent) in the recent evaluation period. These projections are based not on actual accidents in 2000 and 2001, by rather on the baseline distribution of accidents by cause (Section 2), projected upward to reflect increased aviation operations (Section 3). These projections tell us what would likely have happened, if accidents in 2000 and 2001 had followed baseline patterns.

Then, we compare the accidents that actually occurred in 2000 and 2001 against these projections. That tells us whether our estimate of accidents Capstone likely prevented is realistic.

4.1.1 Projected Accident Prevention

The safety benefits we predict for Capstone depend on three factors:

1. The types of accidents (and rates of occurrence) seen in 1990 through 1999
2. The "best-expected" effectiveness against these accidents by a complete Capstone implementation
3. The FAA's progress in implementing Capstone during 2000 and 2001.

Besides the safety benefits Capstone is designed to produce, we may also see additional benefits from increased IFR capability, changes in safety posture from Capstone or other causes, and changes in operations from pilots using Capstone capabilities in ways we have not predicted.

For navigation-based accidents, Capstone capabilities are available if avionics is installed and operational in the aircraft and if the aircraft is within both GPS coverage and geographic coverage of the on-board databases. In the interim evaluation period, about 45 percent of part-135 aircraft based in the Y-K Delta were Capstone-equipped and about 50 percent of Y-K Delta part-135 flights used Capstone-equipped aircraft.[36] Average pilot effectiveness in using the Capstone capabilities to avoid accidents was approximately 50 percent, based on surveys of training levels and assessment by trainers. Because of these limitations, we estimate that Capstone would have prevented only about 25 percent of potential CFIT and GPS-map accidents in the interim evaluation period.

For accidents caused by air traffic, Capstone can only prevent collisions if all aircraft involved are equipped with Capstone avionics. Preventing collisions between part-135 aircraft and other aircraft in the Y-K Delta depends on how many part-135 aircraft are equipped and how many other aircraft operating in the Y-K Delta are equipped.

The part-135 fleet in the delta went from 5 percent equipped in January 2000 to 85 percent equipped by December 2001. However, that fleet accounts for only about 70 percent of total aircraft operations in the delta. Almost none of the aircraft accounting for the remaining 30 percent of operations are Capstone-equipped. So, in January 2000, if a Capstone-equipped plane had a random encounter with another plane, there was only a 4 percent chance that the other plane would also have Capstone avionics. That chance rose to about 60 percent by December 2001.

Combining these two probability vectors and averaging over the 2000/01 period yields about one chance in five that both a part-135 aircraft and some other aircraft it might encounter in the Y-K Delta would have both been Capstone-equipped during the evaluation period. Taking training levels into account, Capstone's projected effectiveness for preventing mid-air collisions was 11 percent during the evaluation period.

Capstone might prevent a collision during take-off, even if only one plane were Capstone-equipped—if a tower had a "Brite" display that allowed the tower operator to observe the equipped plane. Since responding to the tower operator does not require the pilot to use avionics, it does not depend on Capstone pilot training. However, tower display capability was not yet implemented by December 2001.

Capstone's net projected effectiveness in preventing all accidents caused by traffic–in mid air and during take-off–during 2000 and 2001 was 9 percent.

Figure 4-1 (next page) shows the projected effectiveness of Capstone in preventing navigation and traffic accidents (total and fatal) among Y-K Delta part-135 operators in the interim evaluation period. We adjusted total accident counts for growth in operations (from Section 3.3). Error bars represent the standard deviation for a two-year interval, which is somewhat less than the standard deviation of the annual counts.

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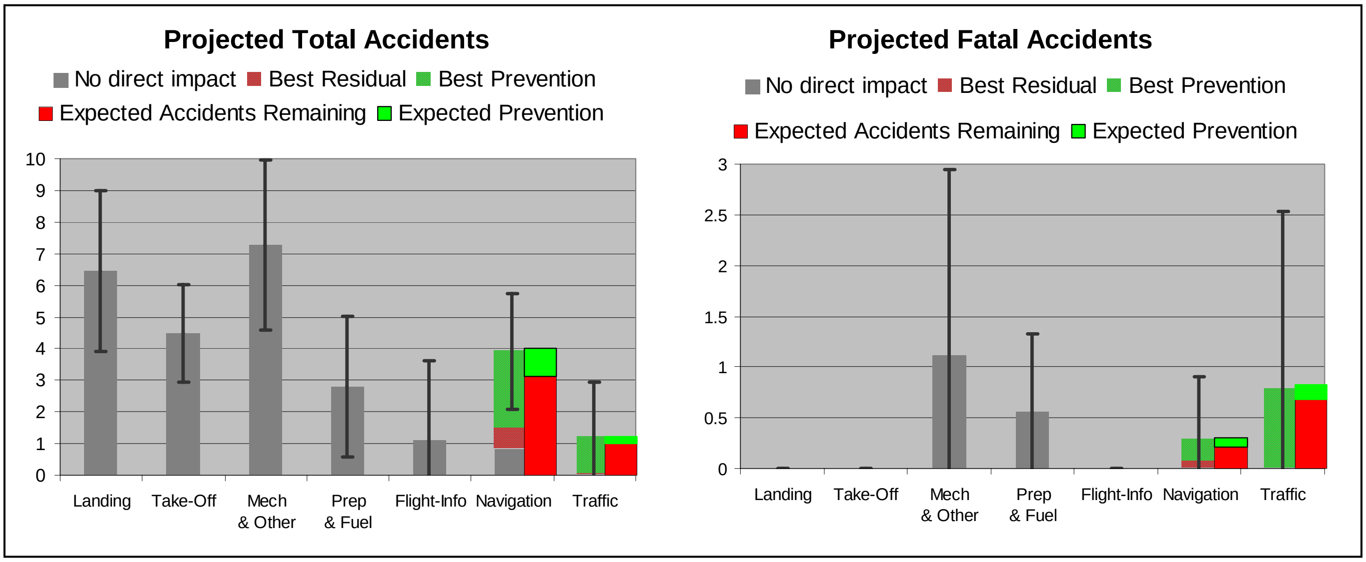
[36] Based on analysis of SVFR operations at Bethel. Operations in better weather or at other locations could have a slightly different ratio.

The number of accidents Capstone might have prevented—given the capabilities that existed in the evaluation period—is much smaller than the statistical variation in numbers of accidents. It will take time—and a higher proportion of Capstone-equipped planes and more pilot training—for that prevention level to rise above normal year-to-year variation. For fatal accidents, it will take even longer for accident prevention to rise above year-to-year variation—because historically, fatal accidents caused by navigation or traffic problems have occurred less than once per year in the Y-K Delta.

Figure 4-1. Projected Total and Fatal Accidents for Y-K Delta Part-135 Operators, with Estimated Potential Effect of Capstone Technology, 2000–2001

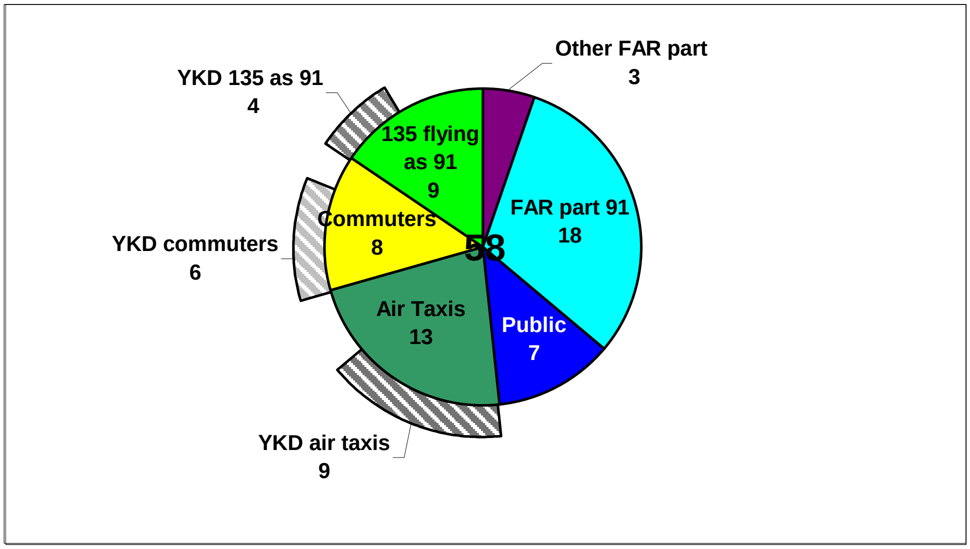


These data show projected–not observed–accidents in 2000 and 2001, calculated by adjusting accident numbers from 1990 through 1999 upwards for increased operations. The gray "no direct impact" bars represent accident causes that Capstone does not address. The green striped "best prevention" areas show the projected number of accidents we estimate Capstone could have prevented, if fully implemented; the red striped "best residual" areas show Capstone-relevant projected accidents that would have occurred even with full implementation. The solid green "expected prevention" bars –navigation and traffic only–adjust the striped green "best prevention" bars to reflect the fact that Capstone was not fully implemented in 2000 and 2001. Thus, fewer of the projected accidents would be prevented. The solid red "expected accidents remaining" bar is total projected accidents less solid green "expected prevention" accidents. The "I" lines centered on the top of each bar show one standard deviation of the two-year moving average from 1990 through 1999– an indication of how the two-year sum varies from year to year. Typically, two-thirds of the observed biannual totals are within one standard deviation of the mean.

4.1.2 Analyzing Capstone Area Accidents, 2000 and 2001

In 2000 and 2001 there were 58 accidents and incidents in the Capstone area, 30 of which involved part-135 operators. Nineteen of those involved part-135 operators in the Y-K Delta. Figure 4-2 breaks-out the accidents by Capstone area/Y-K Delta part-135 operator and by FAR part.

Figure 4-2. Accidents in the Capstone Area by FAR Part of Flight 2000–2001

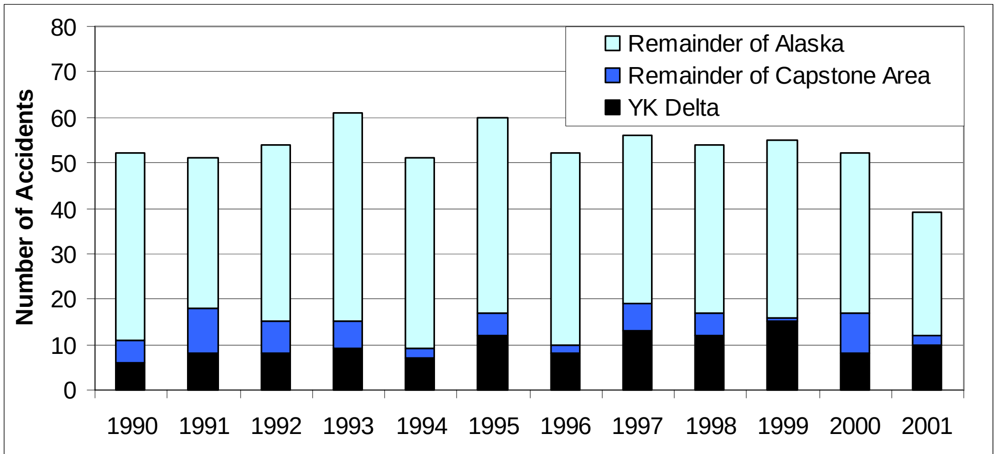


The pie shows the 58 accidents in the Capstone area by the FARs under which each flight operated. The gray outer wedges show the 19 accidents where the flight was operated by one of the Y-K Delta part 135 operators that are the focus of Capstone.

The number of part-135 accidents among aircraft based in the Y-K Delta, in the Capstone area, and throughout Alaska varies from year to year. Figure 4-3 (next page) shows accidents from 1990 through 2001 for these three groups.

We considered whether we could predict the expected accidents among Y-K Delta part-135 operators (in the absence of Capstone), based on variations in the number of accidents elsewhere. That is, if accidents among part-135 operators statewide went up some percentage, could we expect the same increase among Y-K Delta part-135 operators as well? We discovered, however, that the year-to-year accident variations for Y-K Delta part-135 operators and for all Alaska part-135 operators are too different to justify applying the statewide change to the Y-K Delta. Nor could we use percentage changes in numbers of accidents involving part-135 operators outside the Y-K Delta but still within the Capstone area—again, we found no similarity in accident variation between part-135 operators in the Y-K Delta and in the broader Capstone area.

Figure 4-3. Accidents of FAR Part-135 Operators, 1990–2001
Y-K Delta, Capstone area, and Remainder of Alaska



Source: NTSB (2002) Accident and Incident Database
Note: We used information on owners and operators to determine FAR part 135 flying as 91.

4.1.3 Capstone Area Accidents

Figure 4-4 (next page) breaks out the 58 Capstone area accidents into the nine accident categories used in Section 2.2. (There were no accidents caused by fuel problems, so only eight causes appear on the chart.) The distribution of accidents appears similar to that in the baseline period. Applying the analysis used to generate Figure 4-1 (which shows projected 2000 and 2001 accidents by cause for Y-K Delta part-135 operators), Figure 4-5 (page 61) shows the projected number of accidents by cause[37] for the entire Capstone area, compared with the number of accidents observed. For most causes the observed number is quite close to the projected number; however, landing and mechanical/other accidents are down by slightly more than one standard deviation. The figure also illustrates the very small changes we project from the Capstone program during the evaluation period, when Capstone was only partly implemented and only in the Y-K Delta.

[37] Again, the nine categories have been collapsed to seven by combining fuel and flight prep; and mechanical and other.

Figure 4-4. Accidents in the Capstone Area by Cause, 2000-2001

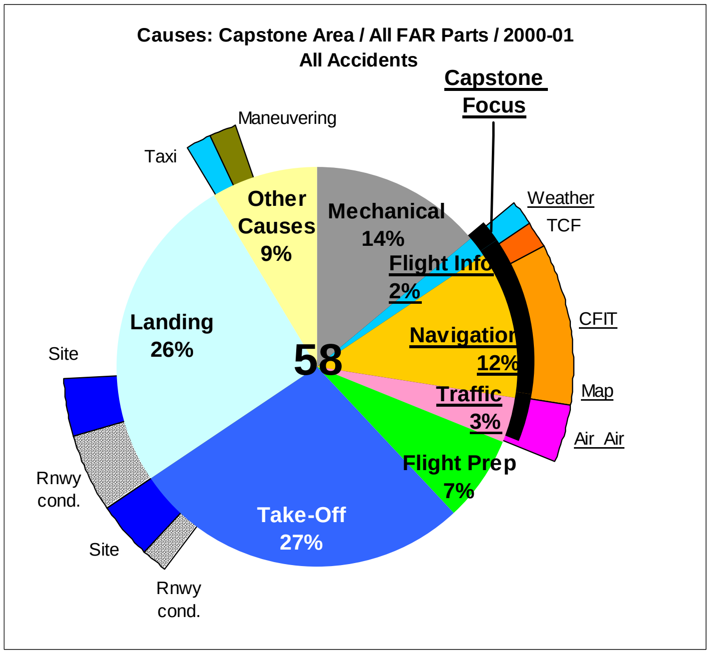


Figure 4-4 shows the same 58 accidents as in Figure 4-2, this time by the nine cause categories used in section 2.2. There were no fuel accidents, so there are only eight slices. The outer wedges show detailed cause categories (the same used in Figures 2-5 and 2-6).

Detailed Causes:

- Flight Info
  Weather= Accidents where the availability of weather information was a factor.
- Navigation
  TCF = CFIT accidents that occur on approach or departure
  CFIT: Controlled Flight into Terrain accidents
  Map = pilot did not know aircraft's location
- Traffic
  Air_Air = Collisions between aircraft when both are moving, including mid-air collisions, but also collisions while taking off, landing or taxiing
- Flight Prep
  Wt_Bal = aircraft not loaded within weight and balance restrictions
- Take-off and Landing
  Runw_cond= accidents related to runway conditions such as potholes, debris on the runway, etc.
  Site= unusual hazards of off-runway sites
- Other
  Taxi=collisions with objects (not a/c) while taxiing
  Maneuvering=typically, stalling the aircraft while maneuvering

Figure 4-5. Projected and Measured Accidents in the Capstone Area by Cause, 2000-2001

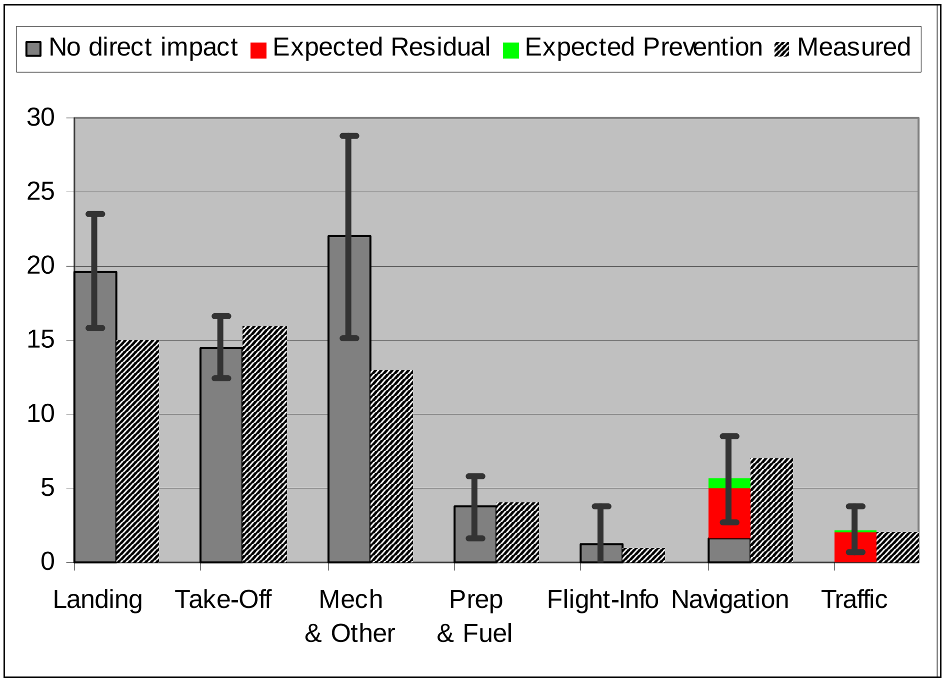


Figure 4-5 compares the projected accidents (bars on left) with measured (observed) accidents (bars on right) for the Capstone area. The gray "no direct impact" bars (and portions of bars) show accidents with causes that Capstone doesn't address; the solid green "expected prevention" areas represent the number of the projected accidents we believe Capstone could have prevented, given its actual implementation in 2000 and 2001; the red bars "expected residual" areas are the remainder of potentially Capstone-preventable accidents . The black-and-white striped "measured" bars on the right show the 58 Capstone area accidents in 2000 and 2001 by cause.

4.1.4 Y-K Delta Part-135 Accidents

Figures 4-6 (page 62) and 4-7 (page 63) repeat the above analysis for just Y-K Delta part-135 operators. As discussed in Section 2, these are the operators most affected by Capstone implementation and therefore most likely to show measurable safety benefits.

Figure 4-6 shows the 19 Y-K Delta part-135 operator accidents by cause, and Figure 4-7 compares those accidents with projected accidents and expected prevention of those projected accidents. For the most part, accident numbers in 2000 and 2001 are similar to those in previous years, but there are several variations worth noting:

1. There were no accidents caused by improper flight preparation or by fuel mismanagement, and zero is more than one standard deviation below the baseline. It is possible this decrease is only a statistical anomaly-it was not observed in the Capstone area as a whole. However, this category more than any other is directly affected by the safety attitudes and practices of pilots and their companies. Section 3.4 describes improvements in safety

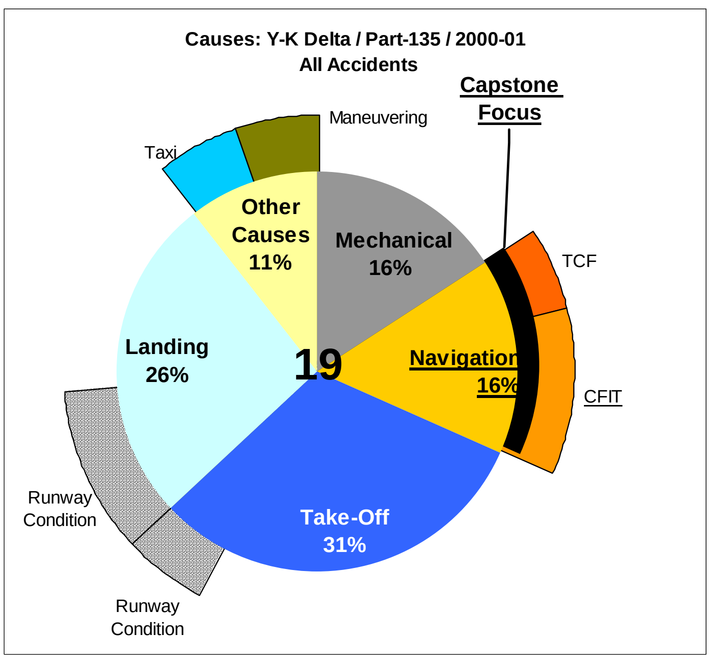
posture that could be manifested in just this way. It is possible that the increased focus on safety by Y-K Delta operators, of which Capstone implementation is a part, contributed to this decline.

2. There were no accidents attributable to lack of flight information. This might be due to improved weather information from Capstone AWOS installations or due to better risk avoidance by pilots, resulting from improved safety posture. However, the number declines by less than one accident and even zero is well within one standard deviation from the baseline. This number may simply be part of normal variation, even without Capstone.

3. There were no accidents caused by other aircraft traffic. However, zero accidents is within one standard deviation of the baseline level—it's within normal year-to-year variation. Also, while traffic accidents are a direct focus of Capstone capabilities, limited implementation means we wouldn't expect Capstone to have affected this type of accident in 2000/02.

All other accident types were within one standard deviation of the baseline mean, including navigation accidents targeted by Capstone's GPS-map and CFIT-avoidance capabilities. This finding is consistent with projections, when we take into account the limited level of implementation in the evaluation period.

Figure 4-6. Accidents of Y-K Delta Part-135 Operators by Cause, 2000-2001



The nineteen accidents of Y-K Delta Part 135 operators in 2000 and 2001 fell into just four of the nine cause categories, and five detailed cause categories. See Figure 4-4, above, for explanations of the detailed categories.

Figure 4-7. Projected and Measured Accidents of Y-K Delta Part-135 Operators by Cause, 2000-2001

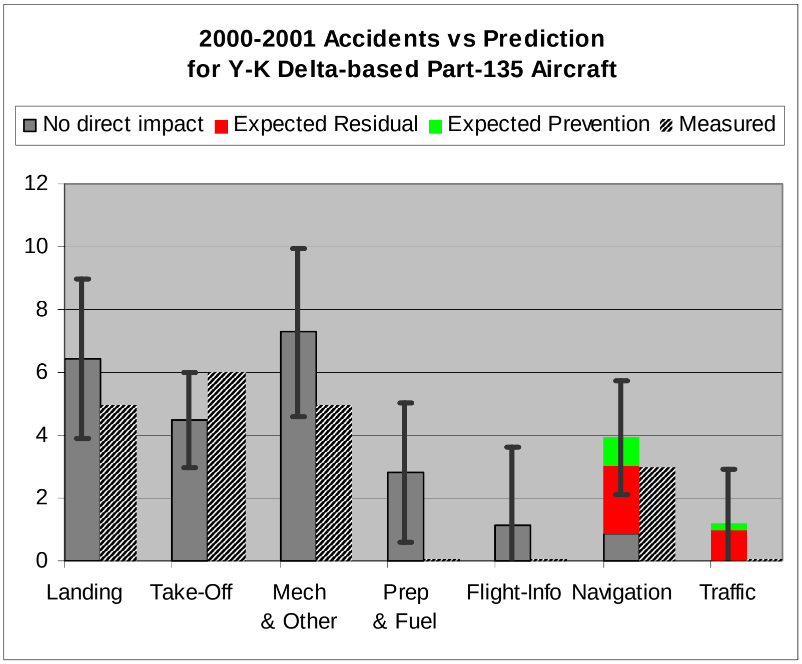


Figure 4-7 repeats the projected accident numbers from figure 4-1 (left bar of each pair) and compares it with observed accidents (right bar of each pair) for Y-K Delta Part-135 operators. The gray "no direct impact" bars (and portions of bars) are projected accidents with causes that Capstone doesn't address. The green "expected prevention" areas for navigation and traffic causes show the number of projected accidents we would expect Capstone to have prevented, given its actual implementation level in 2000 and 2001; the red "expected residual" areas show Capstone–relevant accidents that we expect would have occurred despite Capstone's implementation. The black-and-white striped "measured" bars show the Y-K Delta Part-135 operators' 19 accidents in 2000 and 2001.

4.2 Y-K Delta Part-135 Accidents by Equipped and Non-Equipped Aircraft

This section contrasts the accident rates between equipped and non-equipped part-135 aircraft based in the Y-K Delta during 2000 and 2001. This is a second way of evaluating the possible safety benefits of Capstone. Aircraft were gradually equipped over the interim evaluation period, and for much of the period there were no systematic differences in how equipped and non-equipped planes were used and the conditions they flew in. In early 2000, when few planes were equipped, Capstone-equipped planes weren't representative of the fleet as a whole. By the end of 2001, when about 85 percent of part-135 aircraft had been equipped, it was the non-equipped planes that were not representative of the fleet. Nevertheless, these two groups of aircraft in the Y-K Delta still provide the most sensitive measure of the safety effects of Capstone avionics.[38]

[38] Comparing equipped and non-equipped sub-populations is convenient for direct assessment of safety changes associated with Capstone's implementation. Because the non-equipped sub-population is essentially gone by mid-2002, we cannot repeat this analysis for future years. The results must be interpreted with caution because of the small numbers of accidents in each sub-group each year.

We have good data about the dates that each aircraft were returned to service after Capstone avionics were installed; we also know about how many aircraft those operators had that were not equipped as of December 2001. This information allows us to calculate the number of total aircraft-days for equipped and non-equipped aircraft in the Y-K Delta part-135 fleet[39] (Figure 4-8). From these data we can calculate the accident rate per aircraft day, shown in Figure 4-9.

Figure 4-8. Count of Equipped and Non-Equipped Aircraft-Days, Y-K Delta Part-135 Operators

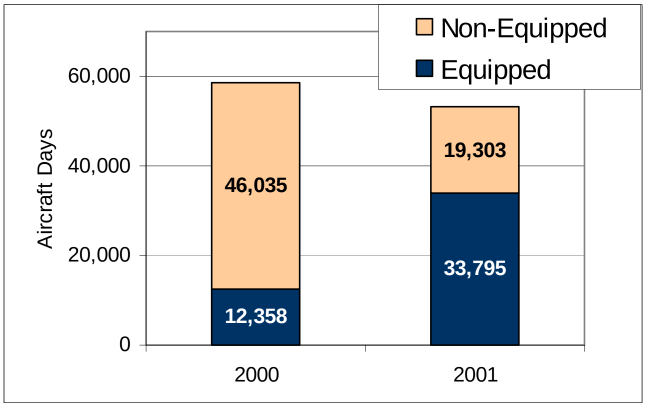
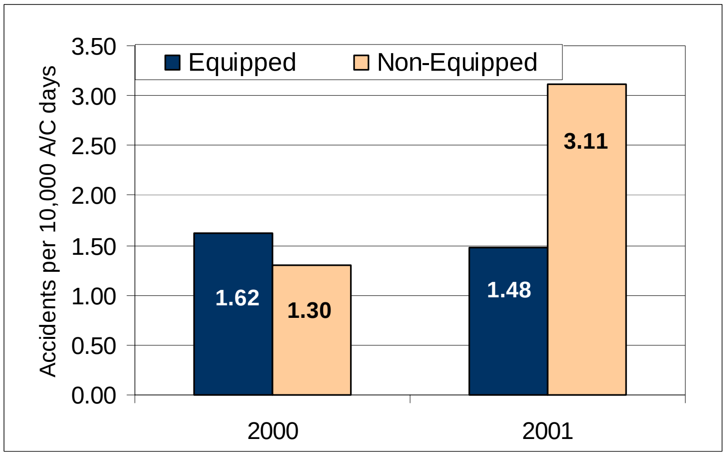


Figure 4-9. Accident Rates for Capstone Equipped and Non-Equipped Aircraft, Y-K Delta part-135 Operators



In 2000, equipped and non-equipped aircraft belonging to Y-K Delta part-135 operators had similar accident rates. In 2001, the rate of accidents among Capstone-equipped aircraft was less than half that of non-equipped aircraft. The data set isn't big enough to

[39] We eliminated some Capstone-equipped aircraft from the analysis: Northern Air Cargo aircraft fly under part 121; PenAir is no longer a Y-K Delta part-135 operator, nor are UAA, FAA, and the US Fish and Wildlife Service. This was necessary because we had to define the fleet strictly as Y-K Delta part-135 operators to be consistent in our counts of equipped aircraft, non-equipped aircraft, and accidents. Also, because we had no information about how quickly operators replaced aircraft that crashed, the 19 accident aircraft were subtracted from the fleet on the dates they crashed.

allow us to make statistically significant predictions about future years. With only 19 accidents in 2001, if we split the fleet in some way unrelated to accidents (by paint color, for example) there would be a 30 percent chance that we might see this big a difference in accident rates, just by chance. However, the results are promising, if not conclusive.

One of the Capstone-equipped aircraft accidents should have been prevented by Capstone. The aircraft flew into a hillside in flat light conditions–a navigation/CFIT accident. Why didn't Capstone equipment prevent this accident? Did limited pilot training in use of Capstone avionics (as characterized in Section 3) interfere with the pilot's use of the CFIT-avoidance capability?

The NTSB narrative for this accident is included in Appendix C, with additional information from pilot interviews by Leonard Kirk of the University of Alaska Anchorage's Aviation Technology Division. From these documents it is apparent that the limited training of the pilot, the pilot's attitude toward accident risks, and the potential that his activities might be monitored led him to actively defeat the operation of Capstone's CFIT-avoidance capability. While this is a rather extreme example of the limitations of training, it nevertheless is consistent with our discussions of the importance of both training and attitudes.

Even if this accident hadn't happened–and there had been no navigation-caused accidents among Capstone-equipped planes– a reduction to zero would have been within normal year-to-year variation.

4.3 User Assessments of Capstone Safety Benefits and Problems

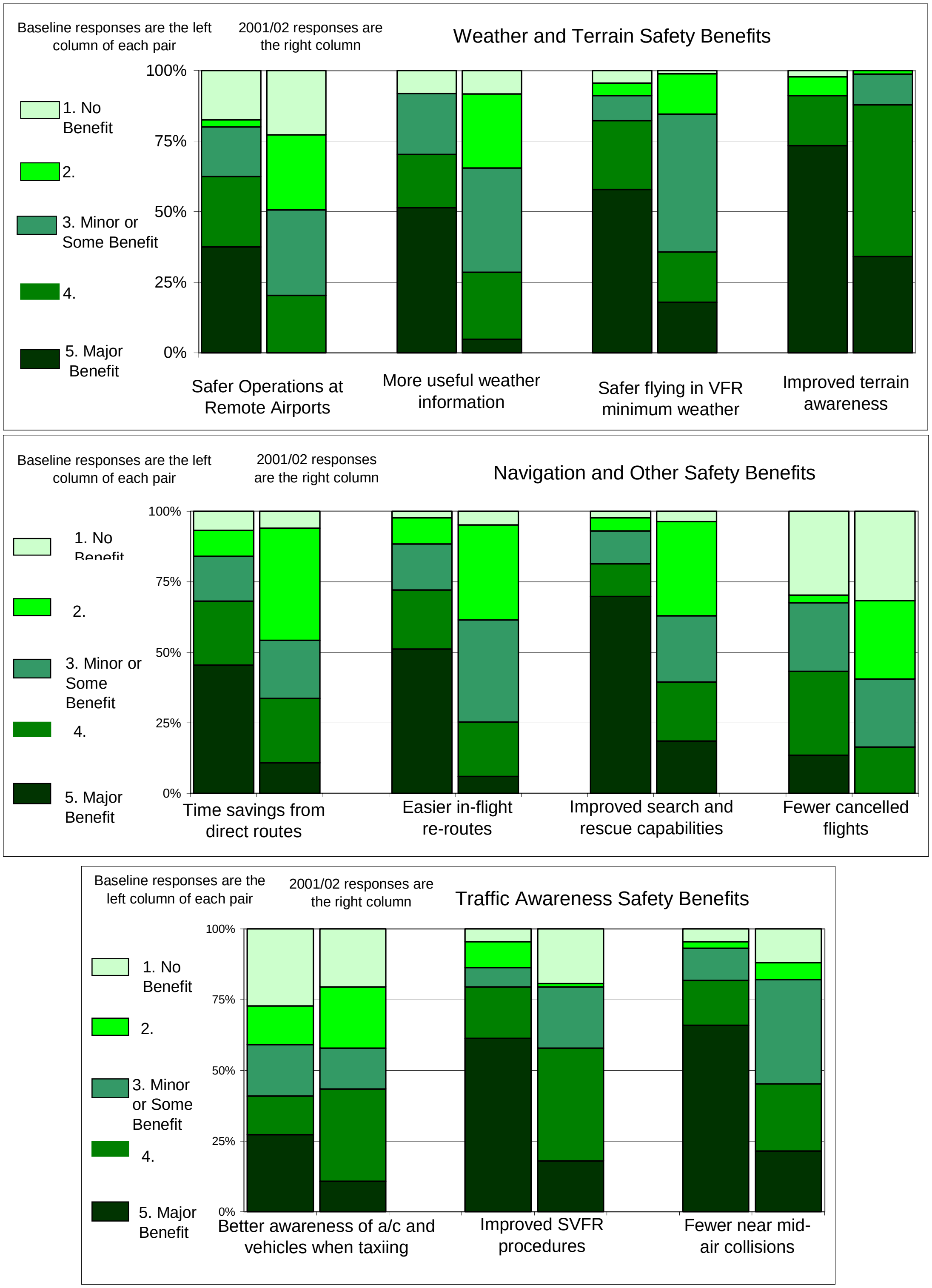
During the baseline study and again in the winter of 2001/02, UAA asked pilots to assess the expected safety benefits of Capstone. The pilots we talked to in the baseline period were familiar with Capstone and some had had classroom training, but few had flown with the equipment. In 2001/02 all the pilots had flown aircraft with Capstone avionics, although a significant number (over 10 percent) had not been trained to use the equipment. Figure 4-10 (page 67) summarizes their answers about expected safety benefits.

We asked about 11 potential benefits and gave the pilots an opportunity to cite benefits that we had not listed (almost no one did). They rated each potential benefit on a 1-to-5 scale from "no benefit" to "major benefit." In general, pilots tended to rate the safety benefits lower in 2001/02 than they had in the baseline period. This pattern is consistent with pilots' optimistic expectations giving way to reality as they gained experience using Capstone avionics.

To some extent, these ratings also reflect incomplete Capstone implementation. For example, "improved terrain awareness" showed a relatively small change in user assessments. Terrain awareness in flight is a function that has been implemented in Capstone from the start. By contrast, pilots assessed "improved SVFR procedures" far lower in 2001/02—which is not surprising, since that potential use of Capstone is not yet implemented. Likewise, there was little change in “fewer near mid-air collisions” and in “safer flying in VFR minimum weather”. These benefits largely reflect fully implemented capabilities. However, “more useful weather information” was rated much lower, reflecting the fact that pilots can’t yet receive in the cockpit the weather information from the newly installed AWOS stations.

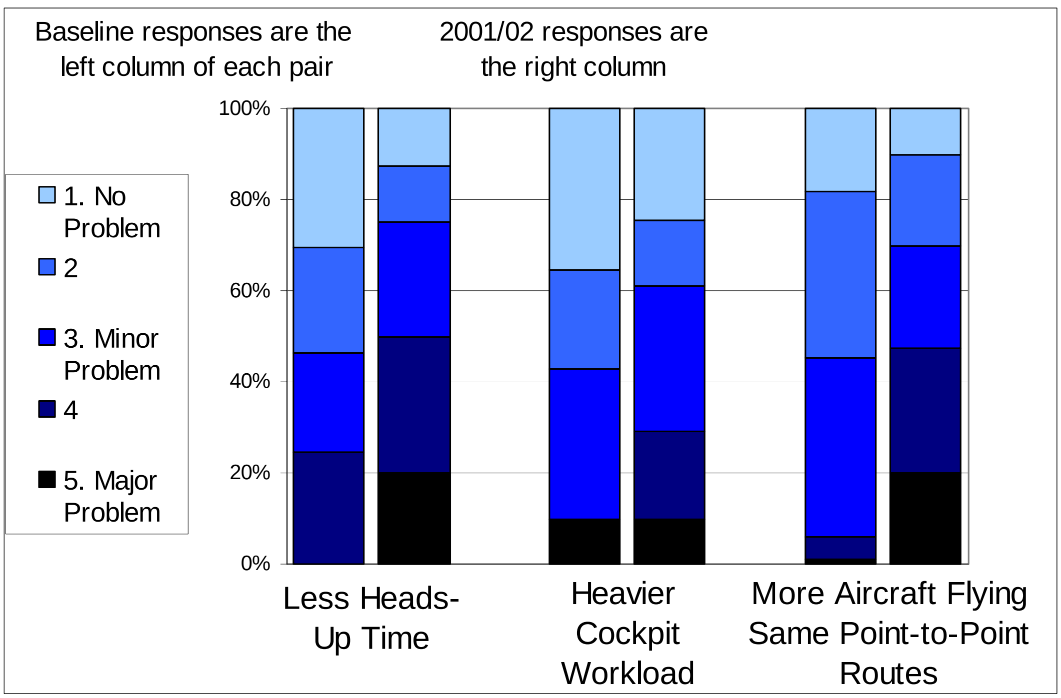
The majority of pilots rated all the potential benefits we listed as at least of minor benefit. The percentage that chose 3, 4, or 5 ranged from 60 to 97 percent, except for the two measures that involved new instrument approaches–“fewer cancelled flights” and “safer operations at remote airports.” Again, those capabilities were phased in over the 2000/01 period. Also, in order for IFR benefits to be fully realized, operators will have to gain instrument capability as well.

Figure 4-10. Pilot Assessments of Capstone Safety Benefits, Fall 2000 and Winter 2001/02



As Figure 4-11 shows, the pattern in pilots' ratings of potential Capstone problems is similar to their estimate of benefits. They agreed that items on our list represented potential problems; few identified any additional problems; and their optimistic ratings before using the equipment gave way to a more realistic assessment after they had used it. The problem pilots rated as most serious—less heads-up time—is addressed by training. In their comments and interviews, several pilots and operators noted that this is a major reason pilots flying Capstone-equipped aircraft need thorough training. In addition, pilots commented that in the winter, when they're wearing heavy gloves, they find it more difficult to push the buttons and turn the knobs on Capstone equipment.

Figure 4-11. Pilot Assessments of Capstone Safety Problems, Fall 2000 and Winter 2001/02



4.4 Interim Evaluation

Table 4-1 summarizes our assessments of Capstone's impact on safety. The first column lists individual capabilities or factors that might affect safety. The next group of columns characterizes the implementation status of each capability in 2000 and 2001. The third group of columns assesses the effects of each capability as implemented (or in some cases, not implemented).

Table 4-1. Capstone Phase I: Interim Assessment of Safety Effects by Components and Capabilities

	No Y-K Delta part-135 Implementation	Planned Future Implementation	Partly implemented in 2000/02	Nearly Complete by 12/31/01	Negative	Not Known or Not Significant	Positive	Very Positive
Capability or Contributing Factor	Status				Impact: 2000/01			
Navigation Systems								
En Route Terrain (CFIT) Avoidance				X		X		
Approach Terrain (TCF) Avoidance	X							
Location				X		X		
Runway Alignment			X			X		
Non-precision Instrument Approaches			X			X		
Flight Information Systems								
FIS-B: text weather				X		X		
FIS-B: graphical weather			X			X		
FIS-B: additional AWOS observations		X				X		
Spatial Icing product		X				X		
Additional AWOS (VHF voice)			X	X		X		
Pilot reports guided by traffic display				X			X	
Traffic Systems								
Cockpit display of ADS-B aircraft			X			X		
Cockpit Display of Transponder a/c (TIS-B)	X					X		
Radar-like Services: Surveillance			X			X		
Radar-like Services: Approach Control		X				X		
Tower "Bright" display		X				X		
Flight Following Displays for operators		X				X		
Over-all								
Installation of Capstone Avionics				X			X	
Installation of Ground Systems			X				X	
Pilot training on Capstone Avionics			X				X	
Operator Safety Postures			X				X	
IFR Capable operations			X				X	

Our confidence in these assessments varies, depending on the available data. Table 4-2 describes the basis for our assessments. A few consist only of a conjectured rationale for improved safety—which should be regarded skeptically. The best are measured changes in accident rates, which over time will provide very high confidence. At this time the grounding for most of our assessments is in between these extremes and is based on (1) what pilots and operators using the equipment have told us, and (2) on measurement of factors that contribute to changes in safety but are not themselves measures of improved safety. Each of these is an interim evaluation that we can make with more confidence later, when Capstone has been in existence longer.

Table 4-2. Capstone Phase I: Basis for Assessments of Safety Effects by Components/Capabilities

Capability or Contributing Factor	Rationale for Benefit	Ability to Characterize Potential Benefits	Consistent with User Expectations	Factors in Rationale Measured	Assessed change in accidents consistent with Rationale
Navigation Systems					
En Route Terrain (CFIT) Avoidance	X	X	X	X	
Approach Terrain (TCF) Avoidance	X	X			
Location	X	X			
Runway Alignment	X				
Non-precision Instrument Approaches	X			X	
Flight Information Systems					
FIS-B: text weather	X				
FIS-B: graphical weather	X				
FIS-B: additional AWOS observations	X				
Spatial Icing product	X	X			
Additional AWOS (VHF voice)	X			X	
Pilot reports guided by traffic display	X	X		X	X
Traffic Systems					
Cockpit display of ADS-B aircraft	X	X	X	X	
Cockpit Display of Transponder a/c (TIS-B)	X				
Radar-like Services: Surveillance	X				
Radar-like Services: Approach Control	X		X		
Tower “Bright” display	X		X		
Flight Following Displays for operators	X		X		
Over-all					
Installation of Capstone Avionics	X	X	X	X	X
Installation of Ground Systems	X	X	X	X	X
Pilot training on Capstone Avionics	X	X		X	
Operator Safety Postures	X			X	X
IFR Capable operations	X			X	

Based on Tables 4-1 and 4-2, we have developed the following interim assessments of the effects on aviation safety of Capstone Phase I in southwest Alaska during 2000 and 2001:

Safety posture in the Capstone area has increased substantially. Capstone has played a significant role, in particular through providing additional weather stations, GPS approaches, avionics, and training.

Pilots and operators are generally pleased with the program. Their expectations may have originally been too optimistic; their views about the potential benefits and problems associated with Capstone have become more realistic. They still see the program’s benefits as valuable and the problems as tractable with training and experience.

Accidents still happen–even some of types that Capstone was designed to prevent. Examining the reasons why will be a focus of our continuing research. We know that both training and attitude are important factors in Capstone's full effectiveness, and that these changes can't be realized as quickly as avionics and ground systems can be installed.

The lower accident rate among Y-K Delta part-135 Capstone-equipped aircraft in 2001 indicates that Capstone may already be improving safety in the Y-K Delta. The rate was 1.5 accidents per 10,000 aircraft days among equipped planes, compared with 3.1 among non-equipped planes. We will need more data before we can be confident that this difference results from the Capstone program rather than from random variation.

An unanticipated use of Capstone equipment may also be producing safety benefits. Pilots told us that they get up-to-date information on their destinations by contacting other pilots in those locations—and they identify those pilots using Capstone's ADS-B feature. This could explain the absence of landing accidents caused by poor runway conditions, since pilots can learn about those conditions in advance and be prepared for them.

Improved infrastructure that supports IFR flight is encouraging Y-K Delta operators to use IFR operations. Additional weather stations and GPS approaches have increased the number of Y-K Delta airports with instrument approaches from 3 to 13. At the same time, the number of IFR-certified commercial aircraft operating in the area rose from 8 to 22, and will likely continue to increase.

We didn't expect to see Capstone's full benefits during this evaluation period because the program was only partly implemented. Avionics were installed gradually over the two-year period; pilots had limited training and experience using the equipment; and not all the traffic and flight information capabilities were functional, even by December 2001.

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5 Findings and Recommendations

Capstone Phase I has not yet been fully implemented. To fully realize Capstone's potential benefits, the FAA must finish equipping the fleet as planned and building the ground infrastructure to support the system's capabilities. Operators must continue to provide training and support for pilots to use the equipment effectively. Our preliminary recommendations include:

- It is definitely worthwhile for the FAA to continue this program. Only when all the Capstone equipment is in place and pilots have been well-trained—and have used the equipment for a longer period—can we expect to see the full safety benefits.

- The Capstone program won't see its full benefits unless pilots and operators support it and use all its capabilities. Safety research needs to continue tracking pilot and operator attitudes about the program and assessing the effectiveness of pilot training. The FAA needs to continue to market the program to pilots and Flight Standards District Offices (FSDO's) need to assure pilots and operators that the technology won't be used for enforcement.

- Operators also need to allocate time and money for thorough initial and continuing training. FAA oversight could help to ensure this happens.

- Simulators with Capstone avionics would be a valuable addition to the pilot training currently available.

- In order to get the most benefit out of data-link weather and other relevant information the Capstone potentially makes available in the cockpit, pilots need to be able to access this information wherever they fly, and not just in a part of the Y-K Delta. It's important to increase the number of ground-based transceiver stations so they cover at least the full Y-K Delta.

- To fully realize the potential benefits of radar-like services, the FAA should work to provide approach-control services for Bethel airport using Capstone's capabilities.

- The FAA should require future Capstone participants to provide more information on how often and where they fly, what training they provide, who their pilots are, and what their qualifications are. Lack of such information in the Y-K Delta hampers our ability to estimate safety benefits. Operators in Phase I of the program weren't required to provide this information when they received the Capstone equipment.

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Appendix A

Comparison of Baseline and Interim Accident Analyses

Data Limitations

As identified in the baseline report, data to characterize flight operations, particularly in remote areas, are very limited. Data to characterize accidents that have occurred is of much higher quality because of systematic collection by the National Transportation Safety Board (NTSB) and the FAA. Nevertheless, when accidents with specific causes or in specific populations are examined, the numbers per year are small and subject to large percentage variations.

The National Transportation Safety Board (NTSB) and the FAA compile excellent documentation of accidents and events leading to them, but data on flight operations in rural Alaska are very limited. This makes accident rates per flight hour or per operation less accurate. Further, though well documented, the total numbers of accidents associated with particular causes or types of aircraft operations are small and subject to large percentage variations from year to year. For these reasons a simple comparison of accident statistics with and without Capstone is not informative for the brief evaluation time to date.

Our approach combines knowledge of aviation, Y-K delta operations, and factors that influence safety to build a framework that helps interpret empirical observations and measurements. We have organized this knowledge as a *safety model* for the Capstone Area. The inputs to this model are safety factors that we have measured. The parameters that influence the impact of safety factors are derived from prior studies, from analysis, or from the expert judgment of team-members. The outputs from the model are predicted changes in accidents. We validate predictions of the model against observed accidents by Capstone-equipped aircraft, and contrast these with accidents by non-equipped aircraft in the Capstone Area and elsewhere in Alaska. We compare these predictions with the expectations and experiences of pilots and operators using Capstone.

Conceptually, were sufficient data available, a simpler approach could be used: we could statistically characterize changes in safety and correlate these with changes in safety factors – such as the availability of weather warnings, equipage or training with Capstone avionics, or the existence of the Capstone program as a whole. This approach could validate relationships empirically and might be less sensitive to differences in judgment, but the amount of data required is large and the results obtainable from limited data are small. Also, such an approach would not build a common understanding of importance of particular safety issues and contributing factors. The numbers of Capstone Area accidents in the baseline and evaluation period to date are too few to average-out random variations and show statistical significant correlations with individual safety factors.

Table A.1 Accidents, Incidents and Fatalities in the Capstone Area 1990-99 and 2000-01

Accidents, Incidents and Fatalities in the Capstone Area, 1990-99 and 2000-01	All Accidents & Incidents		Accidents		Accidents w/ Fatalities		Fatalities	
	1990-99	*2000-01*	*1990-99*	*2000-01*	*1990-99*	*2000-01*	*1990-99*	*2000-01*
Air Carriers Operating Under FAR Part Number 121								
Non Scheduled	2	0	2	0	1	0	4	0
Scheduled	1	2	1	1	0	0	0	0
Air Carriers Operating Under FAR Part Number 135								
Non Scheduled	89	13	86	13	9	1	12	1
Scheduled	33	8	30	8	1	1	6	10
135 Operating as Part 91	33	9	31	8	5	2	9	2
Air Carriers Operating Under FAR Part 91								
FAR Part 91	140	18	139	18	9	0	17	0
FAR Part 91 - Public	10	7	10	7	1	1	2	1
Other								
FAR Part 125	1	1	1	1	0	0	0	0
FAR Part 129	0	0	0	0	0	0	0	0
FAR Part 133	0	0	0	0	0	0	0	0
FAR Part 137	0	0	0	0	0	0	0	0
Total	309	58	300	56	26	5	50	14

Source: NTSB (2002) Accident and Incident Database. Data cover 1/1/90 through 12/31/2001.

Accident Classification Methods

Description of Methodologies

This report extends the method developed for the baseline study. By doing this we use as much data as possible, overcome some of the weaknesses in the data, and can provide a better explanation of how Capstone avionics affect safety. Both the baseline method and interim method use as a starting point all accidents in the YK delta between January 1, 1990 and December 31, 1999,[1] and from January 1, 2000 through December 31, 2001 as the recent period. Both use FAR part number to group accidents. Table A.1 shows counts of accidents and incidents, fatal accidents and fatalities in the YK delta for 1990-99 and 2000-01.

There are important differences between the two methods. The methods differ in (1) geographic coverage (2) avionics categories and, (3) method for assessing avionics relevance. The baseline method includes information about more accidents and more operators. The baseline method looks at the pattern of accidents in the Capstone area and Alaska during the baseline and recent

[1] The earlier published totals for the baseline period in this report differ from the earlier version because we updated the data to cover the period from 10/15/99 through December 31, 1999 missing from the earlier version. The dataset extending through December 31, 1999 also contained better latitude and longitude information. We used this to make some adjustments to earlier accident counts.

periods. Then it evaluates accidents in the recent period to see if the pattern of accidents and accident rates are different than they were in the baseline and different from the pattern of accidents statewide. It categorizes accidents as “yes”--Capstone avionics would have been addressed all accident causes, “no”--Capstone avionics would not have addressed any of the accident causes or “possible” where avionics would have addressed some but not all of the causes. The strength of this method is that it uses nearly all the available data and makes comparisons with other areas. Its weakness is that in order to make comparisons, it uses accident rates (accidents per 100,000 departures) and the data on departures are weak. Departures data are limited, especially at lower than statewide levels. The APO Terminal Forecast Survey Summary Report from the FAA’s Aviation Policy and Plans Office uses historical data on traffic counts from FAA Form 5010, the Airport Master Record. These are the only systematic data available for the Capstone area, and the published data for Capstone airports are only available for 1999. For airports with control towers, airport managers report the number of aircraft cleared for takeoff or landing. For airports without towers, which include all the Capstone area airports except Bethel, airport managers estimate the annual traffic counts. It slightly undercounts unscheduled air taxi and general aviation departures, since it would not count departures from off-airport locations. However, we think such departures are only a small part of the total.

Another weakness in the baseline method is that it assumes that all avionics components are equally effective in preventing accidents.

The method used in the interim report focuses on FAR part 135 operators based in the YK delta (the majority of Capstone participants). It tracks Capstone equipped aircraft. In the baseline period, this method evaluates accidents in terms of which of the seven avionics components would have been relevant to the accident and then assigns a measure of effectiveness from 0 to 100 percent to each component. For the remainder of accidents where no components would have been relevant, the method categorizes accidents by phase of flight or other cause. It applies this to the recent period, adjusting for equipage and training and anticipates the number and mix of avionics related accidents for 2000 and 2001. The strength of the interim method is that it tracks the Capstone equipped aircraft specifically and assigns an effectiveness measure to each component of the avionics. This method can better explain how and why accidents could occur in Capstone equipped aircraft.

The two methods used different decision rules to classify baseline period and evaluation period accidents as to avionics relevance. The baseline method categorized accidents in 1999, prior to full program implementation. The method posited best-case scenarios. Based on discussions with the FAA, it made optimistic assessments of avionics relevance. The interim method categorized baseline accidents in 2002, after the start of the program and made, as it turns out, more realistic assessments of avionics relevance.

Baseline and Interim Methods Applied to Baseline Accidents

Both the baseline and interim methods assessed whether or not Capstone avionics would have been helpful in baseline accidents. Here, we compare the two assessments of avionics relevance for accidents, fatal accidents and fatalities among FAR part 135 operators based in the YK delta. In the baseline period there were 101 accidents, 10 fatal accidents and 20 fatalities. Figure A.1 compares the "yes" and "no" counts in the interim method to the "yes", "no" and "possible" counts in the baseline methods. It also presents a detailed breakdown of the coding used in the interim method to assess avionics relevance.

Figure A.1

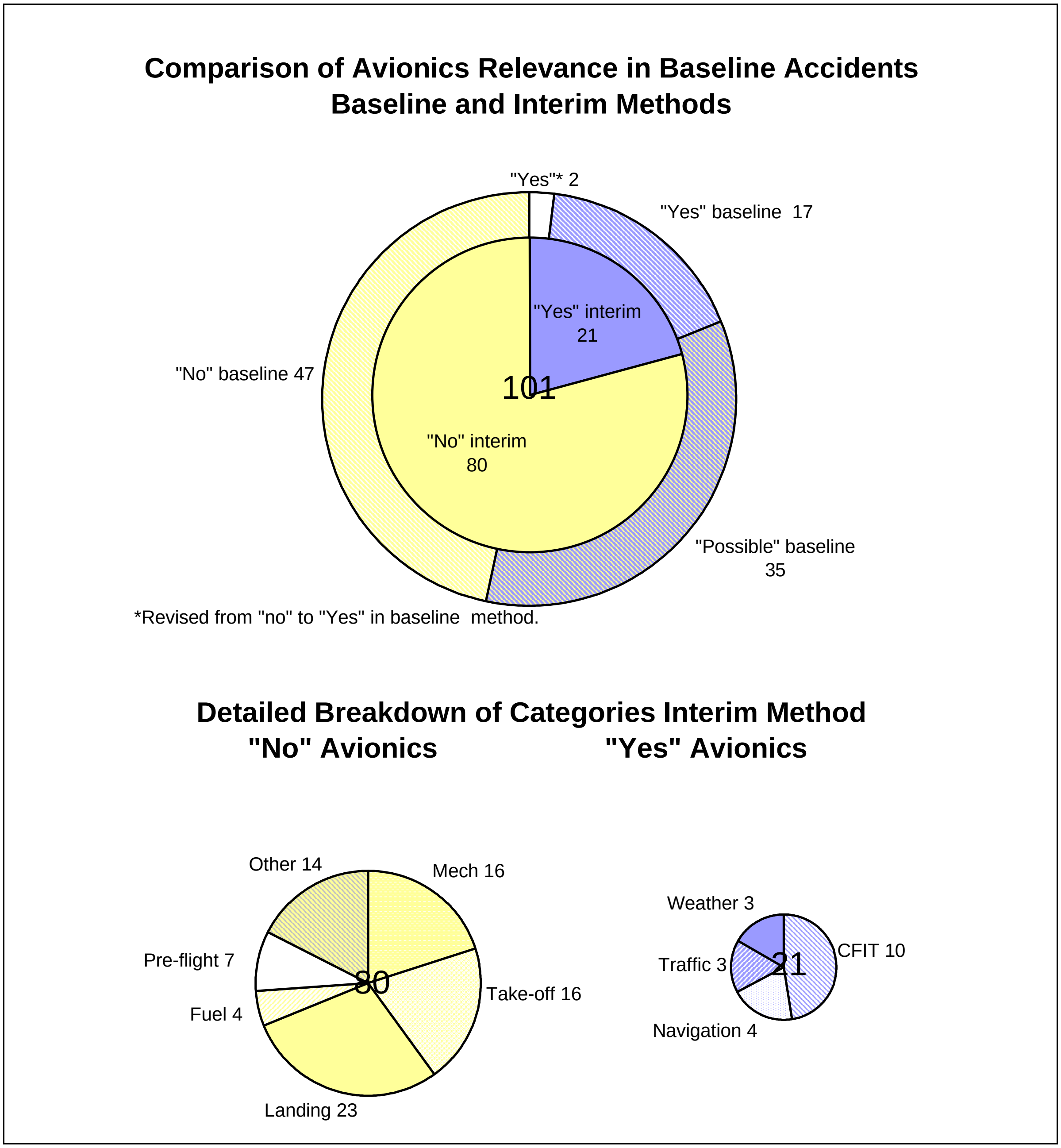


Figure A.2 shows that in the baseline period, both methods make the same assessment of Capstone avionics relevance for fatal accidents. Of the ten fatal accidents involving 135 operators based in the YK delta, both methods anticipate that avionics might have been helpful in three cases and not helpful in seven. The interim method assessed which avionics components would have been helpful in fatal accidents and found that avionics addressing CFIT accidents might have been helpful in one fatal accident and avionics addressing traffic might have been helpful in two fatal accidents. Six out of ten fatalities were in accidents where avionics addressing CFIT might have been helpful.

Figure A.2

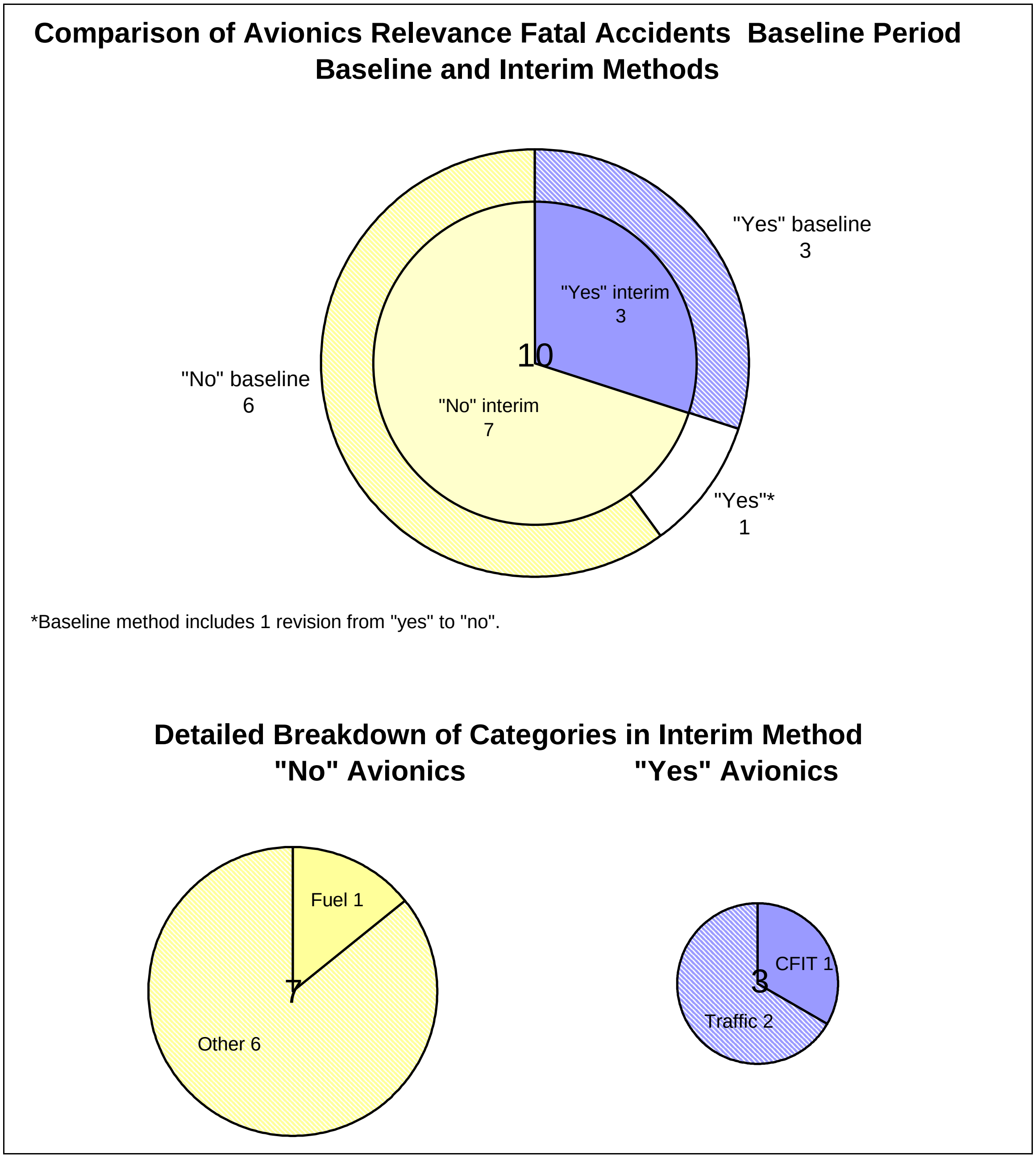
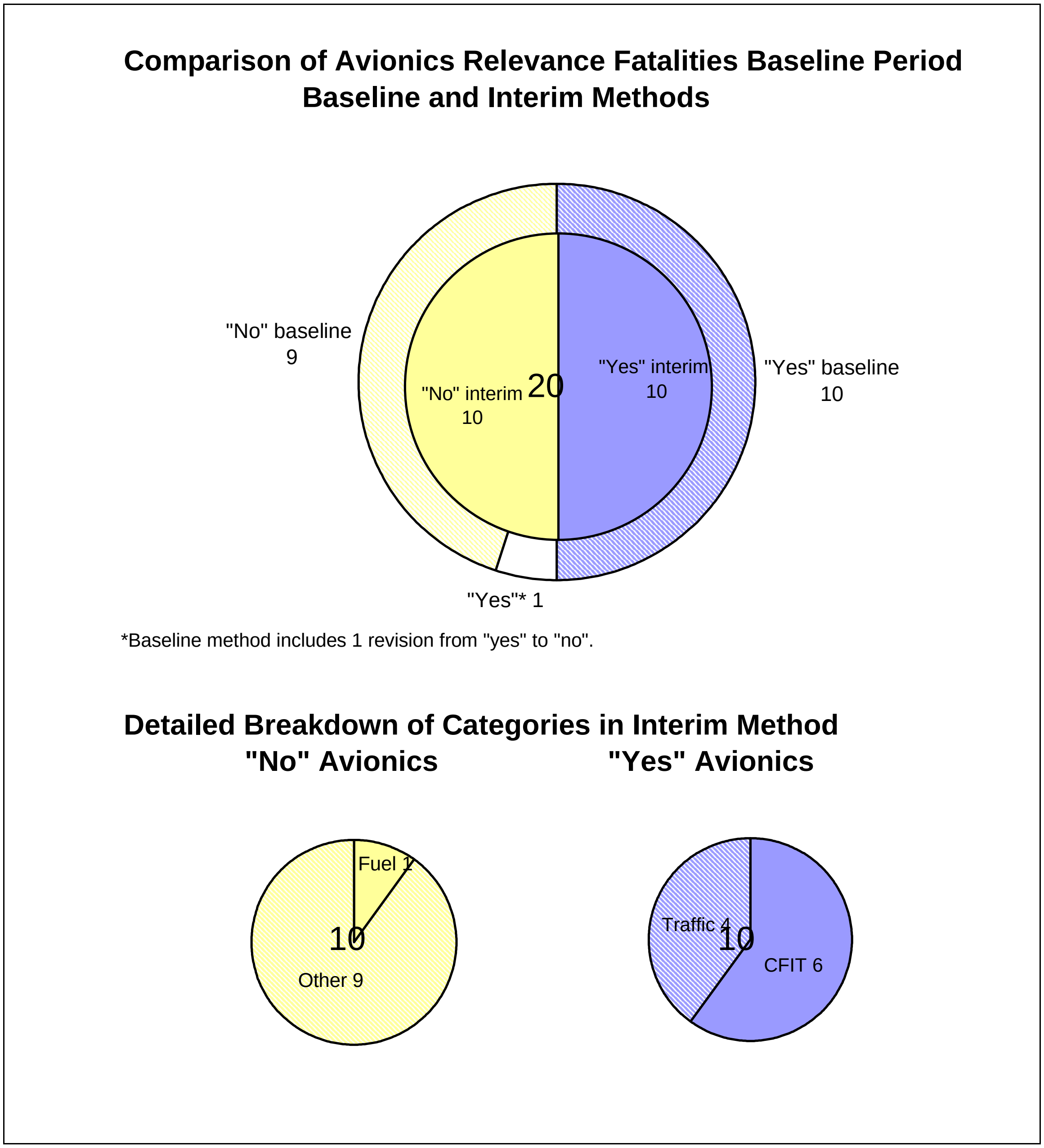


Figure A.3 shows that both methods anticipated that Capstone avionics might have been helpful in preventing half of all fatalities in the baseline period.

Figure A.3



Baseline and Interim Methods Applied to 2000-2001 Accidents

Both the baseline and interim methods evaluated 23 accidents in 2000-01. Figure A.4 shows that the baseline method determined that avionics would have been helpful in two accidents, possibly been helpful in four accidents and not helpful in 17 accidents. The interim method determined that avionics would have been relevant in three accidents. These are the two accidents coded as “yes” in the baseline method and one of the accidents coded as “possible”. The remaining 20 accidents were coded as “no” in the interim method.

Figure A.4

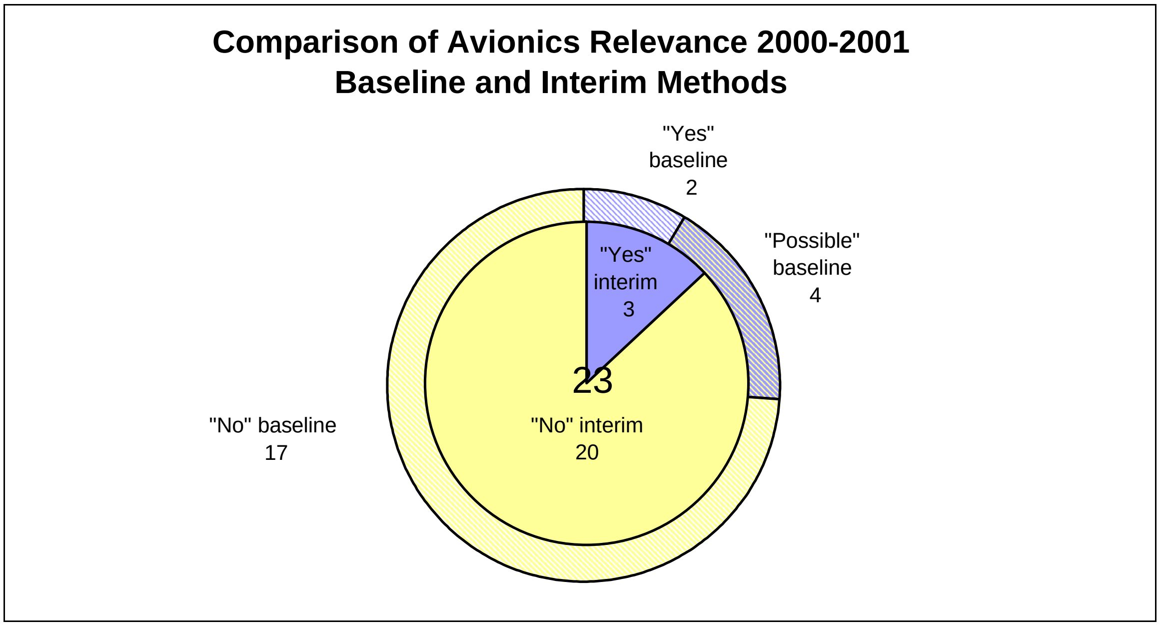
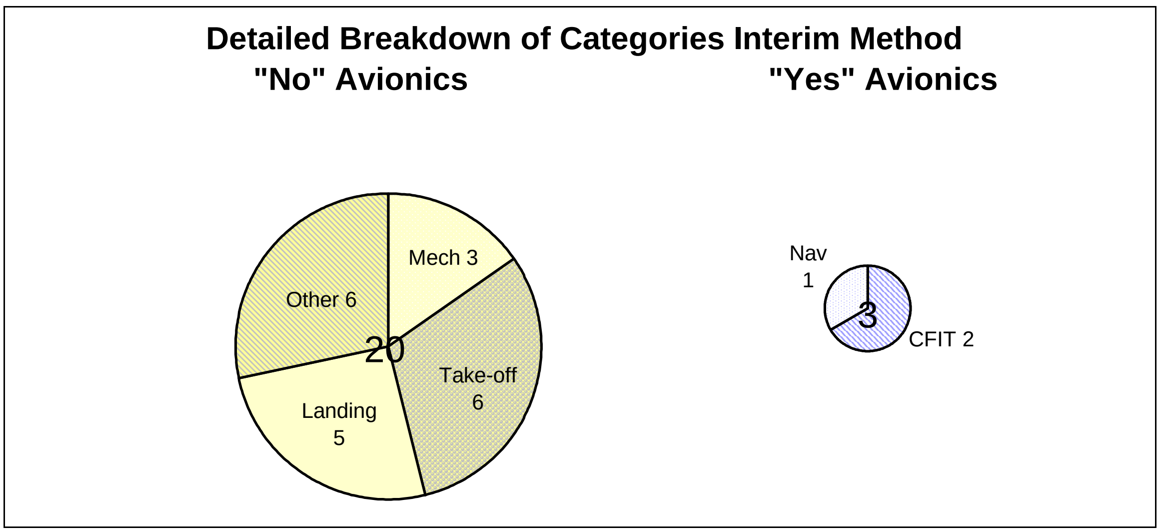


Figure A.5 shows how the interim method further categories accidents. The 20 accidents coded as “no” are divided into causes or phases on flight. The three accidents coded as “yes” are linked to avionics components that were relevant.

Figure A.5

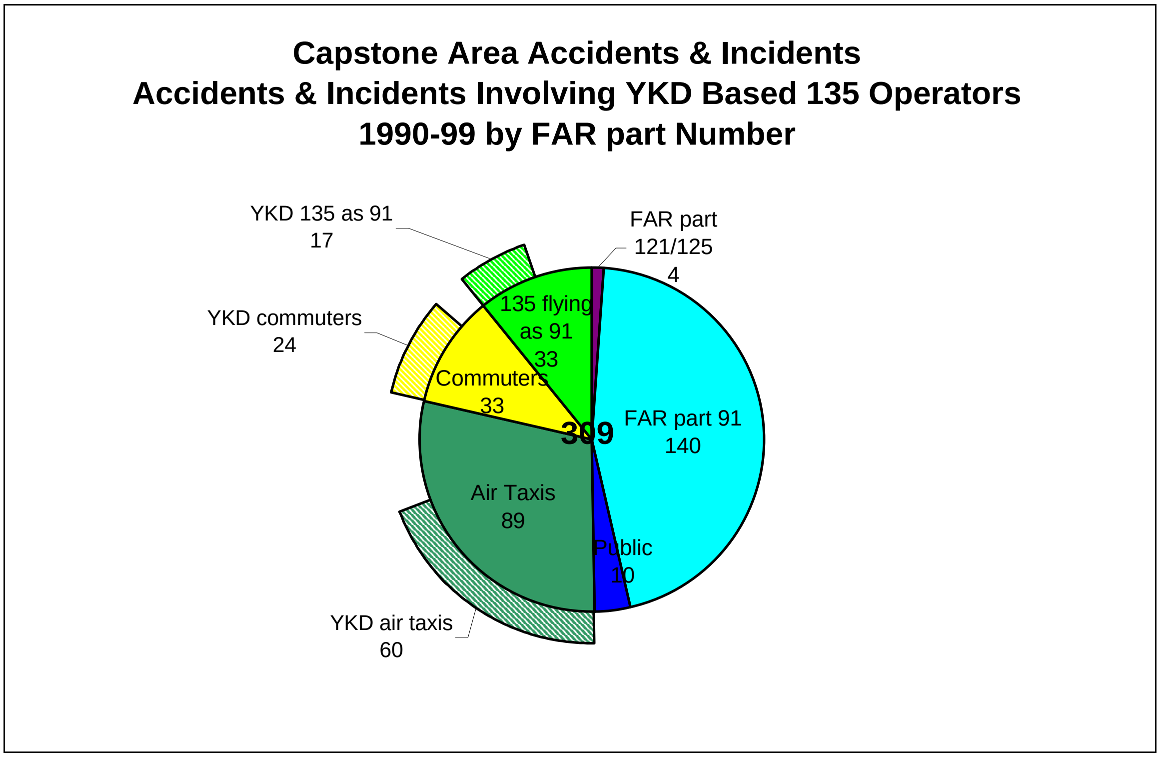


Accidents by FAR part

Accidents 1990-99 by FAR part

Figure A.6 shows the different sets of accidents. There were 309 accidents and incidents in the area between 1990 and 1999. Of these, 155 involved FAR part 135 operators. Of the 155 involving FAR part 135 operators, 101 were based the delta.

Figure A.6



Accidents 2000-01 by FAR part

Figure A.7 shows that in 2000 and 2001 there were 58 accidents and incidents in the YK delta. Nineteen involved part 135 operators based in the delta.

Figure A.7

Capstone Area Accidents & Incidents
Accidents & Incidents Involving YKD Based 135 Operators
2000-01 by FAR part Number

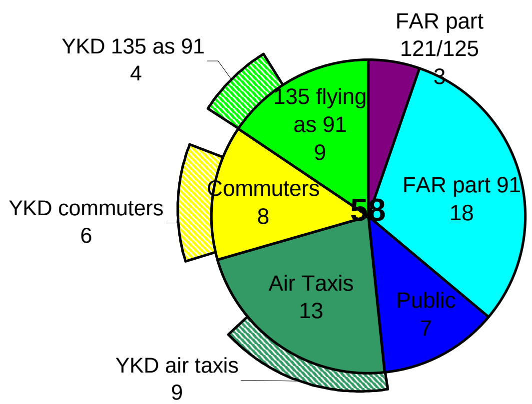


Figure A.8 shows that in 2000-01 there were 5 fatal accidents in the Capstone area. One involved a part 135 operator based in the delta.

Figure A.8

Capstone Area Fatal Accidents
Fatal Accidents of 135 Operators Based in the YK Delta
2000-01 by FAR part Number

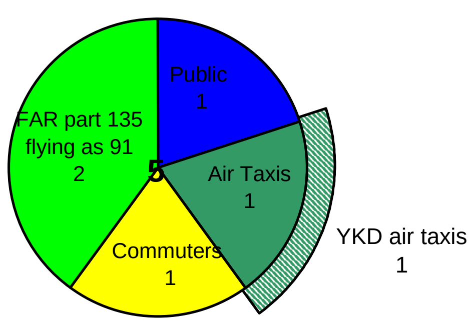
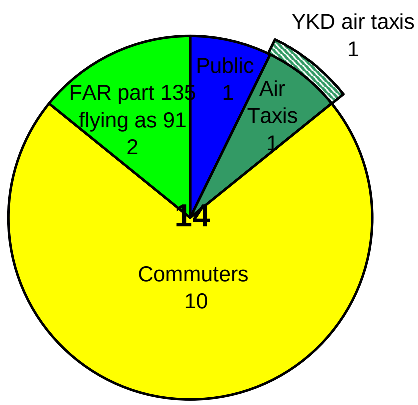


Figure A.9 shows that there were fourteen fatalities in the Capstone area in 2000-01. Only one was the result of an accident involving a part 135 operator based in the delta.

Figure A.9

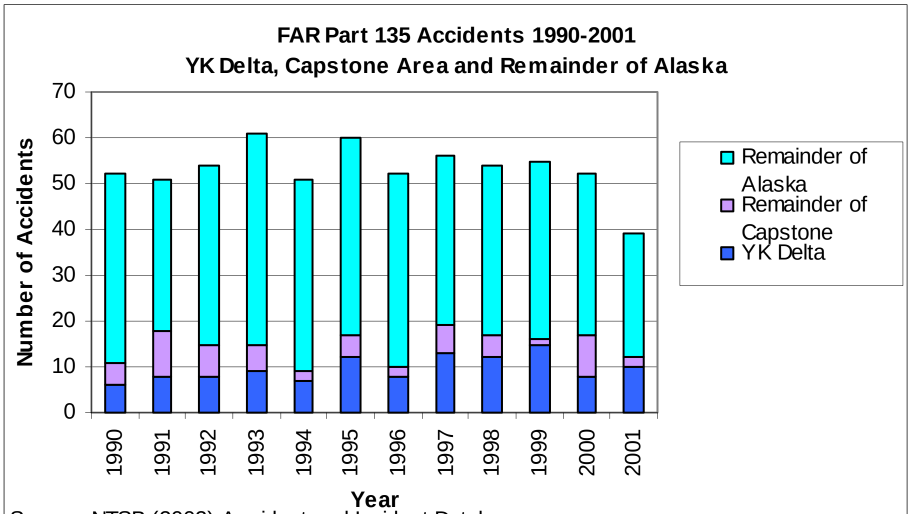
Capstone Area Fatalities
Fatalities of FAR part 135 Operators Based in the YK Delta
2000-01 by FAR part Number



Alaska, Capstone Area, and YKD Accidents per Year
for Part 135 Operations

Figure A.10 (page A-11) shows all part 135 accidents for Alaska, the Capstone area, and the YK delta. Figures A.11 through A.13 (pages A-11 to A-12) show the three component parts of this total: part 135 flying under part 91; part 135 air taxi operations, and part 135 commuter operations. Statewide, accidents involving air taxis are lower in 2000 and 2001 than in earlier years. In the Capstone area and YK Delta, there were fewer accidents involving air taxis in 2000 and 2001 than in late 1990s. Statewide, accidents involving commuters are lower in 2000 than in the previous four years, but are not as low as in the mid 1990s. In 2001, all of the commuter accidents in Alaska were in the Capstone area. It is difficult to see a pattern in the number of accidents involving part 135 operators flying as 91. These accidents are at the same level in 2001 as in the mid to late 1990s. Overall, statewide FAR part 135 operators showed very little change between 1990 and 2000 and are down slightly in 2001. This is true in the Capstone area as well.

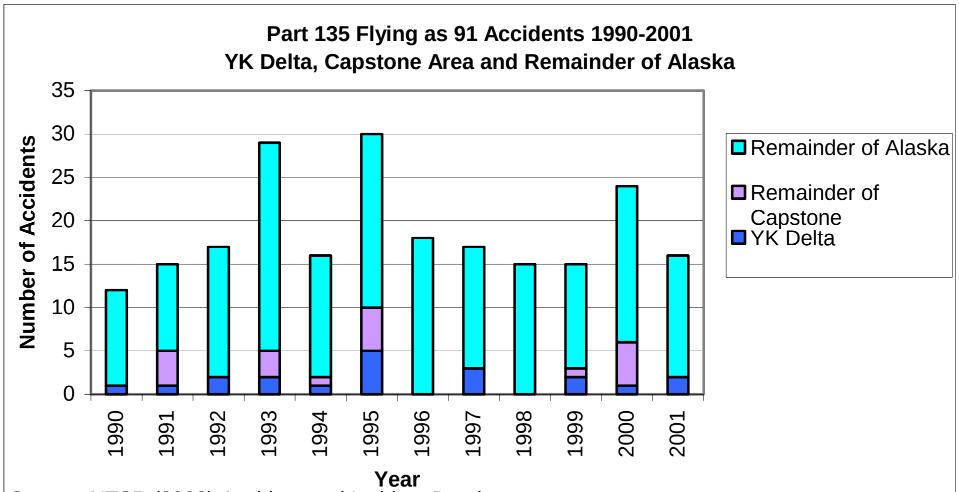
Figure A.10.



Source: NTSB (2002) Accident and Incident Database

Note: We used information on ow ners operators to determine FAR part 135 flying as 91.

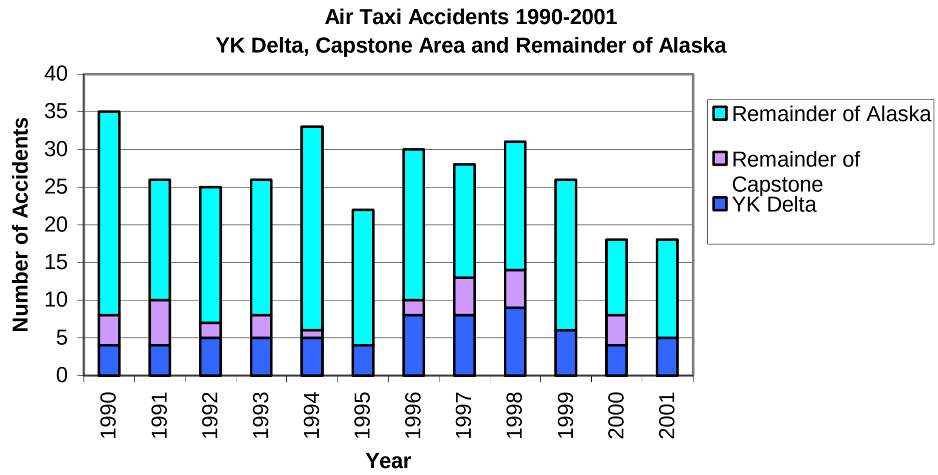
Figure A.11.



Source: NTSB (2002) Accident and Incident Database

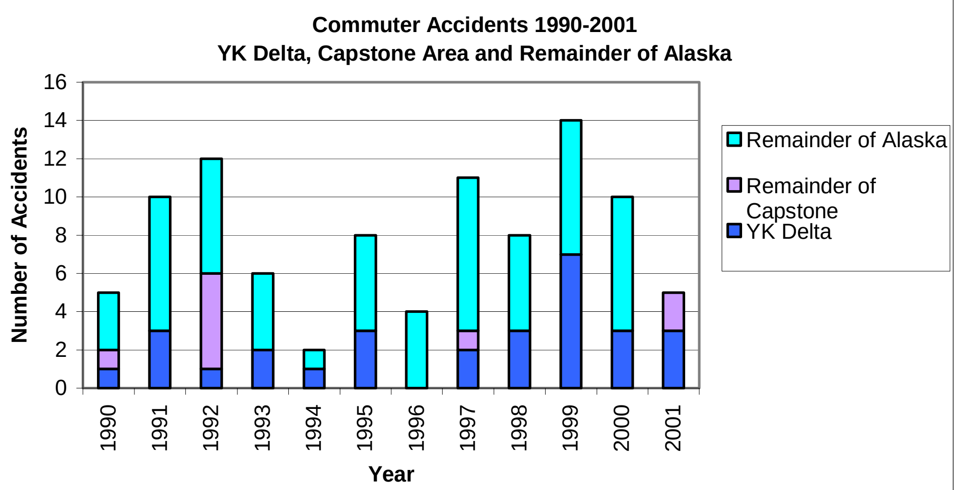
Note: We used information on owners operators to determine FAR part 135 flying as 91.

Figure A.12.



Source: NTSB (2002) Accident and Incident Database

Figure A.13



Source: NTSB (2002) Accident and Incident Database

Appendix B. Capstone Area Accidents, 1990 – 1999

The tables below present the Capstone area accidents from 1990–1999 (Table B-1, page B-3) and for 2000–2001 (Table B-2, page B-12). For each accident, the first column is the NTSB identification number; this number references the reports which we used to assign cause categories and probabilities. Column 2 is the date of the accident; column 3 is the level of the most severe injury resulting from the accident–none, minor, serious, or fatal. Column 3 lists the capstone relevance and cause category; a "no:" means that the accident was not capstone relevant, and a cause category. The cause category explanations are listed below, with the abbreviations used in the table in parentheses at the end of the relevant paragraph.

Mechanical Failure (Engine failure, inoperable control surfaces, failed landing gear, propeller or shaft failure. (mech)

Navigation Usually Controlled Flight into Terrain (CFIT) while en route, most often associated with reduced visibility. In the YK Delta, CFIT also occurs in nominal VFR conditions when "flat light" on snow-covered ground prevents recognition of terrain. Terrain Clearance Floor (TCF) warnings are a Terrain Awareness and Warning System (TAWS) function planned for Capstone Phase 2 that addresses the 20%-30% of CFIT accidents on approach or departure. These are not directly addressed by Capstone Phase 1 avionics. Rarely, accidents are due to mislocation, which can be addressed by a GPS- map display. (CFIT, TCF)

Traffic Usually mid-air collisions or near mid-air collisions (NMACs) between aircraft. Also includes accidents from last-moment avoidance of other aircraft and from jet blast on airport surface. (traffic, NMAC)

<u>Flight Info</u>rmation Usually inadequate weather information, especially icing, but also visibility; rarely convective weather. (Surface winds contributing to take-off or landing accidents have been included under take-off or landing rather than here.) Occasionally, lack of information on changes in procedures or facility status. (Wx, ice, IMC)

Fuel Mismanagement Usually fuel exhaustion. Occasionally, failure to switch fuel tanks. (fuel)

Flight Preparation Failure to ensure cargo is tied-down and within the aircraft's **weight and balance** limits. Failure to check fuel for the presence of water. Rare in the lower 48 but significant in the YK Delta is failure to remove ice or snow from the aircraft – often resulting in serious or fatal accidents. (preflt, wtbal)

Take-off and **Landing** Failure to maintain control (especially in wind), improper airspeed, or inadequate care near vehicles or obstacles. The YK Delta also includes unusually high numbers of accidents from poor runway **conditions**, from hazards at off-runway **sites** such as beaches and gravel bars, and from obstacles in water that are struck by float-planes. (tkoff, torwcond, tsite. Ldg, lrwcond, lsite)

Other Includes a variety of unusual causes such as bird strikes or collisions with ground vehicles.

Column 5 shows the estimated probability that Capstone would have applied. Most often, this is either 100 percent or zero–while every accident has multiple causes, it is usually evident whether Capstone avionics could have prevented the accident. Occasionally, the accident causes are unknown, or the contributions of two quite different factors(such as a mechanical failure in bad weather) make it difficult to determine whether Capstone would, in fact have been helpful. In those cases the author has estimated the likelihood, based o the accident narrative.

Column 6 shows the authors' estimate of how likely it is that Capstone could have actually prevented the accident, if all Capstone capabilities were fully implemented and the pilot trained and experienced in using those capabilities.

Table B-1. Capstone Area Accidents, 1990 – 1999, with Causes and Best Prevention Likelihood

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC90LA035	2/27/1990	NONE	no:ldg	0	0
ANC90LA038	3/9/1990	NONE	no:appro	0	0
ANC90FA039	3/16/1990	FATL	no:vfr>imc>disor	0	0
ANC90FA047	3/29/1990	NONE	no:ldg	0	0
ANC90LA057	4/15/1990	NONE	no:ldg	0	0
ANC90LA058	4/15/1990	NONE	no:fuel	0	0
ANC90FA061	4/16/1990	FATL	no:mnvr	0	0
DCA90MA030	6/2/1990	SERS	yes: TCF	100	90
ANC90FA086	6/9/1990	FATL	no:fuel	0	0
ANC90LA096	6/23/1990	NONE	no:ldg	0	0
ANC90LA102	6/29/1990	MINR	no:ldg	0	0
ANC90LA108	7/2/1990	NONE	no:mech	0	0
ANC90LA114	7/8/1990	NONE	no:ldg	0	0
ANC90LA119	7/18/1990	NONE	no:other	0	0
ANC90LA123	7/25/1990	NONE	no:ldg	0	0
ANC90LA124	7/27/1990	NONE	no:mech	0	0
ANC90LA125	7/27/1990	NONE	no:tkoff	0	0
ANC90LA137	8/8/1990	NONE	no:tkoff		
ANC90LA143	8/12/1990	FATL	no:unknown	0	0
ANC90LA145	8/14/1990	NONE	no:mech	0	0
ANC90LA149	8/17/1990	NONE	no:lsite	0	0
ANC90LA157	8/24/1990	NONE	no:tsite		
ANC90LA153	8/26/1990	NONE	no:ldg	0	0
ANC90LA168	9/12/1990	NONE	no:fuel	0	0
ANC90LA176	9/15/1990	NONE	no:taxi		
ANC90LA177	9/16/1990	NONE	no:preflt/wet-gas	0	0
ANC90LA181	9/21/1990	NONE	no:ldg	0	0
ANC90LA184	9/22/1990	NONE	no:tkoff		
ANC90LA189	9/30/1990	FATL	yes: Wx/CFITorRLS	100	75
ANC91LA005	10/12/1990	NONE	no:lrwcond		
ANC91LA006	10/15/1990	MINR	no:tsite	0	0
ANC91LA007	10/16/1990	SERS	no:unknown		

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC91LA015	12/11/1990	NONE	no:appro	0	0
ANC91LA033	3/8/1991	NONE	no:mech	0	0
ANC91IA037	3/18/1991	NONE	no:lrwcond	0	0
ANC91T#A01	3/21/1991	MINR	no:tkoff		
ANC91LA038	3/27/1991	MINR	yes: Wx/CFIT	100	75
ANC91LA040	3/28/1991	NONE	no:ldg	0	0
ANC91IA052	4/8/1991	NONE	no:mech	0	0
ANC91LA055	5/3/1991	NONE	no:ldg	0	0
ANC91LA057	5/8/1991	MINR	no:carbheat	0	0
ANC91LA060	5/22/1991	NONE	no:wtbal	0	0
ANC91LA065	6/4/1991	NONE	no:tsite	0	0
ANC91LA066	6/5/1991	NONE	no:mech	0	0
ANC91LA074	6/15/1991	NONE	no:fuel		
ANC91LA080	6/23/1991	NONE	no:tsite	0	0
ANC91LA158	6/26/1991	NONE	no:mech	0	0
ANC91GA087	7/3/1991	NONE	no:other	0	0
ANC91LA096	7/4/1991	NONE	no:mech		
ANC91LA100	7/16/1991	NONE	no:ldg	0	0
ANC91LA108	7/23/1991	NONE	no:mech	0	0
ANC91FA107	7/24/1991	FATL	yes: Wx:vfr>imc>diso	0	0
ANC91LA118	8/8/1991	NONE	no:tkoff	0	0
ANC91T#A02	8/14/1991	NONE	no:unknown		
ANC91LA125	8/14/1991	NONE	no:tkoff	0	0
ANC91LA127	8/18/1991	NONE	no:tkoff		
ANC91LA134	8/24/1991	NONE	no:mech		
ANC91LA135	8/24/1991	NONE	no:tkoff	0	0
ANC91FA142	9/3/1991	NONE	no:preflt/oil-cap	0	0
ANC91LA143	9/4/1991	NONE	no:tkoff	0	0
ANC91LA153	9/25/1991	MINR	no:lsite	0	0
ANC92FA002	10/3/1991	NONE	no:mech	0	0
ANC92LA003	10/5/1991	NONE	no:ldg		
ANC92TF#01	10/9/1991	NONE	no:unknown		
ANC92LA008	10/17/1991	NONE	no:ldg	0	0
ANC92LA007	10/18/1991	MINR	no:ldg	0	0
ANC92LA010	10/26/1991	NONE	no:tkoff	0	0

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC92LA014	11/7/1991	NONE	no:mnvr	0	0
ANC92LA016	11/8/1991	NONE	no:ldg	0	0
ANC92FA022	12/22/1991	FATL	yes: Wx/TCF	100	75
ANC92LA025	1/6/1992	NONE	no:lrwcond	0	0
ANC92LA031	2/4/1992	NONE	no:ldg	0	0
ANC92LA045	2/28/1992	NONE	no:mech	0	0
ANC92LA049	3/21/1992	NONE	no:mech	0	0
ANC92LA052	3/24/1992	MINR	no:tkoff	0	0
ANC92LA056	4/1/1992	FATL	no:drugs&alc	0	0
ANC92LA070	5/9/1992	NONE	no:tkoff	0	0
ANC92LA086	5/21/1992	NONE	no:ldg	0	0
ANC92LA080	5/26/1992	NONE	no:mech		
ANC92LA095	6/18/1992	NONE	no:mech	0	0
ANC92IA100A	6/26/1992	None	yes: NMAC, Wx?	100	100
ANC92IA100B	6/26/1992	None	yes: NMAC, Wx?	100	100
ANC92LA102	7/4/1992	NONE	no:tkoff	0	0
ANC92FA106	7/13/1992	FATL	no:wtbal	0	0
ANC92LA108	7/20/1992	NONE	yes: CFIT	100	90
ANC92T#A06	7/21/1992	NONE	no:unknown		
ANC92LA109	7/22/1992	NONE	no:mech	0	0
ANC92LA110	7/23/1992	NONE	no:tkoff	0	0
ANC92FA116	7/30/1992	FATL	yes: Wx/terrain/control	100	50
ANC92LA118	8/3/1992	NONE	no:mech	0	0
ANC92LA122	8/8/1992	MINR	yes: Wx/CFIT ?	100	75
ANC92LA126	8/9/1992	MINR	no:mech	0	0
ANC92LA140	8/22/1992	NONE	no:tkoff	0	0
ANC92IA147	8/29/1992	NONE	no:mech	0	0
ANC92LA168	9/8/1992	NONE	no:tkoff	0	0
ANC92FA159	9/9/1992	SERS	no:mech	0	0
ANC92LA161	9/9/1992	MINR	no:ldg	0	0
ANC92LA167	9/9/1992	NONE	no:carbheat	0	0
ANC92LA172	9/13/1992	MINR	no:appro		
ANC92LA174	9/17/1992	NONE	no:fuel	0	0
ANC93LA005	10/6/1992	NONE	no:ldg	0	0
ANC93LA014	11/11/1992	SERS	yes: WxApro/GPS/ice	70	70

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC93LA019	12/4/1992	NONE	yes: Wx/CFIT	100	75
ANC93LA024	1/5/1993	MINR	yes: Wx/TCF	100	80
ANC93LA029	1/29/1993	NONE	no:mech		
ANC93LA037	2/27/1993	NONE	no:torwcond	0	0
ANC93FA045	3/20/1993	FATL	yes: Wx/CFIT	100	75
ANC93LA048	3/25/1993	MINR	yes: Wx/TCF	100	80
ANC93LA052	4/12/1993	NONE	no:torwcond	0	0
ANC93LA059	5/1/1993	NONE	no:torwcond	0	0
ANC93FA060	5/6/1993	NONE	yes: CFIT	100	80
ANC93LA065	5/16/1993	NONE	no:ldg	0	0
ANC93IA085	5/26/1993	NONE	no:mech	0	0
ANC93LA072	5/29/1993	NONE	no:ldg	0	0
ANC93LA073	5/29/1993	NONE	no:ldg	0	0
ANC93LA078	6/3/1993	NONE	no:lsite	0	0
ANC93LA098	6/19/1993	NONE	no:mech	0	0
ANC93LA111	7/3/1993	NONE	no:tsite	0	0
ANC93LA126	7/24/1993	NONE	no:tkoff	0	0
ANC93LA135	8/5/1993	NONE	no:lsite	0	0
ANC93LA144	8/13/1993	MINR	no:tkoff		
ANC93LA169	9/5/1993	NONE	no:taxi		
ANC93LA180	9/19/1993	NONE	no:ldg		
ANC93LA182	9/20/1993	NONE	no:ldg		
ANC94LA008	10/4/1993	NONE	no:tkoff		
ANC94LA006	10/6/1993	NONE	no:ldg	0	0
ANC94LA010	10/8/1993	NONE	no:lsite	0	0
ANC94LA016	11/8/1993	NONE	no:appro	0	0
ANC94IA020	11/30/1993	NONE	no:mech	0	0
ANC94LA021	12/3/1993	NONE	no:ldg		
ANC94LA022	12/3/1993	NONE	no:tsite	0	0
ANC94LA031	2/8/1994	NONE	yes: GPS&TCF	100	90
ANC94LA034	2/11/1994	NONE	no:tsite	0	0
ANC94LA066	6/4/1994	MINR	no:mnvr	0	0
ANC94LA068	6/6/1994	NONE	no:mech	0	0
ANC94LA072	6/28/1994	NONE	no:ldg	0	0
ANC94FA080	7/11/1994	FATL	no:wtbal	0	0

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC94LA081	7/12/1994	NONE	no:tsite	0	0
ANC94LA099	8/5/1994	NONE	no:tkoff	0	0
ANC94LA102	8/9/1994	MINR	no:ldg	0	0
ANC94LA112	8/19/1994	NONE	no:lsite	0	0
ANC94T#A03	8/29/1994	NONE	no:unknown		
ANC95LA002	10/1/1994	NONE	no:tsite	0	0
ANC95LA010	11/12/1994	NONE	no:ldg	0	0
ANC95LA013	11/18/1994	NONE	no:ldg	0	0
ANC95LA017	12/12/1994	SERS	no:tkoff	0	0
ANC95LA020	12/13/1994	NONE	Wx/CFIT	100	80
ANC95LA024	12/25/1994	NONE	no:taxi	0	0
ANC95LA031	12/31/1994	NONE	no:ldg	0	0
ANC95LA025	1/4/1995	NONE	no:lrwcond	0	0
ANC95LA028	1/15/1995	NONE	no:mech	0	0
ANC95LA029	1/20/1995	NONE	no:mech	0	0
ANC95LA036	3/20/1995	NONE	Wx/CFIT	100	90
ANC95LA040	3/29/1995	NONE	no:ldg	0	0
ANC95LA043	4/14/1995	NONE	SfcMM/traffic/Twr?	100	90
ANC95LA045	4/15/1995	NONE	no:ldg	0	0
ANC95LA050	5/8/1995	NONE	no:wtbal	0	0
ANC95LA058	5/25/1995	NONE	no:ldg	0	0
ANC95LA060	5/28/1995	NONE	no:ldg	0	0
ANC95LA084	6/5/1995	NONE	no:ldg	0	0
ANC95LA110	6/9/1995	NONE	no:ldg	0	0
ANC95LA071	6/10/1995	NONE	no:fuel	0	0
ANC95LA077	6/12/1995	NONE	no:txrwcond	0	0
ANC95LA080	6/22/1995	NONE	no:tkoff	0	0
ANC95LA097	7/5/1995	NONE	no:taxi	0	0
ANC95LA098	7/5/1995	NONE	no:ldg	0	0
ANC95LA100	7/12/1995	NONE	no:ldg	0	0
ANC95FA104A	7/14/1995	FATL	yes: Traffic/water	100	100
ANC95FA104B	7/14/1995	FATL	yes: Traffic/water	100	100
ANC95LA105	7/16/1995	NONE	no:mech	0	0
ANC95LA108	7/19/1995	NONE	no:tkoff	0	0
ANC95LA123	8/1/1995	NONE	no:tsite	0	0

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC95LA136	8/10/1995	NONE	no:ldg	0	0
ANC95LA138	8/14/1995	NONE	no:ldg	0	0
ANC95LA154	8/29/1995	NONE	no:ldg	0	0
ANC95LA156	9/3/1995	NONE	no:tkoff	0	0
ANC95LA161	9/8/1995	NONE	no:tkoff	0	0
ANC95LA171	9/17/1995	NONE	no:lrwcond	0	0
ANC96LA005	10/17/1995	MINR	no:mech	0	0
ANC96LA012	11/3/1995	NONE	no:preflt/frost	0	0
ANC96LA017	11/18/1995	NONE	no:mech	0	0
ANC96LA019	12/16/1995	NONE	no:tkoff	0	0
ANC96LA033	3/13/1996	NONE	no:lsite	0	0
ANC96LA053	4/20/1996	NONE	no:mech	0	0
ANC96LA062	4/30/1996	MINR	no:mech	0	0
ANC96LA067	5/1/1996	NONE	no:mech	0	0
ANC96LA063	5/2/1996	NONE	no:mech	0	0
ANC96LA064	5/2/1996	NONE	no:preflt/frost	0	0
ANC96FA081	6/3/1996	FATL	no:mech	0	0
ANC96LA082	6/4/1996	MINR	no:tkoff	0	0
ANC96IA085	6/5/1996	NONE	no:other	0	0
ANC96FA102	7/20/1996	FATL	no:mech	0	0
ANC96LA105	7/20/1996	NONE	no:mech	0	0
ANC96LA123	7/26/1996	SERS	no:taxi	0	0
ANC96LA115	8/2/1996	NONE	no:mech	0	0
ANC96LA117	8/3/1996	SERS	no:taxi	0	0
ANC96LA119	8/5/1996	NONE	no:tkoff	0	0
ANC96LA132	8/17/1996	NONE	no:lsite	0	0
ANC96LA153	9/8/1996	NONE	no:taxi	0	0
ANC96LA159	9/20/1996	NONE	no:tkoff	0	0
ANC96TA163	9/24/1996	SERS	no:tkoff	0	0
ANC96LA164	9/24/1996	NONE	no:preflt/ice	0	0
ANC97FA008	11/26/1996	FATL	no:unknown	0	0
ANC97FA009	11/30/1996	FATL	no:mnvr	0	0
ANC97LA010	12/4/1996	NONE	no:tkoff	0	0
ANC97LA012	12/5/1996	NONE	no:fuel	0	0
ANC97TA016	12/31/1996	NONE	no:carbheat	0	0

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC97LA019	1/12/1997	NONE	yes: m-apr>cfit	0	0
ANC97LA022	1/17/1997	SERS	yes: Wx/CFIT	100	80
ANC97FA024	1/29/1997	FATL	no:mech	0	0
ANC97LA027	2/22/1997	NONE	yes: Wx/TCF	0	0
ANC97LA030	2/26/1997	NONE	no:tkoff	0	0
ANC97FA037A	3/25/1997	FATL	yes: Traffic	100	100
ANC97FA037B	3/25/1997	FATL	yes: Traffic	100	100
ANC97LA042	3/27/1997	MINR	no:mech	0	0
ANC97LA044	3/31/1997	NONE	no: Fuel	0	0
ANC97LA048	4/7/1997	NONE	no:ldg	0	0
ANC97LA054	4/11/1997	FATL	no:mnvr	0	0
ANC97LA055	4/12/1997	NONE	no:mech	0	0
ANC97LA064	4/30/1997	NONE	no:ldg	0	0
ANC97LA067	5/3/1997	NONE	no:ldg	0	0
ANC97LA073	5/3/1997	NONE	no:tkoff	0	0
ANC97LA094	6/28/1997	NONE	no:tkoff	0	0
ANC97TA098	7/7/1997	MINR	no:ldg	0	0
ANC97LA106	7/19/1997	NONE	no:mech	0	0
ANC97LA109	7/21/1997	NONE	no:ldg	0	0
ANC97GA126	8/20/1997	FATL	? IMC/CFIT/Helo		
ANC97LA129	8/24/1997	SERS	no:fuel	0	0
ANC97LA133	8/26/1997	NONE	no:ldg	0	0
ANC97LA135	8/26/1997	SERS	no:mnvr	0	0
ANC97LA138	9/1/1997	SERS	no:ldg	0	0
ANC97LA140	9/1/1997	MINR	no:tkoff	0	0
ANC97LA142	9/3/1997	NONE	no:mech	0	0
ANC97LA134	9/6/1997	NONE	no:ldg	0	0
ANC97TA148	9/13/1997	NONE	no:mech	0	0
ANC97LA149	9/14/1997	NONE	no:ldg	0	0
ANC97LA154	9/23/1997	NONE	no:tkoff	0	0
ANC97FA155	9/26/1997	FATL	? VMC/CFIT or mnvr?		
ANC97LA157	9/29/1997	NONE	no:mech	0	0
ANC98IA004	10/20/1997	NONE	no:prefIt/aileron	0	0
ANC98LA005	10/20/1997	NONE	no:fuel	0	0
ANC98LA012	12/15/1997	NONE	no:fuel	0	0

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC98LA013	12/16/1997	NONE	no:ldg	0	0
ANC98LA014	1/2/1998	NONE	no:mech		
ANC98LA018	1/30/1998	MINR	yes: Wx/ice	0	0
ANC98LA025	2/24/1998	NONE	no:ldg	0	0
ANC98LA023	2/26/1998	NONE	yes: SfcMM/traffic	100	90
ANC98LA024	3/3/1998	NONE	no:lsite	0	0
ANC98LA029	3/12/1998	NONE	no:taxi-site		
ANC98LA028	3/21/1998	NONE	no:other	0	0
ANC98GA036	4/8/1998	FATL	yes: vfr>known imc		
ANC98LA040	4/22/1998	MINR	yes: Wx/CFIT	100	75
ANC98LA056	5/21/1998	NONE	no:torwcond		
ANC98LA059	5/29/1998	NONE	no:mech		
ANC98LA050	6/4/1998	NONE	no:ldg		
ANC98LA065	6/6/1998	NONE	no:ldg		
ANC98LA073	6/14/1998	NONE	no:tkoff	0	0
ANC98LA104	6/17/1998	NONE	no:bird		
ANC98LA078	6/19/1998	NONE	no:mech	0	0
ANC98LA090	7/1/1998	NONE	no:ldg	0	0
ANC98LA098	7/14/1998	NONE	no:mech		
ANC98LA099	7/16/1998	MINR	no:mech	0	0
ANC98LA101	7/17/1998	MINR	no:mech	0	0
ANC98LA118	8/8/1998	NONE	no:ldg		
ANC98LA129	8/22/1998	MINR	no:mech		
ANC98LA138	9/2/1998	NONE	yes: Wx/CFIT	100	75
ANC98LA148	9/11/1998	NONE	no:ldg	0	0
ANC98LA149	9/13/1998	NONE	no:tsite		
ANC98LA155	9/22/1998	NONE	no:tsite		
ANC98LA156	9/23/1998	NONE	no:ldg		
ANC98LA158	9/24/1998	NONE	no:tsite		
ANC98LA159	9/25/1998	NONE	no:ldg		
ANC98LA160	9/25/1998	NONE	no:ldg		
ANC98LA161	9/26/1998	MINR	no:tkoff		
ANC98LA163	9/27/1998	NONE	no:tkoff		
ANC99LA001	10/4/1998	NONE	no:tkoff		
ANC99LA002	10/8/1998	MINR	no:preflt/wet-gas		

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC99LA009	10/26/1998	MINR	no:mech		
ANC99LA016	12/17/1998	SERS	yes: Wx/CFIT	100	75
ANC99LA017	12/18/1998	NONE	no:tkoff		
ANC99FA021	1/10/1999	MINR	no:mech		
ANC99LA022	1/10/1999	NONE	Wx:ice	0	0
ANC99LA023	1/12/1999	NONE	Wx:ice	0	0
ANC99FA028	2/11/1999	SERS	yes: TCF	0	0
ANC99LA039	3/27/1999	NONE	no:lsite		
ANC99LA045	4/11/1999	NONE	no:ldg		
ANC99LA051	4/19/1999	NONE	no:lrwcond		
ANC99LA054	4/21/1999	NONE	no:ldg		
ANC99LA062	5/15/1999	NONE	no:preflt/gustlock		
ANC99LA158	6/5/1999	NONE	no:ldg		
ANC99LA082	6/24/1999	NONE	no:mech		
ANC99LA093	7/19/1999	NONE	no:preflt/wet-gas		
ANC99LA095	7/20/1999	NONE	no:watertaxi		
ANC99LA097	7/22/1999	MINR	no:fuel		
ANC99LA098	7/28/1999	NONE	no:tkoff		
ANC99LA104	7/31/1999	NONE	no:lsite		
ANC99LA121	8/20/1999	MINR	no:tsite		
ANC99LA134	9/6/1999	NONE	no:tkoff		
ANC99LA148	9/6/1999	SERS	no:lsite		
ANC99LA144	9/13/1999	NONE	no:lsite		
ANC99LA153	9/17/1999	NONE	no:taxi		
ANC99LA156	9/20/1999	NONE	no:tkoff		
ANC00LA005	10/7/1999	NONE	no:other		
ANC00LA008	10/27/1999	NONE	yes: Wx/ice	0	0
ANC00LA009	10/28/1999	NONE	yes: Wx/ice	0	0
ANC00LA015	11/16/1999	MINR	no:preflt/frost		
ANC00LA017	12/6/1999	NONE	no:preflt/snow-ice		
ANC00FA018	12/7/1999	FATL	yes: Wx/CFIT	100	75
ANC00LA021	12/24/1999	MINR	no:preflt/frost		

Table B-2. Capstone Area Accidents, 20000 – 2001, with Causes and Best Prevention Likelihood

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC00LA025	02/07/00	NONE	no:torwcond		
ANC00LA033	03/04/00	NONE	no:mech		
ANC00TA039	03/29/00	NONE	WxHelo>imc>cfit	100	90
ANC00LA041	04/12/00	MINR	Wx/CFIT	100	90
ANC00LA044	04/13/00	NONE	no:tkoff		
ANC00LA069	06/13/00	NONE	no:tkoff		
ANC00FA076	06/22/00	FATL	no:tkoff		
ANC00LA074A	06/22/00	MINR	Traffic/water	100	90
ANC00LA074B	06/22/00	MINR	Traffic/water	100	90
ANC00TA075	06/22/00	NONE	no:tkoff		
ANC00FA081	06/30/00	FATL	no:preflt/tkoff/mech		
ANC00LA087	07/02/00	NONE	no:tkoff		
ANC00LA086	07/12/00	NONE	no:ldg		
ANC00LA098	07/26/00	NONE	no:tkoff		
ANC00LA116	08/09/00	NONE	no:ldg		
ANC00TA109	08/29/00	SERS	no:downdraft		
ANC00LA112	09/02/00	NONE	no:preflt/frost		
ANC00LA115	09/06/00	NONE	no:lrwcond		
ANC00LA119	09/11/00	SERS	no:tkoff		
ANC00LA122	09/13/00	NONE	no:mech		
ANC00LA133	09/14/00	NONE	no:lrwcond		
ANC00FA128	09/20/00	FATL	Wx/CFIT ?	100	75
ANC01LA001	10/01/00	NONE	no:tsite		
ANC01LA004	10/07/00	NONE	no:tkoff		
ANC01LA011	10/22/00	NONE	no:mech		
ANC01LA017	11/03/00	NONE	no:tkoff		
ANC01LA016	11/09/00	NONE	no:carbheat		
ANC01LA019	11/14/00	NONE	no:ldg		
ANC01IA022	12/12/00	MINR	Wx/pireps	100	100
ANC01LA024	12/16/00	NONE	no:preflt/wet-gas		
ANC01LA028	01/03/01	NONE	no:ldg		
ANC01LA031	01/19/01	NONE	no:tkoff		

NTSB Report Number	Date of Accident	Injury Level	Capstone Relevance: Cause	Percent Prob that Capstone applies	Best Expected Pcnt Prob of Prevention
ANC01TA032	01/23/01	NONE	no:ldg		
ANC01LA034	01/31/01	NONE	no:ldg		
ANC01LA036	02/06/01	SERS	Wx/CFIT	100	80
ANC01LA041	03/07/01	NONE	no:tsite		
ANC01LA052	03/28/01	NONE	no:lsite		
ANC01LA046	04/03/01	SERS	(cap!)Wx/CFIT	100	90
ANC01LA056	04/14/01	NONE	no:mnvrg		
ANC01TA047	04/17/01	MINR	Wx/CFIT	100	75
ANC01TA049	04/21/01	NONE	no:ldg		
ANC01LA059	04/24/01	NONE	no:taxi		
ANC01LA053	05/03/01	NONE	no:ldg		
ANC01LA057	05/15/01	NONE	no:mech		
ANC01IA058	05/17/01	NONE	no:mech		
ANC01LA066	06/02/01	NONE	no:mech		
ANC01LA071	06/16/01	NONE	no:lrwcond		
ANC01LA083	06/19/01	NONE	no:mech		
ANC01GA075	06/25/01	FATL	no:lost control		
ANC01LA117	07/25/01	NONE	no:tkoff		
ANC01LA098	07/28/01	NONE	no:ldg		
ANC01LA108	08/13/01	NONE	no:tkoff		
ANC01LA125	08/22/01	NONE	no:lsite		
ANC01LA131	09/01/01	NONE	no:tkoff		
ANC01LA136	09/02/01	NONE	no:mech		
ANC02TA001	10/05/01	NONE	no:ldg		
DCA02MA003	10/10/01	FATL	no:preflt/ice		
ANC02LA002	10/16/01	MINR	TCF	0	0

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Appendix C. Assessments of CFIT Crash of Capstone Equipped Aircraft, April 3, 2001

NTSB Synopsis of Accident Identification #ANC01LA046

The commercial certificated pilot and six passengers were en route between remote villages on a VFR scheduled commuter flight. The pilot contacted the village agent at the destination airport via radio, and received a weather report as 800 feet overcast, with the visibility as 5 miles. The director of operations for the company reported that the weather at the accident scene was an indefinite ceiling of about 500 feet, and a visibility of about 2 miles. After departure, the pilot proceeded toward the destination airport about 450 feet above the ground. About 10 minutes after departure, the pilot said the horizon began to become obscured and the area ahead of the airplane turned white. He said there was no precipitation, rather the ground and sky became indistinguishable. He began a right turn toward the east, but about 2 seconds after beginning the turn, the airplane suddenly collided with snow-covered terrain. A passenger reported the visibility was about 1 mile under gray skies. The airplane was equipped with an avionics package provided by the FAA's Capstone Program. The Capstone Program is a joint industry/FAA demonstration program that features, among others, global positioning system (GPS) avionics, weather and traffic information provided through automatic dependent surveillance-broadcast (ADS-B), traffic information service-broadcast (TIS-B) equipment, and terrain information depicted on a multifunction display (MFD) installed in the cockpit. The Capstone program provides radar-like services to participating air carrier aircraft operating in a nonradar environment of Western Alaska. Terrain depiction information, based on GPS data, is one of several visual display options available to the pilot on the MFD. Selection of the terrain mode for display, provides the pilot with color shading depicting areas of terrain that are black (2,000 feet below the aircraft), green (between 2,000 and 700 feet below the aircraft), yellow (between 700 and 300 feet below the aircraft), and red (at or within 300 feet of the aircraft). Accurate depiction of terrain (in the terrain mode) requires the pilot to manually set a barometric pressure setting in the MFD menu. The Capstone avionics equipment does not receive barometric pressure data from the aircraft's altimeter. Selection of the map mode does not provide any terrain awareness information. During the interview with the NTSB IIC, the pilot said that he selected the moving map display with a five mile scale. He did not observe any warning flags illuminated on the MFD, and he did not manually enter any barometric pressure data into the MFD. The pilot said that he routinely utilized his own personal GPS receiver that has a color moving map display. He said he is more familiar with his own GPS, and had it installed on the top of the instrument panel glare shield. He said that since the terrain in Western Alaska is usually quite flat, he routinely utilized the Capstone map mode with the GPS "go to" function for each leg/destination of a route, not the terrain mode.

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.

The pilot's continued VFR flight into instrument meteorological conditions, and his failure to maintain adequate distance/altitude from terrain, resulting in a collision with terrain while maneuvering. Factors in the accident were flat light conditions, snow-covered terrain, and the pilot's failure to utilize on-board Capstone flight/navigation instruments to display terrain awareness data.

NTSB Full Narrative of Accident Identification #ANC01LA046

Aircraft: Cessna 207, registration: N1581U, Injuries: 2 Serious, 2 Minor, 3 Uninjured.

On April 3, 2001, about 1745 Alaska daylight time, a wheel-equipped Cessna 207 airplane, N1581U, sustained substantial damage after colliding with terrain, about eight miles north of Nightmute, Alaska. The airplane was being operated as a visual flight rules (VFR) scheduled domestic passenger flight under Title 14, CFR Part 135, when the accident occurred. The airplane was operated as Flight 262 by Grant Aviation Inc., Anchorage, Alaska. The commercial certificated pilot and one passenger received serious injuries, two passengers received minor injuries, and three passengers were not injured. Visual meteorological conditions prevailed in the area of the accident, and VFR company flight following procedures were in effect. The accident flight originated at the Nightmute Airport, about 1730. The intended routing of Flight 262 was from Bethel, Alaska, to Toksook Bay, Alaska, to Nightmute, to Newtok, Alaska, and then a return to Bethel.

During a telephone conversation with the National Transportation Safety Board (NTSB) investigator-in-charge (IIC), on April 3rd, the director of operations for the operator reported that the flight had crashed, and search and rescue operations were underway. On April 6, 2001, the NTSB IIC interviewed the pilot who stated that while he was en route to Toksook Bay, he contacted the village agent via radio. The weather conditions were reported by the agent as 800 feet overcast, visibility 5 miles, with a light wind from the southeast. Before departing Nightmute, the pilot said he set the airplane's altimeter to the field elevation (15 feet msl). After departure, he proceeded toward Newtok, but skirted an area of low hills by flying toward the east before turning toward Newtok. He said he was flying about 450 feet above the ground. About 10 minutes after departure, the pilot said the horizon began to become obscured and the area ahead of the airplane turned white. He said there was no precipitation, rather the ground and sky became indistinguishable. He began a right turn toward the east, but about 2 seconds after beginning the turn, the airplane suddenly collided with snow-covered terrain.

In the Pilot/Operator report (NTSB Form 6120.1/2), the director of operations reported the weather conditions at the accident site as an estimated indefinite ceiling of 500 to 600 feet agl, and the visibility was estimated as two miles in haze/whiteout with no precipitation.

On September 13, 2001, in a telephone conversation with the NTSB IIC, the right front seat passenger reported that as the flight progressed toward Newtok, the visibility was about one mile under gray sky conditions. Just prior the accident, the visibility began to decrease, and the airplane then collided with the snow. The passenger did not report any precipitation.

The airplane came to rest on its right side. The engine and propeller were torn off the airframe. The pilot provided emergency care for the passengers, and contacted an over-flying jet airplane on a hand-held radio. Emergency personnel arrived by helicopter about 2 hours later.

The airplane was equipped with an avionics package provided by the Federal Aviation Administration's Capstone Program. The Capstone Program is a joint industry/FAA demonstration program that features, among others, global positioning system (GPS) avionics, weather and traffic information provided through automatic dependent surveillance-broadcast (ADS-B), traffic information service-broadcast (TIS-B) equipment, and terrain information depicted on a multifunction display (MFD) installed in the cockpit. The Capstone program provides radar-like services to participating air carrier aircraft operating in a non-radar environment of Western Alaska. At the time of the accident, position information from Capstone equipped airplanes, to the Anchorage Air Route Traffic Control Center (ARTCC), Anchorage, Alaska, is provided by the ADS-B equipment in the airplane, and requires ground based radio repeater sites to facilitate the transmittal of position data. The area of the accident was not within radio coverage of a currently established repeater site.

Terrain depiction information, based on GPS data, is one of several visual display options available to the pilot. Other options include custom maps, VFR sectional charts with topographical features, IFR charts, flight plan and traffic information, and weather data. The airplane's position can be displayed in relation to its location over the terrain, and may include bearing and distance information to selected points. Selection of the terrain mode for display, provides the pilot with color shading, depicting areas of terrain that are black (2,000 feet below the aircraft), green (between 2,000 and 700 feet below the aircraft), yellow (between 700 and 300 feet below the aircraft), and red (at or within 300 feet of the aircraft). Accurate depiction of terrain (in the terrain mode) requires the pilot to manually set a barometric pressure setting in the multifunction display menu. The Capstone avionics equipment does not automatically receive barometric pressure data from the aircraft's altimeter. Selection of the map mode does not provide any terrain warning/awareness information.

During the interview with the NTSB IIC, the pilot said that he received training in the use of the Capstone equipment from the University of Alaska, Anchorage, and from his company. He also said that during the accident flight, he selected the moving map display with a five mile scale. He did not observe any warning flags illuminated on the multifunction display. He did not manually enter any barometric pressure data into the Capstone equipment. The pilot said that he routinely utilized his own personal GPS receiver that has a color moving map display. He said he is more familiar with his own GPS, and had it installed on the top of the instrument panel glare shield. He said that since the terrain in Western Alaska is usually quite flat, he routinely utilized the Capstone map mode with the GPS "go to" function for each leg/destination of a route, not the terrain mode.

The closest official weather observation station to the accident site is Hooper Bay, Alaska, which is located 71 nautical miles northwest of the accident site. On April 3, at 1835, an Aviation Routine Weather Report (METAR) was reporting in part: Wind, 140 degrees (true) at 9 knots; visibility, 9 statute miles; clouds and sky condition, 800 feet broken, 1,200 feet broken, 3,100 feet overcast; temperature, 32 degrees F; dew point, 28 degrees F; altimeter, 28.92 in Hg.

On April 3, at 1753, a METAR from Bethel, located 81 nautical miles east of the accident site, was reporting in part: Wind, 160 degrees (true) at 18 knots, gust to 24 knots; visibility, 10 statute miles; clouds and sky condition, 1,900 feet broken, 2,600 feet overcast; temperature, 35 degrees F; dew point, 32 degrees F; altimeter, 28.94 in Hg.

Accident Evaluation of April 3, 2001 Crash of Capstone Equipped C207 by Leonard Kirk, UAA/ATD

This accident is of particular interest to this writer (Leonard F. Kirk UAA/ATD Capstone Coordinator) because I was directly involved in training the pilot who operated the aircraft. The training was provided in Bethel, Alaska as part of the University of Alaska contract with the FAA Capstone project. On June 28 and 29 2000 the PIC received two days of training on the use of Capstone avionics and classroom exercises included flight plans to Newtok and Nightmute, Alaska which are the two communities involved in this accident.

The accident information important to this discussion is copied from the NTSB factual report and attached here in italics. As a pilot, Capstone instructor, and evaluator of the Capstone project I add the following information:

The pilot was not using the equipment as he was trained to do. The pilot believed the equipment was a “Big Brother” attempt to violate him and therefore the pilot attempted to fool “Big Brother” by misusing the equipment. The pilot failed to keep the “Baro Aiding” feature of the MFD up with current altimeter and created a 1200 foot error in the terrain feature of the MFD and by doing so eliminated the terrain alerting feature. The pilot felt the displayed altitude was able to be seen by the FAA and he allowed the error to exist so the FAA would think he was flying higher than he actually was. The altitude reported by the UAT box is based on a 29.92”Hg. setting on the encoder and is not controlled by the pilot. However, this pilot did not accept the instruction he was given and instead attempted to fool the system. The failure to properly use the terrain feature was also an attempt to eliminate the red from the MFD because the passengers are aware of the system and do not like seeing the red. The UAA/ATD produced a short training video based on this accident and it is available for those pilots who fly the equipment in the accident area.

Appendix D. Data on Aircraft Equipped and Accidents of Y-K Delta Part 135 Fleet, 2000 and 2001

Table D-1 (next page) below shows the data we used to calculate the accident rated for equipped and non-equipped aircraft in the Y-K Delta Part 135 fleet in 2000 and 2001. Each row represents either the return to service of a newly Capstone-equipped aircraft, or an accident of an aircraft in the Y-K Delta part 135 fleet. Column 1 which each row represents. Column 2 is either the date a newly equipped aircraft returned to service, or the date an accident occurred. Column 3, for accidents only, indicates whether an accident involved an equipped or non-equipped aircraft. Columns 4 and 5 indicate our estimate of the number of equipped and non-equipped aircraft in the fleet on each date. We started with a fleet total of 164. We subtracted aircraft that crashed, wither from the equipped or non-equipped parts of the fleet as appropriate. Some of these aircraft returned to service, but because we don’t know which ones, or when, we simply dropped them from the analysis. Columns 6 and 7 show the number of equipped and non-equipped aircraft days that have elapsed since the previous row: these columns are simply the days elapsed since the previous row times the number of non-equipped aircraft (Column 6) or times the number of Equipped aircraft (column 7).

Table D-2 (page D-6) shows the summary data for 2000–2001, and for 2000 and 2001 separately, that we used to calculate the accident rates for equipped and non-equipped aircraft.

Table D-1. Data for Analysis of Y-K Delta Equipped and Non-equipped Aircraft Accidents

Return To Service Date or Accident	Date	Equipped or Non-Equipped Accident?	Nbr Aircraft Not Equipped	Nbr Aircraft Equipped	Non-equipped a/c days	Equipped a/c days
RTS Equipped a/c	1-Jan-00		163	1	0	0
Accident	**07-Feb-00**	**Non-EQ ACC**	**162**	**1**	**5994**	**37**
RTS Equipped a/c	11-Feb-00		161	2	644	8
RTS Equipped a/c	18-Feb-00		160	3	1120	21
Accident	**04-Mar-00**	**Non-EQ ACC**	**159**	**3**	**2385**	**45**
RTS Equipped a/c	4-Mar-00		158	4	0	0
RTS Equipped a/c	7-Mar-00		157	5	471	15
RTS Equipped a/c	10-Mar-00		156	6	468	18
RTS Equipped a/c	22-Mar-00		155	7	1860	84
RTS Equipped a/c	23-Mar-00		154	8	154	8
RTS Equipped a/c	27-Mar-00		153	9	612	36
RTS Equipped a/c	3-Apr-00		152	10	1064	70
RTS Equipped a/c	3-Apr-00		151	11	0	0
RTS Equipped a/c	11-Apr-00		150	12	1200	96
RTS Equipped a/c	11-Apr-00		149	13	0	0
RTS Equipped a/c	12-Apr-00		148	14	148	14
RTS Equipped a/c	13-Apr-00		147	15	147	15
RTS Equipped a/c	21-Apr-00		146	16	1168	128
RTS Equipped a/c	21-Apr-00		145	17	0	0
RTS Equipped a/c	25-Apr-00		144	18	576	72
RTS Equipped a/c	25-Apr-00		143	19	0	0
RTS Equipped a/c	26-Apr-00		142	20	142	20
RTS Equipped a/c	27-Apr-00		141	21	141	21
RTS Equipped a/c	4-May-00		140	22	980	154
RTS Equipped a/c	4-May-00		139	23	0	0
RTS Equipped a/c	8-May-00		138	24	552	96
RTS Equipped a/c	23-May-00		137	25	2055	375
RTS Equipped a/c	26-May-00		136	26	408	78
RTS Equipped a/c	30-May-00		135	27	540	108
RTS Equipped a/c	31-May-00		134	28	134	28
RTS Equipped a/c	1-Jun-00		133	29	133	29
RTS Equipped a/c	1-Jun-00		132	30	0	0
RTS Equipped a/c	5-Jun-00		131	31	524	124
RTS Equipped a/c	14-Jun-00		130	32	1170	288
RTS Equipped a/c	16-Jun-00		129	33	258	66
RTS Equipped a/c	21-Jun-00		128	34	640	170

Return To Service Date or Accident	Date	Equipped or Non-Equipped Accident?	Nbr Aircraft Not Equipped	Nbr Aircraft Equipped	Non-equipped a/c days	Equipped a/c days
Accident	**22-Jun-00**	**Non-EQ ACC**	**127**	**34**	**127**	**34**
RTS Equipped a/c	23-Jun-00		126	35	126	35
RTS Equipped a/c	28-Jun-00		125	36	625	180
RTS Equipped a/c	11-Jul-00		124	37	1612	481
Accident	***12-Jul-00***	***EQ ACC***	***124***	***36***	***124***	***36***
RTS Equipped a/c	12-Jul-00		123	37	0	0
RTS Equipped a/c	20-Jul-00		122	38	976	304
RTS Equipped a/c	27-Jul-00		121	39	847	273
RTS Equipped a/c	28-Jul-00		120	40	120	40
RTS Equipped a/c	29-Jul-00		119	41	119	41
RTS Equipped a/c	31-Jul-00		118	42	236	84
RTS Equipped a/c	1-Aug-00		117	43	117	43
RTS Equipped a/c	4-Aug-00		116	44	348	132
RTS Equipped a/c	6-Aug-00		115	45	230	90
RTS Equipped a/c	9-Aug-00		114	46	342	138
RTS Equipped a/c	16-Aug-00		113	47	791	329
RTS Equipped a/c	21-Aug-00		112	48	560	240
RTS Equipped a/c	21-Aug-00		111	49	0	0
Accident	**06-Sep-00**	**Non-EQ ACC**	**110**	**49**	**1760**	**784**
Accident	**14-Sep-00**	**Non-EQ ACC**	**109**	**49**	**872**	**392**
RTS Equipped a/c	15-Sep-00		108	50	108	50
RTS Equipped a/c	15-Sep-00		107	51	0	0
Accident	**20-Sep-00**	**Non-EQ ACC**	**106**	**51**	**530**	**255**
RTS Equipped a/c	27-Sep-00		105	52	735	364
RTS Equipped a/c	30-Sep-00		104	53	312	159
RTS Equipped a/c	6-Oct-00		103	54	618	324
RTS Equipped a/c	12-Oct-00		102	55	612	330
RTS Equipped a/c	12-Oct-00		101	56	0	0
RTS Equipped a/c	12-Oct-00		100	57	0	0
RTS Equipped a/c	20-Oct-00		99	58	792	464
RTS Equipped a/c	20-Oct-00		98	59	0	0
RTS Equipped a/c	27-Oct-00		97	60	679	420
Accident	***03-Nov-00***	***EQ ACC***	***97***	***59***	***679***	***413***
RTS Equipped a/c	9-Nov-00		96	60	576	360
RTS Equipped a/c	17-Nov-00		95	61	760	488
RTS Equipped a/c	17-Nov-00		94	62	0	0
RTS Equipped a/c	27-Nov-00		93	63	930	630
RTS Equipped a/c	29-Nov-00		92	64	184	128

Return To Service Date or Accident	Date	Equipped or Non-Equipped Accident?	Nbr Aircraft Not Equipped	Nbr Aircraft Equipped	Non-equipped a/c days	Equipped a/c days
RTS Equipped a/c	18-Dec-00		91	65	1729	1235
RTS Equipped a/c	18-Dec-00		90	66	0	0
Accident	***03-Jan-01***	***EQ ACC***	***90***	***65***	***1440***	***1040***
RTS Equipped a/c	3-Jan-01		89	66	0	0
RTS Equipped a/c	5-Jan-01		88	67	176	134
Accident	**19-Jan-01**	**Non-EQ ACC**	**87**	**67**	**1218**	**938**
RTS Equipped a/c	14-Feb-01		86	68	2236	1768
RTS Equipped a/c	18-Mar-01		85	69	2720	2208
RTS Equipped a/c	18-Mar-01		84	70	0	0
RTS Equipped a/c	21-Mar-01		83	71	249	213
RTS Equipped a/c	21-Mar-01		82	72	0	0
Accident	***03-Apr-01***	***EQ ACC***	***82***	***71***	***1066***	***923***
RTS Equipped a/c	10-Apr-01		81	72	567	504
RTS Equipped a/c	11-Apr-01		80	73	80	73
RTS Equipped a/c	12-Apr-01		79	74	79	74
RTS Equipped a/c	13-Apr-01		78	75	78	75
RTS Equipped a/c	13-Apr-01		77	76	0	0
Accident	**14-Apr-01**	**Non-EQ ACC**	**76**	**76**	**76**	**76**
RTS Equipped a/c	17-Apr-01		75	77	225	231
Accident	**24-Apr-01**	**Non-EQ ACC**	**74**	**77**	**518**	**539**
Accident	**03-May-01**	**Non-EQ ACC**	**73**	**77**	**657**	**693**
RTS Equipped a/c	3-May-01		72	78	0	0
RTS Equipped a/c	3-May-01		71	79	0	0
RTS Equipped a/c	12-May-01		70	80	630	720
RTS Equipped a/c	14-May-01		69	81	138	162
RTS Equipped a/c	15-May-01		68	82	68	82
RTS Equipped a/c	16-May-01		67	83	67	83
Accident	***17-May-01***	***EQ ACC***	***67***	***82***	***67***	***82***
RTS Equipped a/c	29-May-01		66	83	792	996
Accident	**19-Jun-01**	**Non-EQ ACC**	**65**	**83**	**1365**	**1743**
RTS Equipped a/c	22-Jun-01		64	84	192	252
RTS Equipped a/c	4-Jul-01		63	85	756	1020
RTS Equipped a/c	4-Jul-01		62	86	0	0
RTS Equipped a/c	5-Jul-01		61	87	61	87
RTS Equipped a/c	6-Jul-01		60	88	60	88
RTS Equipped a/c	13-Jul-01		59	89	413	623
RTS Equipped a/c	14-Jul-01		58	90	58	90
RTS Equipped a/c	16-Jul-01		57	91	114	182

Return To Service Date or Accident	Date	Equipped or Non-Equipped Accident?	Nbr Aircraft Not Equipped	Nbr Aircraft Equipped	Non-equipped a/c days	Equipped a/c days
RTS Equipped a/c	16-Jul-01		56	92	0	0
RTS Equipped a/c	16-Jul-01		55	93	0	0
RTS Equipped a/c	16-Jul-01		54	94	0	0
RTS Equipped a/c	20-Jul-01		53	95	212	380
RTS Equipped a/c	23-Jul-01		52	96	156	288
RTS Equipped a/c	24-Jul-01		51	97	51	97
Accident	***25-Jul-01***	***EQ ACC***	***51***	***96***	***51***	***96***
RTS Equipped a/c	26-Jul-01		50	97	50	97
RTS Equipped a/c	26-Jul-01		49	98	0	0
RTS Equipped a/c	27-Jul-01		48	99	48	99
RTS Equipped a/c	30-Jul-01		47	100	141	300
RTS Equipped a/c	2-Aug-01		46	101	138	303
RTS Equipped a/c	6-Aug-01		45	102	180	408
Accident	***13-Aug-01***	***EQ ACC***	***45***	***101***	***315***	***707***
RTS Equipped a/c	13-Aug-01		44	102	0	0
RTS Equipped a/c	16-Aug-01		43	103	129	309
RTS Equipped a/c	17-Aug-01		42	104	42	104
RTS Equipped a/c	20-Aug-01		41	105	123	315
RTS Equipped a/c	20-Aug-01		40	106	0	0
RTS Equipped a/c	23-Aug-01		39	107	117	321
RTS Equipped a/c	29-Aug-01		38	108	228	648
RTS Equipped a/c	5-Sep-01		37	109	259	763
RTS Equipped a/c	7-Sep-01		36	110	72	220
RTS Equipped a/c	7-Sep-01		35	111	0	0
RTS Equipped a/c	13-Sep-01		34	112	204	672
RTS Equipped a/c	23-Sep-01		33	113	330	1130
RTS Equipped a/c	3-Oct-01		32	114	320	1140
RTS Equipped a/c	8-Oct-01		31	115	155	575
RTS Equipped a/c	11-Oct-01		30	116	90	348
Accident	**16-Oct-01**	**Non-EQ ACC**	**29**	**116**	**145**	**580**
RTS Equipped a/c	2-Nov-01		28	117	476	1989
RTS Equipped a/c	19-Dec-01		27	118	27	5546
RTS Equipped a/c	20-Dec-01		26	119	26	119
End of Period	31-Dec-01		26	119	286	1309

Table D-2. Summary Statistics for Equipped and Non-equipped Aircraft: Aircraft –days, Accidents, and Accidents per 10,000 Aircraft-days, 2000–2001

	Non-Equipped	Equipped
2000–2001		
Total aircraft-days, 2000-2001	65,401	46,062
Total Accidents	12	7
Avg Accidents per 10,000 a/c days	1.83	1.52
2000		
Total aircraft-days, 2000	46,035	12,.358
Total Accidents	6	2
Avg Accidents per 10,000 a/c days	1.30	1.62
2001		
Total aircraft-days, 2001	19,303	33,795
Total Accidents	6	5
Avg Accidents per 10,000 a/c days	3.11	1.48

Appendix E. Capstone Phase I Participants

Table E.1. Capstone Area Operators: Participation and Number of Equipped Aircraft

Operator name	Participation Date	Completed as of 12/31/00	Added in 2001	Completed as of 12/31/01	In Progress as of 12/31/01	Total
Alaska Central Express	N/A					
Alaska Island Air	2001		2	2		2
Arctic Circle Air	2000	12		12		12
Arctic Transportation Services Inc.	2000	8	3	11		11
BellAir, Inc	N/A					
Cub Drivers	2000	1		1		1
Craig Air	2000	2	4	6		6
ERA Aviation	2001		5	5		5
Frontier Flying Service	2000	4	1	5		5
Grant Aviation	2000	4	11	15	2	17
Hageland Aviation	2000	7	14	21		21
Hangar One Air Inc.	N/A					
Inland Aviation Services Inc.	2001		3	3		3
Kusko Aviation Inc.	2000					
Larry's Flying Service	2000	4	1	5	2	7
Neitz Aviation Inc	2000	1		1		1
Northern Air Cargo	2000	1	4	5		5
PenAir	2000	4		3		3
Ptarmigan Air	2000	4		4		4
Shannon's Air Taxi (Shade Av)	2000	1		1		1
Tanana Air Service	2000	4	1	5		5
Townsend, Richard A.	N/A					
Vanderpool, Sr., Robert W.	N/A					
Village Aviation	2000	5	1	6		6
G & L Air Svc (George Walters)	2000	1		1		1
Yukon Helicopters, Inc.	2000	3	2	5		5
Yute Air Service	2000	7	5	12		12
Alaska State Troopers	N/A					
FAA Alaskan Region	2000	1		1		1
Kuspuk School District	N/A					
Office of Aircraft Services	2000	1	1	2		2
UAA	2000	1		1		1
Total Aircraft		**76**	**58**	**133**	**4**	**137**

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Appendix F. Pilot Survey Research Methodology and Frequencies

Objective

This survey was part of a larger effort to collect information about qualifications, practices and attitudes of pilots and company management for aviation operators in Alaska. Based on survey responses, focus group results, and consultation with to Alaskan aviation safety experts, the National Institutes of Occupational Safety and Health (NIOSH) will develop policy options designed to reduce aviation fatalities.

NIOSH contracted with the Institute of Social and Economic Research (ISER) of the University of Alaska Anchorage to design and administer two statewide aviation safety surveys, one of air carrier managers and one of active commercial pilots. This document describes the methodology for the pilot survey, which addressed pilot demographics, flight hours (total, aircraft type, and instrument hours), Alaska flying experience, attitudes about safety, flying practices, and other salient risk factors.

Instrument Development

Focus Groups

We hypothesized that there were measurable differences in attitudes, policies and behaviors of pilots and operators that put some pilots and operators at greater risk of a crash than others. We further hypothesize that aspects of the economic and/or regulatory environment may be reinforcing those higher-risk characteristics. To investigate these hypotheses, NIOSH conducted focus group meetings between May and November of 2000 among pilots, operators, and villagers in five Alaska regions. Both NIOSH and ISER reviewed the findings of previous Alaska aviation studies. Findings from these two sources became the foundation of the research questions, and core of both the pilot and operator survey questionnaires.

Draft Questionnaire

Respondents were asked to reply to questions about flight practices, attitudes, and perceptions from their personal perspective. The questionnaire consisted of several sections:

1. Pilot demographics, certifications and flight experience
2. Flight experiences in their current employment relevant to the identified safety issues
3. Training provided by their current employer relevant to the identified safety issues
4. Attitudes about those safety issues and about potential ways to address them
5. For pilots who fly with Capstone equipment, questions about their experiences with and attitudes about that equipment.

Pre-Test

The questionnaires were pre-tested on six pilots to filter out confusing questions and terms, confirm that perception and attitude questions worked, and to determine the time required to administer the survey. We also had to deal with sensitivity to questions about practices that are contrary to federal aviation regulations (FARs). In addition to an understandable reluctance to admit to breaking the law, some pilots also raised concerns that their survey responses to such questions would be used for enforcement purposes. For the same reasons, we chose not to ask pilots questions about their employers that might call for explanations of practices or procedures contrary to FARs.

Use of previously collected data

While prior studies examining crashes in commuter and air taxi services have provided useful leads on comparative information and examples of how to conduct this type of research, they do not provide the specific information needed for the reduction of deaths related to air crashes in Alaska. No existing information, such as that available from the NTSB or FAA accident data reporting systems, has been identified of the type required for these studies. Additionally, appropriate denominators and exposure estimates of commercial pilots are inaccurate and unreliable. Our review of the scientific and technical literature did not yield the number of commercial pilots per year or the number of pilot flight hours or flights per year in Alaska.

Sample Design

The pilot was the unit of analysis in this study. The survey population consists of pilots who flew for:

- Air carrier companies who identify themselves as air transportation companies who transport passengers and/or freight, operating in Alaska (other than companies who are scheduled airline companies operating only aircraft having more than 10 seats), as of November 2000.
- Government agencies that have public use aircraft operating in Alaska (such as the Alaska Department of Fish and Game, Alaska State Troopers, U.S. Department of Interior, etc.).

The Capstone sample had three groups, as shown in Table F-1 (next page):

a. We randomly selected about one-quarter of pilots whose employers participated from the NIOSH operator survey's large operator stratum. This random sampling produced 41 responses to the Capstone module[2].

b. We randomly selected companies having only one or two pilots for a combined pilot/operator survey. Obtaining both operator and pilot information in one contact reduced the time burden on small operator respondents. Four of these pilot-operators were Capstone participants.

c. We interviewed 61 pilots in person either at their place of work in Bethel or at Capstone training sessions in Bethel or Anchorage. These pilots were all the Capstone pilots we could contact at a given time and place (for example, during a 4-day visit to Bethel, or at a given training class).

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[2] The large operator stratum consisted of all companies/operators that were shown as employing 3 or more pilots by the FAA's VIS database in June, 2001. The design sampling fraction for large operators was 21.5 percent. However, we had to sample discrete numbers of pilots in small companies, so the actual sampling fraction varied by company size from 40 percent (2 pilots in a 5-pilot company) to 21.51 percent (20 pilots in a 93-pilot company). Over all large operators, it averaged 24.8 percent.

Table F-1. Capstone Operators and Pilots Completing Capstone Module Surveys

	One or Two Pilots	Three or More Pilots	Total
Capstone Participating Operators*	6	17	23
Capstone Operators Sampled	4	16	20
Pilot Responses from group a	n/a	41	41
Pilot Responses from group b	4	n/a	4
Pilot Responses from group c:	1	60	61
Total Capstone Pilot Interviews	5	101	106

*This table includes PenAir, an original Capstone operator, which ceased most of their operations in the Y-K Delta in 2001.

Survey Protocols

We generated the pilot sample from interviews with the air carrier operators. ISER interviewed operators from August 2001 through February 2002; we interviewed pilots from December 2001 through February 2002. As described above, the universe from which we drew the pilot sample was the pilots employed by operators that we interviewed. In the final section of the large operator/company questionnaire we requested a list of pilots employed by that carrier and their telephone numbers. If the operator provided the list, the interviewer verified that the number of pilots on the list was the same as the number reported in question 1 (pilots currently employed by the carrier). If the numbers were different, the interviewer resolved the inconsistency, either by correcting question 1 or correcting the pilot list, as appropriate. Once the numbers were the same, the interviewer chose a pilot sampling sheet with the same number of pilots as listed. The pilot sampling sheets (generated by an excel spreadsheet) randomly selected which pilots on a numbered list should be interviewed. We generated a new sampling sheet, with different random sample, for each company.

If the operator refused to provide pilot information after follow-up by an interviewer experienced in turning around refusals, we tried one of several options. We preferred option (1) or (2), but used option (3) when that was all the operator would agree to.

1. Work with the operator to obtain contact information only for pilots selected for interview. We would never see the full list of employees. The interviewer would direct the operator to choose names based on where they fell on list. For example, the interviewer, using a sampling sheet, would direct the operator to choose the 3rd, 5th and 8th pilots on the operator's list. The operator then provided us with names and contact phone numbers for the selected pilots.
2. Obtain a list of pilot names without contact information; draw the sample and mail the questionnaire to the company for delivery to the selected pilots.
3. Work with the operator (as above) so that the operator could select the random sample, but in addition, have the operator distribute the questionnaires to the selected pilots (rather than providing contact information to ISER).

In all cases when ISER mailed questionnaire to pilots we included a self addressed stamped envelope for the pilot to return the questionnaire to ISER. We also provided a form so that the pilot could mail us their telephone number, in which case we would call the pilot directly and conduct the survey over the telephone.

Initially we mailed surveys or called all selected pilots, and followed-up by telephone and fax as necessary. In most cases, we expected interviewers to complete surveys over the telephone. In cases where telephone contact was unsuccessful or where the pilots preferred face to face contact, interviewers arranged to complete the interview in person.

Our methodology incorporated the standard strategies used to obtain high survey response rates. We trained interviewers thoroughly so that they understood the goals of the research, the questionnaire, and the protocols for administering the questionnaire. We followed up by telephone (wherever possible) if we did not receive a response to an initial contact by mail. If necessary, we followed up with face-to-face contact where both telephone and mail contacts were unsuccessful. We did not assign the “unable to contact” disposition to a telephone number until we had made repeated calls on different days of the week and at different times of day. Likewise, we attempted face-to-face contacts on different days of the week and at different times of day. If potential respondents refused the survey, interviewers experienced at turning refusals around called them and attempted to change their minds. This rigorous telephone interview approach minimizes non-response bias at the outset by generating a non-biased sample, and then by ensuring a high response rate.

Interviewer Training

ISER hired and trained interviewers for telephone and face-to-face, interviews with respondents. The initial training was 16 hours and used the following outline:

Day 1

- Research ethics - statement of professional ethics
- Confidentiality
- History of ISER
- Purpose of survey
- Background
- Purposes and structure of Alaska Aviation Safety Survey
- Selecting the respondent
- General rules for interviewing
- Thumbnail sketch
- Style
- Introductions
    - Special interview circumstances
    - Handling reluctant respondents
- Some techniques to prevent or turn around a refusal:
- Misinterpreted questions
- Vague answers and answers that don't fit
- Clarifying respondent's role using positive feedback
- Disposition of interview and record keeping
- Evaluation

Day 2

Practice interview
- Disposition of interviews, record keeping
- Paired interviewer practice
- Readiness check —1
- Practice interviews
- Readiness check —2
- Initial sample assignment

Interviewers are evaluated and approved by the field supervisor for readiness prior to their starting telephone interviews

Confidentiality

All respondents received voluntary participation and confidentiality information in a consent form. Participants who responded by mail or face-to-face were given a copy of the form to keep, and also signed a copy that was attached to the interview. If respondents returned a mail for fax survey without a signed consent form, we considered them to have given their implied consent. For telephone respondents, interviewers read the consent form and obtained the respondent's verbal consent. The form included the following items:

1. The authority and purpose for data collection,
2. an explanation that participation was voluntary,
3. An explanation of the confidentiality of their responses, including assurances that

- responses would not be used in any enforcement actions ,
- although survey results would be available to the air carrier operator and pilot associations, federal agencies, and other interested parties, this would be in summary format only -- without any personal or corporate identifiers.
- the information provided is kept confidential. Responses are locked in a file cabinet with access limited to research staff on the project

Current Events

Respondents were expected to naturally refer to their own experience and prior flying experience in thinking about their responses. Three events occurred during the course of this survey, which are certain to have affected pilot's responses. On September 11 there were the tragic events at the World Trade Center and the shut-down of aviation nationwide. In response to the uncertainty in the aviation industry and concern among respondents we stopped interviewing for one week. On October 11, there was the worst commercial crash in Alaska since 1987 involving one of the largest regional operators in Alaska. On October 19, there was a helicopter crash in Anchorage involving another of the largest regional carriers. How and to what extent these events may have influenced pilots' responses is unknown, but a series of events of this magnitude are likely to have affected public attitudes, perceptions, and business practices.

Survey Dispositions and Response Rates

Table F-2 shows the response rates for Capstone operators and pilots. Every operator and pilot selected for the NIOSH sample was ultimately assigned a disposition code:

- Refusals
- Respondent Unavailable During the Study
- Completed Interview

The response rate is calculated as:

$$\frac{\text{Total \# of completed interviews}}{\text{Number in the original sample}}$$

For purposes of calculating the response rates, we did not include the 61 Capstone pilot modules obtained by Dr Daniels in Bethel and at Capstone training classes.

Table F-2. Response Rates for Capstone Operators and Pilots

	Sample	Completed Interviews	Response Rate
Capstone Operators	20	18	90%
Pilots Employed by Capstone Operators*	62*	45	73%

*We estimated the Capstone pilot response rate from large operators as being the same as the response rate for all pilots employed by Capstone operators. Several large operators have both Capstone and non-Capstone pilots. We used the fraction of responding pilots who are Capstone pilots to estimate the number of non-responding Capstone pilots from large operators.

Data Set

A data editor reviewed the completed survey forms for completeness and consistency; whenever possible, our interviewers called back respondents to resolve any problems we found. We reconfirmed our data entry programs to reject some types of incorrect data. We entered a sample of the surveys twice and compared the two entries to measure the accuracy of data entry. Once all the survey data was entered, we reviewed it and corrected for missing or unreasonable values.

Weighting

We calculated two sets of weights for the pilot Capstone modules. The first–*pilotwt* and *normalized pilotwt*–weighted sample pilots to represent all pilots flying for the 19[3] operators whose pilots we interviewed. The second set–*totalwt* and *normalized totalwt*–adjusts the first set of weights to represent all pilots in our universe: pilots employed by air taxi and commuter air operators and public agencies flying in Alaska.

To weight to the operators represented in the survey, we calculated a separate weight for each company

$$\text{Pilotwt} = \frac{\text{Total pilots employed by company}}{\text{Total Pilot Interviews completed from company}}$$

This formula reflects the fact that the pilot's probability of selection was different for each company size. We then normalized this weight, so that the weighted total pilots equaled the number of respondents (261):

$$\text{Normalized Pilotwt} = \frac{\text{Pilotwt} * 106}{\text{Sum of Pilotwt for the full (106) sample}}$$

To adjust the sample to represent all pilots in our universe, we needed to account for the operator's probability of selection, as well. We multiplied the (non-normalized) pilot weight by the (non-normalized) company weight[4]. The calculation of the company weights is discussed in the methodology documentation for the operator survey.

Totalwt = Pilotwt * Company Weight

The normalized the total weight adjusts the weighted total of pilots to equal the number of respondents (106):

$$\text{Normalized Totalwt} = \frac{\text{Totalwt} * 106}{\text{Sum of Totalwt for the full (106) sample}}$$

Use of normalized weights is appropriate to accurately calculate statistical significance and confidence intervals from the survey data. Since the pilot sample was stratified by company there is a unique weight for each of the 133 air operators represented in the sample. Consequently, the weights themselves are confidential.

The following pages show the instrument with weighted frequencies included.

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[3] Although we had only 18 completed operator interviews, we picked up one pilot interview from a company that refused the operator interview.

[4] For the company that had refused the operator interview, we used the appropriate company weight for that company's stratum. While it would be preferable to re-calculate all the company weights taking the additional company into account, the change is very small and does not affect the results measurably.

SURVEY INSTRUMENT WITH FREQUENCIES: CAPSTONE PILOT MODULE

CP1. Have you received formal training to use the Capstone equipment?

15 No→ **Skip to Question CP3**

90 Yes **1** no answer

CP2. If you received **Capstone classroom training**, please tell me how many hours you received and who provided the training. If you received **classroom with Capstone simulator** training, how many hours did you receive? who provided the training? How about **flight or Capstone-equipped flight simulator** training?

Type of Training	Hours	Training was taught by		
		UAA personnel	Someone in your company	Someone else (please specify)
a. Classroom	**41** – none **15** – 4 hr **16** – 8 hr **9** others 1–16 hr **12** no answer	**22**	**25**	**1**- another company; **2** – combination **1** – no answer
b. Classroom with Capstone simulator	**36** – none **20** – 8 hr **25** other 1–24 hr **12** no answer	**32**	**20**	**1** – combination **4** – no answer
c. Flight or Capstone-equipped flight simulator	**40** – none **24** – 1 or 2 hrs **13** – 8 hr **4** others .3–24 hr **2** trainer @400hr **10**– no answer	**14**	**37**	3 – no answer

CP3. How useful is the GPS Capstone equipment? Is it very useful, somewhat useful, or not useful? How useful is MFD equipment? What about radar-like services?

	Very useful	Somewhat useful	Not useful
GPS	**92**	**14**	**0**
MFD	**87**	**17**	**1**
Radar-like services	**65**	**11**	**22**

CP4. Which of the following functions of the Capstone avionics do you routinely use? Do you use flight planning? (CONTINUE READING LIST AND MARK ALL THAT APPLY)

53 Flight Planning
88 Traffic Avoidance
51 Radar-Like Services
9 Other (please specify): _**data link, FIS, WX, GPS approaches**

104 Navigation
80 Terrain avoidance
2 None

CP5. Which functions do you like best about Capstone avionics?

CP6. What do you dislike the most about Capstone avionics?

CP7. How often do you use the new GPS-based instrument approaches at remote airports? Do you use it daily, weekly, monthly, less than monthly, or never (IF NEVER, PROBE:) Is that because you don't fly to those airports or never use instrument approaches) (NOTE: NEW GPS-BASED APPROACHES ARE AT HOLY CROSS, KALSKAG, KIPNUK, KOLIGANEK, MOUNTAIN VILLAGE, PLATINUM, RUSSIAN MISSION, SCAMMON BAY, ST. MICHAEL)

12 Daily **31** Weekly **19** Monthly **14** Less than monthly
10 Never, we don't fly to those airports
20 Never, we never use instrument approaches

CP8. I am going to read a list of possible benefits that you may have experienced from the Capstone program in the Bethel area. Please tell me if you have experienced **fewer cancelled flights due to new instrument approaches at remote airports** and, if so, was the benefit very small, of some benefit, significant, or a major benefit? (CONTINUE READING LIST AND MARK A BOX IN EACH ROW)

	Doesn't Apply	No Benefit	Very Small Benefit	Some Benefit	Signifi-cant Benefit	A Major Benefit
a. Fewer cancelled flights due to new instrument approaches at remote airports	18	25	22	19	13	0
b. Safer operations at remote airports due to new instrument approaches	18	18	21	24	16	0
c. Safer flying in minimum legal VFR conditions	15	1	12	41	15	15
d. Fewer near mid-air collisions	15	10	5	31	20	18
e. More useful weather information	15	7	22	31	20	4
f. Better knowledge of other aircraft and ground vehicle locations when taxiing	15	17	18	12	27	9
g. Improved SVFR procedures due to better pilot and controller knowledge of aircraft locations	15	16	1	18	33	15
h. Easier in-flight diversions or re-routes	15	4	28	30	16	5
i. Time savings from more direct flight routes	15	5	33	17	19	9
j. Improved terrain awareness for pilots	15	0	1	9	44	28
k. Improved search and rescue capabilities	15	3	27	19	17	15

CP9. If you feel there are other benefits that Capstone provides, will you please tell me about them?

CP10. You may have experienced some problems with the Capstone program in the Bethel area? Have you had less heads-up time? (IF R ANSWERS NO, MARK "NO PROBLEM" AND CONTINUE READING LIST. IF R ANSWERS YES, ASK THE FOLLOWING:) Was this a very small problem, a minor problem, a significant problem, or a major problem?

	Doesn't Apply	No Problem	Very Small Problem	Minor Problem	Signifi-cant Problem	Major Problem
a. Less heads-up time	16	25	19	18	20	0
b. Heavier workload in the cockpit	15	29	18	27	0	8
c. More aircraft flying in the same airspace because they are using GPS point-to-point routing	15	15	30	32	4	1

CP11. If you feel there are other problems that Capstone may cause or add to, will you please tell me about them?

CP12. When you fly for <COMPANY>, how often is the aircraft Capstone-equipped? Is there **always, usually, sometimes, rarely, or never** Capstone equipment installed?

43 Always **29** Usually **17** Sometimes **16** Rarely **0** Never

Skip to Question CP 15

CP13. When your aircraft **is** Capstone-equipped, how often do you use that equipment? Always, usually, sometimes, rarely, or never?

75 Always **21** Usually **0** Sometimes **7** Rarely **0** Never

Skip to Question CP 15

CP14. How much does the Capstone equipment help you to make go/no go decisions under the following conditions? Under low-ceiling conditions, does it help you a small amount, a great deal, or not at all? (CONTINUE READING LIST AND MARK A RESPONSE FOR EACH.)

	Doesn't Apply	Not at all	A small amount	A great deal	Don't know/no answer
a. Low ceilings	0	43	42	10	11
b. Low visibility	0	44	38	13	11
c. High winds	0	75	16	4	11
d. Icing potential	0	78	10	5	13

CP15. There might be some reasons why pilots choose not to use Capstone equipment? Would one reason be that it is too distracting? too difficult to use? (CONTINUE READING LIST AND MARK A RESPONSE IN EACH ROW.)

	Yes	No	Don't Know/ No Opinion/ No Answer
a. Too distracting	37	51	18
b. Too difficult to use	28	63	14
c. Don't want company watching aircraft location at all times	52	30	24
d. Don't trust equipment to provide reliable information	4	78	24
e. Concerned that equipment might break	4	77	26

CP16. If there are other reasons you believe pilots might choose not to use Capstone equipment, will you tell me about them?

The next five questions ask about potentially dangerous situations that pilots sometimes encounter. Capstone equipment might be helpful in preventing or coping with these particular problems. Therefore, we're interested in how often pilots in the Yukon Kuskokwim Delta encounter these problems. For each situation I read, think about how often in the last 12 months you've encountered it; has it been daily, weekly, monthly, less often than monthly, or never? (READ EACH QUESTION CP17 THROUGH CP21 AND RECORD RESPONSE.)

	Daily	Weekly	Monthly	Less often than monthly	Never	Don't Know/ No Answer
CP17. How many times during the past year have inaccurate weather forecasts caused you to encounter instrument meteorological conditions when you didn't expect to?	4	30	24	23	1	24
CP18. How many times during the past year have deteriorating ceilings or visibility made you unsure of your own position relative to the surrounding terrain?	2	14	13	27	15	35
CP19. During the past year, how many times have you unexpectedly seen other aircraft close enough to you that you felt it created a collision hazard?	0	10	20	43	4	29
CP 20. During the past year, how many times have you been cleared into SVFR when the separation between aircraft in the pattern made you uncomfortable?	0	10	14	36	10	36
CP21. During the past year, how many times might your go/no go or routing decisions have been improved if you would have had access to real time weather or Special Use Airspace status?	4	9	34	31	1	27

CP22. How do you think the Capstone program has affected flight safety in the Yukon Kuskokwim Delta? Has it made flying much less safe, somewhat less safe, had no effect on safety, made flying somewhat safer, or much safer?

0 Much less safe
8 Somewhat less safe
17 No change in flight safety
30 Somewhat safer
38 Much safer
14 No Answer

CP23. And finally, is there anything else that you would like us to know about Capstone, safety, or about flying in the Yukon Kuskokwim Delta?

Thank you for your time. All information you have provided is confidential and cannot be used for enforcement purposes.

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Appendix G Acronyms

A & P	Airframe and Powerplant (aviation mechanic certification)
ADS-B	Automatic Dependent Surveillance – Broadcast
ASOS	Automated surface observing system
ATC	Air Traffic Control or Controller
AWOS	Automated weather observing system
CDTI	Cockpit Display of Traffic Information
CFIT	controlled flight into terrain
CTAF	Common Traffic Advisory Frequency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FIS-B	Flight Information System – Broadcast
GBT	Ground-based Transceiver
GPS	Global Positioning System
IFR	Instrument Flight Rules
ISER	Institute of Social and Economic Research, U Alaska Anchorage
IMC	Instrument Meteorological Conditions
METAR	Meteorological Aviation Report
MFD	Multi-Function Display (of Capstone avionics)
NDB	Non Directional Beacon – a navigation aid
NEXRAD	Next generation Radar
NIOSH	National Institutes of Occupational Safety and Health
NMAC	Near Mid Air Collision
NOTAM	Notices to Airmen
NTSB	National Transportation Safety Board
PIREP	Pilot Report
SVFR	Special Visual Flight Rules
TAF	Terminal Aerodrome Forecast
TAWS	Terrain Awareness and Warning System
TCF	terrain clearance floor
TIS-B	Traffic Information System – Broadcast
UAA-ATD	University of Alaska Anchorage Aviation Technology Division
UAT	Universal Access Transceiver
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Variable Omni-directional Radio – a navigation aid
Wx	Weather

For detailed definitions of a wide variety of aviation terms, refer to the FAA's Pilot/Controller Glossary, available at

http://www.faa.gov/atpubs/PCG/