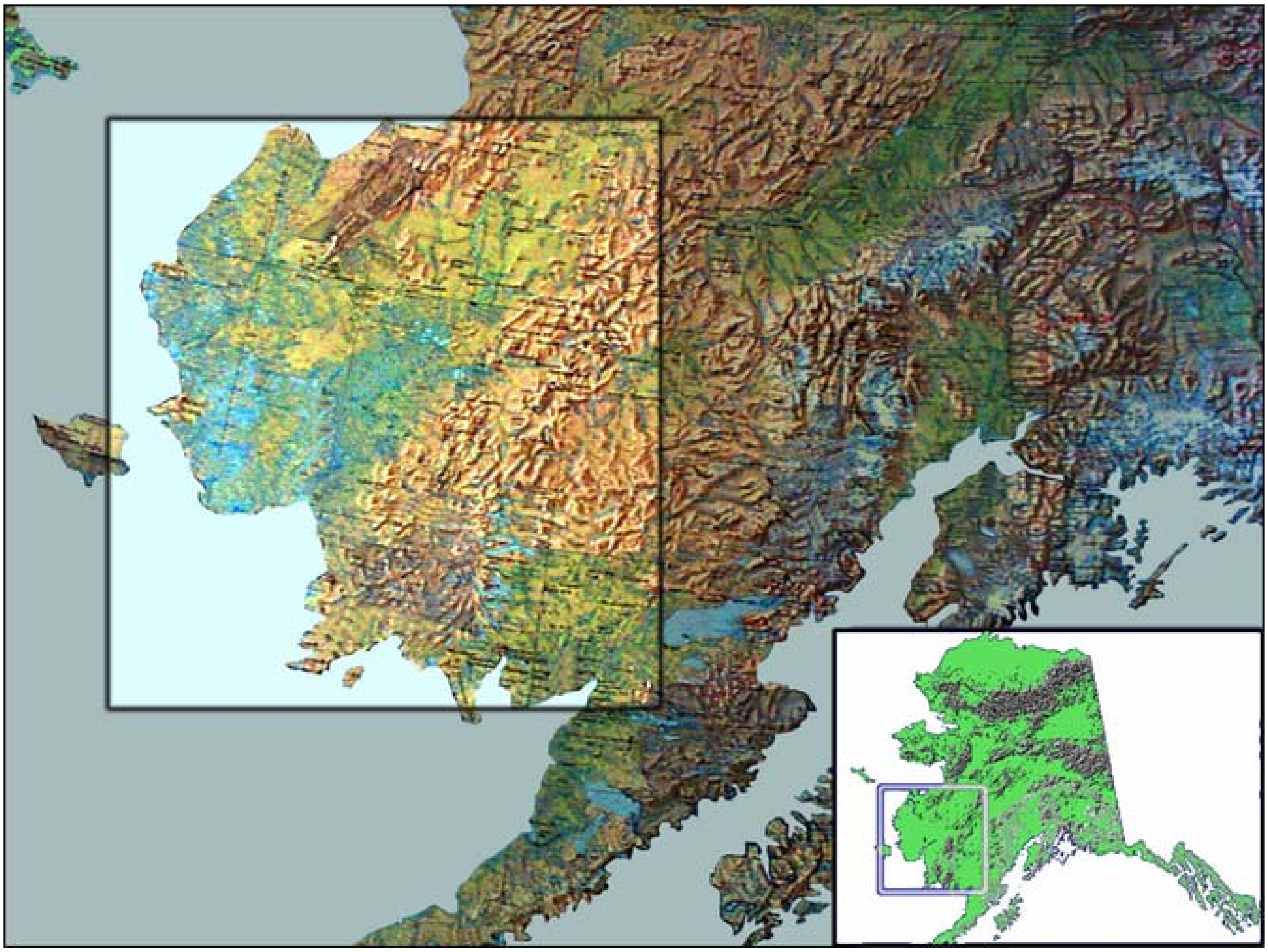
The Safety Impact of Capstone Phase 1

Summary Report through 2003

May 2004



UNIVERSITY *of* ALASKA ANCHORAGE

Aviation Technology Division

CAASD

The MITRE Corporation's Center for Advanced Aviation System Development

Highlights of the Summary Report through 2003

- Capstone equipped aircraft have had a consistently lower accident rate than aircraft before Capstone and non-equipped aircraft during Capstone. From 2000 through the end of 2003 the rate of accidents for Capstone equipped aircraft was lower by 40%.

- The rate of accidents for YK Delta-based Part-121 and Part-135 airplanes has been falling since 2001 and is now at the lowest rate since 1990.

- Historically the rate of Part-135 accidents within the YK Delta has been two to four times the rest of Alaska, but in 2003 the accident rate for the Delta was below the rest of the state for the first time.

- At villages where Capstone has created instrument approaches, the fraction of time weather makes air travel unavailable has been reduced by 50%.

- Operator flight monitoring is now used routinely by 94% of YK Delta operators. 65% report it has improved their organization's safety awareness and decision-making.

- Capstone's traffic, terrain, flight planning and navigation functions are used frequently by pilots and are rated highly. However FIS-B (which has been provided on the "as-available" developmental network) has been shut down at Aniak and St. Mary's, has had poor availability, and cannot be overlaid with traffic on cockpit displays. Use of FIS-B by pilots has become rare.

- Lower rates are being observed for all classifications of accidents. The historical rate of occurrence of individual types of accidents (such as CFIT or mid-air collisions) was too infrequent for reductions to reach statistical significance within the next several years.

The Safety Impact of Capstone Phase 1

Summary Report through 2003[1]

Capstone is a joint initiative by the FAA Alaska Region and the aviation industry to improve aviation safety and efficiency in Alaska by using new technologies. Phase 1 of Capstone is taking place in the watershed of the Yukon and Kuskokwim rivers in Southwest Alaska – the YK Delta – which is relatively isolated, has had limited infrastructure, and has had a high rate of aviation accidents. Capstone has installed new avionics in all Part-135 aircraft based in the Delta. Phase 1 continues with new ground-based capabilities, expanded services and training, and information gathering on the safety of YK Delta aviation. This report briefly evaluates operations and accidents in 2003 and characterizes the changes in YK Delta aviation that have taken place since Capstone began implementation in 2000.

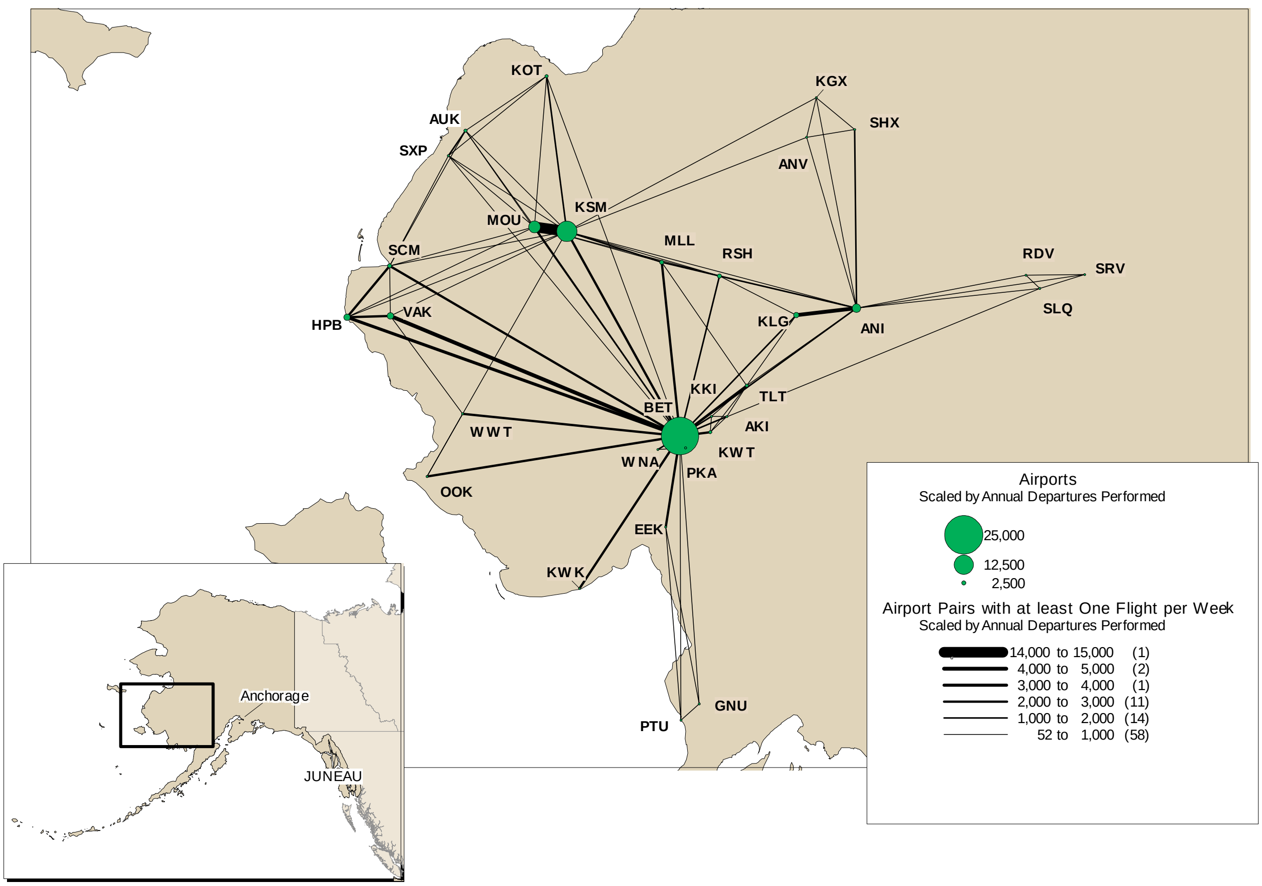


Figure 1 Airport Departures and Route Traffic in the Yukon-Kuskokwim Delta

[1] The contents of this material reflect the views of the authors. Neither the Federal Aviation Administration nor the Department of Transportation, makes any warranty or guarantee, or promise, expressed or implied, concerning the content or accuracy of the views expressed herein.

Aviation is critical to Alaska not only for routine travel and commerce, but for nearly any kind of emergency – only 10% of Alaska is accessible by road, and waterways are impassible most of each year. But Alaska is also very large, sparsely populated, and crisscrossed by mountains that block radio and radar so that services and infrastructure that would be available in the Lower 48 are missing from many areas. The benefits of aviation as a lifeline are substantial, but the safety consequences of operating in these conditions are also substantial: the accident rate for rural Alaskan commercial aviation is 2.5 times the US average.

Accident rates in the YK Delta have been even higher. Essentially all passengers and 95% of all cargo arrive in the YK Delta by scheduled air service through Bethel or through smaller hubs at Aniak and St Mary's. Service between Bethel and Anchorage is by larger turbine and jet aircraft, but service to YK Delta villages is on small single-engine or light-twin aircraft that prior to Capstone were limited to visual operations. Pilots for these flights often face weather hazards – fog, ice-fog, white-out or flat-light conditions that can be localized and change rapidly – and weather information has been limited. There are few navigational aids. Radar coverage is largely unavailable below 5000 feet, while icing concerns and short distances often keep operations below 2000 feet. Runways are short, mostly gravel or dirt, and are damaged regularly by freeze/thaw and water.

Accidents Before Capstone

The types and causes of accidents prior to Capstone are shown in Figure 2 for commercial aircraft (operating under Federal Aviation Regulations Part-135) based in the YK Delta. These are the aircraft most directly affected by Capstone. Major categories (the inner pie slices) are explained below. Some accidents also fall within some special sub-category (outer pie segments) but many do not. The dark band and underlined categories and sub-categories identify causes of accidents that are targeted by Capstone.

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

Mechanical Failure — Engine failure, inoperable control surfaces, failed landing gear, propeller or shaft failure. (There were no fatal accidents in this category by YK Delta based Part-135. In the Lower 48, 10% of mechanical accidents are fatal.)

Flight Information — 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.

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 mis-location, which can be addressed by a GPS- **map** display.

Traffic — Usually mid-air collisions between aircraft. Also includes accidents from last-moment avoidance of other aircraft.

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.

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 an off-runway **site** such as beaches and gravel bars, and from obstacles in water that are struck by float-planes.

Other Taxi[2] or airport vehicle accidents, low altitude maneuvering for game spotting or photography, spatial disorientation, improper carburetor heat, bird strikes.

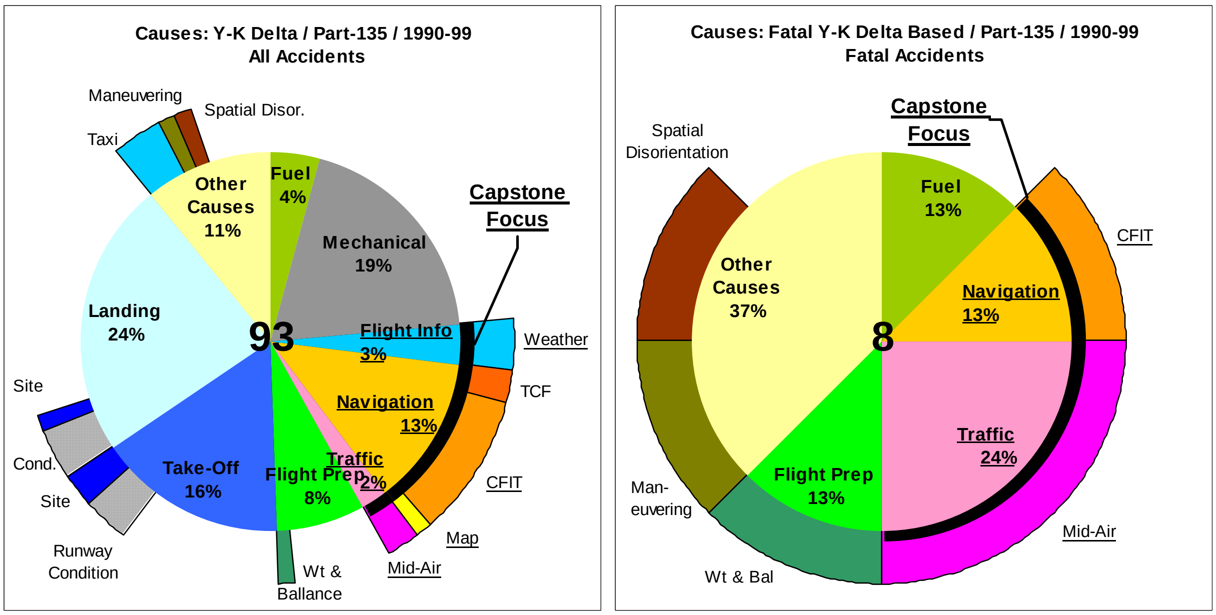


Figure 2 93 Accidents and 8 fatal accidents by YK Delta Part-135 aircraft 1990-1999

Causes of over-all accidents and causes of fatal accidents had very different percentages. Many accidents were associated with take-off, landing and mechanical problems, but relatively few of these caused injuries and none caused fatalities. By contrast, accidents from inadequate flight preparation, fuel mismanagement, lack of flight information, collisions with other aircraft, and difficulty navigating were much more likely to cause injuries and fatalities. Differences such as these are consistent with recent accident studies[3] for the US as a whole. The percentage of fatal accidents associated with traffic (collision or interaction with other aircraft) was higher than in the Lower 48; the percentage associated with navigation was comparable. "Weather" accidents (which are split between several of the categories[4] used here) were often fatal in both the Lower 48 and Alaska. The focus of Capstone is on these more serious types of accidents.

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[3] Annual *Nall Report*, AOPA Air Safety Foundation

[4] Weather contributes to accidents associated with navigation, flight preparation, and spatial disorientation, which have a high fraction of fatal accidents. It also contributes to take-off and landing accidents that cause few fatalities in the YK Delta – none from 1990 to 1999. (In the Lower 48 take-off accidents have significant fatalities.)

The Capstone Program

The capabilities of Capstone Phase 1 target four serious safety problems in Alaska:

- CFIT accidents (within the navigation category)
- Accidents associated with aircraft traffic – especially mid-air collisions
- Inadequate flight information – especially weather information
- Inadequate infrastructure to support IFR operations

By expanding IFR infrastructure, Capstone is also intended to increase routine and emergency access to villages and enable more efficient Radar-like operations in YK Delta hub airports.

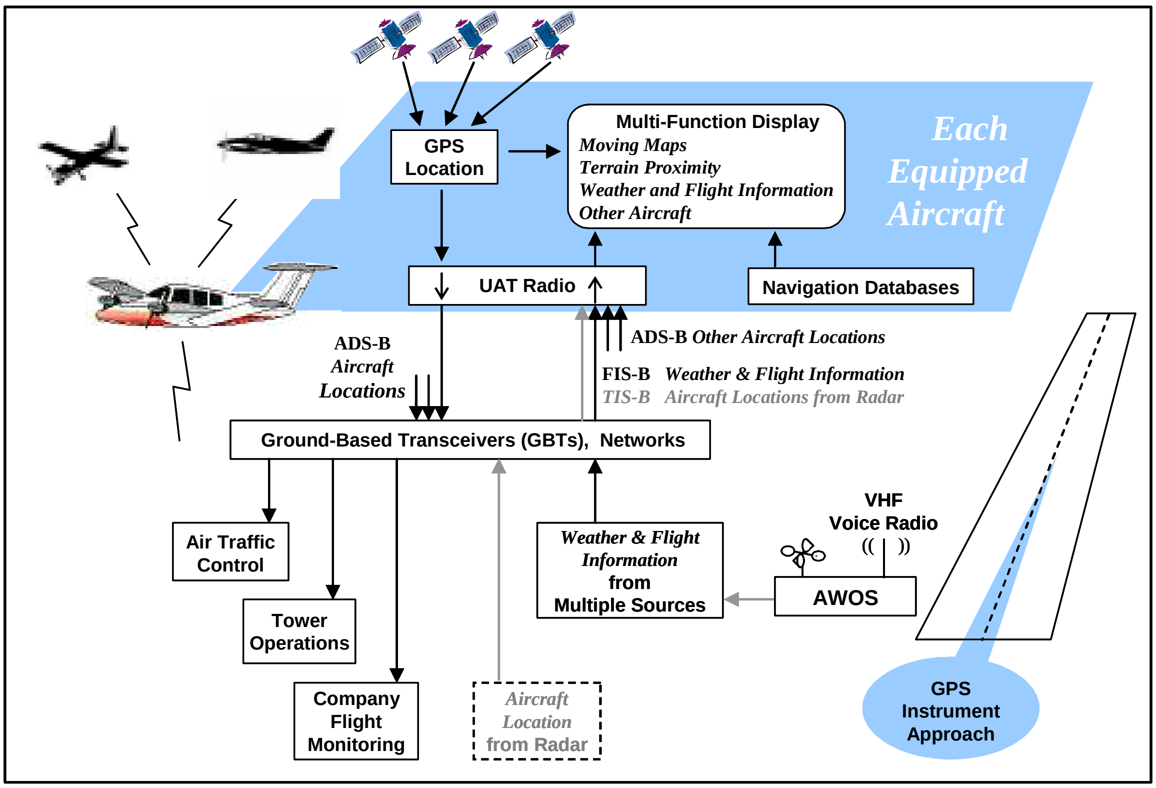

Figure 3 Capstone Avionics, Ground Systems, and Capabilities
Capabilities not operational in 2002 are gray

Capstone's Phase 1 capabilities are based on new ground systems and services for the YK Delta and new avionics installed in commercial aircraft based there. Many use new technologies that have become available only recently or are being implemented for the first time. How Capstone works is illustrated in Figure 3 and described as follows:

- Accidents associated with ***navigation*** are addressed by showing pilots their location on a ***moving map*** on a Multi-Function Display (MFD). The location of the aircraft is derived from GPS, and the map is stored as part of an onboard navigation database. ***En route CFIT*** is addressed using terrain elevations from the database. Nearby terrain is compared to the aircraft's altitude and GPS location and then color-coded on the MFD (yellow if close in altitude, red if immediately hazardous). The GPS unit also has programmable functions to aid en route flight planning and may reduce pilot navigation workload.

- Accidents associated with aircraft ***traffic*** are addressed by ATC radar-like services (below) and by showing pilots the relative locations of other Capstone-equipped aircraft. This is derived from Automatic Dependent Surveillance Broadcast (ADS-B) messages transmitted via a Universal Access Transceiver (UAT) by other aircraft and received and processed to provide a Cockpit Display of Traffic Information (CDTI) – one of the functions of the MFD. CDTI also enhances pilot situational awareness and aids pilot-pilot coordination at non-towered airfields. In the future, locations of aircraft that are not Capstone equipped but are visible to ATC radar might be provided by Traffic Information Service Broadcast (TIS-B) from a network of Ground Based Transceivers (GBTs).

- ***Weather and flight information*** are provided by new Automated Weather Observing Systems (AWOS) at remote airports, and by Flight Information System Broadcast (FIS-B) of weather text and NEXRAD[5] graphics. FIS-B is distributed by data-network to GBTs that broadcast to equipped aircraft. Aircraft with Capstone avionics receive these broadcasts on a UAT and display them to pilots on the MFD.

- ***Increased IFR operation*** is supported at remote airfields by AWOS installations, which allow GPS instrument approaches to be approved for commercial operations. For qualified aircraft, this allows safe IFR operations in low visibility conditions that would be unsafe for VFR operations. IFR operations are improved and expanded by Air Traffic Control (ATC) use of ADS-B to support cost-effective ***radar-like services***. ADS-B takes an aircraft's location from GPS[6] and transmits it once per second over the UAT. GBTs receive these messages from all nearby Capstone equipped aircraft, and forward them to ATC computers where they are processed and the aircraft locations displayed much like aircraft locations from radar. This allows controllers to provide flight following and surveillance-based separation services in airspace that is not visible to radar.

- Late in 2002, tower operators at Bethel airport began regular use of a "Brite" display of ADS-B targets to help them visually locate aircraft and better coordinate arrival sequencing.

- In 2002, managers in companies that operate Capstone equipped aircraft began using ***flight monitoring*** on PCs connected to the Internet to monitor the location of their aircraft. This has the potential to significantly improve awareness of risks and to facilitate further improvements in safety posture.

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[5] Next Generation Weather Radar

[6] ADS-B applications may use or require other on-board navigation sources instead off or in addition to GPS. Capstone avionics use GPS and barometric altimetry.

Capstone's Progress on Implementation: Avionics

In 2000-2001 Capstone equipped almost 6 aircraft per month, reaching 140 of 165 active YK Delta Part-135 aircraft by December 2001. By early 2003 a total of 200 aircraft were equipped – several of which operate as government or "public use" aircraft. Equipped airframes account for 100% of operations by Part-135 aircraft based in the YK Delta.

Commercial pilots using Capstone are trained by their companies, often using training materials, videotapes, simulators, and assistance with instruction made available through the University of Alaska. From observations of pilots (during simulator and flight training and follow-ups) we have assessed the effectiveness of different training levels[7] in enabling pilots to use Capstone avionics to avoid targeted types of accidents. These assessments range from 25% for pilots with little or no training, to 90% for pilots with significant classroom/simulator instruction and operational experience.

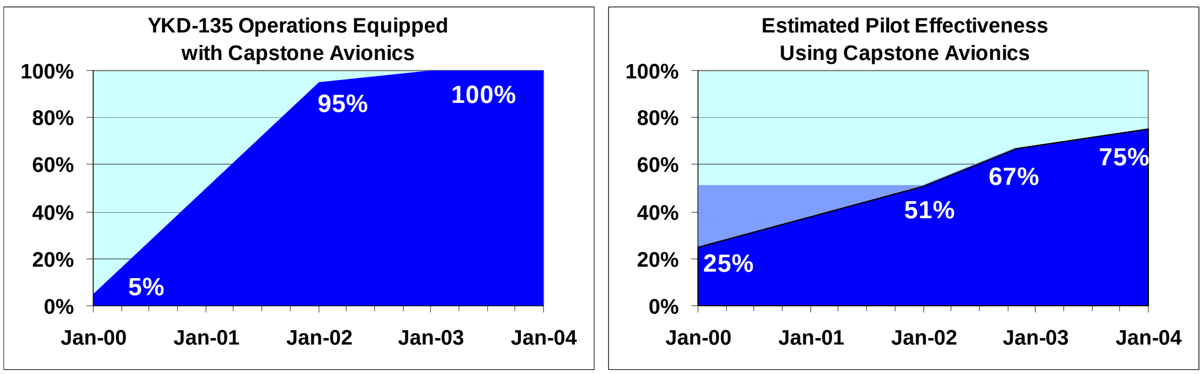

Figure 4 Equipage and Effectiveness of Training with Capstone Avionics for Operations by Part-135 Aircraft based in the YK Delta

We have surveyed YK Delta commercial pilots on the hours and types of training they have received to estimate their effectiveness at avoiding accidents with Capstone. Near the end of 2001, we estimated this at 50% - suggesting only *half* of Capstone-preventable accidents would be avoided. By the end of 2002, this had increased to *two-thirds*. By the end of 2003 the average effectiveness we assessed based on levels of training and experience reached 75%. In addition, an aggressive program has been undertaken to train local FAA Flight Standards inspectors on Capstone, which should help both pilots and their companies in using the technologies safely and effectively.

Radar-Like Services

Beginning January 1, 2001, radar displays for air traffic controllers at Anchorage Center have shown Capstone-equipped aircraft near Bethel even though radar coverage is not available below 5000 feet. This operational approval of ADS-B to provide "radar-like services" is the first of its kind in the world. Controllers can monitor aircraft and vector them to provide air-to-air and air-to-ground separation that is based on very accurate surveillance. This allows operations that are much more precise and efficient than the non-radar procedural separation of IFR aircraft that was in use before Capstone.

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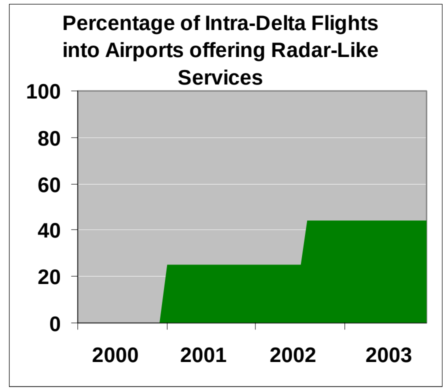
[7] Capstone Phase 1 Interim Safety Study 2000/2001 http://alaska.faa.gov/capstone/docs/2001%20UAA%20report.pdf

Initially, surveillance for air traffic control was supported only through the GBTs located at Bethel, so radar-like services were not available in other parts of the Capstone area. In August 2002 operational ATC surveillance was also added at Aniak and Saint Mary's. FAA has vertically divided the Bethel air traffic control sector to take better advantage of ADS-B surveillance. More complete services for approach and departure are planned with establishment of a Bethel Approach Control, but the target date for this has been slipped from 2004 into 2005.



The number of approaches to which radar-like services are available is tabulated from operations records. The number of flights that actually request and are given this service is not recorded but is believed to be very much fewer.

Tower Display

The "Brite" display of ADS-B targets is in operational use at the Bethel tower, but was unavailable during most of the first years of Capstone implementation. In past years, technical problems with ground processing and communications have limited its availability. Data on recent availability and use of the tower display is not available.

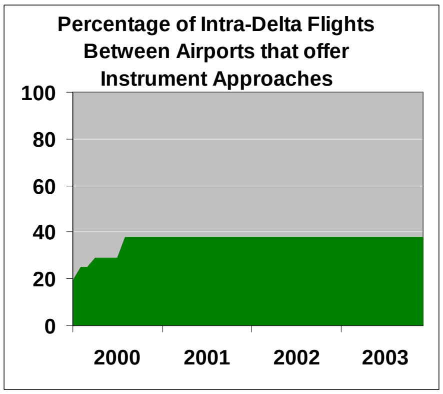
AWOS and Non-Precision GPS Approaches

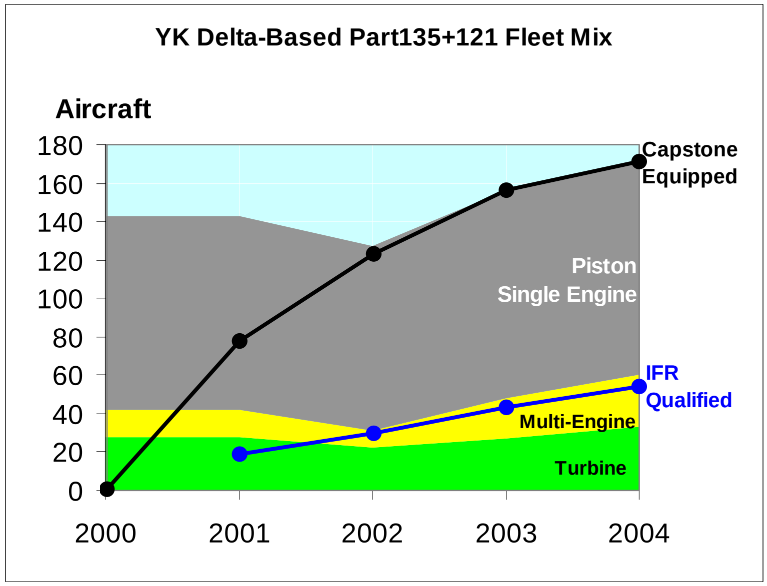
Ten airports in or near the YK Delta have received AWOS stations and associated GPS non-precision instrument approaches. New AWOS more than double the number of full-time weather reporting sites in the YK Delta, and reduce the distance between weather observations to less than 50 miles on most flight routes. Pilots can listen to vocalized current weather observations by phone prior to departure or by radio when in flight near these sites. Because these AWOS are not connected to networks for national weather-data distribution, observations from these sights are not yet available on Capstone avionics via FIS-B.

Figure 5 Locations of AWOS and Non-Precision GPS Instrument Approaches

IFR Operations, Fleet Changes, and Improved Access to Villages

The new GPS approaches double the percentage of YK Delta flight segments flown with IFR infrastructure available at both ends. We believe that this change (as well as radar-like services) has changed the air transportation market in the YK Delta, making IFR-capable flights more reliable than VFR and providing a larger competitive advantage to operators who increase the capability of their aircraft. Commercial operators have upgraded to more capable aircraft classes suited to IFR and have increased their number of IFR-qualified aircraft. IFR commercial operations have historically had a much lower accident rate. These changes are almost certain to improve safety.





Also of great significance is the improvement in village access offered by these instrument approaches. Comparing nearby weather patterns to the minimum ceiling and visibility for approach under Visual Flight Rules finds airports such as Kipnuk and Scammon Bay were inaccessible nearly 30% of the time. IFR operation is reducing the time that villages with AWOS/NPAs are inaccessible by an average of 50%.

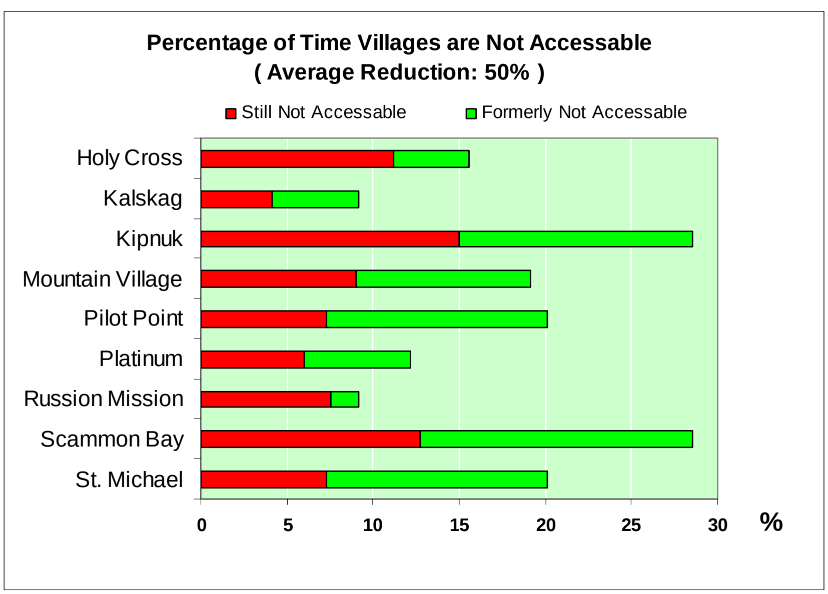
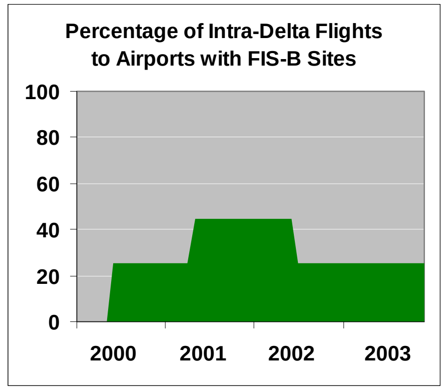


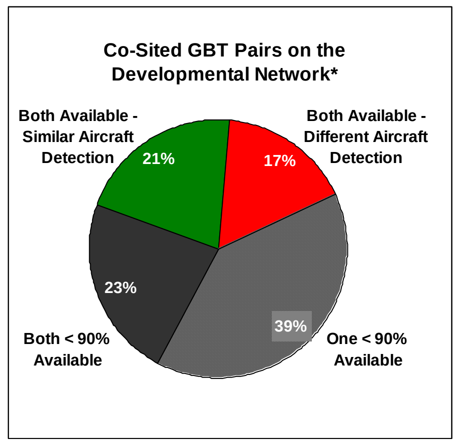
Figure 6 Reductions in the percentage of time villages are without air transportation

Flight Information

In addition to the AWOS capabilities described above, the network of GBTs can provide FIS-B to Capstone aircraft in most of the YK Delta. The products available to pilots are Meteorological Aviation Reports (METARs), Terminal Area Forecasts (TAFs), and NEXRAD graphics from the weather radar at Bethel. Notices to Airmen (NOTAMs), Pilot Reports (PIREPs) and weather messages based on the newly installed AWOS are not yet available on FIS-B. In the future, graphical icing products may become available which would be much more effective in helping pilots avoid localized icing – of particular concern in Alaska.



Commissioning of ATC surveillance at Aniak and Saint Mary's in 2002 removed those locations from the "developmental network" providing FIS-B and operator flight monitoring for VFR aircraft. These services are currently provided on an "as available" basis using prototype systems that lack the ability to monitor whether FIS-B is operational. Some indication of the reliability of FIS-B can be had from reliability data on flight monitoring, but this is only approximate. From anecdotal reports we believe FIS-B has had additional persistent failures (associated with feeds of weather information) that are not reflected in data on flight monitoring.



Most sites on the developmental network have redundant GBTs for availability and validation, but of 101 site-months with two GBTs, in only 38 did both GBTs have 90% availability. Of these 38 site-months with high dual GBT availability, only 21 had essentially similar reporting of traffic. These differences in detecting aircraft between co-sited GBTs do not necessarily affect FIS-B uplink or the usefulness of flight monitoring, but do indicate likely installation problems with site preparation, antennas, or cabling. These problems are **not** reflected in the commissioned and maintained systems being used by the FAA for radar-like services.

Flight Monitoring

Beginning in 2002, Capstone has provided internet/PC software for flight monitoring and aircraft location data from the GBT network to air-transport companies operating in the YK Delta. Nearly all YK Delta operators signed-up for flight monitoring, and these companies use it extensively for oversight, management, planning, and monitoring the safe operation of their aircraft. Figure 7 shows the results of interviews conducted with company officials on their use of flight monitoring and their assessment of the impact of flight monitoring on their company's safety and decision-making.

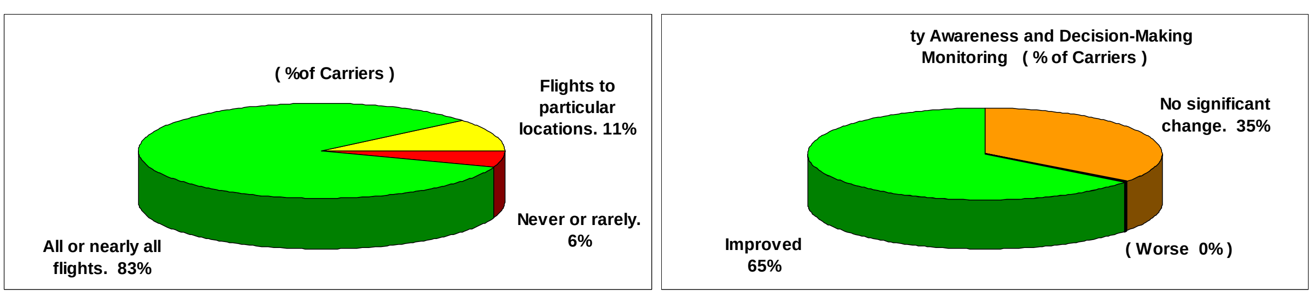


Figure 7 Flight monitoring use and self-assessed impact on safety awareness and decision-making

Feedback from Pilots

Surveys in the winter of 2003/2004 asked pilots how often they use the capabilities of Capstone Phase 1 avionics and ground systems, how easy that capability is to use (relative to other avionics they are familiar with), and how useful they find the capability to be. Pilot responses are summarized in the array of pie charts in Figure 8. We compared the reported use, ease-of-use, and usefulness of the capabilities to the reported training levels and Capstone flight-time of each pilot and detected no significant correlation between assessments and training or experience factors.

The vast majority of pilots responding report frequent use of the **traffic display** and high regard for the display's usefulness. If responses are omitted from two pilots who fly almost exclusively IFR operations (and are provided separation service by ATC), routine use becomes nearly unanimous.

Use of the **terrain display** is split more evenly between those who use it routinely and those who use it rarely (but not never). This seems likely to correspond to the types of flight operations in which different pilots are engaged. The vast majority of pilots view the terrain display as very useful.

Pilot use and valuation of **flight planning** capabilities is more divided, which may reflect the relatively complex nature of flight planning functions The consensus of responding pilots is that the flight planning functions of the Capstone Phase 1 avionics are as easy or easier to use than similar functions in other avionics.

Routine use of the Capstone avionics' **navigation** functions was unanimous for all pilots responding, and all pilots rated usefulness of the capability a highly.

Pilots report they rarely or never use **flight information** (weather) as it is currently offered. This stands in marked contrast to the other Capstone capabilities. Based on comments received on FIS-B availability, and on our evaluation of the reliability and availability of FIS-B, it is clear that intermittent service, and loss of service at Aniak and Saint Mary's, have resulted in a capability that is too rarely available to be used. Also, PIREPs and NOTAMs have yet to be made available over FIS-B. Further, because of constraints imposed by the FAA's certification office, pilots are unable to view traffic superimposed on weather.[8] The assessed usefulness of FIS-B by the pilots is mixed, and it is not clear whether this reflects limitations of the weather and information products, the lack of consistent coverage and reliability, or the inability to overlay it with traffic. This area of concern is highlighted in Figure 8.

Use of the non-precision **GPS Approach**, is mixed. While 20% of pilots use it routinely (including those pilots flying predominantly IFR operations), 20% more use these approaches "rarely", presumably only when forced to do so by below-minimum weather. Usefulness is reported significantly higher than use, suggesting that some pilots are not yet able to use this capability due to limitations in training or equipment.

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[8] The restriction is intended to prevent losing sight of traffic icons when displayed over graphical weather, but it is unclear why this should be of greater concern than the accepted overlay onto color-coded terrain or VFR sectionals– which appear to have greater visual clutter.

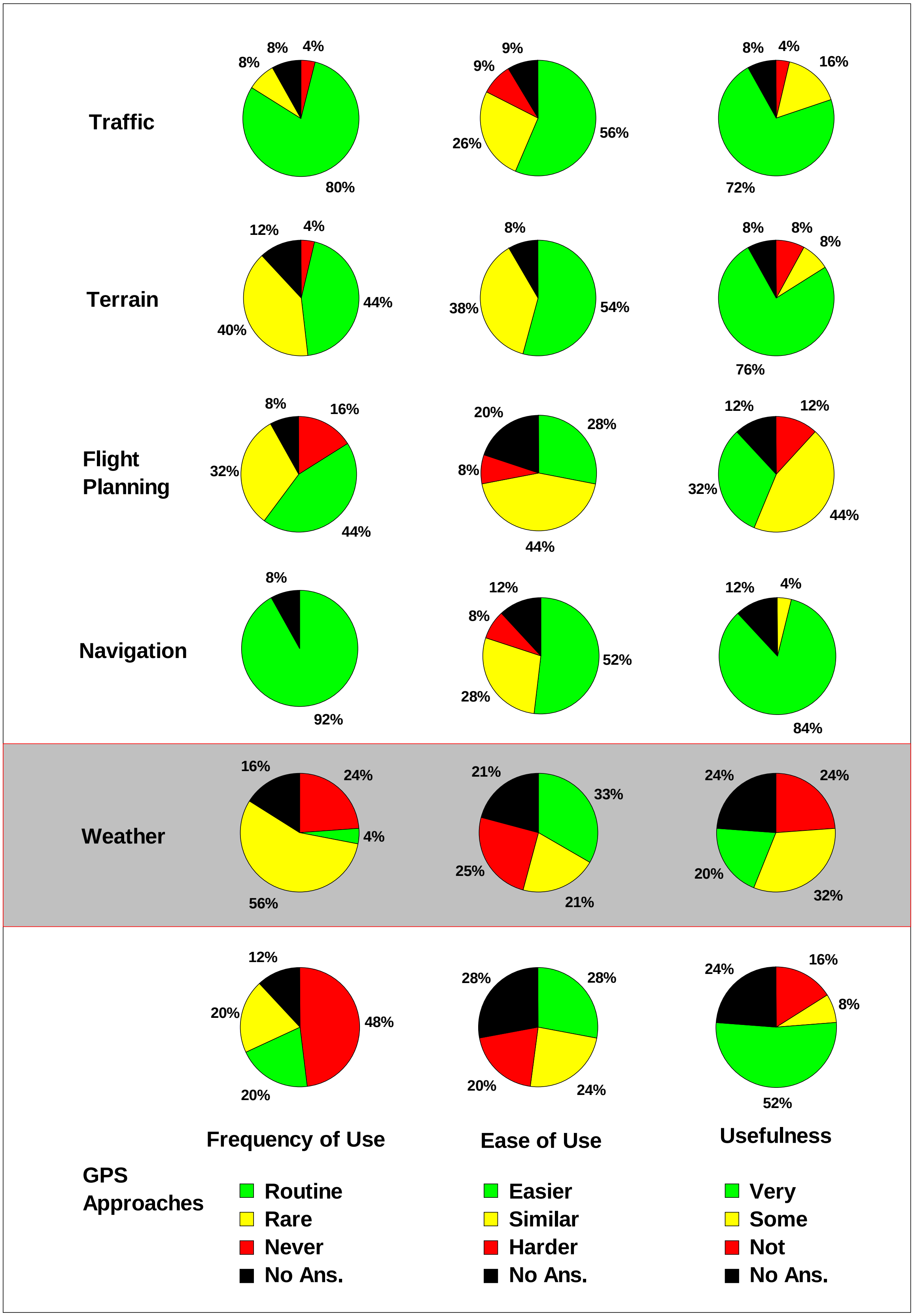

Figure 8 Pilot reported *use*, *ease of use*, and *usefulness* of Capstone services and capabilities

Safety Expectations based on Progress

The safety benefit expected from Capstone depends on the types (and rates of occurrence) of accidents before Capstone, the projected effectiveness of a complete implementation, and the progress on implementation that Capstone has actually made. Since the safety impact of Capstone is best quantified over time, we expect to see changes from increased IFR capability, changes in safety posture from Capstone and other causes, and changes in operations from using Capstone capabilities in ways not predicted. As of this report, we can quantify expectations for only two of the accident types that are the direct focus of Capstone: accidents associated with navigation/CFIT and those associated with traffic.

The level of Capstone equipage and the effectiveness of Capstone training should have a positive on impact on the prevention of navigation/CFIT accidents. From 2000 through 2003 an average of 72% of YK Delta-based Part-135 flight operations were equipped, and the average effectiveness of pilots using Capstone avionics was assessed to be 59%. For 2000-2003 we estimate 40% of preventable navigation and CFIT accidents should be avoided as a result of Capstone. Since warnings on Terrain Clearance Floor violations are not included in Phase 1 avionics (they are planned for Phase 2), collisions with terrain during approach are not directly affected. For en route CFIT the full-implementation effectiveness was assumed to be 90%.

Progress on implementation affects traffic/mid-air accidents differently. While an average of 72% of Part-135 flight operations from 2000 through 2003 were equipped, only about 2/3 of all flights are Part-135 (the remainder are mostly Part-91 and public use). On average, if a Part-135 aircraft was at risk of a mid-air collision with a second aircraft, the chance they were both Capstone-equipped was only 48%. Limited training levels can reduce this further. For 2000-2003 we estimate that 25% of mid-air accidents should be avoided as a result of Capstone (assuming full-implementation effectiveness of 100%).

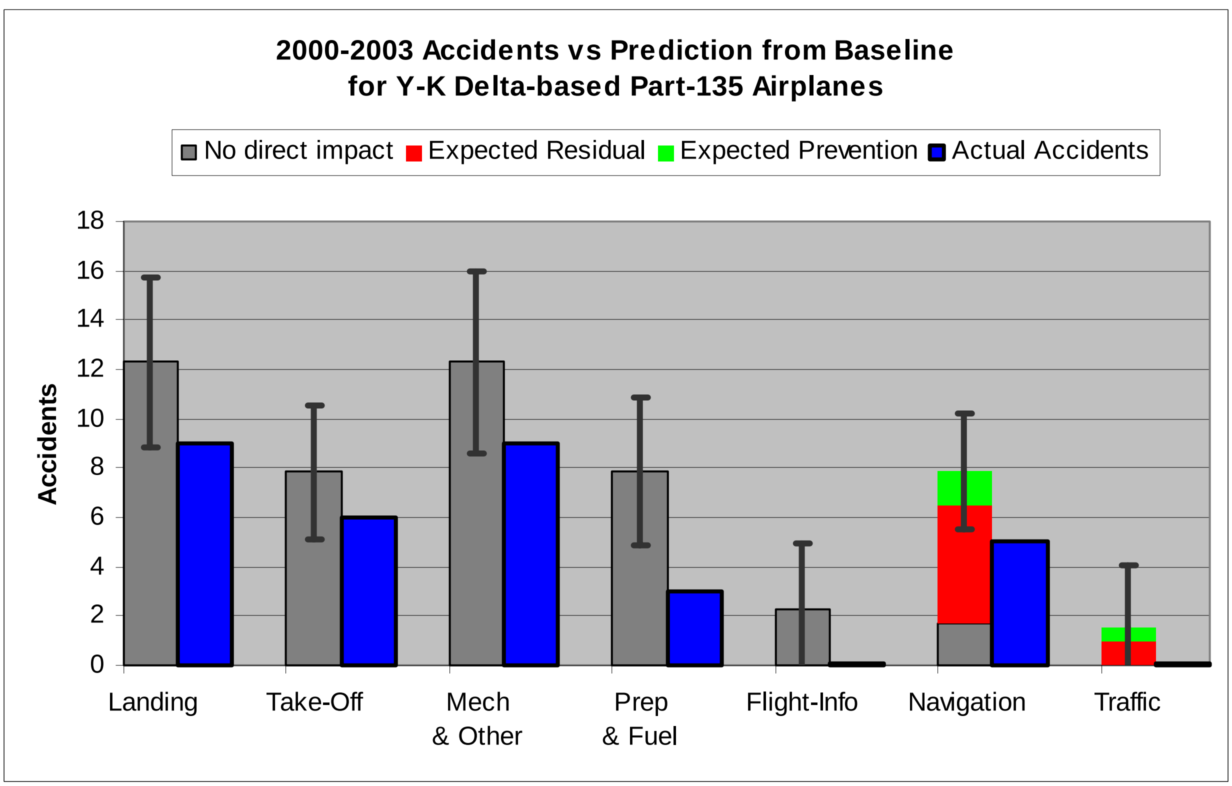

Figure 9 2000-2003 Accidents vs Prediction for YK Delta Part-135

Figure 9 uses these estimated safety benefits for Navigation and Traffic accidents to project the number of accidents we should expect in 2000-2003 for Part-135 aircraft based in the YK Delta and compares this to the number that actually occurred. The projection uses the types and rates of accidents from 1990-99 scaled-up for observed growth in operations. The figure also shows error bars for the numbers of accidents that should be expected from history. This is the standard deviation for four-year periods scaled for growth. If there were no underlying changes in accident rates, the chance of observing a number in this range would be about 67%. For small numbers such as these, this variability is large compared to the average value (this is particularly true for fatal accidents, which are only about one tenth as numerous). In many cases, observing zero accidents is well within typical variations, and a gap in accidents will need to persist for several years before we can be certain it is significant. The estimated navigation and traffic accidents prevented by Capstone in 2000-2003 are comparable to these expected random variations. This means that further time will be needed at high levels of equipage and training before reductions of specific types of accidents can become statistically significant.

Accidents in 2003

The left side of Figure 10 shows a detailed categorization of YK Delta Part-135 airplanes involved in accidents in 2003. All Part-135 aircraft based in the YK Delta were Capstone equipped. The right side of the figure shows all Part-135 accidents since Capstone implementation began – both equipped and not. (In each case the population reported is airplanes based in the YK Delta flown by historically Part-135 operators, including those changed to Part-121 since 2000. In 2003 this omits one crash by a helicopter and one crash inside the Delta by an airplane based elsewhere. Neither were capstone equipped and neither were from causes targeted by Capstone.)

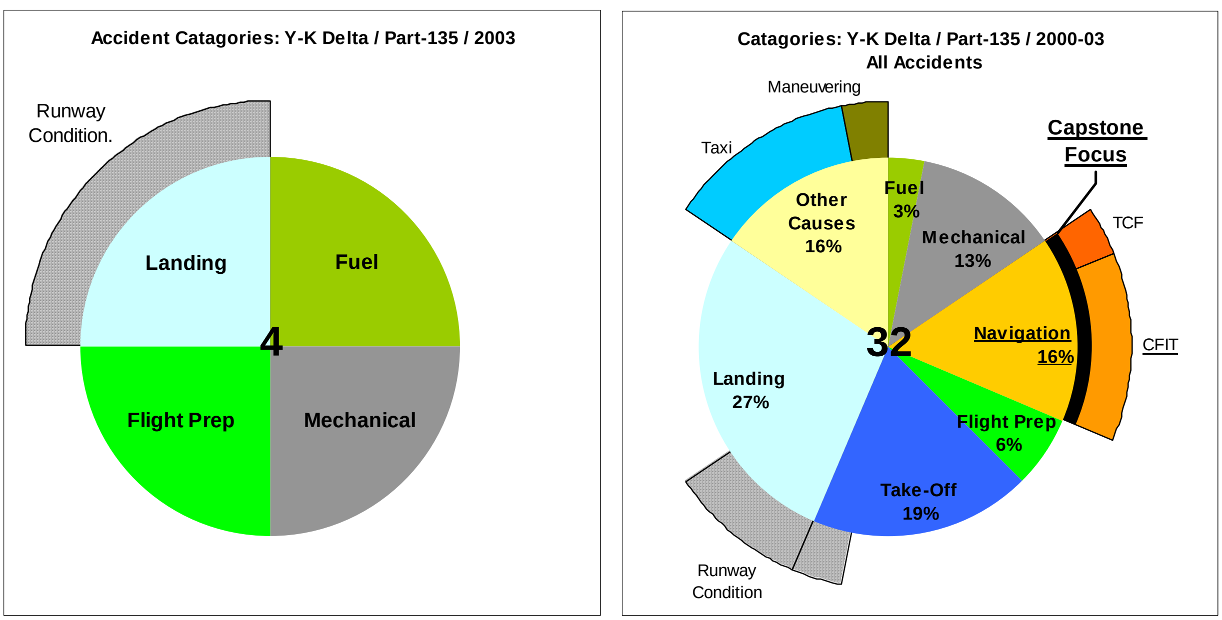

Figure 10 Categories of Accidents to YK Delta Part-135 Airplanes in 2003, and Since the Beginning of Capstone Implementation

Figure 11 shows accident categories for non-equipped and equipped aircraft since 2000. The breakdowns of accidents by major category are essentially similar and within the levels of variation one should expect for this number of occurrences. The 2003 MITRE report noted that Capstone-equipped aircraft had no accidents involving poor runway conditions (two *sub*-categories) compared to three accidents (23% of the total) for non-equipped aircraft. A potential explanation was offered:

> "From observations and discussions during surveys it was observed that when flying to a remote village airstrip, some pilots are monitoring the traffic display to identify other aircraft that go there before them. The pilots contact the other aircraft by voice radio, request information on conditions at their destination, and are forewarned of hazards they should avoid." However it was also noted that "in the baseline, most YKD-135 runway condition accidents were from general deterioration of a runway that pilots were aware of and had misjudged to be manageable."

One such accident has now occurred for a Part-135 aircraft, but lack of runway condition information was not indicated as a cause. Thus, the proposed explanation continues to have merit, and reports of pilots using the system in this way have continued.

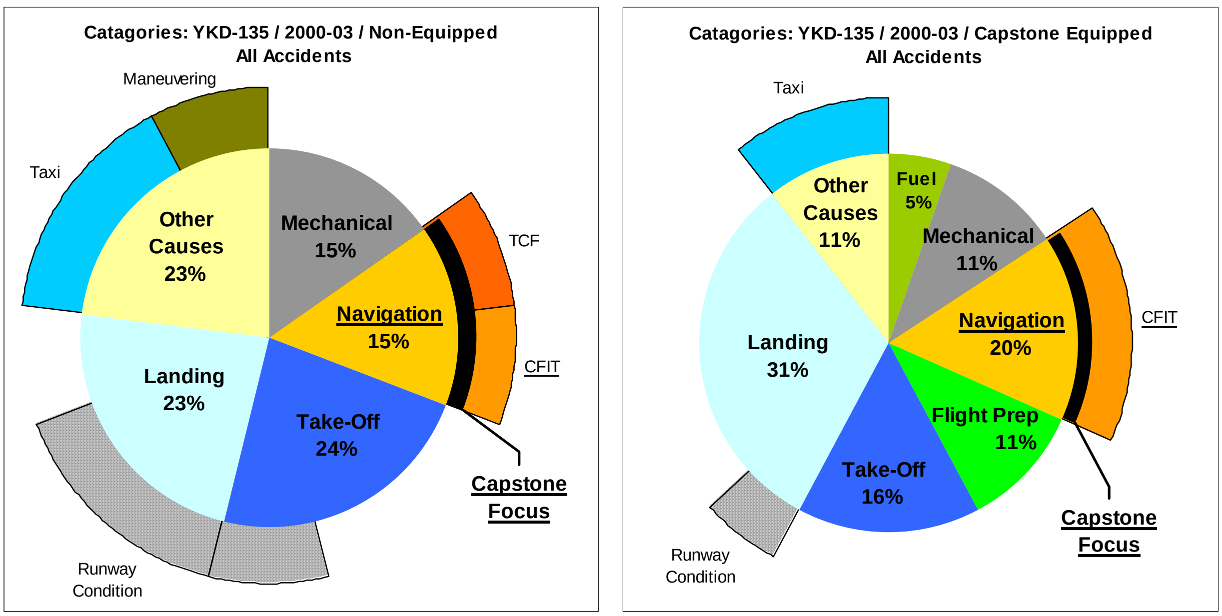

Figure 11 Categories of Accidents by Non-Equipped and Capstone-Equipped YK Delta Part-135 Aircraft 2000--2003

Comparison of YK Delta Accident Rates to Other Parts of Alaska

Figure 12 shows departure count, accident count, and accidents per 100,000 departures for Part-135 and Part-121 aircraft within the YK Delta and for all other flights in Alaska. The scale for accident rate (the wide red bars) is the same in both the upper and lower sections of the figure, indicating that over time the accident rate within the YK Delta has been two to four times the rate for other parts of Alaska. From year to year, the accident rate in the Delta is also much more variable than in the remainder of Alaska.

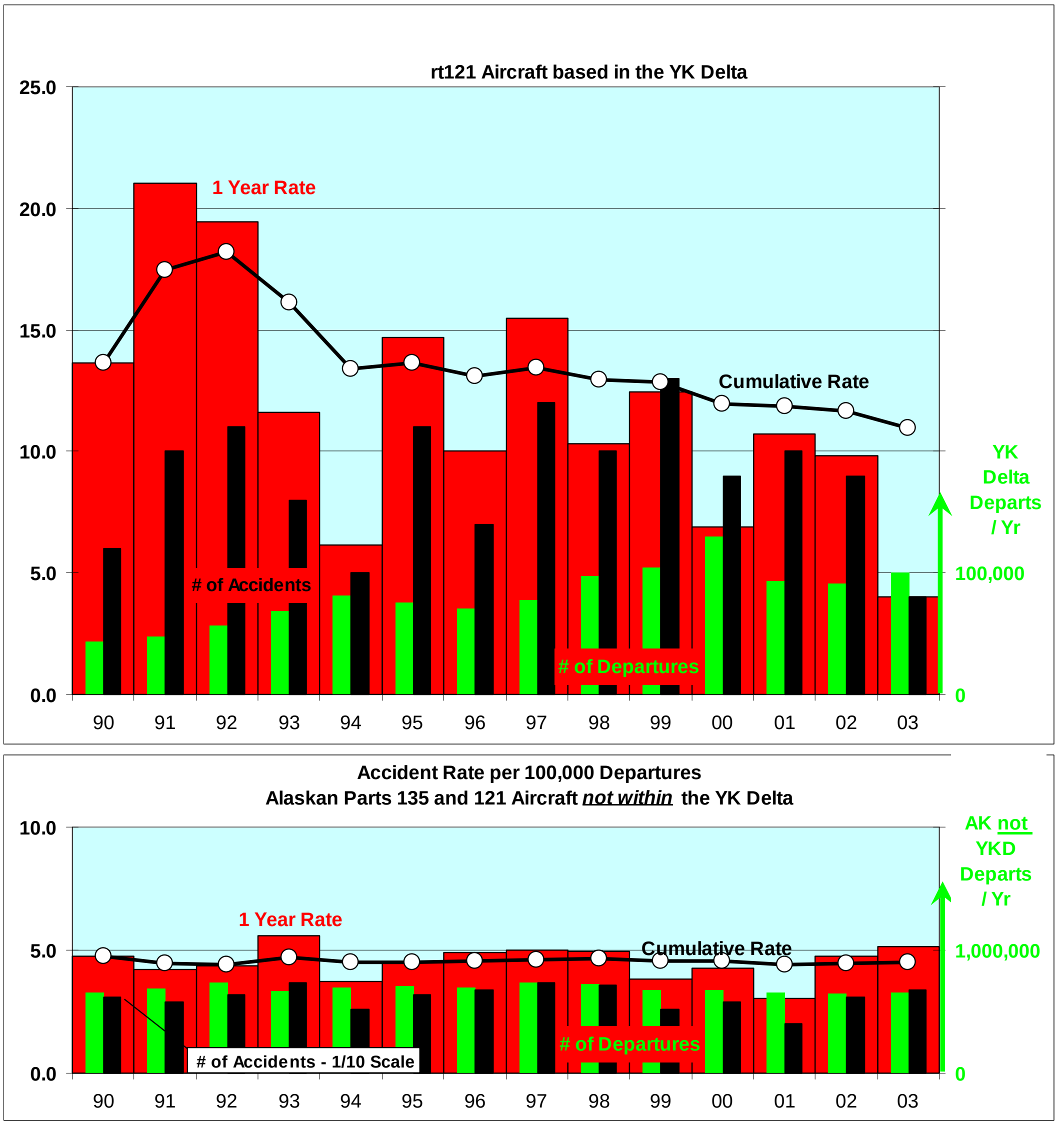

Figure 12 Accident Rates for YK Delta Part-135 Aircraft and Those Based Elsewhere in Alaska

The continuous curve (black line with white dots) on each chart represents the cumulative total rate of accidents per departure from 1990 to the year shown. For other parts of Alaska, this cumulative rate has been quite stable. For operations in the YK Delta, there was a substantially higher rate of accidents in the early '90s from which the cumulative average has been slowly falling. The figure also shows that **the accident rate for the past year for commercial flights in the YK Delta, all of which are Capstone-equipped, is the lowest it has been since the beginning of our accident baseline in 1990, and the accident rate in the Delta has fallen to below the rate for the rest of the state for the first time.**

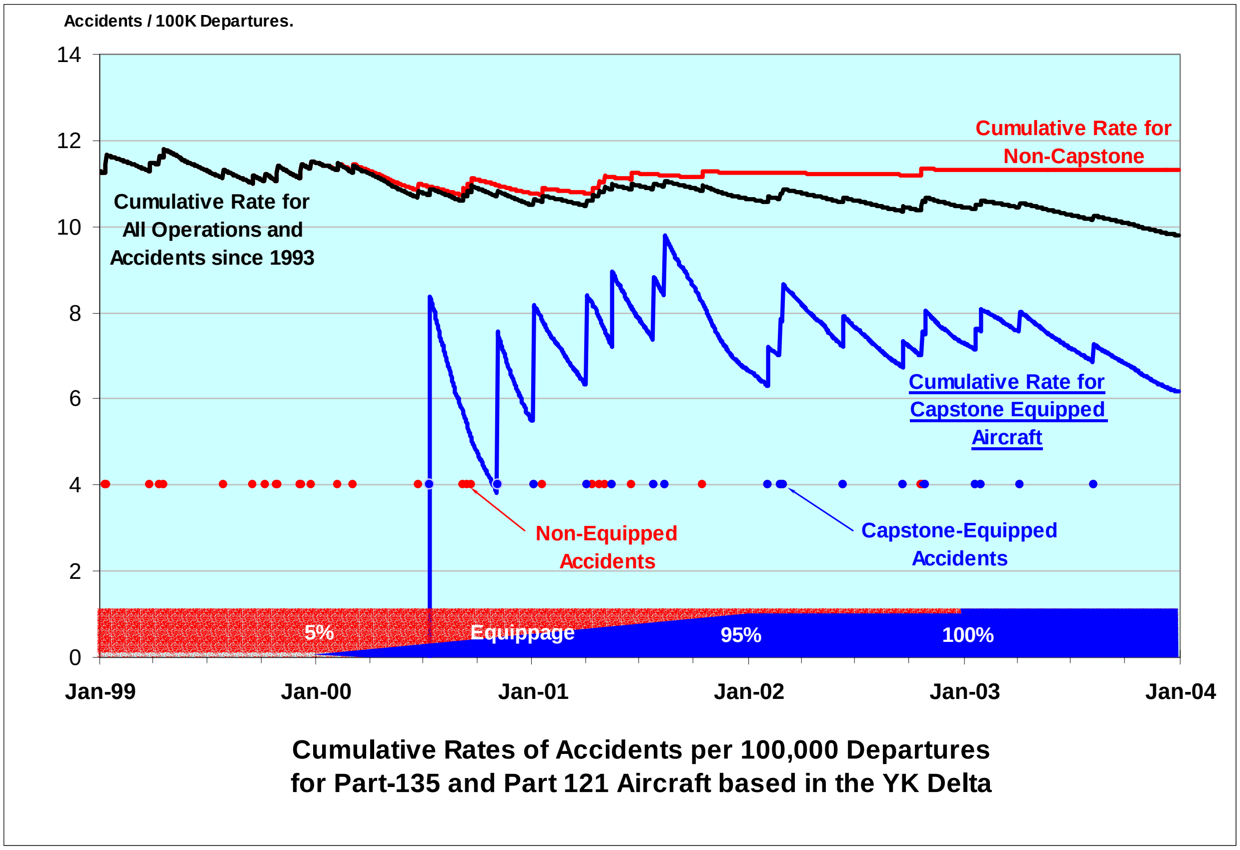

Figure 13 Relative accident rates for YK delta part-135 aircraft without and with Capstone avionics

The relative stability of Part-135 accident rates in the YK Delta since 1993 extends through the end of 2002 for aircraft not equipped with Capstone. A time-magnified view for 1999-2003 (using daily data), is shown in red on Figure 13. The blue line is the equivalent curve for Capstone equipped aircraft. There were no accidents and few operations before July '00, so this curve is less stable. Nevertheless, the Capstone equipped accident rate appears to have trended strongly towards stability at a rate significantly below that for non-equipped aircraft. **The rate of accidents by Capstone equipped aircraft is lower than that for non-equipped aircraft.** The rate for equipped aircraft still varies[9] due to the smaller volume of data. **The percentage improvement from 2000 through 2003 is over 40%, though this has varied and will continue to vary significantly because of random fluctuations.** These results do not determine whether the improvement is due to safety benefits of the specific Capstone capabilities, or to a heightened attention to safety on the part of pilots and companies flying Capstone equipped aircraft.

[9]The end of 2001 was a low-point, corresponding to the 40% difference observed at the time of the 2002 report. The end of 2002 was a high point, with only about a 25% reduction.

Notes on operations data used in this report

Understanding annual accident counts (and changes in accident counts) is best based on a characterization of accident rates, which are measured in this reports as accidents per 100,000 departures. Historically, for Part 135 operations within the YK Delta, this number of departures has not been measured. Only at Bethel could it be characterized (from the FAA's ATADS tabulation of air traffic at towered airports).

Recently, additional information has become available in the form of monthly T-100 Segment Data, compiled by the Bureau of Transportation Statistics from Form 4100 scheduled air carrier reports. Small scheduled air carriers in Alaska began providing this data in January 2002. T-100 includes for each carrier/origin/destination, the number of departures performed, the number that were scheduled (which may be zero), and the total passengers, freight and mail moved on the segment in revenue operations. Prior to January 2002, small scheduled carriers reported quarterly on form 298C. Schedule T-1 of 298C reports passengers, fright and mail moved on scheduled flights from origins to destinations. Schedule E-1 (available only from 1995) reports passengers (only) from origins (only) on flights that were not scheduled. Schedule A-1 reports total aircraft revenue miles, revenues seat-miles, passenger-miles, freight ton-miles, and mail ton-miles for each carrier's operations as a whole.

Also, beginning with July 2002, data from Capstone's flight monitoring system "CRABS" (for Comprehensive Real-Time Analysis of Broadcasting Systems – developed and operated by the Johns Hopkins University Applied Physics Laboratory) has been collected which allowed us to estimate hours flown by unscheduled charter operators as a percentage relative to flight hours by scheduled operators.

The availability of T-100 data allows operations by carriers with scheduled flights to be known accurately for 2002 and 2003, including all flights from Bethel, flights from Bethel to elsewhere in the YK Delta, and total flights between hubs or villages within the YK Delta. It also allows characterization relative to Alaska as a whole. We used this geographic distribution of flights to determine a scale factor for operations within the YK Delta as a whole relative to operations at Bethel as reported in ATADS tower data. We estimated operations in Alaska outside the Delta similarly, using Alaska towers other than Bethel.

We validated the estimate for the YK Delta two ways. First, we examined the geographic distribution of passenger, freight and mail movements in 298C T-1 and E-1 data for the period from 1995 through 2001 and confirmed that these were relatively constant. Second, we modeled these operations independently from the ATADS data and compared the results. For scheduled flights by scheduled carriers we derived regression models for the number of flights per passenger, per ton of freight, and per ton of mail from 2002-2003 T-100 data on routes with non-zero scheduled flights. This provided a formula (as set of scaling relationships) to estimate the number of scheduled flights by carrier/origin/destination from the 1990-2001 T-1 reports. A similar (though slightly more complicated) calculation for unscheduled flights was derived from 298C E-1 data using load estimates taken from A-1. We estimated charter flights as a fixed ratio to flights by scheduled carriers using flight-hour ratios observed by CRABS. We compared the sum of these three types of operations to what we derived by scaling ATADS.

For the period 1995 through 2001 both estimates correspond closely except for an anomalous increase in reported BET tower operations in the final two quarters of 1999 and the four quarters of 2000. In this period, which has been remarked on in previous reports, reported tower operations exceeded all levels before or since and did *not* correspond to carrier reported passenger enplanements, cargo, or mail. This 18 month period was in the early part of Capstone implementation when few aircraft were equipped. If our operations estimates for this period were based on carrier reports instead of tower reports, the operations count for non-Capstone aircraft would be lower, the accident rate would be higher, and the estimated reduction in accidents for Capstone equipped aircraft would be larger than we have shown.