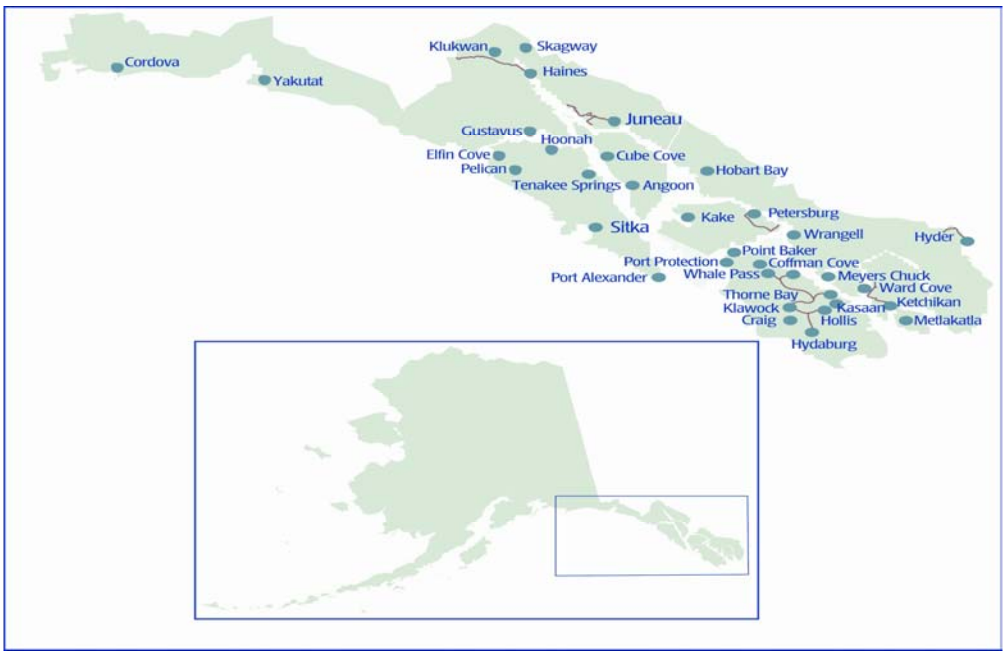
# Implementation Progress of Capstone Phase II
## Summary for 2004

**July 2005**

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**Highlights of the Implementation Progress of Capstone Phase II**

During 2004 the Capstone program made some progress toward implementation of capabilities designed to improve commercial aviation in Southeast Alaska.

During 2004 Capstone has successfully:

- Gained approval for 19 new RNAV Approaches/Departures and four special RNAV routes in Southeast Alaska.
- Completed the first installation of Garmin avionics in a Phase II aircraft.
- Partially completed Capstone Phase II scheduled modifications for 36% of the fleet. The modifications on these aircraft will be complete once Chelton connects the interface with the Universal Access Transceiver.

During 2004, Capstone plans have experienced some setbacks. Descriptions follow.

- Chelton's implementation of the UAT interface and the processing on broadcast services information within the Chelton avionics is substantially behind schedule. The result is few of Capstone's air-ground capabilities and none of the air-air, and ground-air broadcast services capabilities are in place. Cockpit traffic display, operator flight monitoring, FAA radar like services, and cockpit weather display are not yet available. The aircraft already equipped with the Chelton EFIS/PFD/MFD subsystem are not able to display ADS-B traffic or FIS-B weather, and not able to exchange information over the UAT data link. As an interim measure, Capstone plans to install the Garmin UAT subsystems, configured for transmit-only, in these Chelton equipped aircraft without interconnecting them with the Chelton avionics, resulting in these aircraft being "seen" by other fully configured Capstone equipped aircraft and the FAA ground system, even though they can't receive or interpret the data link themselves.
- Reliability of the Chelton system and turnaround time for repaired components has been a key concern of the operators. The Air Data Computer has been especially troublesome in 2004.
- The continuing laborious process of developing and certifying ground infrastructure components appears to be a factor in the delay of the full implementation of the Capstone Phase II program. Certification of the GBTs is not expected before summer 2005.
- At the end of 2004, no helicopter operators in SE had yet agreed to a Capstone installation. The primary reason was the lack of instrument panel space for both a primary flight display and a navigation display. Although commercial operators are anxious to be able to "see" other aircraft via the data link, helicopters are a substantial part of the air traffic flow near Juneau and will remain "invisible" on Capstone displays.

# Implementation Progress of Capstone Phase II

## Summary for 2004[1]

### 1 Introduction

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. FAA started Phase I of the Capstone program during 2000 in the watershed of the Yukon and Kuskokwim rivers of southwest Alaska – the Y-K Delta. In March 2003, the FAA began Phase II in Southeast Alaska. This report summarizes Phase II's progress in 2004.

### 1.1 Background

Capstone Phase II is installing a suite of IFR-capable avionics in commercial aircraft in southeast Alaska, building ground infrastructure for aircraft surveillance and up-link of weather and flight information, installing automated weather observation systems and remote ATC voice communication sites, and increasing the number of airports served by instrument approaches. Capstone is also making important changes in air space requirements to reduce minimum enroute altitudes on some airways so that suitably equipped aircraft can provide greater air transportation access to cities and villages in Southeast Alaska during poor weather conditions. The FAA expects these improvements will reduce the number of mid-air collisions, controlled-flight-into-terrain (CFIT) accidents, and weather-related accidents while lowering weather-related restrictions that affect routine and emergency air transport.

The program focuses on passenger and cargo operations under Parts 133 and 135 of Federal Aviation Regulations (FAR; 14 CFR, Chapter 1). Part-135 operators typically fly air taxi, commuter, and sightseeing (flightseeing) operations. Part-133 operators use helicopters for various non-passenger activities such as helicopter logging. Aircraft owned by these carriers will be eligible to receive Capstone Phase II avionics. Float planes, flying under Visual Flight Rules (VFR) in the summer season, account for a large share of FAR Part-135 operations in Southeast Alaska and will also be receiving this equipment.

### 1.2 Description of the Capstone Phase II Area

Capstone Phase II covers an area of Alaska south of latitude 61 degrees north and east of longitude 146 degrees west. As shown in Figure 1, this area includes Alaska's panhandle and extends westward from the north end of the panhandle along the Gulf of Alaska to Cordova near the eastern edge of Prince William Sound. The area is relatively isolated. Only a few villages are connected by roads, and only Haines and Skagway have a road that connects to the Alcan Highway providing access to cities in Canada, or to the Lower 48. Residents travel by air or water. The 45 communities in the area have more than 75,000 residents with almost half living in the regional hub of Juneau, which is also the state capital. Of the 44 other communities, 29 have fewer than 500 residents. Figure 1 also shows the general levels of flight activity by scheduled operators.

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[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.

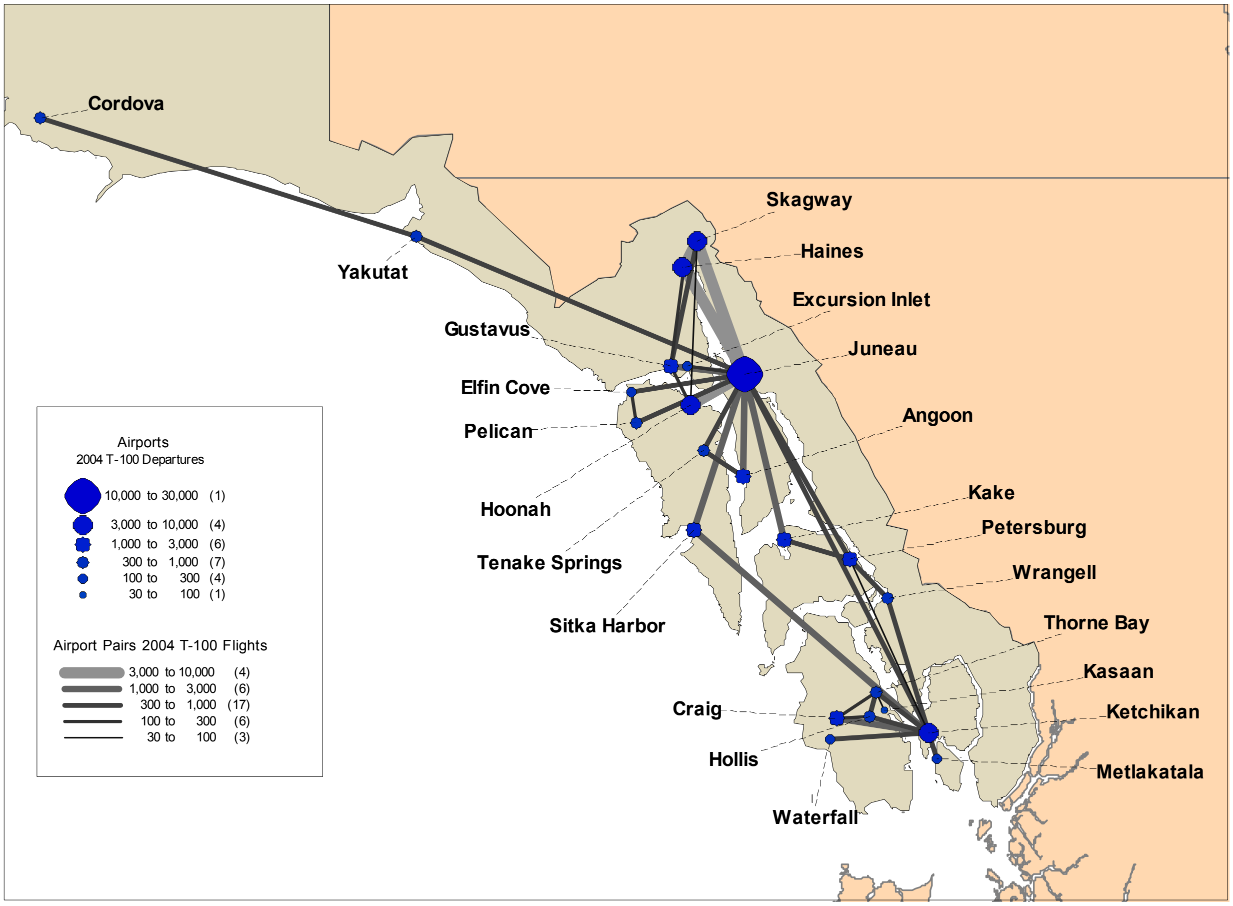



**Figure 1. Southeast Alaska Major Communities**

## 1.3 Aviation Access Prior to Capstone

Southeast Alaska has 102 airport facilities—25 airports, 9 heliports, and 68 seaplane bases. These numbers are greater than those presented in the Baseline Report due to a later analysis of the flight patterns in Southeast Alaska which indicated other facilities should be included. Figure 2 summarizes the scheduled and unscheduled departures in Alaska in 2004 by Part-135 aircraft that are required to report their operations. Operators with no scheduled flights or operating as on-call charters are not required to file flight data with the Bureau of Transportation Statistics and are not included in the figure. This figure indicates that 14% of the flights are either completely within the Capstone Phase II area or are flying from/to other points in Alaska to/from the Capstone Phase II area. Of these, approximately 10% of the Phase II aircraft fly completely within the Capstone Phase II region with 77% departing from six airports.

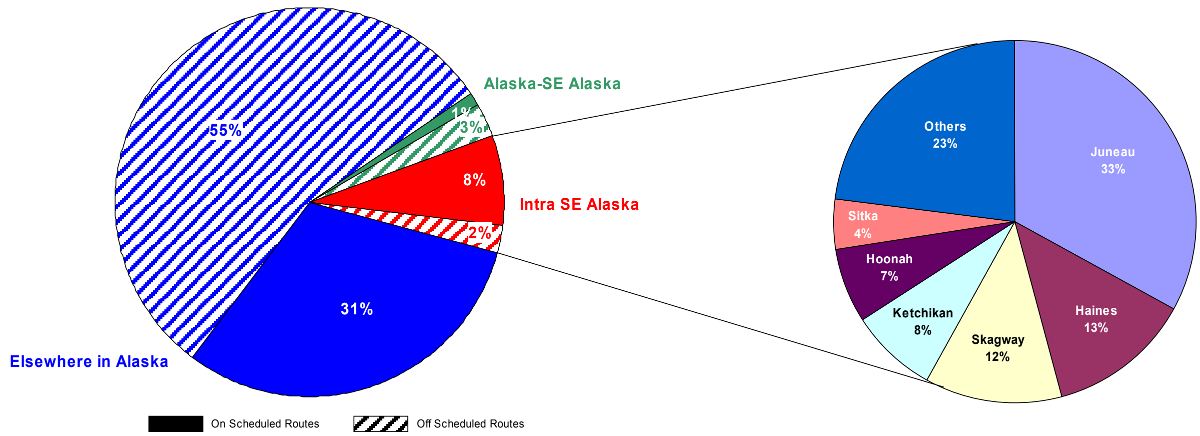



**Figure 2. Scheduled and Unscheduled Alaska Flights To or From Capstone Phase II Airports**

Weather, terrain, and communications are primary limitations on aviation access in Southeast Alaska. Weather hazards include several conditions that create poor visibility and low ceilings. The area is a marine environment with extremely variable weather and frequent storm systems with low ceilings and fog. Many destinations in the area do not have weather reporting facilities. Operators depend on area forecasts and pilot reports to make Go/NoGo decisions. Some flight routes have long distances between weather stations; for example, the route from Yakutat to Sitka is 201 nautical miles between weather stations. The terrain is extremely mountainous, which often causes low enroute ceilings due to fog and clouds trapped in the area's numerous valleys. These low ceilings reduce flight dispatch capabilities due to the Minimum Enroute Altitude (MEA). The mountains and the valley and inlet locations of most airports restrict aircraft-to-ground and line-of-sight communications abilities.

## 1.4 Accidents Prior to Capstone

There were 223[2] accidents within the Phase II area reported by the National Transportation Safety Board from 1990 through 2002. The Capstone Phase II Baseline Report divided these into the categories and sub-categories described in Table 1. The result of this categorization of these accidents is presented in Figure 3.

For all of the accident charts in this section, the inner pie shows all accidents divided into major categories, the outer pie extensions show more detail within the major categories. For example, difficulties with off-airport landing sites may occur, such as soft spots on packed sand or unseen logs during water landings float planes flying in the summer are indicated by the extension labeled as 'Site' outside the wedge labeled 'Landing'.

[2] Revised data after Capstone Phase II operating areas were validated. The previous accident total of 231 in the UAA-ISER's Phase II Baseline Report was modified after the specific operating areas were defined and the accident locations were identified.

**Table 1. Accident causal categories**

**Basic Cause Categories**

1. **Mechanical:** Engine failure, inoperable control surfaces, failed landing gear or floats, propeller or shaft failure.
2. **Navigation:** Controlled Flight into Terrain (CFIT) while en route is often associated with reduced visibility and small navigational errors. Some CFIT accidents are due to pilots being off-course.
3. **Traffic:** Usually mid-air collisions. Also includes ground or water accidents from last-moment avoidance of other aircraft and from jet blast on airport surface.
4. **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.)
5. **Fuel:** Accidents caused by fuel mismanagement.
6. **Flight Prep:** 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.
7. **Takeoff:** Accidents during take-off, including pilots' failure to maintain control in wind, improper airspeed, waterway debris, hazards at remote lakes, rivers without markings or moorings, poor runway conditions and obstacles at off-runway sites.
8. **Landing:** Accidents during landing, including pilots' failure to maintain control in wind, improper airspeed, waterway debris, hazards at remote lakes, rivers without markings or moorings, poor runway conditions and obstacles at off-runway sites.
9. **Other:** Includes colliding with watercraft or ground vehicles, hitting birds and pilots under the influence of alcohol or drugs.
10. **Unknown:** Missing aircraft, cause not determined.

**Cause Sub-Categories**

**Runway:** Accidents on take-off or landing related to runway or waterway conditions such as potholes, submerged obstacles the runway
**Site:** unusual hazards of water or off-runway sites
**Water taxi:** collisions with objects (not a/c) while taxiing on the ocean, rivers or lakes
**Maneuvering:** Typically, stalling the aircraft while maneuvering

**Capstone Relevant Sub-Categories or Categories**

**Weather**: Accidents where the availability of weather information was a factor.
**CFIT:** Controlled Flight into Terrain (or Water) accidents
**TCF:** Terrain Clearance Floor violation - CFIT that occurs on approach or departure.
**Map:** Accidents where the pilot did not know aircraft's location
**Midair:** Midair Collisions between aircraft.
**Runway Collisions:** between aircraft on the ground or water.
**Fuel**: Accidents caused by fule mismanagment.

**NOTE:**

This analysis is from UAA-ISER's Phase II Baseline Report and reflects the applicability of Phase I avionics plus TCF violations and runway collisions. It is updated here only to reflect fuel management enhancements available with the Chelton avionics. Chelton also includes other capabilities such as glide-range guidance that might help with emergency landings and Highway In The Sky (HITS) guidance which may help with complex navigtion. Re-analysis of the historical accidents in light of additional capabilities will be performed in the coming year.

There is a transition period from calendar year (CY) 2003 through CY 2004 that is after the designated project baseline but before implementation has reached a point where any significant benefit could be realized. During this period, only a limited number of aircraft were modified (and these only partially completed) and the supporting ground infrastructure was not yet available. Some benefit could be expected due to improved GPS-WAAS and avionics capabilities, new route structures and additional training received by pilots, but there is insufficient data at this point to provide any meaning analysis. From 2003 through 2004, there were an additional 23 accidents within the Phase II area. Figure 4 shows the categorization of these accidents.

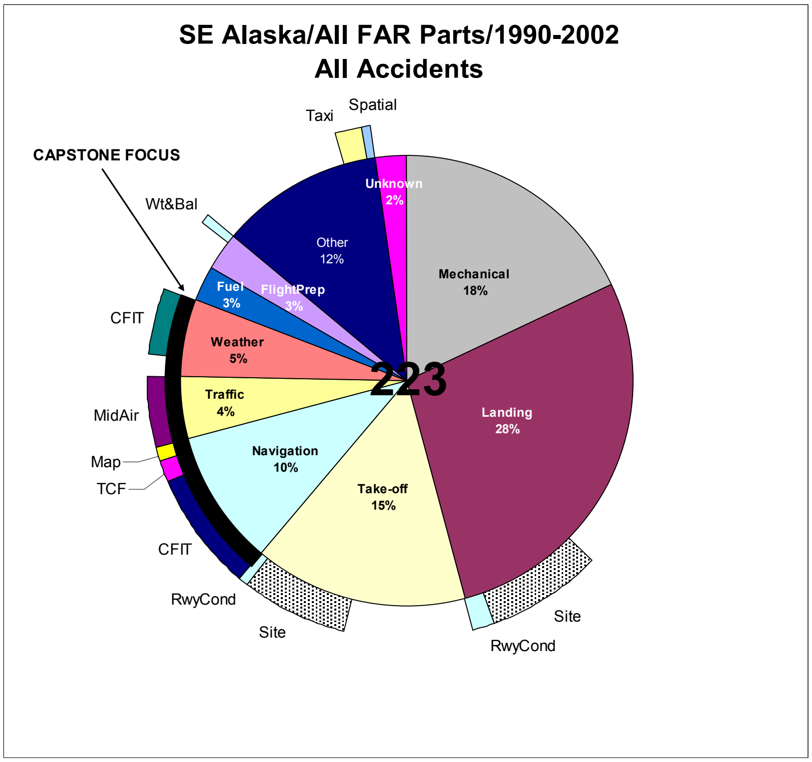
As reflected in Table 2, there is a reduction in the annual rate of accidents in each overall statistical category between the baseline period and the transitional period. It should be noted that numerous factors can have an effect on reducing or increasing annual accident rates such as weather conditions, other safety initiatives, or a general emphasis on safety by pilots and companies. A number of factors can contribute to the accident reductions in the Phase II area and it is too early to determine Capstone's contribution to recent accident reductions in Southeast Alaska.

**Table 2. Baseline Period 1990-2002 and Phase II Period 2003-2004**

| Summary Period | 1990-2002 | 2003-2004 |
|---|---|---|
| Total Accidents | 223 | 23 |
| Average Per Year | 18.6 | 11.5 |
| Total Fatal Accidents | 53 | 5 |
| Average Per Year | 4.4 | 2.5 |
| Total Accidents FAR Part 135/121 | 66 | 7 |
| Average Per Year | 5.5 | 3.5 |
| Total Accidents FAR Part 91/133 | 156 | 16 |
| Average Per Year | 13 | 8 |
| Total Fatal Accidents FAR Part 135/121 | 17 | 1 |
| Average Per Year | 1.4 | 0.5 |
| Total Fatal Accidents FAR Part 91/133 | 36 | 4 |
| Average Per Year | 3.0 | 2.0 |

Capstone avionics, training and information are efforts to help pilots avoid CFIT accidents, collisions between aircraft, and some accidents where flight information is a factor. From 1990 through 2002 during the baseline period and from 2003-2004 during the Phase II transition period in Southeast Alaska about 18 percent, or 44 of the total 246 accidents, are from causes specifically targeted by Capstone Phase II. These might have been prevented if the Capstone program had been in place. These causes are highlighted in the figure with a dark band. Also important are fuel management (categorized as 'Fuel') accidents which the new avionics may help preventing. Even though equipage of Capstone avionics is still in progress and full capabilities are not available, early indications appear promising when comparing the baseline period of 1990-2002 and the initial Phase II period of 2003-2004.

Categories of the 58 ***fatal*** accidents in Southeast Alaska during the same period are shown in Figures 3 and 4. These figures indicate that Capstone could potentially have prevented a much larger fraction of the accidents that were fatal than the non-fatal ones. Nearly half of 58 fatal accidents are from causes specifically targeted by Capstone Phase II and were due to causes that Capstone avionics, training, and data are intended to address. The largest share of fatal accidents is identified as CFIT accidents, operating either in cruise flight or on approach or departure.



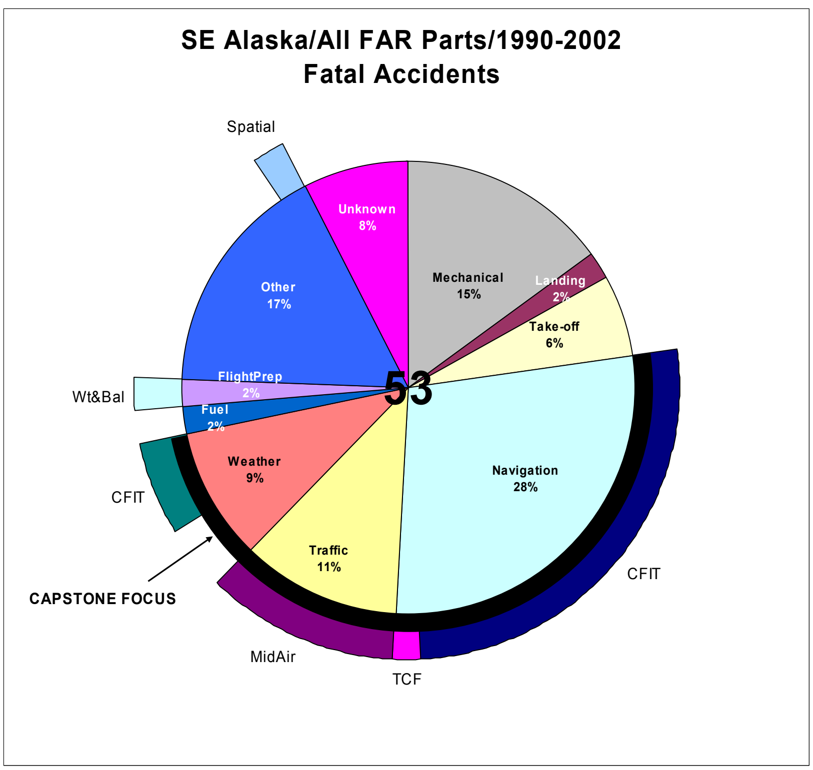
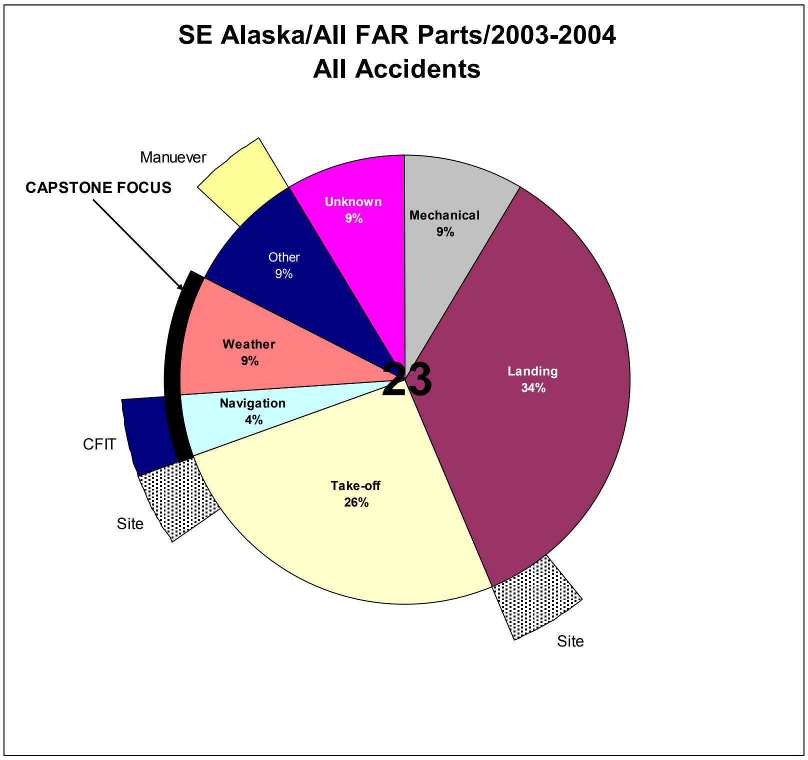




**Figure 3. Accidents in the Phase II area, by Category, 1990-2002**



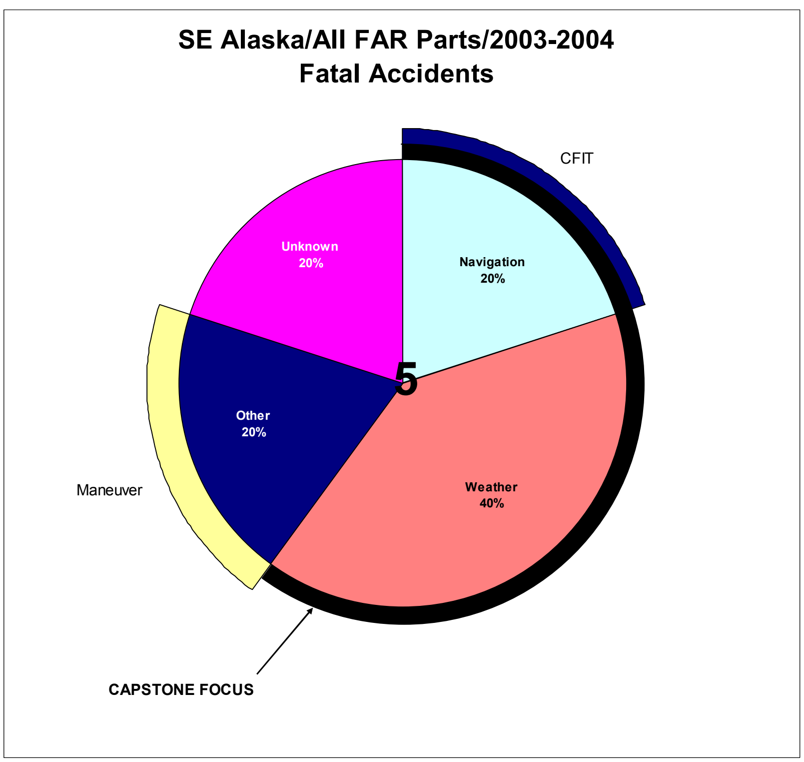




**Figure 4. Accidents in the Phase II area, by Category, 2003-2004**

The primary causes of the overall accidents and the primary causes of fatal accidents had very different percentages. Many accidents which occurred during takeoff, landing, or have a primary cause identified as mechanical, did not have associated fatalities. For example, between 1990 and 2004 there were 57 accidents of fixed wing aircraft categorized as 'Landing' with only 1 having fatalities. By contrast there were 19 accidents of fixed wing aircraft categorized as 'Navigation' (sub-categorized as CFIT or TCF) with 15 accidents having fatalities and there were 9 Mid-Air collisions with 5 suffering fatalities. It is the goal of the Capstone Phase II to address these serious accidents.

Overall accident reduction is cautiously expected in the Phase II area once the avionics equipage and ground infrastructure reach targeted levels. Based on the summary report of the Capstone Phase I area[3] reflecting a 40% reduction in accidents from 2000-2003, it is hoped to see accident reductions in the Phase II area while recognizing differences in the nature of flight operations and other environment factors between the two regions.

[3] The Safety Impact of Capstone Phase 1. Summary Report through 2003
May 2004 University of Alaska Anchorage, MITRE Corp. Center for Advance Aviation System Development

## 2 The Capstone Phase II Program

Capstone seeks near-term safety and efficiency gains in aviation by accelerating implementation and use of modern technology. The capabilities of Capstone Phase II target four serious safety problems in Southeast 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

### 2.1 Program Overview

Capstone implements new technologies enabling pilots to cope with terrain, traffic conflict and weather hazards. These technologies also allow dispatchers/operators better means to monitor their aircraft and give air traffic controllers expanded surveillance coverage to provide Air Traffic Control (ATC) services.

Regarding the expansion of IFR operations, the first objective supporting this goal is to allow the use of GPS/WAAS technology for the enroute portion of flights on routes in Alaska outside the operational service volume of ground based navigation aids. This requires changes to Federal Aviation Regulations, and the results are threefold. First, it permits satellite navigation as the only means of navigation needed onboard the aircraft. Second, it allows the use of lower Minimum Enroute Altitudes (MEAs) than those currently based on ground-based navigation aids. In this process, Capstone used current Terminal Instrument Procedures (TERPS) criteria for enroute airways; however Capstone applied it to the use of the GPS/WAAS navigation signal. Low enroute RNAV GPS MEAs will eventually cover the entire region and become available publicly. Third, it promotes safety by creating and promoting a usable IFR environment that allows an IFR option for pilots that have had to fly predominantly in the visual flight rules (VFR) environment that exists today.

The second objective is to establish new departure and approach procedures, initially at Juneau, Haines, Hoonah and Gustavus airports and, with operator acceptance, expand to other parts of Southeast Alaska. This allows safer airport-to-airport access. These procedures will be developed as “specials” and achieve the lowest possible minimums for RNAV/GPS non-precision approaches by applying waivers with special training and equipment requirements to current TERPS criteria.

Activities supporting these objectives include certifying and installing state-of-the-art GPS/WAAS avionics, amending air routes to achieve lower MEAs, developing special approach and departure procedures, filling communication gaps, and ensuring accomplishment of all supporting training and operational approval guidance for operators as well as FAA oversight personnel.

Capstone is also providing additional flight and traffic information services in Southeast Alaska to improve overall safety. This initiative promotes better situational awareness of weather and other traffic by expanding the Automatic Dependent Surveillance-Broadcast (ADS-B) ground infrastructure to Southeast Alaska and adding data link avionics. This will provide a data link to include ADS-B and Flight Information Services-Broadcast (FIS-B). The objective is to use multiple means to alert pilots of possible traffic conflicts and weather hazards. Adding a universal access transceiver (UAT) to the avionics will enable display of other ADS-B aircraft (cockpit display of traffic information or CDTI). Installing an ADS-B ground system will provide track information to controllers and Automated Flight Service Station (AFSS) specialists. The UAT data link will also be used to relay weather information to the cockpit. Multilateration and Traffic Information Services – Broadcast (TIS-B) are being evaluated for possible inclusion in the future to complete the surveillance picture in the cockpit.

## 2.2 Systems and Capabilities

Capstone is using evaluating the complete Southeast Alaska communications, navigation, and surveillance/air traffic management (CNS/ATM) infrastructure to establish the system necessary for Phase II operations. Figure 5 depicts Phase II capabilities. Avionics systems are being installed to enable instrument approaches/departures and GPS/WAAS navigation on lower-altitude airways. This also requires the publishing of new navigation charts and instrument departure and approach procedures for use by pilots and controllers. New communications transceiver sites support this by preventing gaps when MEAs are lowered below the line-of-sight of existing communication sites. Finally, new weather observation facilities are included at airports to meet the requirements of commercial IFR operations.

There are now two airborne configurations available to the operators: a primary flight display (PFD) multifunction display (MFD) pair developed by Chelton and a Garmin MFD similar to the Phase I avionics. Garmin was added when the operators wanted a less complex and more compact installation. The operators can select the configuration that best suits their operations and aircraft. Both are coupled with WAAS-GPS receivers capable of increased accuracy and integrity to enable Capstone area navigation (RNAV) capabilities. Automated Weather Sensor System (AWOS), Remote Communications Air-Ground (RCAGs) facilities and Remote Communications Outlets (RCOs) complement and support these airborne components. Phase II also includes traffic situation awareness displays in the Juneau Air Traffic Control Tower (ATCT) and Juneau Aeronautical Flight Service Station (AFSS), connection into existing air traffic automation and display facilities at Anchorage ARTCC (Air Route Traffic Control Center) through interconnecting telecommunications via the Alaska NAS Inter-Facility Communications System (ANICS), and ground broadcast transceiver (GBT) sites which communicate with the aircraft avionics.

Capstone Phase II plans to integrate these new and existing systems and equipment to complement RNAV services and provide a lower altitude, usable IFR infrastructure. Together, these systems and equipment should enhance operations and safety in the Southeast Alaska airspace system.

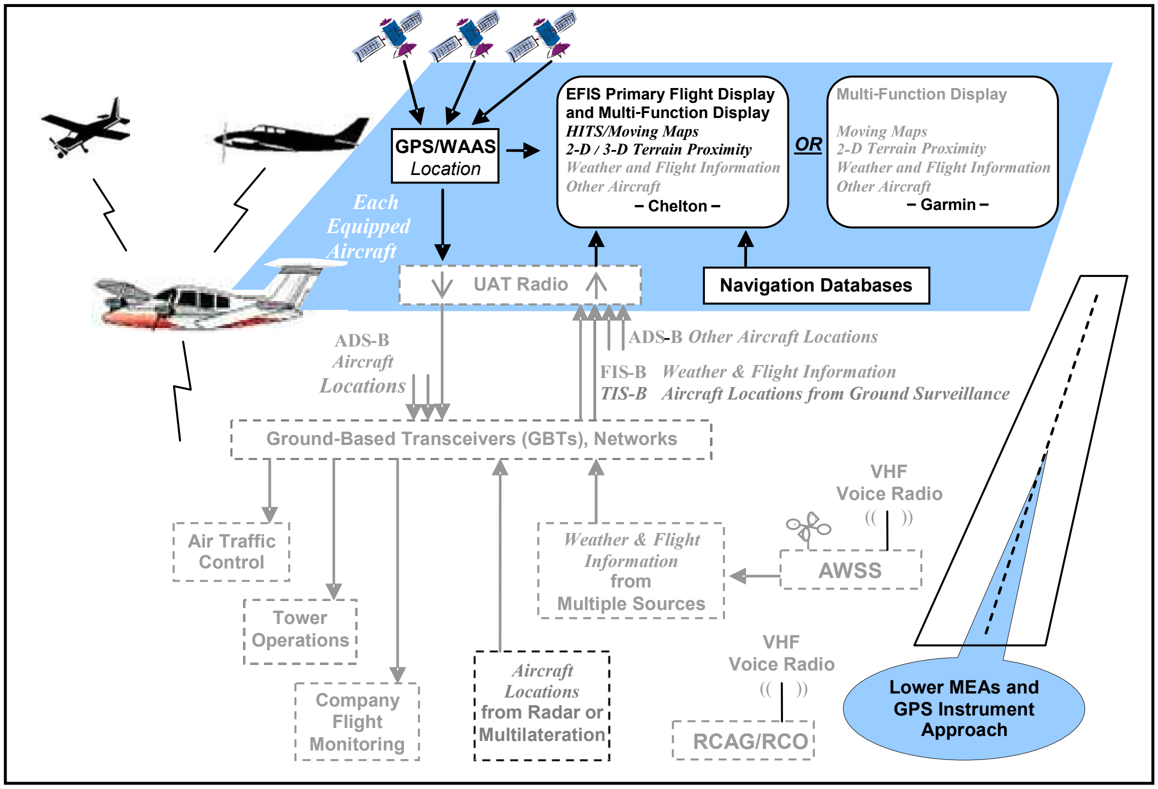



**Figure 5. Capstone Phase II Systems and Capabilities**
**Capabilities not operational in 2004 are gray**

### 2.2.1 Ground System

The ground system will expand the Capstone Phase I data link infrastructure into Southeast Alaska. It consists of the ATC automation within Anchorage ARTCC and new remote GBT sites. It will expand ATC surveillance for radar-like-services and provide weather information to the cockpit and tracking data to enable flight following for commercial operators and FAA AFSS specialists. Communication sites and weather reporting sites are discussed in following sections. A multilateration surveillance system may be installed later in Juneau, supplementing ADS-B in the terminal area for aircraft that have transponders but not ADS-B. Surveillance of these non-Capstone aircraft could then be provided to controllers, and with TIS-B, could also be provided to Capstone-equipped pilots. Surface surveillance (including vehicles) is being evaluated in Juneau.

#### 2.2.1.1 Voice Communications

Communications enhancements include new RCAGs to fill ATC communication gaps, enable new RNAV operations, and lower many minimum enroute altitudes. Initial communications improvements to support Capstone Phase II are shown in Figure 6 and will include a new RCAG facility at the south end of Stephens Passage for direct pilot-controller voice contact and at Mt. Robert Barron for improvements along Lynn Canal and over Icy Bay. Flight Service support will also be improved with the installation of an RCO radio in the same vicinity.  Further communications improvements are expected as needs are documented.[4]

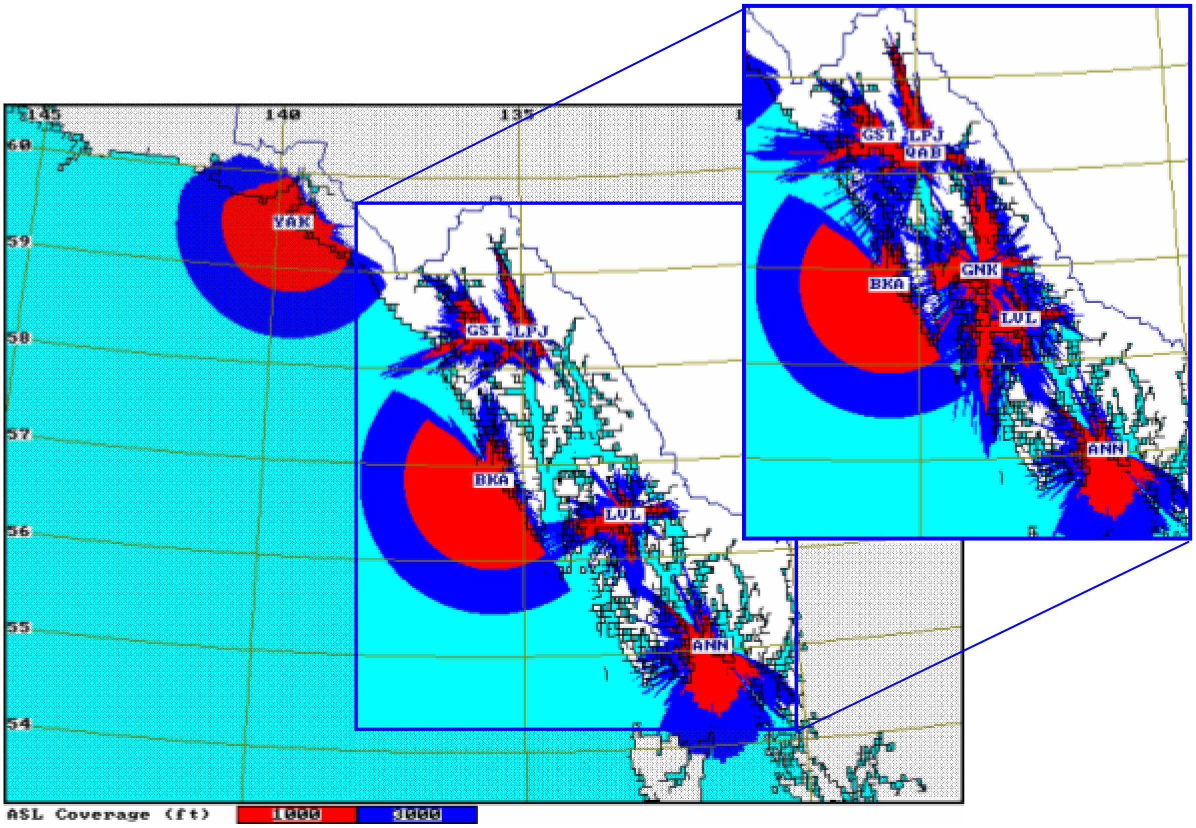



**Figure 6.  Voice Communications Coverage Before Capstone, with Inset showing Coverage Improvement by Capstone Phase II**

#### 2.2.1.2 Next Generation Ground Based Transceivers, and ATC and Broadcast Services

New GBT sites[5] have been chosen to provide surveillance coverage (Figure 7) at, around, and between the key airports with new GPS approaches.  Capstone is also choosing other sites to create and expand a low altitude RNAV route structure in Southeast Alaska.  Initially, 14 sites have been identified.  Surveillance data will be linked back to the MicroEARTS automation system at Anchorage ARTCC.  The data will be used for ATC and distributed to other users including air carrier operations centers (AOCs) and local operators, via the ETMS system, and Aviation Flight Service Station (AFSS) for flight following.  FIS-B (and eventually, TIS-B) will also be available via the Capstone Communications Control Server (CCCS) via the GBTs.  FIS-B weather and other NAS data will be uplinked in Southeast Alaska as it is the Bethel, YK Delta area.

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[4] Current and future voice communications coverage in the Cordova area were not available at the time of this report and are not shown in Figures 6 and 7.

[5] Surveillance sites for the Cordova area were not available at the time of this report and are not shown in Figure 7.

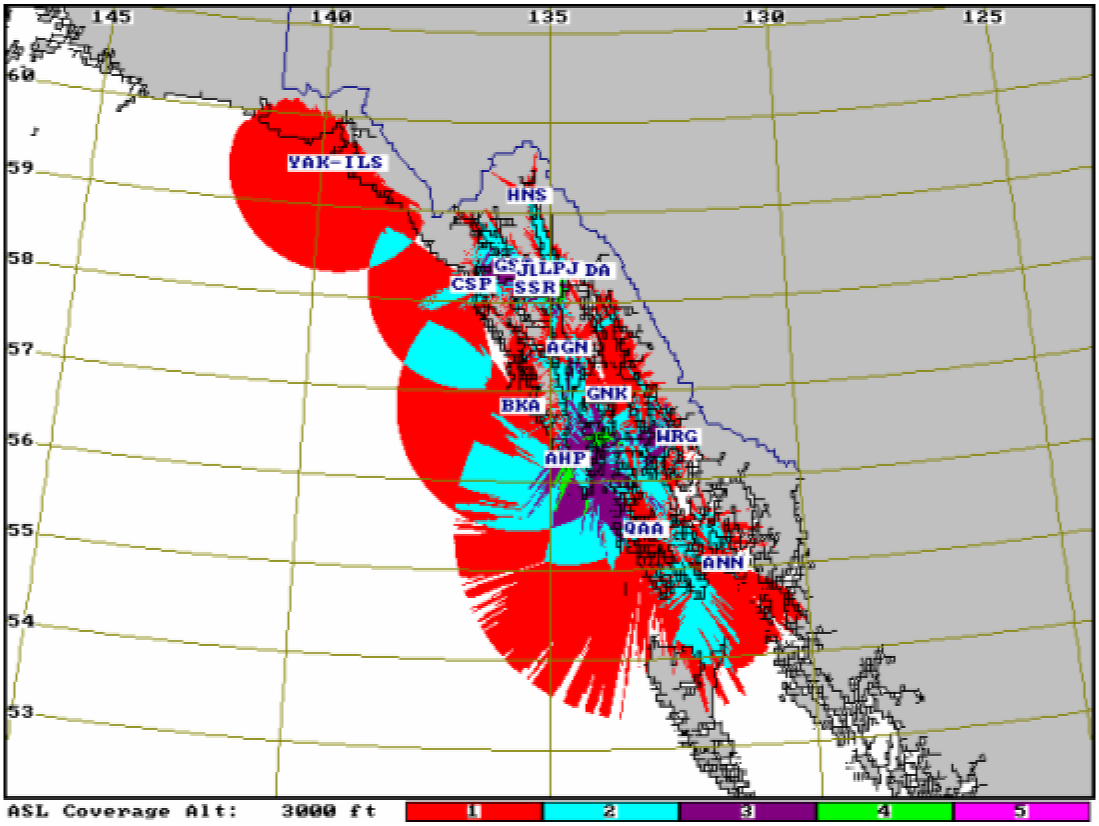


**Figure 7. Surveillance Coverage Planned with New GBTs at 3000 Feet ASL**

### 2.2.1.3 Automated Weather Observation Sites

Commercial air carriers need weather observations for destination airports before performing an instrument approach. Observations are also useful inputs to the overall weather picture because additional sites improve the accuracy and detail of weather forecasts in the region. New Automated Weather Sensor System (AWSS) sites will be installed and report weather conditions including temperature, dew point, wind, altimeter setting, visibility, sky condition, and precipitation. The weather reports from these sites will be available by phone, over radio on aviation frequencies and, once connected to the national weather collection system, can be extracted from other weather data at AFSS, other NAS systems, and over the internet or via FIS-B.

### 2.2.1.4 Other Infrastructure Changes Supporting Capstone Phase II

Situational awareness displays are planned for the Juneau air traffic control tower and the AFSS. Surveillance data derived from the ground system will be used to feed new "BRITE"-like displays in the Juneau ATCT cab. Two displays are planned: one for surface and one for the airport terminal area. The AFSS will also receive a flight following or flight plan monitoring capability. When suitable for integration with ADS-B, a multilateration installation is planned for Juneau to increase the number of "participating aircraft" for surveillance in the area and provide another data feed for TIS-B. Multilateration will identify/locate targets in the terminal area and on the ground at Juneau airport.

### 2.2.1.5 Research and Test of Surface Surveillance

Capstone is building a surface tool at the Juneau airport which allows airport managers, aircraft and others to see vehicle movement on the airport. The system will use ADS-B technology with moving maps installed in a number of vehicles and laptop displays for the control tower, flight service station and airport manager. This system, currently in the developmental stage, is intended to help reduce accidents with ground vehicles, such as snow removal equipment. This is a research, development, and test activity only.

With the system, ADS-B equipped vehicles operating on the airport will transmit their location and be able to receive information regarding aircraft both on the ground and approaching the airport. Aircraft arriving or departing will be able to see the location of ADS-B equipped ground vehicles. The control tower, airport manager and flight service station will have monitors to view vehicle and aircraft movement and positions. The system should contribute to a reduction in vehicle/aircraft taxiing accidents as well as runway incursions.

Fifteen vehicles have been equipped with a UAT and ten of those have displays. Surveillance displays are installed at the AFSS, airport manager's office and the airport maintenance office. Data collection and analysis to determine acceptability of equipment performance and coverage area is complete. Johns Hopkins University has issued a report of the analysis with results being favorable. A test and evaluation report/plan is currently being developed and will be evaluated to determine whether we proceed to the next steps; i.e., convert to 978MHz system and make it an operational program.

### 2.3 Airspace

To provide RNAV services, Capstone is developing an end-to-end (airport-to-airport) RNAV airspace structure. This dictates changes in both the enroute and the approach/departure airspace structures. The Capstone enroute initiative is providing RNAV/GPS MEAs that are significantly lower than the conventional MEAs that exist in Southeast Alaska. The MEAs in Southeast Alaska are often limited by line-of-sight issues with navaids and/or communications sites that are blocked by terrain. Using satellite navigation allows for lower MEAs, but not lower than the Minimum Obstruction Clearance Altitude (MOCA), on existing Victor and Colored airways in Southeast Alaska. Satellite navigation allows RNAV/GPS routes to be established in areas that optimize flight efficiency not based on the location of ground based navaids. The initial approach/departure procedure changes are in effect between Juneau and the airports of Hoonah, Gustavus, and Haines. Based on user/operator input and acceptance, this will expand to other city-pairs, for instance, from Ketchikan. Figure 8 depicts an IFR Enroute Low Altitude chart showing new GPS MEAs identified as “G” altitudes.

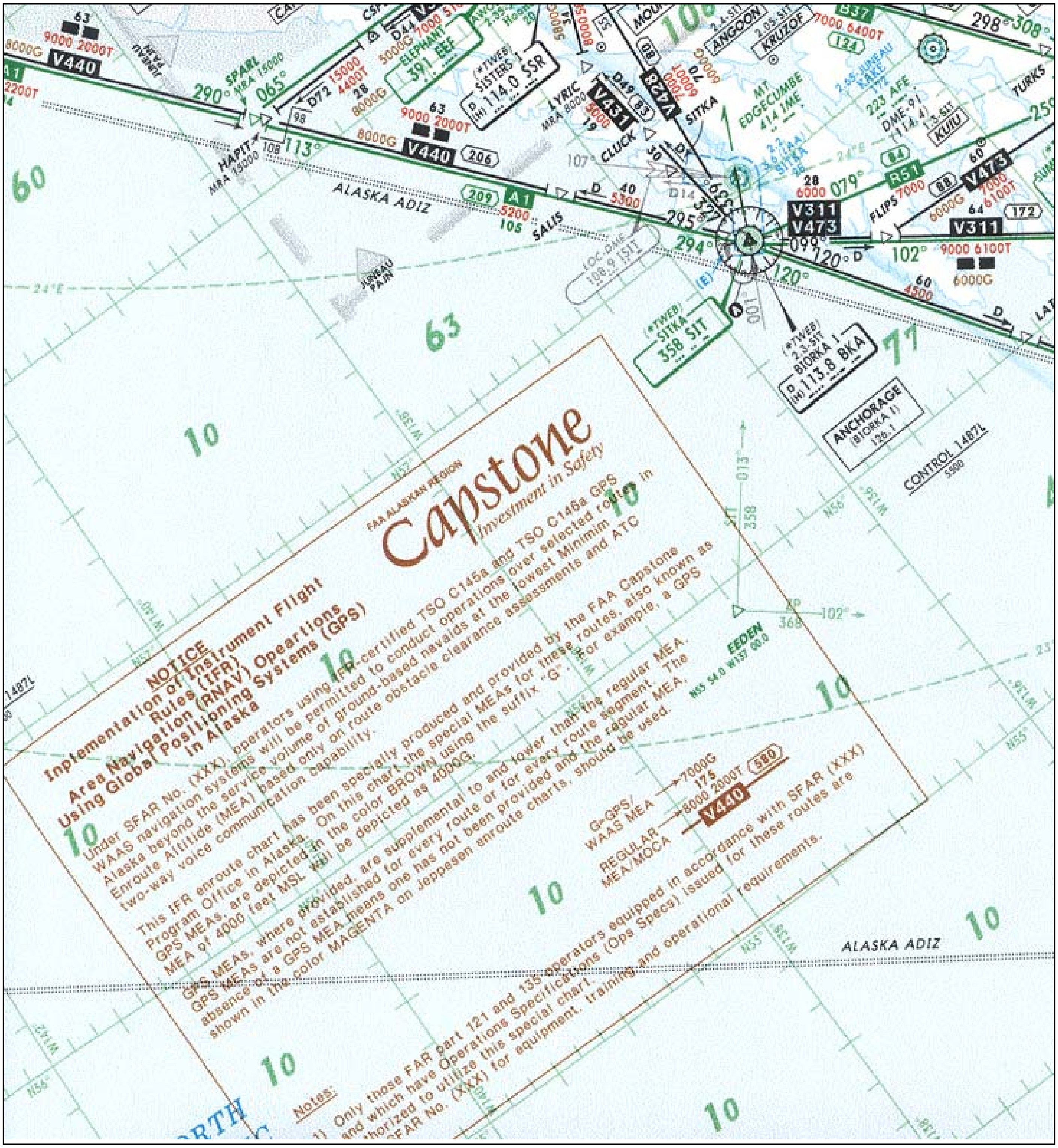


**Figure 8. IFR Enroute Low Altitude Chart Showing New GPS Altitudes**

Figure 9 shows how Hoonah, Haines, Juneau, Gustavus departure and approach RNAV procedures (including holding procedures and fixes) are being modified or created to provide a low altitude IFR structure in SE Alaska. New procedures have been published as Special (or Public, as appropriate) procedures.

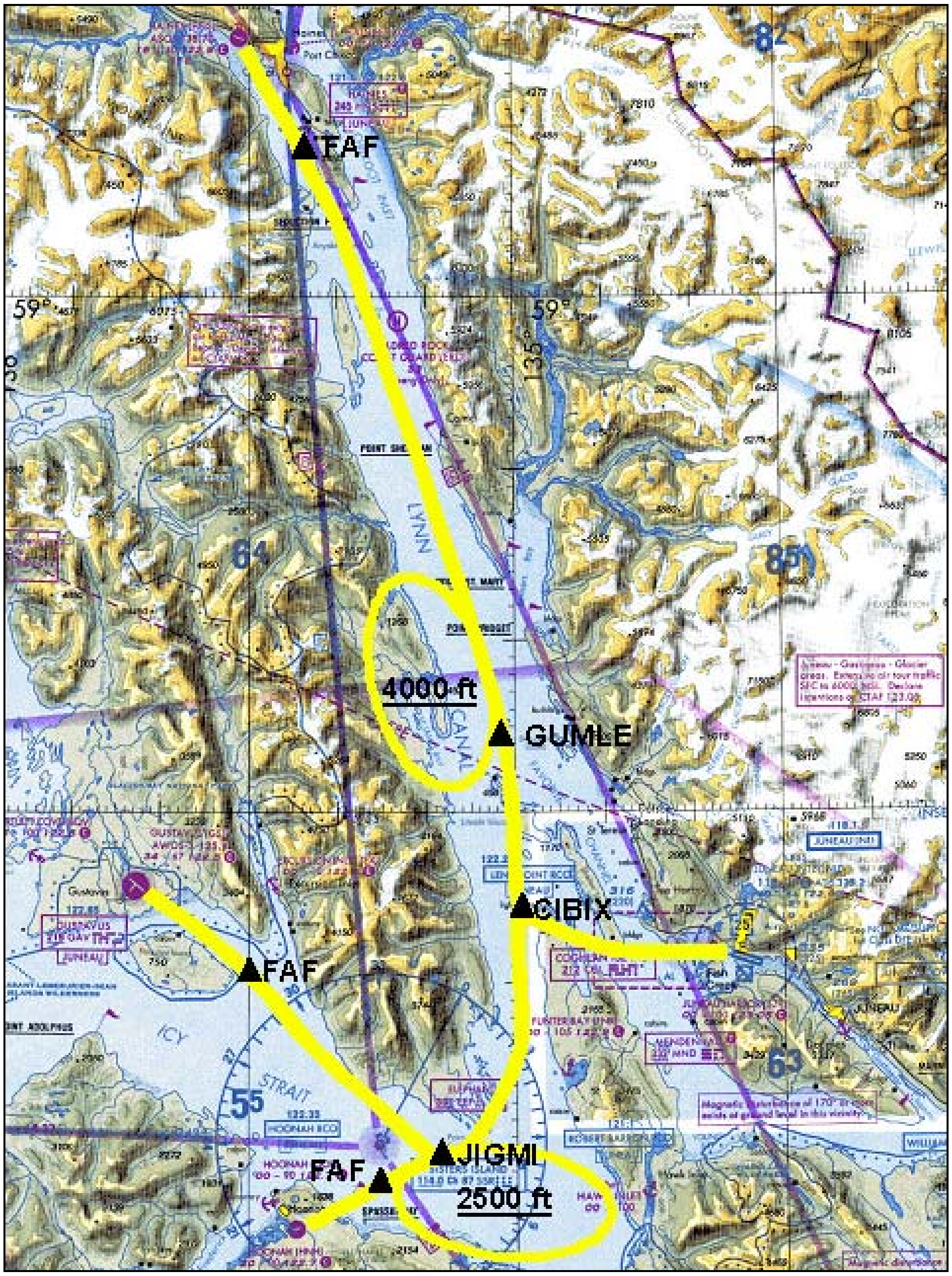


**Figure 9. Depiction of Initial Departure and Approach RNAV Structure**

## 2.4 Aircraft Systems

Installation of government-provided avionics began in 2003 for planned equipage of up to 200 commercially operated aircraft (estimated 150 fixed-wing and 50 rotor-wing) in and around Southeast Alaska. The intent of the Phase II avionics is to increase pilot situational awareness and increase navigational performance during IFR and VFR operations. A description of the avionics is provided below. The avionics package will include the following functions, in stages:

Stage 1 (initial avionics – Primary Flight and Navigation Displays)

- Primary flight display functions, including heading, pitch and roll attitude, airspeed, vertical speed, etc., as well as flight path.
- Display 3-dimensional views of terrain. The system will include terrain alerting and warning system (TAWS) that meets TSO-151a, Class B.
- Navigation display functions using GPS/WAAS including position, course, waypoints and fixes, groundspeed, etc.

Stage 2 (full avionics to operate air-to-air and with ground system – Universal Access Transceiver)

- ADS-B air-to-air traffic targets along with TIS-B targets (when TIS-B becomes available) on a multi-function navigation display and primary flight display when appropriate. Traffic warnings will also be provided.
- Display FIS-B information (text and graphics).

Chelton Flight Systems (formerly Sierra Flight systems) was selected to provide it's EFIS-2000 Primary Flight Display (PFD) (Figure 10), its Navigation Display (Figure 11), and supporting avionics. Garmin-AT Corporation was selected to provide their MX20 Multifunction Display (Figure 12) with supporting avionics, which is often the choice of helicopter operators to better meet their special operational requirements at lower workloads. Both avionics sets include GPS-WAAS receivers. Garmin has also been selected to provide a stand-alone UAT ADS-B system which will be used with both types of avionics. The Capstone program will oversee integration of these systems with the ground system and provide avionics units to individual aircraft operators. Installation of these avionics is covered under a multiple make, model, and series FAA Supplemental Type Certificate (STC).


**Figure 10. Chelton EFIS-2000 Primary Flight Display**


**Figure 11. Chelton Navigation Display**


**Figure 12. Garmin MX-20 Multi-Function Display**

## 3 Capstone Phase II Progress

The Phase II Capstone Program has accomplished some important milestones since beginning in 2002. New MEA routes and RNAV Approach and Departure procedures have been certified for a number of airports. Aircraft equipment installations are progressing. Design and site selection, along with some installations, for AWSS and GBT ground infrastructure are continuing.

However, by spring 2005 only a few of the planned capabilities of the program have been realized; completion of the remainder continues to be delayed. The following points are important to understanding these delays and the current status of the program.

1. The original contracts for Phase II avionics were let to Chelton for an EFIS/PFD/MFD subsystem and to Avidyne for a UAT subsystem. The contract with Avidyne was terminated by the FAA and a subsequent contract for the UAT subsystem was then made with Garmin AT (who had built the avionics for Phase I). This need for a second contract resulted in a delay in the original plans for the delivery of the airborne UAT subsystem.
2. Capstone's original plan was to offer the operators options on four levels of equipage: 1) standalone ADS-B system only, 2) standalone ADS-B system and a navigation display, 3) standalone ADS-B system, a navigation display, and a primary flight display, and 4) standalone ADS-B system and a navigation display, a primary flight display, and a secondary GPS/WAAS navigator. Chelton did not initially offer a navigation display system without the PFD, but it became available in 2003 but no operators have ordered that configuration. After numerous delays and technical difficulties with Chelton avionics, and after desires by helicopter and VFR operators for a less complex system, Capstone let another contract with Garmin AT to provide a second avionics alternative that would more closely resemble Capstone Phase I and meet these desires for a less complex system. The numerous delays and technical difficulties with the Chelton avionics as well as the need for a second contract to provide an alternative to Chelton avionics, has resulted in significant delays in the delivery of avionics for SE. By the end of 2004, under pressure from the Capstone office, Chelton implemented a complete hardware change in AHRS and GPS sensors as well as numerous EFIS software, installation manual, and flight manual supplement changes.
3. Capstone's plan was to use the new MOPS-compliant UAT data link that was defined post-Phase I to provide ADS-B and related broadcast services. This meant that new GBTs and airborne UATs needed to be specified, developed, and procured. Standards development progressed as predicted; however, it took longer then expected to produce new certified UAT avionics and to specify and deliver new GBTs.
4. Chelton's implementation of the UAT interface and the processing on broadcast services information within the Chelton avionics is substantially behind schedule. The result is few of Capstone's air-ground capabilities and none of the air-air, and ground-air broadcast services capabilities are in place. Cockpit traffic display, operator flight monitoring, FAA radar like services, and cockpit weather display are not yet available. The aircraft already equipped with the Chelton EFIS/PFD/MFD subsystem are not able to display ADS-B traffic or FIS-B weather, and not able to exchange information over the UAT data link. As an interim measure, Capstone plans to install the Garmin UAT subsystems, configured for transmit-only, in these Chelton equipped aircraft without interconnecting them with the Chelton avionics, resulting in these aircraft being "seen" by other fully configured Capstone equipped aircraft and the FAA ground system, even though they can't receive or interpret the data link themselves.
5. No helicopter operators in SE have yet agreed to a Capstone installation. Although commercial operators are anxious to be able to "see" other aircraft via the data link,

helicopters are a substantial part of the air traffic flow near Juneau and will remain “invisible” on Capstone displays.

Sixty-two aircraft were equipped by the end of 2004, all Chelton except for 1 Garmin installation. Several operators were dissatisfied with Chelton-installed avionics and repair infrastructure and have chosen to exchange theirs with Garmin for some or all of their aircraft. As of spring 2005, two of these have already made the change and three others are scheduled.

Testing of the next generation GBT ground systems is going well and nearing completion. As of spring 2004, 14 GBTs have been prepared and installed and are awaiting the communication facilities. Installation of avionics from Garmin has begun and installation of the GBTs will begin soon.

### 3.1 Progress in 2004

Progress continued during 2004 in the Capstone Phase II Program. Developing infrastructure for such a complex aviation system is a multi-year task. Progress has been slower than anticipated on certification of the GBTs, weather stations and other elements. Aircraft modification is progressing at a reasonable pace with 36% of the scheduled aircraft partially modified. The following paragraphs present the progress attained during 2004.

### 3.2 Voice Communications

The RCAG sites at Gunnuk Mountain and Robert Baron were brought online in 2004. Construction continues on the final scheduled RCAG site at Cape Spencer.

### 3.3 Ground Based Transceivers

The site selection, surveys, and construction began for the 14 new GBTs. Figure 7 (in Section 2) shows the locations. Some installations have begun and will be available when the certification is complete. Certification was anticipated in 2004 but the testing and the certification was still ongoing at the end of 2004. Final certification testing is now underway and expected to be complete by summer 2005. The full benefits of the Capstone program cannot be realized until this certification is complete and the units are brought online.

### 3.4 Automated Weather Observation Stations

Hoonah currently has an operating AWOS that has been added to the Phase II program. The Angoon AWOS, was scheduled to be online in 2004 but was not operational at the end of the year. When completed, Southeast Alaska will have 19 stations. Figures 13 and 14 depict the current operational stations.

| Location | Station Identifier | Type of Reporting |
|---|---|---|
| Annette | PANT | ASOS |
| Elfin Cove | PAEL | Apaid |
| Cordova | PACV | ASOS |
| Gustavus | PAGS | AWOS/Apaid |
| Haines | PAHN | ASOS |
| Hoonah | PAOH | AWOS/Apaid |
| Hydaburg | PAHY | AWOS |
| Juneau | PAJN | ASOS/FCWOS/LAWRS |
| Kake | PAFE | AWOS |
| Ketchikan | PAKT | ASOS |
| Klawock | PAKW | ASOS |
| Metlakatla | PAMM | AWOS |

| Location | Station Identifier | Type of Reporting |
|---|---|---|
| Petersburg | PAPG | AWOS |
| Port Alexander | PAAP | Apaid |
| Sitka | PASI | ASOS |
| Skagway | PAGY | ASOS |
| Wrangell | PAWG | AWOS/FCWOS |
| Yakutat | PAYA | ASOS/WSO |

**Figure 13. Southeast Alaska Weather Facilities by Location**

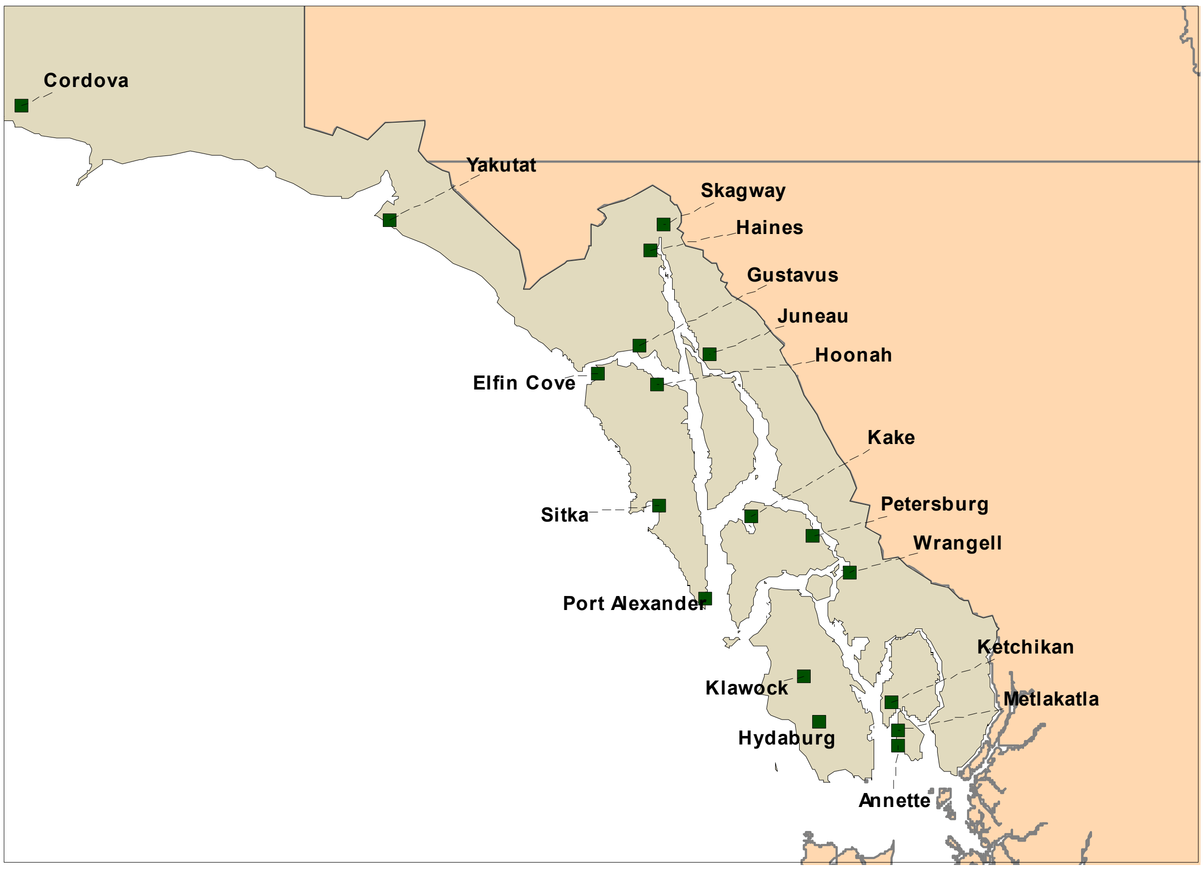


**Figure 14. Southeast Alaska Weather Reporting Facilities**

## 3.5 Tower Displays

The new displays have not been installed as of the end of 2004. They are planned for installation after ADS-B surveillance becomes available.

## 3.6 Airspace

Capstone Phase II accomplished a number of airspace "firsts" since the start of the program. The initial year saw the first commercial use of a GPS/WAAS navigation system and the first commercial use of airspace optimization, providing access to airspace that would otherwise be inaccessible with conventional avionics. Stand-alone GPS Approaches and Departures were developed, flight tested and approved for Gustavus, Haines, Hoonah and Juneau in 2003. Minimum Enroute Altitudes were developed and approved for over 1,500 miles of airspace in Southeast Alaska.

The FAA issued SFAR No. 97, allowing the use of GPS/WAAS systems for the enroute portion of flights on routes in Alaska outside the operational service volume of ground based navigation aids. Highway In The Sky (HITS) synthetic flight path guidance was separately certified as part of the new avionics package. This provides a series of target boxes that the pilot can use to navigate in lateral and vertical dimensions along departure, enroute or arrival paths.

In 2004, the FAA certified 19 new RNAV Approach/Departure Procedures at Angoon, Juneau, Kake, Ketchican, Klawock, Petersburg, Sitka and Wrangell. They also certified four special RNAV routes, known as R2010, R2015, R2020 and R2025.

### 3.7 Aircraft Systems

A total of 45 aircraft installations were completed in 2004 bringing the total aircraft equipped to 62. These installations are only partially complete. All Chelton equipment is installed with the exception of the Universal Access Transceiver (UAT). Chelton has not completed the necessary interface between their system and the UAT. This year (2004) included the first Garmin installation, including the UAT, in the Phase II area. An additional 12 aircraft were in modification but not completed at the end 2004. Figure 15 shows the progress of the installations. Only one of the 62 equipped aircraft, belonging to the University of Alaska Anchorage, was non-commercial. The rest were Part 135. Of the 62 equipped aircraft, six are IFR, and five of those are Class 1 (twin engine piston) while one is a Class 4 turbine powered aircraft. The rest of the aircraft were Class 0 (single engine, piston). The majority of aircraft equipage for Capstone Phase II will take place during the winter months as it is the “off” tourist season.

The Southeast Alaska fleet comprises 210 aircraft. Of those, it is expected that 170 will be equipped with Capstone Phase II avionics. Therefore, at the end of 2004, 29 percent of the aircraft fleet was equipped and 36 percent of those expected to be equipped had been modified.

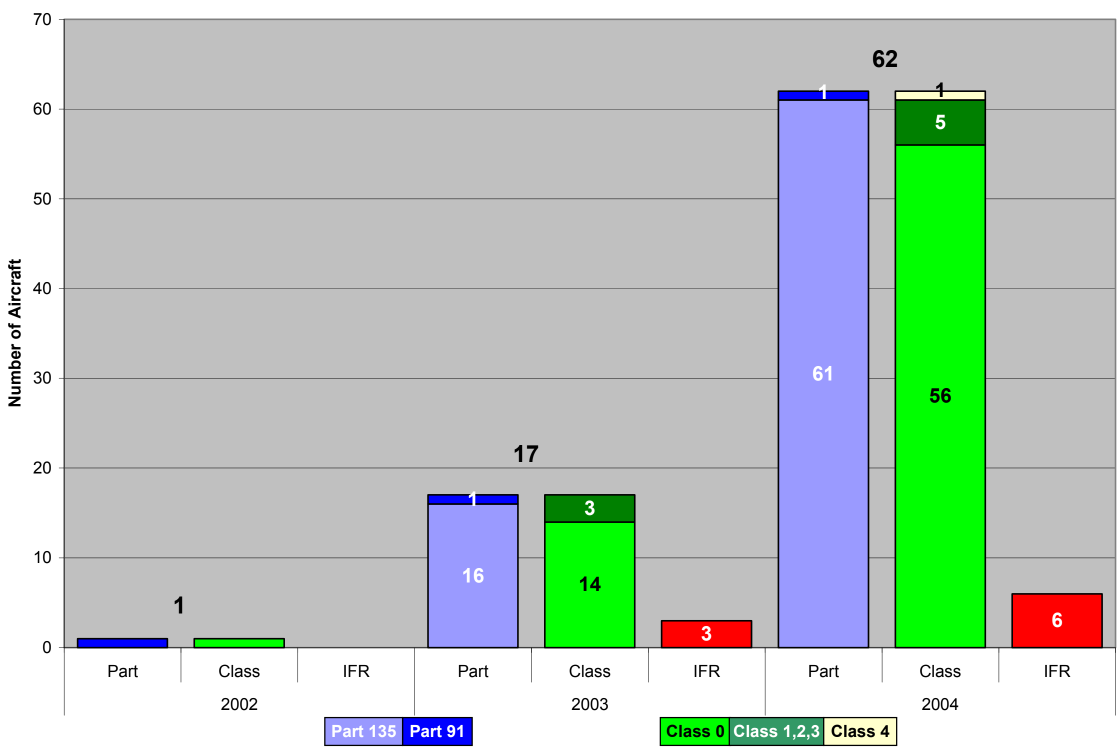


**Figure 15. Aircraft Partially Equipped with Capstone Phase II Avionics in 2004**

## 3.8 Equipment Reliability

A number of the operators and pilots expressed concern with the reliability of the Chelton equipment package. The three primary reasons for this concern were the lack of certified repair stations available in Southeast Alaska, the turnaround times for units sent for repair and an opinion by the FAA that software updates must be done by a certified repair station. It was also noted that there are only two air data computer/pitot static test sets available in the entire region.

Systems reliability data on the Capstone Phase II equipment is not available. An effective aircraft and component reliability program requires an operator to have a number of aircraft of the same type (general 6-8 aircraft minimum) and a capable, full-time records or engineering department. The diverse fleet mix and number of small operators in the Southeast Alaska make this impractical, and reliability programs are not required by the FAA for small Part-135 operators. Therefore, data such as Mean Time Between Failure (MTBF) and other data that could be used to quantify reliability of the system are not available. The only quantitative data available on the reliability of Capstone avionics is from the manufacturer concerning components that have been returned for repair.

Complete manufacturer data is not available on the repair turnaround time on the units, but a sample, shown in Figure 16, from one repair station was analyzed to get an indication of the turnaround times.

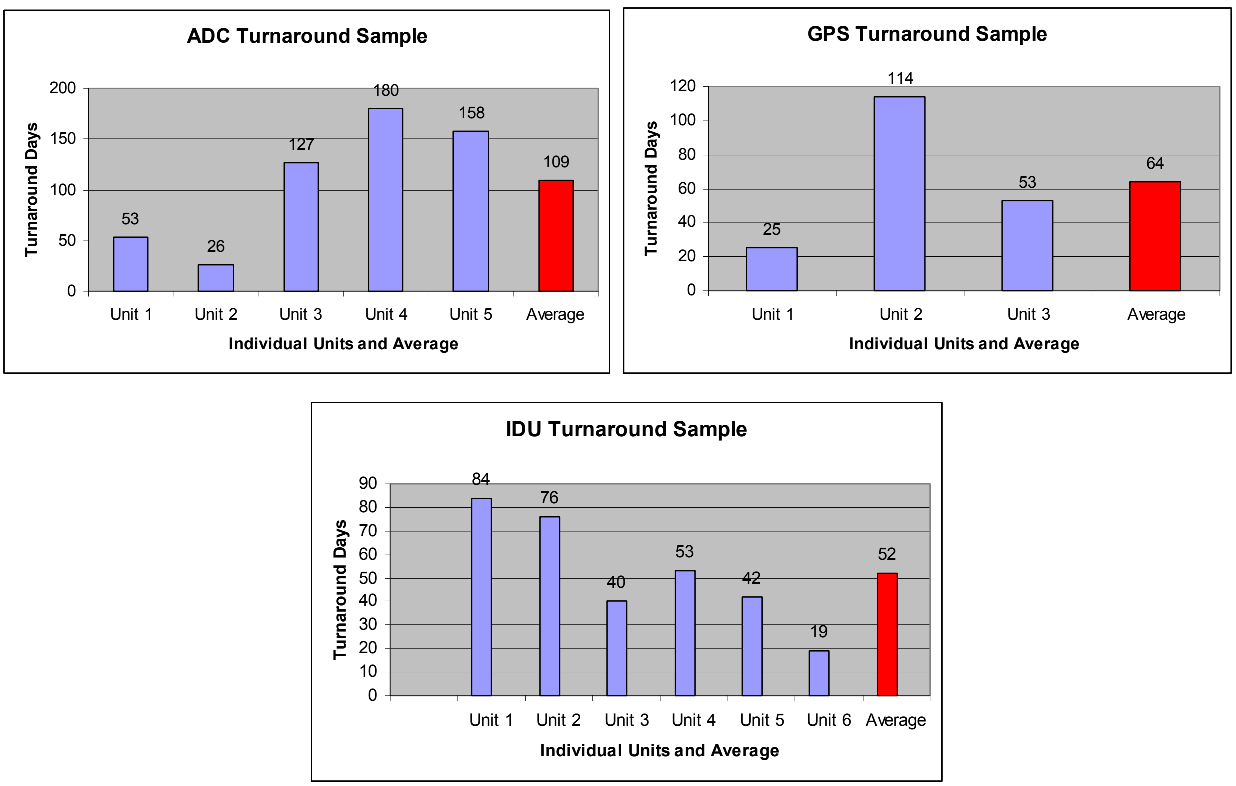


**Figure 16. Sample Repair Turnaround Times**

Air data computers are a key element of the Chelton system and had the highest removal rate of the components for reasons other than updating. During 2004, 26 ADCs had been removed for specific failures and another 15 were sent back to undergo evaluation. Figure 17 indicates that at the end of 2004, 54% of the units removed during 2004 were still in repair, another indicator of turnaround times and reliability.

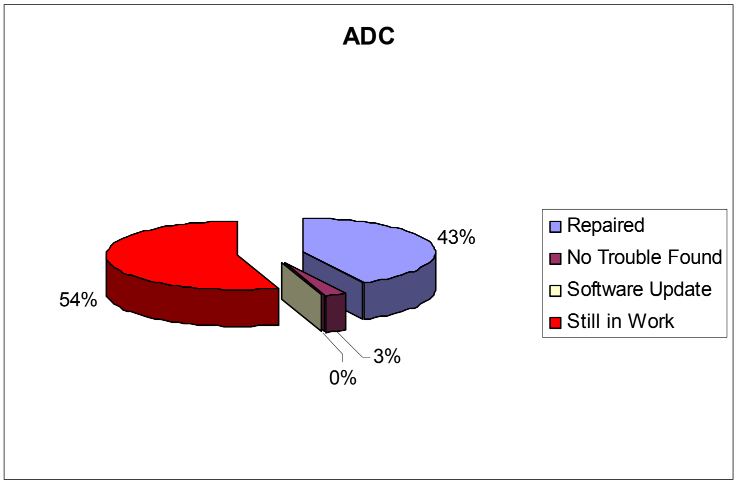


**Figure 17. Air Data Computer Repair Data - 2004**

A Master Minimum Equipment List (MMEL) was developed and approved this year, but at the end of the year, no operators had gained approval for its use. The operators may not see significant benefit from adapting the MMEL since most of the items in the MMEL still require repair within one day.

The reliability turnaround times and lack of adequate test equipment create an economic impact on the operator. Aircraft that are not operating for maintenance or parts reasons do not generate revenue and significantly impact customer satisfaction. The operator or pilot may consider not documenting malfunctions or failures if they know the aircraft may be grounded for any period of time. This increases the safety risks of pilots flying with an aircraft not meeting its airworthiness requirements.

### 3.9 Phase II Operator Training

The University of Alaska Anchorage (UAA) provides initial Capstone training for pilots using a "train-the-trainer" approach. UAA has an agreement with the FAA Capstone office to provide initial training to the air carriers' trainers on the operation and use of the Capstone system. UAA's training program provides each operator with an 8400.10 (Air Carrier Inspector Handbook) compliant training program. The training program outlines ground training, flight training and checking, and recordkeeping. Beginning in spring of 2003, UAA provided initial training for each of the operators. UAA timed the training to coincide as closely as possible to the delivery of a carrier's first Capstone-equipped aircraft. The typical operator had two people receiving 16 hours of classroom training with the avionics training device. The initial training evaluated each participant and his/her ability to properly use the Chelton PFD/MFD avionics. In 2004, the initial class was held for the first Phase II Garmin operator.

In 2004 UAA also entered into an agreement with the FAA to train key maintenance personnel on the Chelton Phase II system. The training focuses on field maintenance with an emphasis on troubleshooting, removing and replacing inoperative components, and updating software.

Eight training classes were held during 2004. Five of those classes were for Chelton software upgrade differences training and were attended by 26 pilots and 3 FAA personnel. The other training classes were attended by 8 pilots, 16 maintenance personnel and 6 FAA Inspectors from the Juneau FSDO. UAA had trained 41 company pilot trainers by the end of 2004. Figure 18 depicts training accomplished by UAA during 2004.

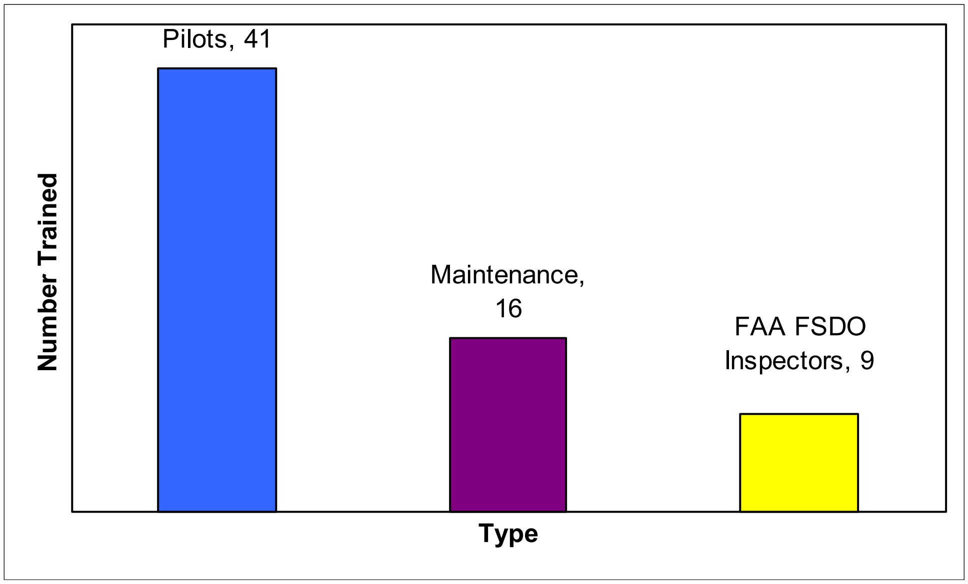


**Figure 18. Cumulative Training Accomplished by UAA**

A survey of the pilots who have attended the UAA Capstone II training indicates that the quality of the training received is more than adequate. Sixty-five percent felt that it was excellent or good and only 4% felt that it was lacking in some areas. Thirty-one percent did not respond to this question in the survey. Figure 19 shows the breakout of the responses to the survey.

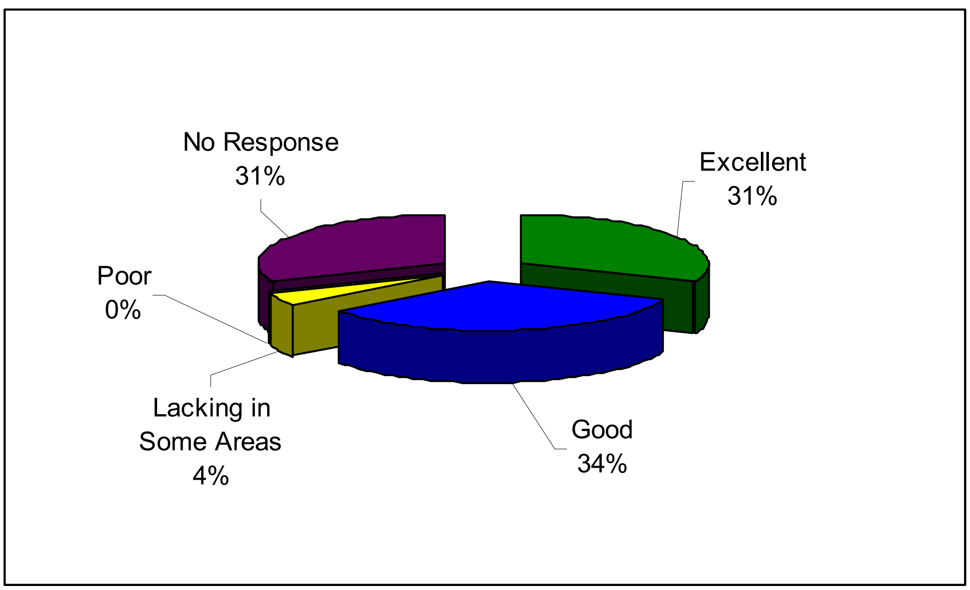


**Figure 19. Quality of Initial Capstone Training - Pilot Ratings**

## 3.10 Pilot Surveys

Pilots operating Capstone-equipped aircraft were surveyed in winter of 2004/2005. Analysis does not provide significant findings due to the small number of respondents. The responses provided below are indicative of pilots' perceptions of the hazards and their acceptance of the Phase II equipment. The questions on hazards are listed and followed by a breakdown of pilot responses in Figure 20. A questionset on using Capstone equipment is followed by a breakdown of pilot responses in Figure 21. We plan to conduct broader surveys in the future as the Capstone Phase II program expands.

1. *How many times during the past year have inaccurate weather forecasts caused you to encounter instrument meteorological conditions which you didn't expect?* (First graph – Figure 20)

2. *How many times during the past year have deteriorating ceilings or visibility made you unsure of your own position relative to the surrounding terrain?* (Second graph – Figure 20)

3. *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?* (Third graph – Figure 20)

4. *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?* (Last graph – Figure 20)

5. *For each of the functions of Capstone avionics listed below, please tell us how often you use that feature, how easy it is to use, and how helpful it is to you?* (Figure 21)

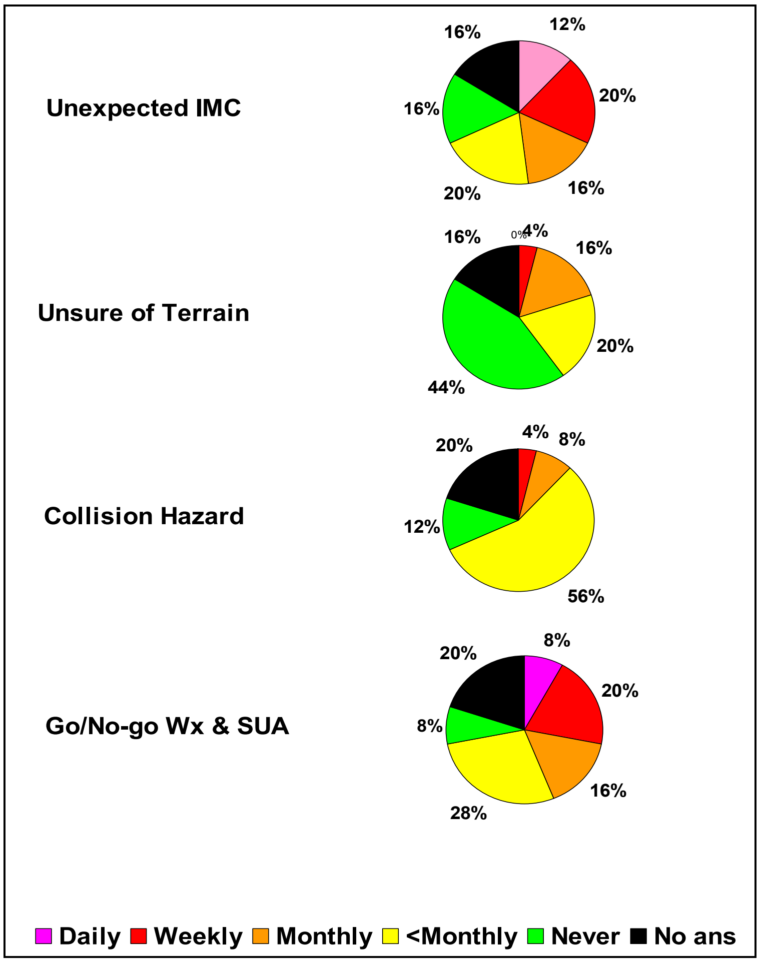


**Figure 20. Pilot-reported Frequencies of Problems Potentially Addressed by Capstone Phase II**

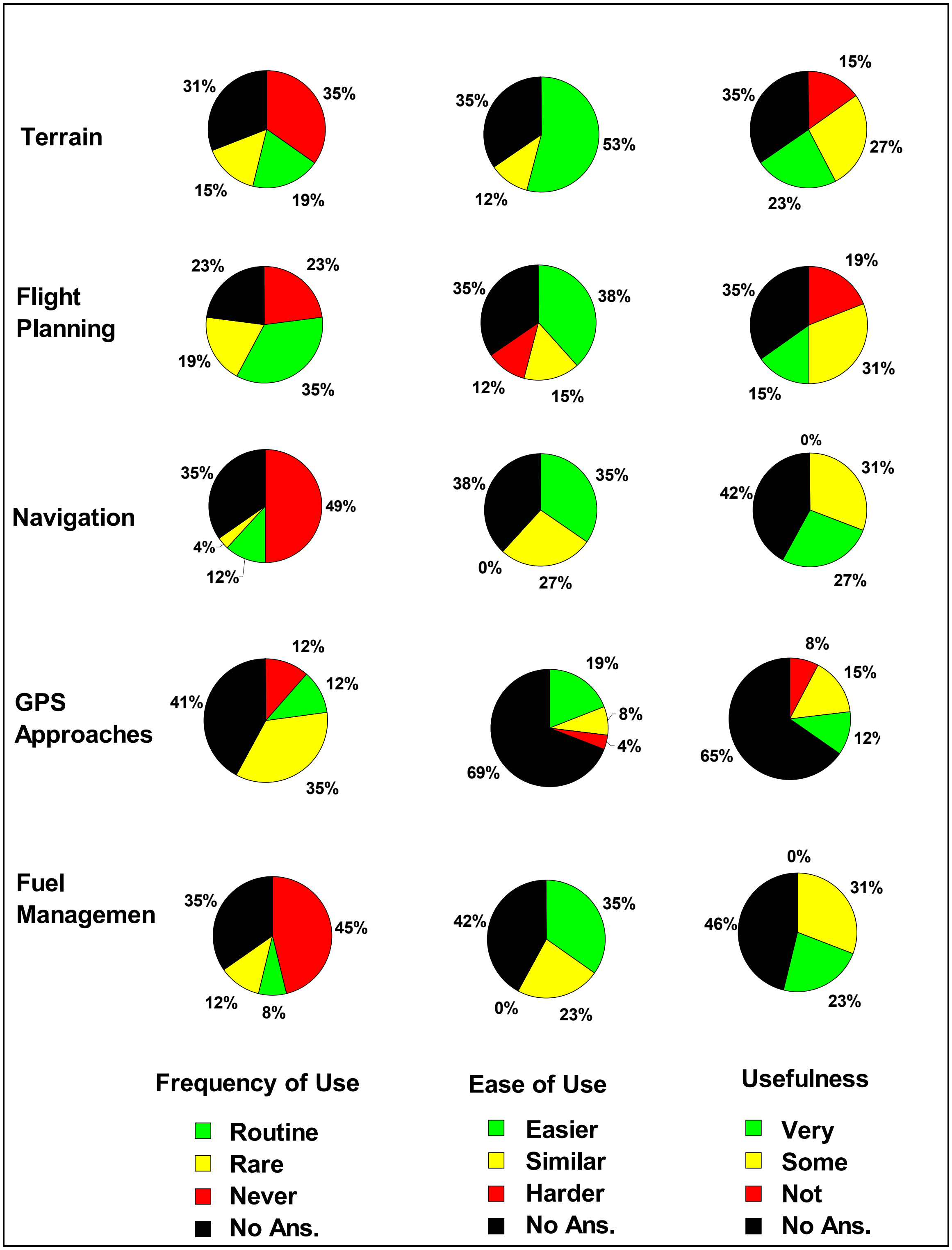


**Figure 21. Pilot-reported Frequency of use, Ease of use, and Usefulness of Capstone Capabilities**

These responses indicate the initial capabilities of the Capstone Phase II program are relevant to pilots' perceived needs, that pilots use the capabilities to varying degrees, and that the usability and usefulness of Capstone are regarded favorably.

## 4 Conclusions

The Capstone Phase II program is progressing with routes being certified, aircraft being equipped with both Chelton and Garmin avionics and the ground infrastructure development being pursued. As discussed in the report, there are a number of challenges facing the program and CY 2005 will be an important year in determining Capstone Phase II success.

## 5 Acronyms and Abbreviations

| | |
|---|---|
| ADS-B | Automatic Dependent Surveillance – Broadcast |
| AFSS | Aeronautical Flight Service Station |
| AGL | Above Ground Level |
| ANICS | Alaska NAS Inter-Facility Communications System |
| AOC | Airline Operational Control |
| Apaid | A person certified by the National Weather Service (NWS) to provide weather information under the terms of a "per-observation" agreement. |
| ARTCC | Air Route Traffic Control Center |
| ASOS | Automated Surface Observing System |
| ATC | Air Traffic Control |
| ATD | Aviation Technology Division UAA |
| AWOS | Automated Weather Observation System |
| AWSS | Automated Weather Sensor System |
| CCCS | Capstone Communications Control Server |
| CDTI | Cockpit Display of Traffic Information |
| CFIT | Controlled Flight into Terrain |
| CNS/ATM | Communications, Navigation Surveillance/Air Traffic Management |
| EFIS | Electronic Flight Information System |
| ETMS | Enhanced Traffic Management System |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FCWOS | FAA Contract Weather Observation Station |
| FIS-B | Flight Information Service-Broadcast |
| FSDO | Flight Standards District Office |
| GPS | Global Positioning System |
| GBT | Ground Based Transceiver |
| HITS | Highway In The Sky (navigation guidance) |
| IDU | Integrated Display Unit (also Multifunction Display) |
| IFR | Instrument Flight Rules |
| LAWRS | Limited Airport Weather Reporting Service |
| MDA | Minimum Descent Altitude |
| MEA | Minimum Enroute Altitude |
| MFD | Multifunction Display (an IDU capable of multiple screens) |
| MMEL | Master Minimum Equipment List |

| | |
|---|---|
| MOCA | Minimum Obstruction Clearance Altitude |
| MSL | Mean Sea Level |
| MTBF | Mean Time Between Failures |
| NPA | Non-Precision Approach |
| PAI | Principle Avionics Inspector |
| PFD | Primary Flight Display |
| PMI | Principle Maintenance Inspector |
| POI | Principle Operations Inspector |
| RCO | Remote Communications Outlets |
| RCAG | Remote Communications Air Ground Facilities |
| RNAV | Area Navigation |
| RNP | Required Navigation Performance |
| SFAR | Special Federal Aviation Regulation |
| STAR | Standard Terminal Arrival Routes |
| STC | Supplemental Type Certificate |
| SUA | Special Use Airspace |
| TAWS | Terrain Awareness and Warning System |
| TCF | (violation of) Terrain Clearance Floor (on approach or departure) |
| TERPS | United States Standard for Terminal Instrument Procedures (TERPS) (FAA Order 8260.3B) |
| TIS-B | Traffic Information Service-Broadcast |
| TSO | Technical Standard Order |
| UAA | University of Alaska Anchorage |
| UAT | Universal Access Transceiver |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VNAV | Vertical Navigation |
| WAAS | Wide Area Augmentation System |
| WSO | Weather Service Office |