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Testimony

Before the Subcommittee on Aviation,
Committee on Transportation and Infrastructure,
House of Representatives

For Release on Delivery
Expected at
9:30 a.m. EDT
Thursday
June 8, 1995

NATIONAL AIRSPACE
SYSTEM

Assessment of FAA's Efforts
to Augment the Global
Positioning System

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063778/154425

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to provide our views on the Federal Aviation Administration's (FAA) efforts to augment the Department of Defense's (DOD) Global Positioning System (GPS). Our testimony today, which is drawn largely from our recent report,¹ addresses (1) whether FAA will have sufficient time under its milestones to augment GPS; (2) what actions the agency has taken to better manage its GPS related efforts; and (3) what the implications are if there are delays in implementing GPS.

GPS satellites transmit radio signals that allow properly equipped air, land, and sea users to calculate the time and their position and speed in any location and weather condition. Because GPS was designed for military purposes, the system, by itself, does not satisfy the requirements of civil air navigation, such as those dictating that a sufficient number of the system's satellite signals be available virtually all of the time. However, when augmented by the wide and local area systems that FAA intends to implement,² GPS is expected to satisfy these requirements. (See app. I for depictions of the wide area augmentation system and one of the local area systems under development.)

We would like to summarize our observations and then turn to a more detailed discussion of them.

-- We are concerned that FAA's schedule will not give the agency enough time to develop and implement its wide area system for augmenting GPS by 1997, when civil aircraft are expected to use the augmented GPS without having to rely on other navigation aids for backup. This schedule is ambitious because the system must be developed, implemented, and commissioned within the next 27 months-- although FAA estimates that software development alone may take that long to complete. Potential software- and satellite-related problems--some of which are beyond FAA's control--could also slow the system's development and implementation.

-- FAA took several actions in 1994 to strengthen its ability

¹National Airspace System: Comprehensive FAA Plan for Global Positioning System is Needed (GAO/RCED-95-26, May 10, 1995).

²The wide area system will use commercial communications satellites to augment GPS signals in the airspace between and around airports so that civil aircraft can navigate in air routes and land on airport runways. The local area system will use ground-based communications equipment to augment the signals in the airspace around airports so that aircraft can land in the worst weather conditions.

to manage its GPS efforts. The agency integrated GPS activities within the agency, secured the necessary funding to accelerate the development of the wide area system, and issued plans for developing and implementing augmentation systems. These actions are encouraging. However, the plans for GPS are not as useful as they could be. They currently lack critical information--such as timetables and funding levels--needed for making sound programmatic and budgetary decisions regarding these augmentation systems.

- Delayed implementation of satellite-based navigation has implications for FAA and system users. FAA foresees that implementing both the wide and local area systems will permit the agency, after a transition period, to start decommissioning its ground network of navigation aids, such as instrument landing systems (ILS). The phasing out could take 10 years. If the schedule for implementing satellite-based navigation slips, FAA will have to defer the significant costs savings associated with phasing out ground-based navigation aids. For example, delays will limit the agency's ability to reduce spending--estimated at \$170 million in 1993--on operation and maintenance expenses for ILSs and other existing ground-based navigation equipment. A delay would also defer the economic and operational benefits that airlines expect from the augmented GPS.

BACKGROUND

DOD designed GPS to support military missions, such as missile guidance and search and rescue. GPS has space and ground components. The space component consists of a worldwide constellation of 24 satellites in six orbits at approximately 11,000 miles above the earth. These satellites are positioned so that a user will have at least four satellites in view at any given location. The satellites transmit radio signals that permit adequately equipped users to calculate the time as well as their speed and tridimensional position (latitude, longitude, and altitude) anywhere on or above the earth's surface and in any weather condition. The ground component includes a master control station, five monitoring stations, and three ground antennae located throughout the world. The master control station tracks and directs the GPS satellites through the monitoring stations and ground antennae, respectively.

Currently, GPS is used domestically as a supplemental means of navigation since it does not meet all of the requirements of civil air navigation, particularly those related to the system's availability and integrity. For example, the integrity of a navigation aid is defined as its ability to provide timely warnings to users about the system's malfunctions. Integrity requirements

for the different phases of flight dictate that warnings be provided to users within seconds. However, GPS' integrity warnings can now take 15 minutes or longer. The development of a wide area augmentation system and local area systems will permit GPS to fulfill all integrity and other civil air navigation requirements and become a primary means of navigation. FAA plans to award a contract this month for developing the wide area system. The agency has not announced a date for awarding a contract to develop local area systems.

FAA and the aviation industry expect that the augmented GPS will provide major benefits to the agency, civil aviation, and others because of its superiority over currently used navigation aids. For example, because FAA expects that the augmented GPS will be able to support runway approaches and landings in all weather conditions, the agency recently canceled its multibillion-dollar project to acquire microwave landing systems--which had been a key element of the program to modernize the air traffic control system. Moreover, airlines expect that the augmented GPS and its applications will result in major operational and economic benefits by reducing flying times and fuel consumption. In addition, the Department of Transportation and FAA anticipate that the augmented GPS will benefit not only aviation users but also other federal agencies and land and sea users having a need for navigation information.³

FAA MAY NOT ACHIEVE FUTURE GPS MILESTONES

Although FAA has met all milestones for GPS to date, the agency will face more complex and difficult tasks in achieving future milestones. In 1993, FAA met several milestones for GPS when the agency approved the use of the system as a supplemental means of navigation for oceanic and domestic air routes as well as nonprecision approaches.⁴ Also, in December 1994, FAA met one of two 1995 milestones ahead of schedule when the agency approved the use of GPS--augmented by on-board-the-aircraft systems--as a primary means of navigation over oceans and remote areas. In addition, FAA will likely meet the other 1995 milestone when the agency completes assessing the feasibility of using local area

³One of our recent reports highlights the need for a governmentwide response to federal agencies' needs for GPS. See Global Positioning Technology: Opportunities for Greater Federal Agency Joint Development and Use (GAO/RCED-94-280, Sept. 28, 1994).

⁴On a nonprecision approach, an aircraft receives electronic guidance for flying toward the runway's centerline. On a precision approach, an aircraft receives not only this guidance but also guidance on the slope of descent to the runway. As a result, on a precision approach, an aircraft can safely descend closer to the ground while attempting to land in bad weather.

systems to support all types of precision approaches. According to GPS project officials, the preliminary testing of two local area demonstration systems has been encouraging, and reports on the performance of these systems are expected to be completed on schedule by the summer of 1995.

We are concerned, however, that the schedule for augmenting GPS will not give the agency enough time to develop and implement the wide area system by 1997, when civil aircraft are expected to use the augmented GPS domestically as a primary means of navigation. (See app. II for a depiction of FAA's milestones for GPS.) The schedule is tight. Over a 27-month period, from June 1995 to September 1997, the FAA contractor must develop and implement the system, and the agency must accept and commission it. FAA estimates that the system's software development alone may take from 24 to 28 months, thereby leaving little time for the agency to accept and commission the system. The schedule might slip if problems affect the system's development and implementation. The following areas, for example, show the potential for delay:

- Although FAA has taken measures such as strengthening its oversight capabilities, the contractor may face difficulties when attempting to develop, integrate, test, and certify the wide area system's software. FAA estimates that when measures to mitigate potential software development problems are taken into account, the software schedule has about a 60-percent probability of success.
- The space component of the wide area system requires that three commercial communication satellites be in place by late 1997--an undertaking that is beyond FAA's control. However, enough satellites may not be in orbit on time because the one company that intends to provide these satellites could delay launches or launch an insufficient number. It has already delayed launching the first of the three satellites from late 1995 to early 1996 because the rocket to launch the satellite will not be available until the later date. In August 1994, FAA estimated that its 1997 milestones may slip up to 18 months if problems, such as the loss of a communication satellite during launch, occur.

FAA'S ACTIONS ARE ENCOURAGING, BUT PLANS PROVIDE INCOMPLETE INFORMATION TO DECISIONMAKERS

In 1994, FAA took several encouraging actions to strengthen its capacity to manage its GPS-related efforts. However, its plans could be more useful to decisionmakers if they included estimated timetables and funding levels for implementing augmentation systems and information on the likelihood of achieving these estimates.

FAA Has Improved Its Ability to Augment GPS

FAA recently took several actions to better position itself for augmenting GPS. First, FAA established a new organization called the Integrated Product Team for GPS and Navigation under the jurisdiction of the Associate Administrator for Research and Acquisitions. According to the head of this organization, the consolidation was intended to improve the integration and coordination of the agency's efforts to augment GPS. Second, FAA requested and obtained increased funding to begin the development of the wide area system.⁵ Third, in mid-1994, FAA released plans for guiding the development and implementation of GPS' augmentations and drafted an agencywide plan for directing the transition to GPS.⁶

Plans Do Not Provide Needed Schedule and Cost Estimates

Among other things, the GPS development and implementation plans and the draft of the transition plan include schedule information on the wide area system and related milestones for using GPS as a primary means of navigation; identify requirements that GPS must satisfy; and highlight benefits that GPS will provide the agency and aviation users. However, these plans provide insufficient information to decisionmakers in the administration and the Congress.

- The plans issued in 1994 do not provide a timetable for implementing the local area systems that will be needed to support precision approaches in the worst weather conditions.
- The plans do not say what level of financial resources FAA needs to implement the wide and local area systems.
- The plans omit information on the likelihood that FAA will meet its milestones and cost estimates, given the effect on the system's development and implementation if potential problems materialize.

A comprehensive plan would help FAA guide and coordinate its

⁵FAA received \$82.8 million for GPS projects in fiscal year 1995, an increase of \$61.9 million over its appropriation for fiscal year 1994. This funding includes \$67.9 million to develop and implement the wide area system. For fiscal year 1996, the administration is requesting \$86.9 million to fund the system.

⁶FAA Satellite Navigation Program Master Plan, FY 94-99, June 15, 1994; GPS Implementation Plan for Air Navigation and Landing, Aug. 1994; and FAA National GPS/CNS Transition Plan, Draft, July 1994.

efforts, marshal its resources, and assess its progress. Also, this plan would help the administration and the Congress ascertain the scope of FAA's efforts, in terms of schedules and costs; assess whether the agency can meet milestones, given the level of resources requested; consider alternative courses of action; and monitor whether the agency's progress toward accomplishing these milestones and transitioning to GPS is on schedule and within budget.

As a result, in our report we recommended that the Secretary of Transportation direct the FAA Administrator to prepare a comprehensive plan for augmenting GPS and transitioning to it and to update this plan regularly. The plan should include, among other things, schedule and cost estimates for developing and implementing the wide and local area augmentation systems as well as information on the probability that FAA will meet these estimates.

IMPLICATIONS OF DELAYED IMPLEMENTATION OF SATELLITE-BASED NAVIGATION

FAA foresees that implementing both the wide area and local area systems will permit the agency, after a transition period, to start decommissioning its ground network of navigation aids, such as ILSs and very high frequency omnidirectional range (VOR) equipment.⁷ Once FAA certifies the augmented GPS as a primary means of navigation domestically, the agency will begin a period of supporting both ground- and satellite-based navigation systems. In the short term, FAA intends to fund both systems and, during this "dual use" period, establish a timetable for phasing out ground-based navigation aids. According to FAA's draft GPS transition plan, actual decommissioning could take 10 years.

If the schedule for implementing satellite-based navigation slips, FAA's future funding needs will be affected. FAA plans to spend almost \$200 million between fiscal years 1996 and 2003 for new and refurbished equipment to sustain the current ground-based navigation system until the transition to GPS is completed. Delays could create additional requirements for new equipment. They may also cause FAA to defer the significant costs savings associated with phasing out ground-based navigation aids. The agency spent an estimated \$170 million in 1993 in operation and maintenance expenses for VORs, nondirectional beacons, ILSs, and other existing

⁷Our report Airspace System: Emerging Technologies May Offer Alternatives to the Instrument Landing System (GAO/RCED-93-33, Nov. 13, 1992) discusses the need for FAA to reassess its requirements for precision landing systems.

equipment.⁸ For example, approximately 120 ILSs are over 20 years old, and FAA project officials expect that these systems, which already experience twice the number of outages as are expected under current design standards, will require increased maintenance in the future.

A delay in the implementation of GPS-based navigation would also adversely affect system users, such as airlines. A delay would defer the economic and operational benefits that the airlines expect from the augmented GPS. Furthermore, these users may have to delay their transition to GPS in terms of both equipping aircraft and training pilots.

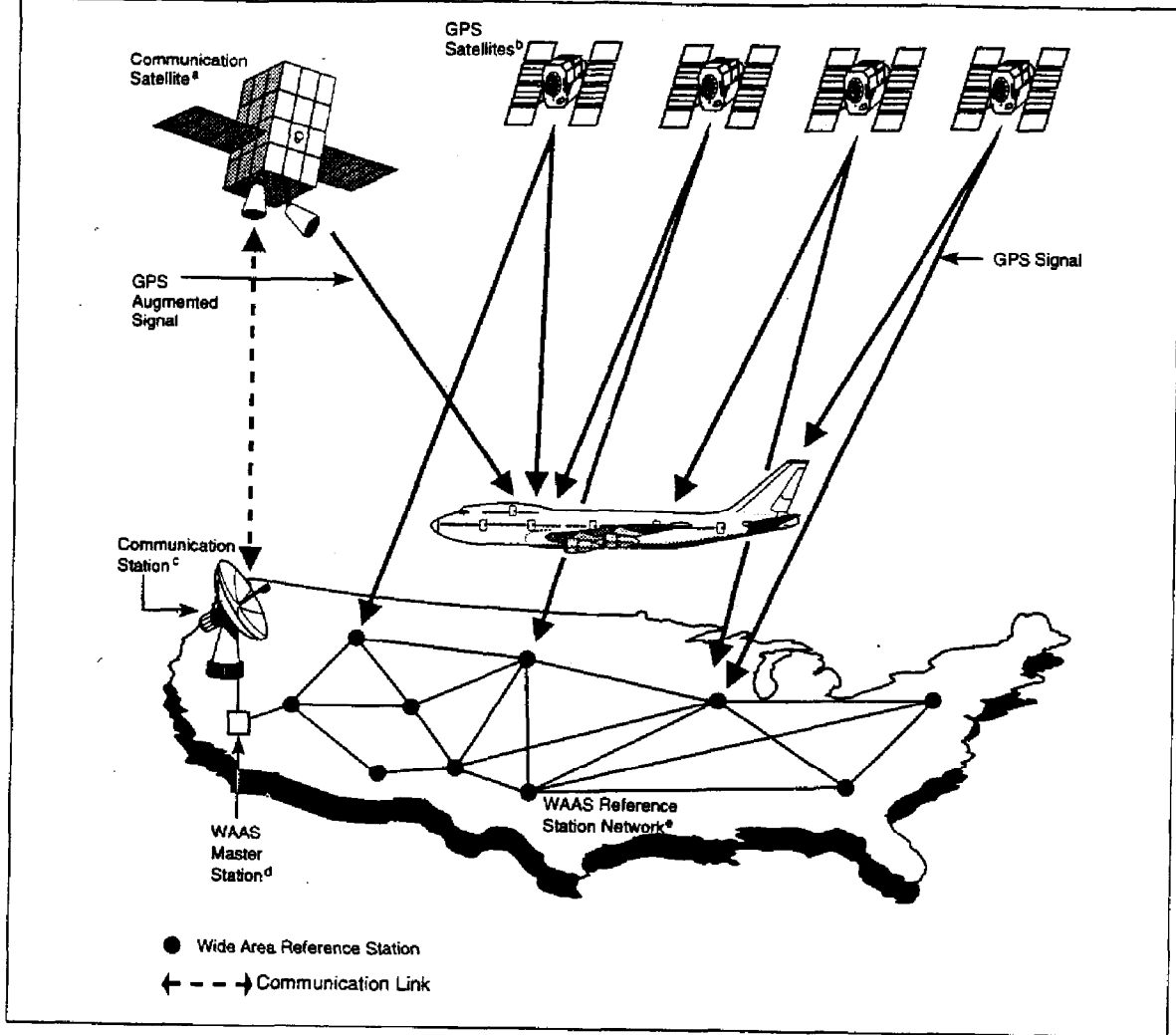
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Mr. Chairman, this concludes our statement. We will be happy to respond to any questions you or other Members of the Subcommittee may have at this time.

⁸FAA Navigation and Landing Resource Requirements, Final Report, July 16, 1993.

DIAGRAMS OF THE WIDE AND LOCAL AREA SYSTEMS

Figure I.1: Wide Area Augmentation System for All Phases of Flight



Legend

WAAS = wide area augmentation system

^aOther communication satellites not shown

^bOther GPS satellites not shown

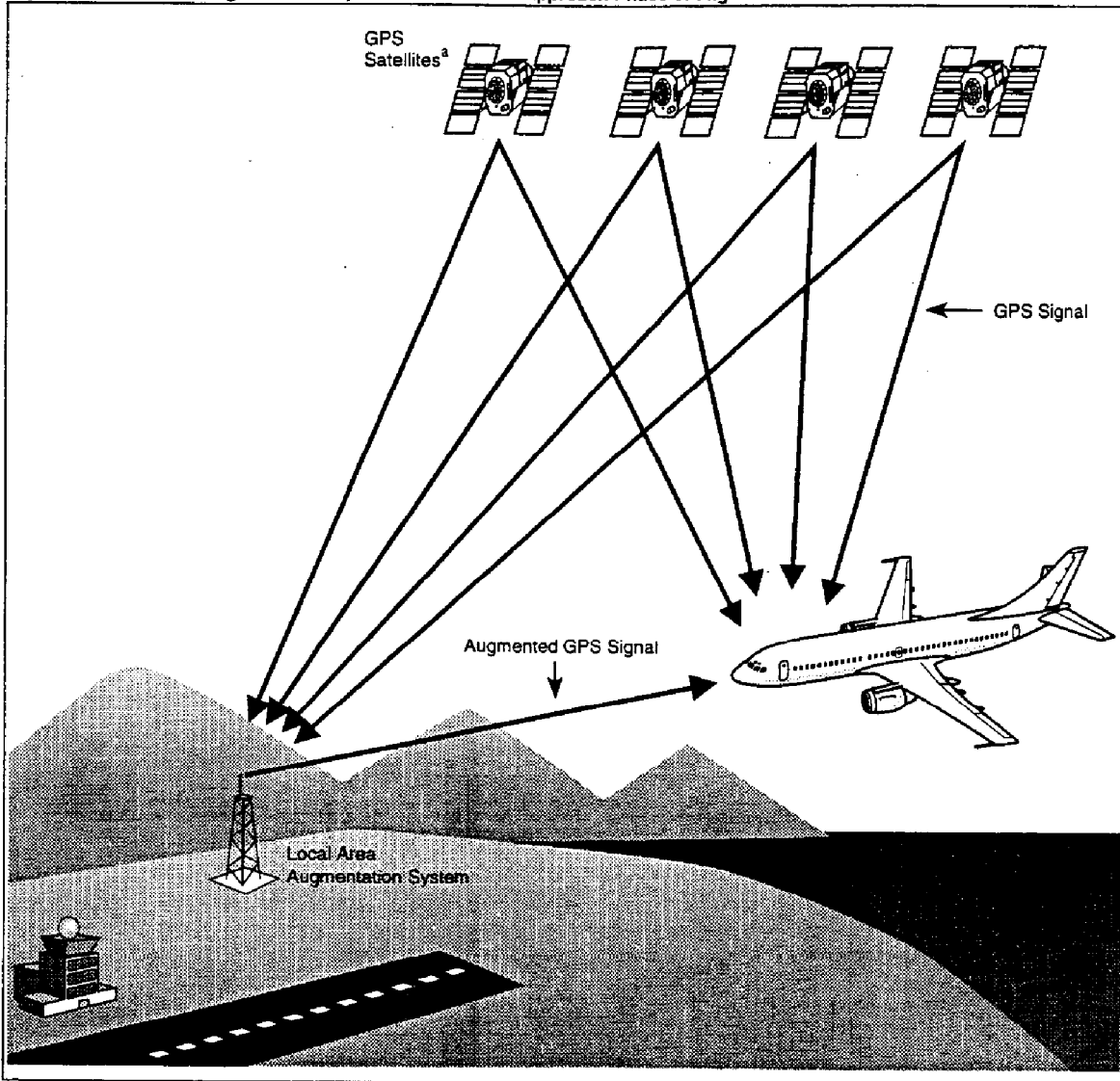
^cOther communication stations not shown

^dOther WAAS master stations not shown

^eOther WAAS reference stations not shown.

Source: Based on FAA's data.

Figure 1.2: Local Area Augmentation System for Precision Approach Phase of Flight



^aOther GPS satellites not shown.

Source: Based on FAA's data.

FAA'S CHANGES TO GPS MILESTONES

Figure II.1 shows the milestones in the schedule for enhancing GPS. Also, it displays the extent to which FAA has accelerated some milestones since they were introduced in 1992. Future milestones in the schedule depend on the implementation of a wide area system for augmenting GPS nationwide by 1997.

Figure II.1: FAA's Fiscal Year Milestones for GPS

Phases of Flight	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005												
Oceanic Air Route	A		B		C																						
Domestic Air Route	A		B				C*	←	←	←	←	←	←	←	C												
Terminal		A	B				C*	←	←	←	←	←	←	←	C												
Nonprecision Approach		A	B				C*	←	←	←	←	←	←	←	C												
Category I Precision Approach				D				B*						C*	←	←	←	←	←	C							
Category II/III Precision Approach																					E	←	←	←	←	←	E

Legend

A: GPS for multisystem navigation. Under this mode, a pilot uses the system in conjunction with one or more commissioned air navigation aids for obtaining reliable information on the aircraft's position. The aircraft must carry equipment for both GPS and the navigation aids, and the pilot must constantly cross-check the GPS-derived positioning information with the other systems' information.

B: GPS augmented for supplemental navigation. Under this mode, the pilot uses the augmented GPS by itself for determining the aircraft's position. However, because the GPS signals may not be available during one of the phases of flight, the aircraft must carry equipment for a commissioned air navigation aid as a backup.

C: GPS augmented to be a primary means of navigation. Under this mode, the pilot uses the augmented GPS by itself. The aircraft does not have to carry equipment for a commissioned air navigation aid as a backup.

B* and C*: Milestones based on the implementation of the wide area augmentation system.

D: GPS augmented for special Category I precision approaches. Under this mode, a pilot uses GPS augmented by privately owned local area systems for flying this type of precision approach.

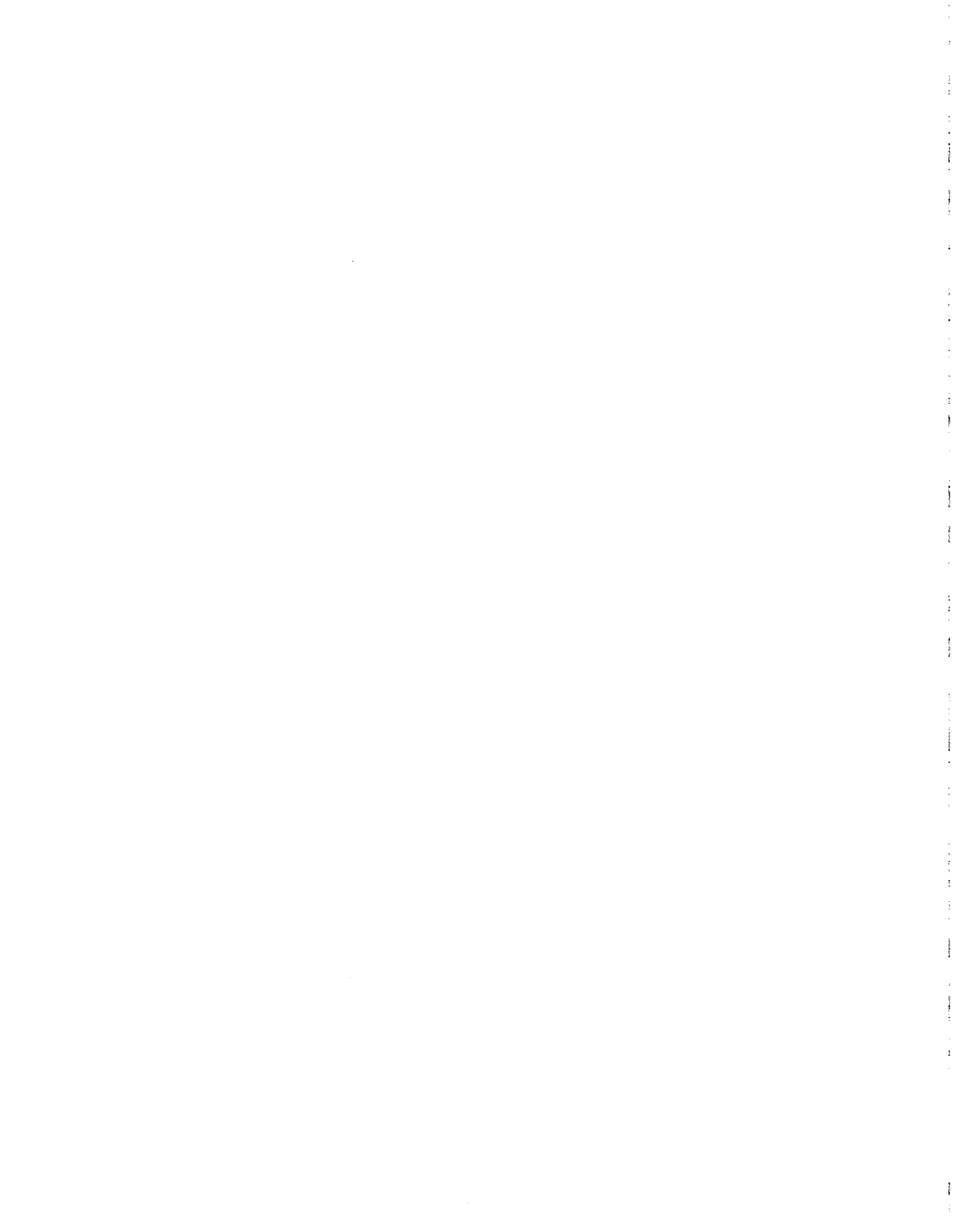
APPENDIX II

APPENDIX II

E: Feasibility determination of GPS' augmentation for supporting Category II/III precision approaches. FAA determines whether GPS augmented by local area systems can support these types of precision approaches.

Source: Based on FAA's 1992, 1993, and 1994 development plans and 1994 implementation plan.

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