CHAPTER 6
SYSTEM IMPROVEMENT PLANS

In the next ten years, exciting new technologies will be implemented to help ease air traffic congestion, add to system capacity, and enhance safety. Some of these changes will be invisible to pilots and will be made seamlessly. Others will entail changing some old habits and learning new procedures. New aircraft equipment will bring powerful new capabilities, but will require training and practice to master.

FLEET IMPROVEMENT

Airlines and other operators will continue trying to find more efficient ways to use the National Airspace System (NAS). More and more users are working with federal agencies to write new policies and develop exchanges of real-time flight information, all in the interest of improving their service as well as their bottom lines. As new business strategies emerge, there also will be changes in the aircraft fleet. For example, as regional jets continue to increase in popularity, they have significant potential to reduce traffic at major airports as well as on the most crowded airways. Providing service along underused area navigation (RNAV) routes directly between smaller city pairs, they can bypass congested hubs and avoid airborne choke points. The number of regional jets is forecast to increase by more than 80 percent in the next decade. Compared to the turboprop airplanes they will replace, RJs fly at similar speeds and altitudes as larger jets, so they mix into traffic streams more smoothly, making en route traffic management easier for controllers. [Figure 6-1]

Figure 6-1. Regional Jets.

At the other end of the spectrum, larger airplanes capable of carrying over 500 passengers are now flying. These "superjumbos" have the potential to reduce airway and terminal congestion by transporting more people in fewer airplanes. This ability is especially valuable at major hubs, where the number of flight operations exceeds capacity at certain times of day. On the other hand, some of these airplanes have a double-deck configuration that might require extensive changes to terminals so that large numbers of passengers can board and deplane quickly and safely. Their size may require increased separation of taxiways and hold lines from runways due to increased wingspans and tail heights. Their weight also may require stronger runways and taxiways, as well as increased separation requirements for wake turbulence. [Figure 6-2]

Figure 6-2. Superjumbo Airplanes.

Other innovative airplanes include the turbofan-powered very light jets (VLJs), which are relatively small turbofan-powered aircraft with 6 to 8 seats, with cruising speeds between 300 and 500 knots, and with a range of around 1,000 nautical miles (NMs). [Figure 6-3] If initial orders are an accurate indicator of their popularity, they will soon form a significant segment of the general aviation fleet. The FAA predicts that the business jet fleet will nearly double over the next ten years, approaching 16,000 airplanes by 2016. At least eight manufacturers are planning VLJs, several prototypes are flying, and the first new airplanes are being delivered to customers. Most are intended for single-pilot operation, and most will be certified for flight up to FL410. All will be technically advanced aircraft, with advanced glass cockpit avionics, digital engine controls, and sophisticated autopilots. These new airplanes will be capable of RNAV, required navigation performance (RNP), and reduced vertical separation minimum (RVSM) operations, and will operate mostly point-to-point, either on Q-Routes or random off-airways routes. With prices well below other business jets and competitive with turboprop singles, VLJs will appeal to many customers who could not otherwise justify the cost of a jet aircraft. VLJs have the potential of providing air taxi/air limousine services at costs comparable to commercial airlines, but with greater schedule flexibility, relatively luxurious accommodations, faster travel times, and the ability to fly into thousands more airports.

Figure 6-3. Very Light Jets are expected to become a sizeable segment of the high-altitude fleet.

ELECTRONIC FLIGHT BAG

As part of an ongoing effort to use the best technology available, industry has improved the timeliness and accuracy of information available to the pilot by converting it from a paper to a digital medium. An electronic flight bag (EFB) is an electronic display system intended primarily for cockpit/flightdeck or cabin use. EFBs can display a variety of aviation data or perform basic calculations, such as determining performance data or computing fuel requirements. In the past, paper references or an airline's flight dispatch department provided these functions. The EFB system may also include various other hosted databases and applications. These devices are sometimes referred to as auxiliary performance computers or laptop auxiliary performance computers.

The EFB is designed to improve efficiency and safety by providing real-time and stored data to pilots electronically. Use of an EFB can reduce some of a pilot's time-consuming communications with ground controllers while eliminating considerable weight in paper. EFBs can electronically store and retrieve many required documents, such as the General Operations Manual (GOM), Operations Specifications (OpSpecs), company procedures, Airplane Flight Manual (AFM), maintenance manuals and records, and dozens of other documents. [Figure 6-4]

In addition, advanced EFBs can also provide interactive features and perform automatic calculations, including performance calculations, power settings, weight and balance computations, and flight plans. They can also display images from cabin-mounted video and aircraft exterior surveillance cameras.

An EFB may store airport maps that can help a pilot avoid making a wrong turn on a confusing path of runways and taxiways, particularly in poor visibility or at an unfamiliar airport. Many runway incursions are due to confusion about taxi routes or pilots not being quite sure where they are on the airport. [Figure 6-5]

The FAA neither accepts or approves Class 1 or 2 EFBs which contain Types A, B, or C application software. Those who operate under 14 CFR parts 91K, 121, 125, 129, or 135 must obtain authorization for use. Advisory Circular 120-76, Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices, sets forth the acceptable means for obtaining both certification and approval for operational use of Class 3 EFBs. It also outlines the capabilities and limitations of each of the three classes of EFBs, which are grouped according to purpose and function. Depending on the features of the specific unit, these devices are able to display a wide range of flight-related information. The most capable EFBs are able to display checklists, flight operations manuals (FOMs), CFRs, minimum equipment lists, en route navigation and approach charts, airport diagrams, flight plans, logbooks, and operating procedures. Besides serving as a cockpit library, they can also make performance calculations and perform many of the tasks traditionally handled by a dispatch department. Some units can also accept satellite weather data or input from global positioning system (GPS) receivers, combining the aircraft position and graphic weather information on a moving map display.

Figure 6-4. Electronic Flight Bag. The EFB has the potential to replace many paper charts and manuals in the cockpit.

Figure 6-5. Moving Map Taxi Diagram on EFB.

Class 1 EFBs are portable. They can be used both on the ground and during flight, but must be stowed for takeoff and landing. They are limited to providing supplemental information only and cannot replace any required system or equipment. It may be connected to aircraft power through a certified power source, to operate the EFB and recharge its batteries. They are allowed to read data from other aircraft systems, and may receive and transmit data through a data link. Class 1 EFBs can display many different kinds of tabular data, such as performance tables, checklists, the FOM, AFM, and pilot's operating handbook (POH).

While a Class 2 EFB is also removable from the aircraft, it is installed in a structural-mounting bracket. This ensures that the EFB will not interfere with other aircraft systems. While Class 1 and 2 EFBs are both considered portable electronic devices, a logbook entry is required to remove the Class 2 EFB from the aircraft. It can be connected to aircraft power and to the aircraft's datalink port. The EFB can exchange data with aircraft systems, enabling it to make interactive performance calculations. It can be used to compute weight and balance information as well as takeoff and landing V-speeds, and to display flight critical pre-composed data, such as navigation charts. Since it is not necessarily stowed for takeoff and landing, pilots can use it to display departure, arrival, and approach charts.

The most capable EFBs are Class 3. These are built into the panel and require a Supplemental Type Certification (STC) or certification design approval with the aircraft as part of its equipment. Paper charts may not be required. Depending on the model, it may be connected to the GPS or Flight Management System (FMS), and it may be able to combine GPS position with the locations and speed vectors of other aircraft and graphic weather information into a single, detailed moving map display. Its detailed database can also provide obstacle and terrain warnings. It is important to remember that an EFB does not replace any system or equipment required by the regulations.

INCREASING CAPACITY AND SAFETY

Safety is, and will remain, the highest priority in all plans to increase capacity for the future. As demand for air travel continues to rise, it is clear that the NAS capacity must grow. Both the number of airport operations and en route capacity must increase simultaneously to accommodate the expanding needs. Neither can realistically be treated separately from the other, but for the sake of convenience, this chapter first discusses increasing the arrival/departure rate, then en route issues.

The number of aircraft operations is expected to increase by about 30 percent over the next decade. Although most parts of the NAS are able to handle current traffic, increasing operations will strain system capabilities unless capacity grows to match demand. The FAA has identified and corrected several existing "choke points" in the NAS. While relatively few airports and airways experience large numbers of delays, the effects snowball into disruptions throughout the rest of the system, especially in adverse weather. Capacity must be increased to manage future growth. The FAA is implementing a number of programs to increase the capacity and efficiency of the NAS. Industry itself is also taking specific actions to address some of the problems.

INCREASING THE DEPARTURE/ARRIVAL RATE

Relatively few routes and airports experience the majority of congestion and delays. In the case of airports, peak demand occurs for only a few, isolated hours each day, so even the busiest hubs are able to handle their traffic load most of the time. Adjusting the number of arrivals and departures to get rid of those peak demand times would ease congestion throughout the system.

MORE RUNWAYS

At some major hubs, adding new runways or improving existing runways can increase capacity by as much as 50 percent, but the process is complex and time-consuming. During the planning phase, the appropriate FAA offices must review the new runway's impact on airspace, air traffic control (ATC) procedures, navigational aids (NAVAIDs), and obstructions. New instrument procedures must be developed, and economic feasibility and risk analysis may be required.

The next phase includes land acquisition and environmental assessment. Often, the airports that most need new runways are "landlocked" by surrounding developed areas, so obtaining land can be difficult. On top of that, residents and businesses in the area sometimes resist the idea of building a new runway. Concerns range from increased noise to safety and environmental impact. While environmental assessments and impact statements are essential, they take time. The FAA is working with other federal authorities to streamline the process of obtaining permits. Good community relations are extremely important, and working with airport neighbors can often address many of the questions and concerns.

The next phase of development involves obtaining the funding. A new runway typically costs between 100 million and one billion dollars. Money comes from airport cash flow, revenue and general obligation bonds, airport improvement program grants, passenger facility charges, and state and local funding programs.

The last phase includes the actual construction of the new runway, which may take as many as three years to complete. In all, over 350 activities are necessary to commission one new runway. The FAA has created the

Runway Template Action Plan to help airport authorities coordinate the process.

SURFACE TRAFFIC MANAGEMENT

In cooperation with the FAA, the National Aeronautics and Space Administration (NASA) is studying automation for aiding surface traffic management at major airport facilities. The surface management system is an enhanced decision support tool that will help controllers and airlines manage aircraft surface traffic at busy airports, thus improving safety, efficiency, and flexibility. The surface management system provides tower controllers and air carriers with accurate predictions of the future departure demand and how the situation on the airport surface, such as takeoff queues and delays at each runway, will evolve in response to that demand. To make these predictions, the surface management system will use real-time surface surveillance, air carrier predictions of when each flight will want to push back, and computer software that accurately predicts how aircraft will be directed to their departure runways.

In addition to predictions, the surface management system also provides advisories to help manage surface movements and departure operations. For example, the surface management system advises a departure sequence to the ground and local controllers that efficiently satisfies various departure restrictions such as miles-in-trail and expected departure clearance times (EDCTs). Information from the surface management system is displayed in ATC towers and airline ramp towers, using either dedicated surface management system displays or by adding information to the displays of other systems.

Parts of the system were tested in 2003 and 2004, and are now ready for deployment. Other capabilities are accepted in concept, but are still under development. Depending on the outcome of the research, the surface management system might also provide information to the terminal radar approach control (TRACON) and center traffic management units (TMUs), airline operations centers (AOCs), and ATC system command centers (ATCSCCs). In the future, additional developments may enable the surface management system to work with arrival and departure traffic management decision support tools.

The surface movement advisor (SMA) is another program now being tested in some locations. This project facilitates the sharing of information with airlines to augment decision-making regarding the surface movement of aircraft, but is concerned with arrivals rather than departures. The airlines are given automated radar terminal system (ARTS) data to help them predict an aircraft's estimated touchdown time. This enhances airline gate and ramp operations, resulting in more efficient movement of aircraft while they are on the ground. Airline customers reported reduced gate delays and diversions at the six locations where SMA is in use.

TERMINAL AIRSPACE REDESIGN

The FAA is implementing several changes to improve efficiency within terminal airspace. While some methods increase capacity without changing existing routes and procedures, others involve redesigning portions of the airspace system. One way of increasing capacity without major procedural changes is to fill the gaps in arrival and departure streams. Traffic management advisor (TMA) is ATC software that helps controllers by automatically sequencing arriving traffic. Based on flight plans, radar data, and other information, the software computes very accurate aircraft trajectories as much as an hour before the aircraft arrives at the TRACON. It can potentially increase operational capacity by up to ten percent, and has improved capacity by 3 to 5 percent for traffic into the Dallas/Ft. Worth, Los Angeles, Minneapolis, Denver, and Atlanta airports.

One limitation of TMA is that it uses information on incoming flights from a single Air Route Traffic Control Center (ARTCC). Another version is under development that will integrate information from more than one ARTCC. It is called multi-center traffic management advisor (McTMA). This system is being tested in the busy Northeastern area, and the results are promising.

Another software-based solution is the passive final approach spacing tool (pFAST). This software analyzes the arriving traffic at a TRACON and suggests appropriate runway assignment and landing sequence numbers to the controller. Controllers can accept or reject the advisories using their keyboards. The early version carries the "passive" designation because it provides only runway and sequence number advisories. A more advanced version, called active FAST (aFAST), is currently under development at NASA Ames Research Center. In addition to the information provided by pFAST, aFAST will display heading and speed, and it is expected to improve capacity by an additional 10 percent over pFAST.

Airlines can help ease congestion on shorter routes by filing for lower altitudes. Although the airplane uses more fuel at a lower cruising altitude, the flight may prove faster and more economical if weather or high traffic volume is delaying flights at higher levels. The tactical altitude assignment program consists of published routes from hubs to airports 200 to 400 NM away. Based on results of evaluation, it is not expected to be implemented nationally, although it may remain available in local areas.

Beyond using existing facilities and procedures more effectively, capacity can often be increased by making relatively minor changes in air traffic procedures. For example, in some instances, departure and arrival patterns have remained unchanged from when there was very little air traffic, and congestion results when today's traffic tries to use them. Likewise, arrival and departure procedures may overlap, either because they were based on lower volumes and staffing or because they are based on ground-based navigation. The interdependence of arrival and departure routes tends to limit throughput in both directions.

Separating departures from incoming traffic can simplify the work of controllers, reduce vectoring, and make more efficient use of terminal airspace. In the **four corner post configuration**, four NAVAIDs form the four corners of the TRACON area, roughly 60 NM from the primary airport. All arrivals to the area fly over one of these "corner posts" (also called arrival meters or feeder fixes). The outbound departure streams are spaced between the arrival streams. [Figure 6-6]

As more and more aircraft are equipped for RNAV, new arrival and departure routes are being created that do not depend on very high frequency omni-directional range (VOR) airways or ground-based NAVAIDs. Shifting traffic to new RNAV routes eases congestion on existing airways. There are already several new RNAV routes in use and many more are being developed.

SEPARATION STANDARDS

Current regulations permit a 3 NM separation within 40 NM of a single radar sensor. The FAA is looking at ways to increase the use of the 3 NM separation standard to improve efficiency and maximize the volume of traffic that can be safely moved into busy terminal areas. The methods involve increasing the size of terminal areas to include more en route airspace, redesigning airspace to encompass multiple airports within a single ATC facility, and consolidating certain TRACON facilities. This will involve major changes on the ground for ATC facilities, and changes in charts and procedures for pilots.

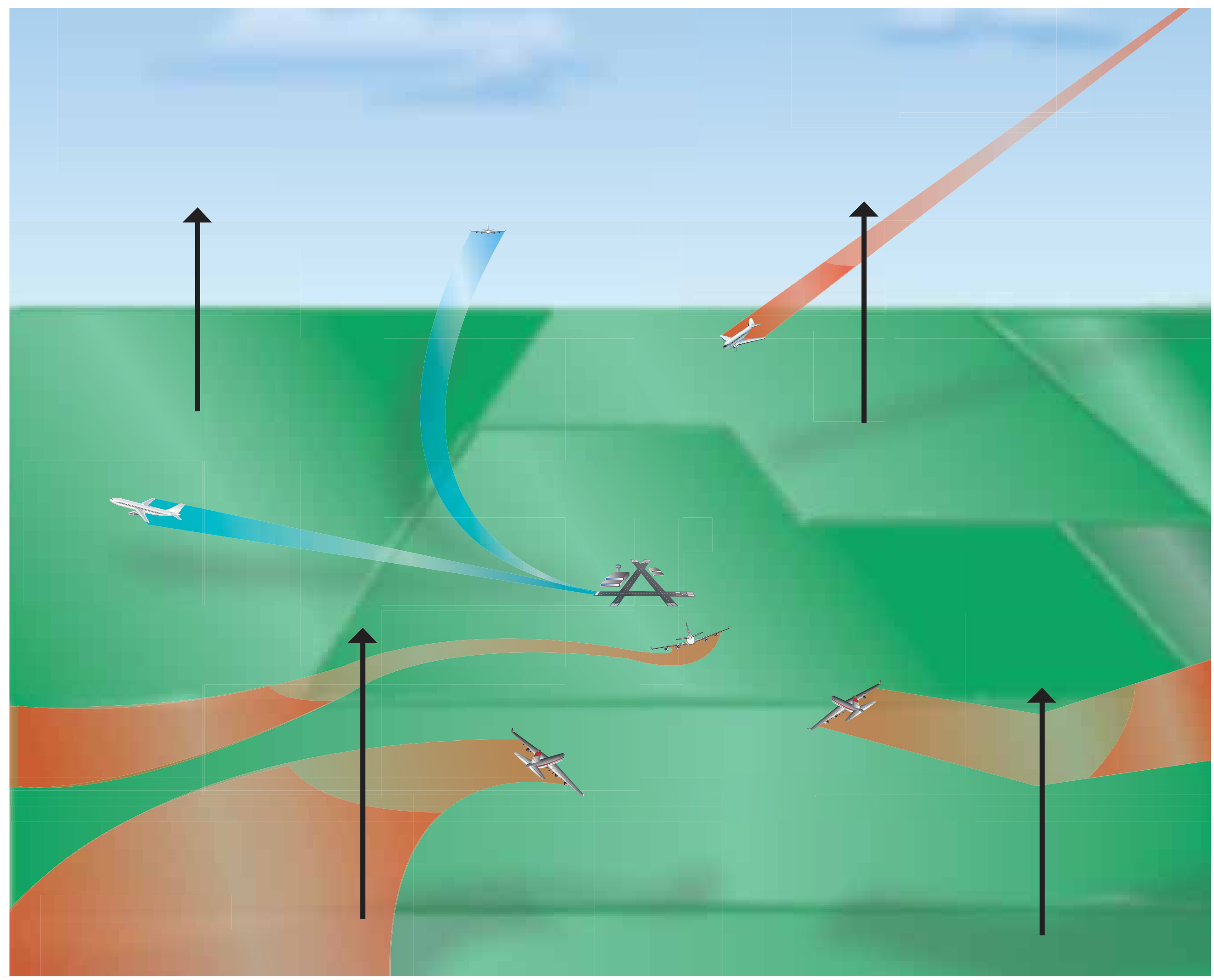

Figure 6-6. Four Corner Post Configuration.

As gaps are filled in arrival and departure streams and the 3 NM separation standard is applied more extensively, traffic advisories from the traffic alert and collision avoidance system (TCAS) are bound to increase. While newer software enhances functionality, provides more timely resolution advisories, and eliminates many nuisance alerts, data link technology based on GPS position information may offer even better results.

MAINTAINING RUNWAY USE IN REDUCED VISIBILITY

Although traffic in congested airspace typically operates under instrument flight rules (IFR), adverse weather and actual instrument meteorological conditions (IMC) can drastically reduce system capacity. Many parallel runways cannot be used simultaneously in IMC because of the time delay and limited accuracy of terminal area radar, and the runways are spaced closer than the minimum allowable distance for wake vortex separation.

LAAS AND WAAS IMPLEMENTATION

The wide area augmentation system (WAAS) became available at most locations in 2003. Additional ground reference stations are expected to become operational in Canada, Mexico, and Alaska by 2008, providing more complete WAAS coverage for the continental United States. The local area augmentation system (LAAS) provides even greater accuracy and may be certified for use in precision approaches at some locations beginning in 2007.

Another benefit of LAAS and WAAS is that better position information can be sent to controllers and other aircraft. Automatic dependant surveillance-broadcast (ADS-B) uses GPS to provide much more accurate location information than radar and transponder systems. This position information is broadcast to other ADS-equipped aircraft (as well as ground facilities), providing pilots and controllers with a more accurate real-time picture of traffic.

For full safety and effectiveness, every aircraft under the control of ATC will need ADS-B. Until that occurs, controllers must deal with a mix of ADS-B and transponder-equipped aircraft. Equipment is already available that can fuse the information from both sources and show it on the same display. **Traffic information service-broadcast (TIS-B)** does just that. Although TIS-B is primarily intended for use on the ground by controllers, the information can be transmitted to suitably equipped aircraft and displayed to pilots in the cockpit. The **cockpit display of traffic information (CDTI)** provides information for both ADS-B and non-ADS-B aircraft on a single cockpit display. [Figure 6-7] Since this information is shown even while the aircraft is on the ground, it also improves situational awareness during surface movement, and can help prevent or resolve taxiing conflicts.

Figure 6-7. Cockpit Display of Traffic Information. This display shows both ADS-B and other aircraft radar targets.

REDUCING EN ROUTE CONGESTION

In addition to the congestion experienced at major hubs and terminal areas, certain parts of the en route structure have reached capacity. Easing the burden on high-volume airways and eliminating airborne choke points are some of the challenges addressed by new airspace plans.

MATCHING AIRSPACE DESIGN TO DEMANDS

More new RNAV routes are being created, which are essentially airways that use RNAV for guidance instead of VORs. They are straighter than the old VOR airways, so they save flight time and fuel costs. By creating additional routes, they reduce traffic on existing airways, adding en route capacity. As new routes are created near existing airways, chart clutter will become more of an issue. Electronic chart presentations are being developed that will allow pilots to suppress information that is irrelevant to their flight, while ensuring that all information necessary for safety is displayed. The high degree of accuracy and reliability of RNP procedures offers another means of increasing capacity along popular RNAV routes. Instead of having all the aircraft that are using the route fly along the same ground track, RNP allows several closely spaced parallel tracks to be created for the same route. In essence, this changes a one-lane road into a multi-lane highway. [Figure 6-8]

REDUCING VOICE COMMUNICATION

Many runway incursions and airborne clearance mistakes are due to misunderstood voice communications. During busy periods, the necessity of exchanging dozens of detailed instructions and reports leads pilots and controllers to shorten and abbreviate standard phraseology, often leading to errors. It stands to reason that better ways to transfer information could reduce voice communications, and thus reduce the incidence of communication errors. One such innovation is similar to the display screen at fast-food drive-up windows. As the cashier punches in the order, it is displayed on the monitor so the customer can verify the order. This kind of feedback reduces the common problem of hearing what is expected to be heard, which is particularly problematic in ATC clearances and read backs. Not only does reducing voice communications reduce frequency congestion, it also eliminates certain opportunities for misunderstanding.

Controller pilot data link communication (CPDLC) augments voice communications by providing a second communication channel for use by the pilot and controller, using data messages that are displayed in the cockpit. This reduces delays resulting from congestion on voice channels. The initial version of CPDLC will display a limited number of air traffic messages, but future versions will have expanded message capabilities and permit pilot-initiated requests.

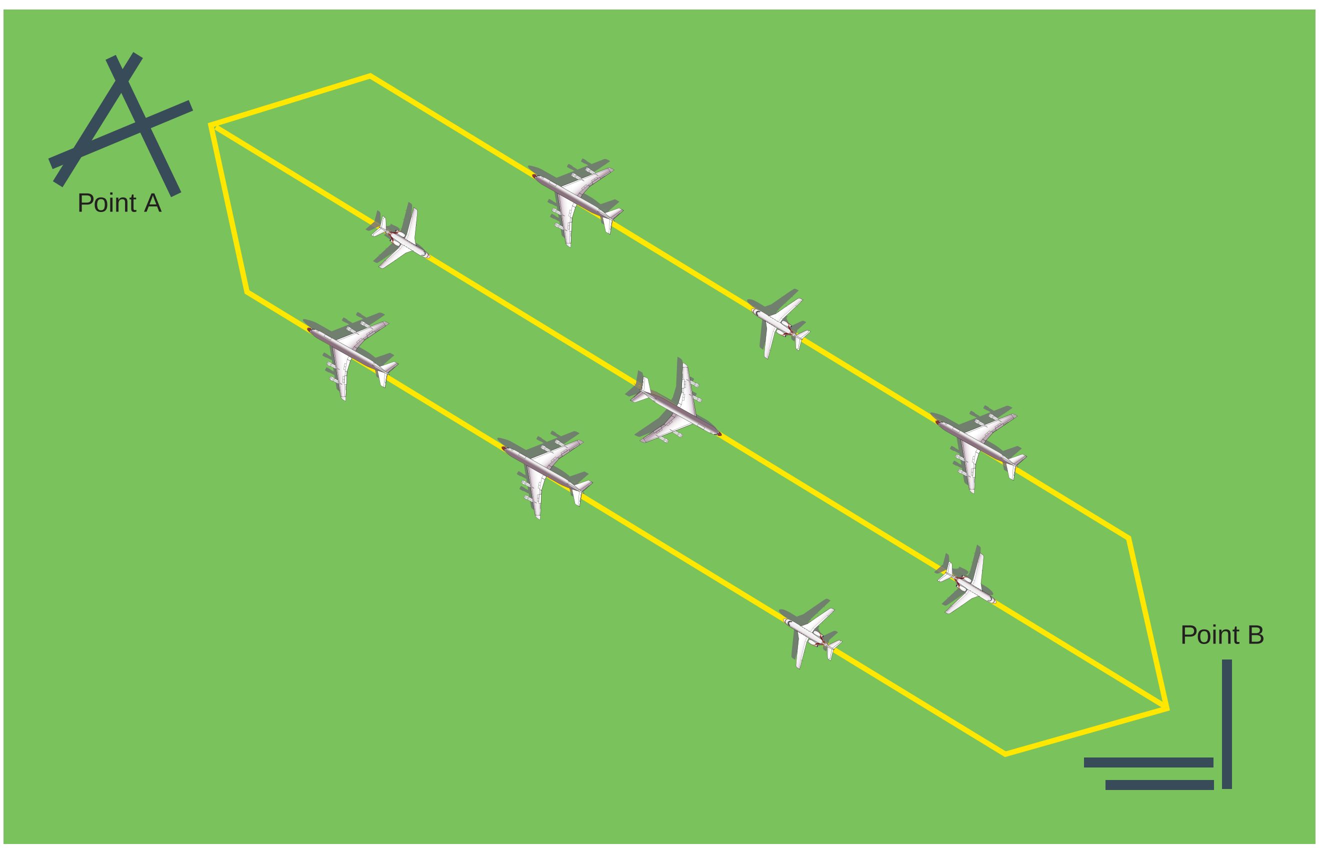

Figure 6-8. RNP allows parallel tracks along the same route, multiplying capacity along that route.

AIRCRAFT COMMUNICATIONS ADDRESSING AND REPORTING SYSTEM

Of course, pilot-controller communication is compromised when the crew is listening to other frequencies or engaged in other communications, such as talking to their company. If these communications could be accomplished silently and digitally, voice communications with ATC would improve. The Aircraft Communications Addressing and Reporting System (ACARS) is a commercial system that enables the crew to communicate with company personnel on the ground. It is often used to exchange routine flight status messages, weather information, and can serve as a non-voice communication channel in the event of an emergency. Many of the messages are sent and received automatically, such as the time the flight leaves the gate (triggered by the release of the parking brake), takeoff and touchdown times (triggered by landing gear switches), and arrival time (triggered when a cabin door is opened). Other information may include flight plans, significant meteorological information (SIGMETs), crew lists, cargo manifests, automatic terminal information service (ATIS) reports, en route and destination weather, clearances, and fuel reports. Some ACARS units can interface with onboard engine and performance-monitoring systems to inform company ground personnel of maintenance or operations related issues. [Figure 6-9]

Figure 6-9. ACARS Communications Display.

Significant valuable meteorological data can be obtained by collecting data from aircraft fitted with appropriate software packages. To date, the predominant sources of automated aviation data have been from aircraft equipped with aircraft to satellite data relay (ASDAR) and ACARS, which routes data back via general purpose information processing and transmitting systems now fitted to many commercial aircraft. These systems offer the potential for a vast increase in the provision of aircraft observations of wind and temperature. Making an increasingly important contribution to the observational database, it is envisioned that ACARS data will inevitably supersede manual pilot reports (PIREPS).

Another use of ACARS is in conjunction with Digital ATIS (D-ATIS), which provides an automated process for the assembly and transmission of ATIS messages. ACARS enables audio messages to be displayed in text form in the flight decks of aircraft equipped with ACARS. A printout is also provided if the aircraft is equipped with an on-board printer. D-ATIS is operational at over 57 airports that now have pre-departure clearance (PDC) capability.

AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST

Unlike TCAS and terrain awareness and warning systems (TAWS), which have been used in airline and military aircraft for at least a decade, ADS-B is a relatively new air traffic technology. It is an onboard system that uses Mode S transponder technology to periodically broadcast an aircraft's position, along with some supporting information like aircraft identification and short-term intent. By picking up broadcast position information on the ground instead of using ground radar stations, ADS-B represents a significant advancement over the existing ATC system by providing increased accuracy and safety. This is possible because ADS-B addresses the major deficiency of TCAS - accuracy. In the TCAS system, aircraft positions are only accurate to a few degrees; thus, the accuracy of TCAS decreases with distance. Moreover, the reliance on transmission timing for range data in TCAS is error-prone. The method used by ADS-B avoids this problem.

In addition to the broadcast of position to the ground, ADS-B can be used to enable a new collection of aircraft-based applications. Unlike conventional radar, ADS-B works at low altitudes and on the ground. It is effective in remote areas or in mountainous terrain where there is no radar coverage, or where radar coverage is limited. One of the greatest benefits of ADS-B is its ability to provide the same real-time information to pilots in the aircraft cockpit and to ground controllers, so that for the first time, both can view the same data.

ADS-B will also enable aircraft to send messages to each other to provide surveillance and collision avoidance through data link. Other aircraft in the immediate vicinity can pick up position information broadcasts from equipped aircraft. This enables equipped aircraft to formulate a display of nearby aircraft for the pilot; the pilot's awareness of the current situation is enhanced. Combined with databases of current maps and charts, the onboard displays can show terrain as well as proximate aircraft. This is a powerful inducement for change. The heightened situational awareness offered by satellite navigation in conjunction with modern database applications and map displays, combined with the position of proximate aircraft, builds a picture in the cockpit equivalent to that on the ground used by the controller. This is particularly important in places like Alaska where aviation is vital, NAS infrastructure is minimal (because of the harsh conditions), and weather changes quickly and in unpredictable fashions.

Eventually, as the fleets equip, it may be possible to save money by retiring expensive long-range radars. Identified by the FAA as the future model for ATC, ADS-B is a major step in the direction of free flight. While ADS-B shows great promise for both air-to-air and air-to-ground surveillance, current aircraft transponders will continue to support surveillance operations in the NAS for the foreseeable future. If enough users equip with ADS-B avionics, the FAA will install a compatible ADS ground system to provide more accurate surveillance information to ATC compared to radar-based surveillance.

In the United States, two different data links have been adopted for use with ADS-B: 1090 MHz Extended Squitter (1090 ES) and the Universal Access Transceiver (UAT). The 1090 ES link is intended for aircraft that primarily operate at FL180 and above, whereas the UAT link is intended for use by aircraft that primarily operate at 18,000 feet and below. From a pilot's standpoint, the two links operate similarly and both support ADS-B and TIS-B. The UAT link additionally supports Flight Information Service-Broadcast (FIS-B) at any altitude when within ground based transmitter (GBT) coverage. FIS-B is the weather information component, and provides displays of graphical and textual weather information. Areas of approved use for the UAT include the United States (including oceanic airspace where air traffic services are provided), Guam, Puerto Rico, American Samoa, and the U.S. Virgin Islands. The UAT is approved for both air and airport surface use. ADS-B broadcast over the 1090 MHz data link has been approved for global use.

REDUCING VERTICAL SEPARATION

Current vertical separation minima (2,000 feet) were created more than 40 years ago when altimeters were not very accurate above FL 290. With better flight and navigation instruments, vertical separation has been safely reduced to 1,000 feet in most parts of the world, except Africa and China.

RVSM airspace has already been implemented over the Atlantic and Pacific Oceans, South China Sea, Australia, Europe, the Middle East and Asia south of the Himalayas. Domestic RVSM (DRVSM) in the United States was implemented in January 2005 when FL 300, 320, 340, 360, 380, and 400 were added to the existing structure. To fly at any of the flight levels from FL 290 to FL 410, aircraft and operator must be RVSM-approved. [Figure 6-10]

REDUCING HORIZONTAL SEPARATION

The current oceanic air traffic control system uses filed flight plans and position reports to track an aircraft's progress and ensure separation. Pilots send position reports by high frequency (HF) radio through a private radio service that then relays the messages to the air traffic control system. Position reports are made at intervals of approximately one hour. HF radio communication is subject to interference and disruption. Further delay is added as radio operators relay messages between pilots and controllers. These deficiencies in communications and surveillance have necessitated larger horizontal separation minimums when flying over the ocean out of radar range.

As a result of improved navigational capabilities made possible by technologies such as GPS and CPDLC, both lateral and longitudinal oceanic horizontal separation standards are being reduced. Oceanic lateral separation standards were reduced from 100 to 50 NM in the Northern and Central Pacific regions in 1998 and in the Central East Pacific in 2000. The FAA plans to extend the 50 NM separation standard to the South Pacific. Because flight times along the South Pacific routes often exceed 15 hours, the fuel and time savings resulting from more airplanes flying closer to the ideal wind route in this region are expected to be substantial. Separation standards of 30 NM are already undergoing operational trials in parts of South Pacific airspace for properly authorized airplanes and operators.

DIRECT ROUTING

Based on preliminary evaluations, FAA research has evidenced tremendous potential for the airlines to benefit from expected routing initiatives. Specifically, direct routing or "Free Flight" is the most promising for reducing total flight time and distance as well as minimizing congestion on heavily traveled airways. Traditionally,

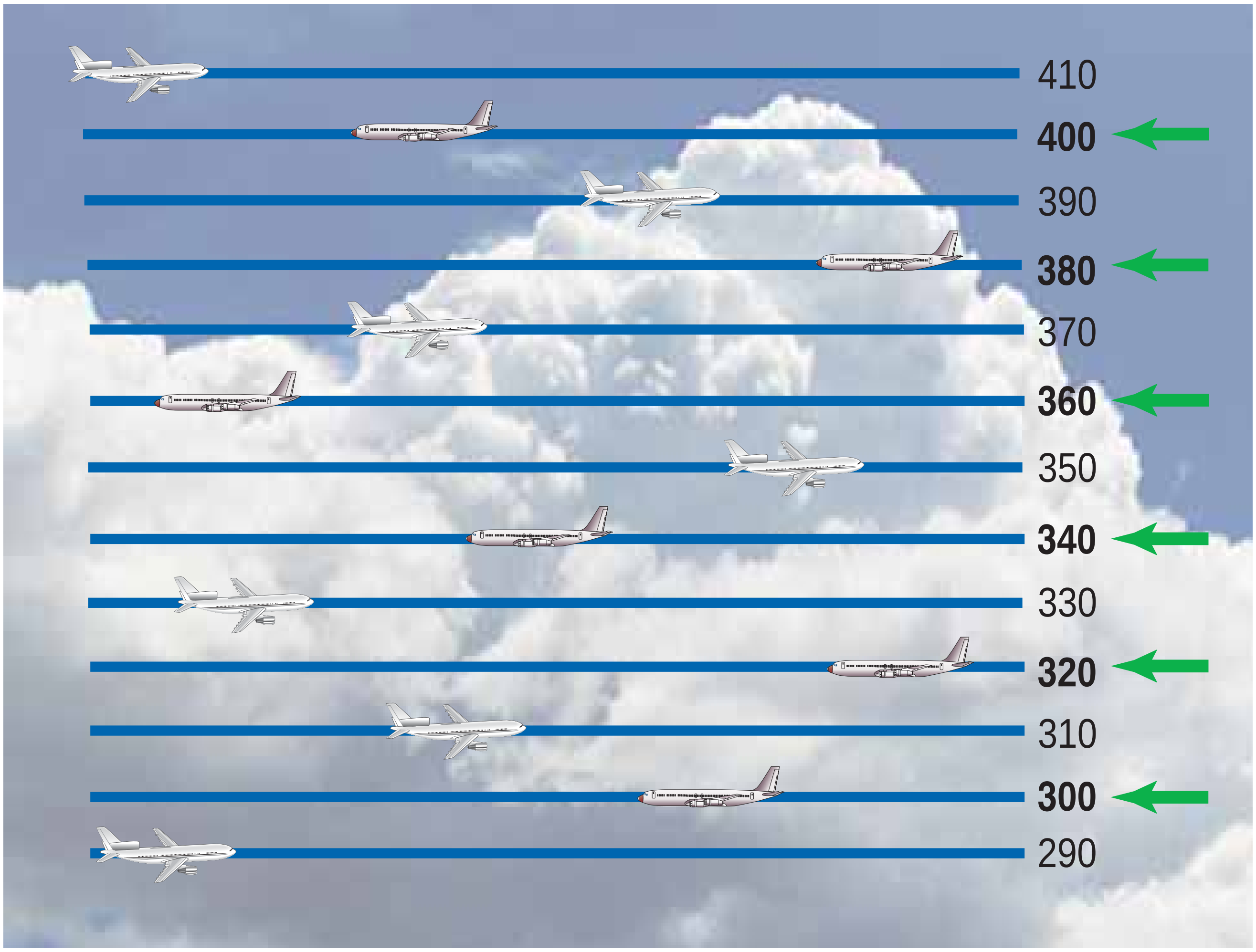

Figure 6-10. DRVSM High Altitude Routes.

pilots fly fixed routes that often are less direct due to their dependence on ground-based NAVAIDs. Through Free Flight, the FAA hopes to increase the capacity, efficiency, and safety of the NAS to meet growing demand as well as enhance the controller's productivity. The aviation industry, particularly the airlines, is seeking to shorten flight times and reduce fuel consumption. According to the FAA's preliminary estimates, the benefits to the flying public and the aviation industry could reach into the billions of dollars once the program is fully operational.

Free Flight Phase 1 began in October 1998 and launched five software tools over the next four years. These were Collaborative Decision Making (CDM), the User Request Evaluation Tool (URET), and the previously discussed SMA, TMA, and pFAST.

CDM allows airspace users and the FAA to share information, enabling the best use of available resources. It provides detailed, real-time information about weather, delays, cancellations, and equipment to airlines and major FAA air traffic control facilities. This shared data helps to manage the airspace system more efficiently, thereby reducing delays.

CDM consists of three components. The first component allows airlines and the FAA's System Command Center in Herndon, Virginia, to share the latest information on schedules, airport demand, and capacity at times (usually during bad weather) when airport capacity is reduced. This shared information is critical to getting the maximum number of takeoffs and landings at airports. The second component creates and assesses possible rerouting around bad weather. This tool enables the Command Center and busy major ATC facilities to share real-time information on high-altitude traffic flows with airline operations centers, thus developing the most efficient ways to avoid bad weather. The third component provides data on the operational status of the national airspace system. Examples include runway visibility at major airports and the current availability of Special Use Airspace.

URET allows controllers to plot changes in the projected flight paths of specific airplanes to see if they will get too close to other aircraft within the next 20 minutes. URET means that controllers can safely and quickly respond to pilots' requests for changes in altitude or direction, which leads to smoother, safer flights and more direct routings. During trials in the Memphis and

Indianapolis en route centers, the use of more direct routes made possible by URET was found to save airlines about $1.5 million per month.

ACCOMMODATING USER PREFERRED ROUTING

Free Flight Phase 2 builds on the successes of Free Flight Phase 1 to improve safety and efficiency within the NAS. Implementation of Phase 2 will include the expansion of Phase 1 elements to additional FAA facilities. This program will deploy a number of additional capabilities, such as CDM with collaborative routing coordination tool (CRCT) enhancements and CPDLC.

The National Airspace System status information (NASSI) tool is the most recent CDM element to be introduced. NASSI enables the real-time sharing of a wide variety of information about the operational status of the NAS. Much of this information has previously been unavailable to most airspace users. NASSI currently includes information on maintenance status and runway visual range at over 30 airports.

The CRCT is a set of automation capabilities that can evaluate the impact of traffic flow management rerouting strategies. The major focus of this tool is management of en route congestion.

IMPROVING ACCESS TO SPECIAL USE AIRSPACE

Special use airspace (SUA) includes prohibited, restricted, warning, and alert areas, as well as military operations areas (MOAs), controlled firing areas, and national security areas. The FAA and the Department of Defense are working together to make maximum use of SUA by opening these areas to civilian traffic when they are not being used by the military. The **military airspace management system (MAMS)** keeps an extensive database of information on the historical use of SUA, as well as schedules describing when each area is expected to be active. MAMS transmits this data to the **special use airspace management system (SAMS)**, an FAA program that provides current and scheduled status information on SUA to civilian users. This information is available at the following link **http://sua.faa.gov/**. The two systems work together to ensure that the FAA and system users have current information on a daily basis.

A prototype system called SUA in-flight service enhancement (SUA/ISE) provides graphic, near-real-time depictions of SUA to automated flight service station (AFSS) specialists who can use the information to help pilots during flight planning as well as during flight. Pronounced "Suzy," this tool can display individual aircraft on visual flight rule (VFR) flight plans (with data blocks), plot routes of flight, identify active SUA and display weather radar echoes. Using information from the enhanced traffic management system, AFSS specialists will see this information on a combined graphic display. This data may also be transmitted and shown on cockpit displays in general and commercial aviation aircraft.

The central altitude reservation function (CARF) coordinates military, war plans, and national security use of the NAS. While SAMS handles the schedule information regarding fixed or charted SUA, CARF handles unscheduled time and altitude reservations. Both subsystems deal with planning and tracking the military's use of the NAS.

The FAA and the U.S. Navy have been working together to allow civilian use of offshore warning areas. When adverse weather prevents the use of normal air routes along the eastern seaboard, congestion and delays can result as flights are diverted to the remaining airways. When offshore warning areas are not in use by the Navy, the airspace could be used to ease the demand on inland airways. To facilitate the use of this airspace, the FAA established waypoints in offshore airspace along four routes for conducting point-to-point navigation when the Navy has released that airspace to the FAA. The waypoints take advantage of RNAV capabilities and provide better demarcation of airspace boundaries, resulting in more flexible release of airspace in response to changing weather. These new offshore routes, which stretch from northern Florida to Maine, are an excellent example of how close coordination between military and civil authorities can maximize the utility of limited airspace.

HANDLING EN ROUTE SEVERE WEATHER

Interpreting written or spoken weather information is not difficult, nor is visualizing the relationship of the weather to the aircraft's route, although verbal or textual descriptions of weather have inevitable limitations. Color graphics can show more detail and convey more information, but obtaining them in flight has been impractical, until recently. The graphical weather service (GWS) provides a nationwide precipitation mosaic, updated frequently, and transmitted to the aircraft and displayed in the cockpit. Whether the display is used to strategize navigation, to avoid weather en route, or for departures and approaches, consideration must always be given to the timeliness of the graphic update. Pilots can select any portion of the nationwide mosaic with range options of 25, 50, 100, and 200 NM. In addition to providing information on precipitation, this service can be expanded to include other graphical data. Some systems will place the detailed weather graphics directly on a moving map display, removing another step of interpretation and enabling pilots to see the weather in relation to their flight path. [Figure 6-11]

Figure 6-11. Prototype Data Link Equipment. This display shows a radar image of weather within 50 NM of the Seattle-Tacoma International Airport (KSEA).

NATIONAL ROUTE PROGRAM

In the U.S., the national route program (NRP), also known as "Free Flight," is an example of applying RNAV techniques. The NRP is a set of rules and procedures that are designed to increase the flexibility of user flight planning within published guidelines. The Free Flight program allows dispatchers and pilots to choose the most efficient and economical route for flights operating at or above FL 290 between city pairs, without being constrained to airways and preferred routes.

Free Flight is a concept that allows you the same type of freedom you have during a VFR flight. Instead of a NAS that is rigid in design, pilots are allowed to choose their own routes, or even change routes and altitudes at will to avoid icing, turbulence, or to take advantage of winds aloft. Complicated clearances become unnecessary, although flight plans are required for traffic planning purposes and as a fallback in the event of lost communication.

Free Flight is made possible with the use of advanced avionics, such as GPS navigation and datalinks between your aircraft, other aircraft, and controllers. Separation is maintained by establishing two airspace zones around each aircraft, as shown in Figure 6-12. The protected zone, which is the one closest to the aircraft, never meets the protected zone of another aircraft. The alert zone extends well beyond the protected zone, and aircraft can maneuver freely until alert zones touch. If alert zones do touch, a controller may provide the pilots with course suggestions, or onboard traffic displays may be used to resolve the conflict. The size of the zones is based on the aircraft's speed, performance, and equipment. Free Flight is operational in Alaska, Hawaii, and part of the Pacific Ocean, using about 2,000 aircraft. Full implementation is projected to take about 20 years.

As the FAA and industry work together, the technology to help Free Flight become a reality is being placed into position, especially through the use of the GPS satellite system. Equipment such as ADS-B allows pilots in their cockpits and air traffic controllers on the ground to "see" aircraft traffic with more precision than has previously been possible. The FAA has identified more than 20 ways that ADS-B can make flying safer. It can provide a more efficient use of the airspace and improve your situational awareness.

DEVELOPING TECHNOLOGY

Head-up displays (HUDs) grew out of the reflector gun sights used in fighter airplanes before World War II. The early devices functioned by projecting light onto a slanted piece of glass above the instrument panel, between the pilot and the windscreen. At first, the display was simply a dot showing where bullets would go, surrounded by circles or dots to help the pilot determine the range to the target. By the 1970s, the gun sight had become a complete display of flight information. By showing airspeed, altitude, heading, and aircraft attitude on the HUD glass, pilots were able to keep their eyes outside the cockpit more of the time. Collimators make the image on the glass appear to be far out in front of the aircraft, so that the pilot need not change eye focus to view the relatively nearby HUD. Today's head-up guidance systems (HGS) use holographic displays. Everything from weapons status to approach information can be shown on current military HGS displays. This technology has

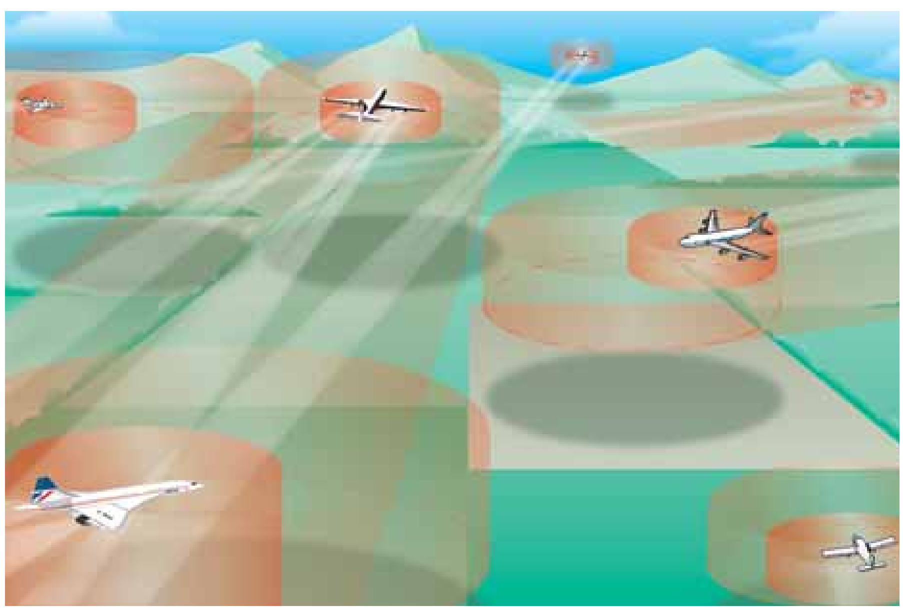

Figure 6-12. Free Flight.

obvious value for civilian aviation, but until 1993 no civilian HGS systems were available. This is changing, and application of HGS technology in airline and corporate aircraft is becoming widespread. [Figure 6-13]

Figure 6-13. Head-up Guidance System.

A large fraction of aircraft accidents are due to poor visibility. While conventional flight and navigation instruments generally provide pilots with accurate flight attitude and geographic position information, their use and interpretation requires skill, experience, and constant training. NASA is working with other members of the aerospace community to make flight in low visibility conditions more like flight in visual meteorological conditions (VMC). **Synthetic vision** is the name for systems that create a visual picture similar to what the pilot would see out the window in good weather, essentially allowing a flight crew to see through atmospheric obscurations like haze, clouds, fog, rain, snow, dust, or smoke.

The principle is relatively simple. GPS position information gives an accurate three-dimensional location, onboard databases provide detailed information on terrain, obstructions, runways, and other surface features, and virtual reality software combines the information to generate a visual representation of what would be visible from that particular position in space. The dynamic image can be displayed on a head-down display (HDD) on the instrument panel, or projected onto a HGS in such a way that it exactly matches what the pilot would see in clear weather. Even items that are normally invisible, such as the boundaries of special use airspace or airport traffic patterns, could be incorporated into such a display. While the main elements of such a system already exist, work is continuing to combine them into a reliable, safe, and practical system. Some of the challenges include choosing the most effective graphics and symbology, as well as making the synthetic vision visible enough to be useful, but not so bright that it overwhelms the real view as actual terrain becomes visible. Integrating ADS-B information may make it possible for synthetic vision systems to show other aircraft. [Figure 6-14]

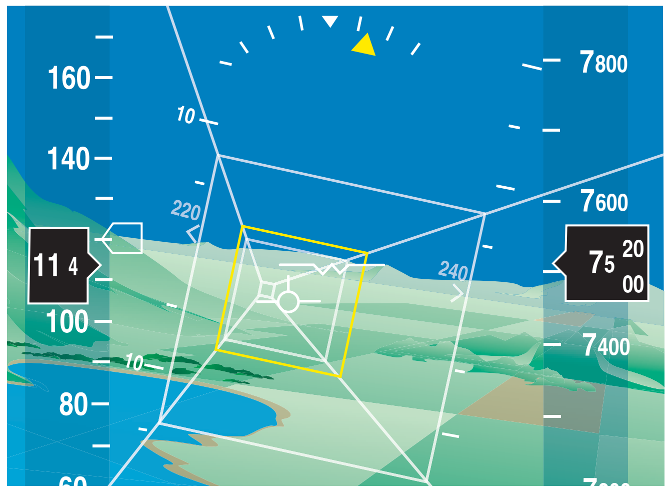

Figure 6-14. Synthetic Vision. This system uses projected images to provide a virtual view of terrain and other data in reduced visibility.

A natural extension of the synthetic vision concept is the **highway in the sky (HITS)** program. This technology adds an easy-to-interpret flight path depiction to an electronic flight instrument system (EFIS) type of cockpit display, which may be located on the instrument panel or projected on a HUD. The intended flight path is shown as a series of virtual rectangles that appear to stand like a series of window frames in front of the aircraft. The pilot maneuvers the aircraft so that it flies "through" each rectangle, essentially following a visible path through the sky. When installed as part of a general aviation "glass cockpit," this simple graphic computer display replaces many of the conventional cockpit instruments, including the attitude indicator, horizontal situation indicator, turn coordinator, airspeed indicator, altimeter, vertical speed indicator, and navigation indicators. Engine and aircraft systems information may also be incorporated. [Figure 6-15]

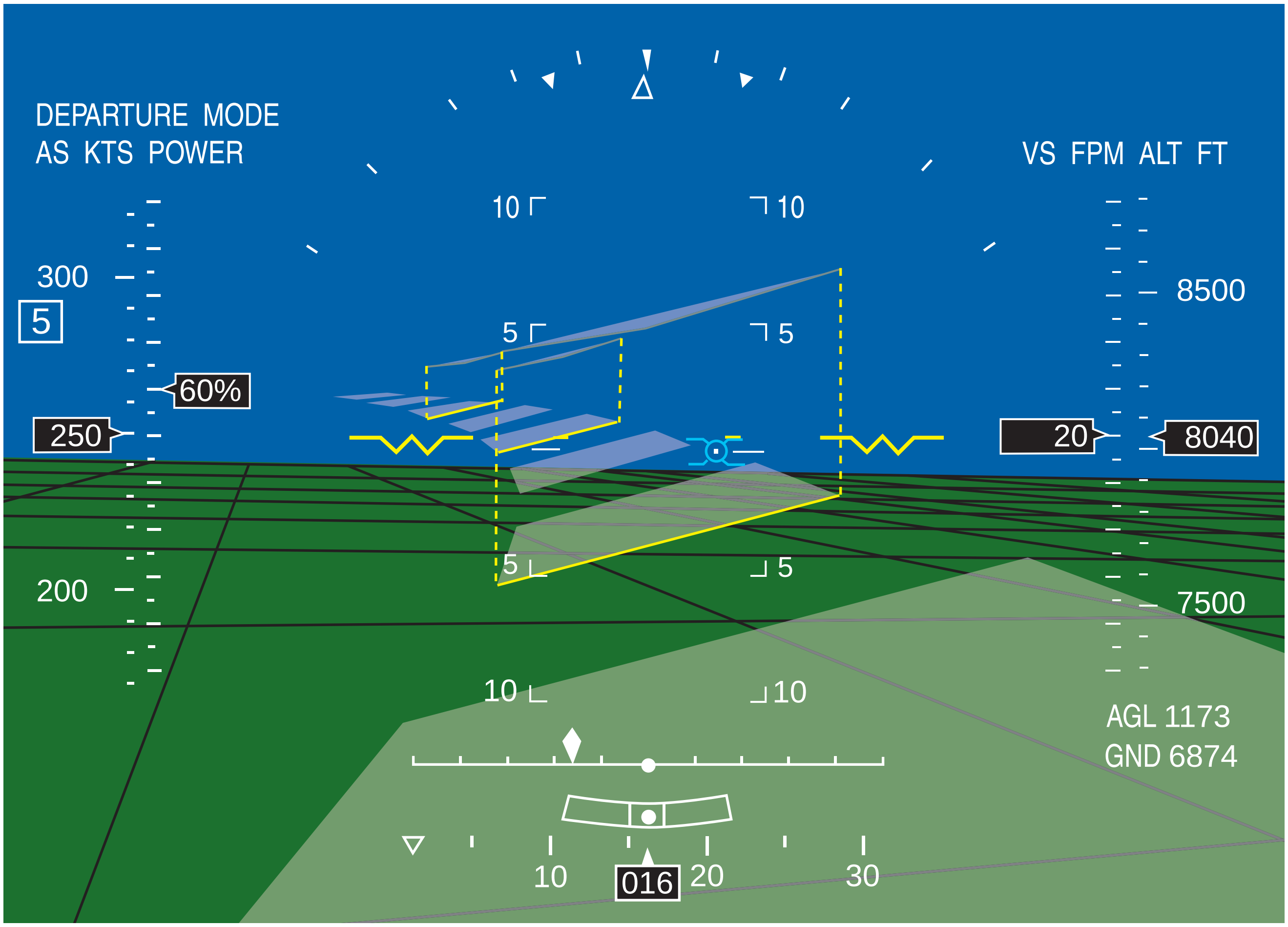

Figure 6-15. Highway in the Sky. The HITS display conveys flight path and attitude information using an intuitive graphic interface.