



Editor: Alberto Broggi
University of Parma, Italy
broggi@ce.unipr.it

Increasing Airport Efficiency: Injecting New Technology

Enrico Piazza, *Park Air Systems*

When dealing with intelligent transportation systems, people generally think about a smart vehicle able to drive autonomously, follow the best route, and safely reach its destination. However, the ITS world embraces many transportation media, making the automotive world just one aspect of ITS research activities.

In this installment, Enrico Piazza describes the results of the Vision project, which applied new technologies to airports. A system able to help move and route planes safely would not only improve airport safety but also enhance airport throughput. He presents results obtained in real airports under real working conditions.

If you have any comment on this department, feel free to contact me. I also seek contributions on the current status of ITS projects worldwide as well as ideas and trends on future transportation systems. Contact me at broggi@ce.unipr.it; www.ce.unipr.it/broggi.

—Alberto Broggi

Many of the world's busiest airports are operating at maximum capacity owing to the rapid growth of air traffic. Constructing new runways and taxiways is often too expensive, if not impossible. Furthermore, owing to

current air-traffic-handling methods, airports cannot always use their infrastructures' potential capacity. During low-visibility conditions especially, airport throughput drops dramatically.

In 2000 an estimated 1.7 billion passengers took scheduled flights on the world's airlines. The International Civil Aviation Organization predicts a 5-percent average annual increase, which would boost that number to approximately 2.3 billion by 2010.¹

Although major air carriers posted cuts between 10 and 20 percent after the 11 September events, the overall traffic reduction has been much smaller owing to the overwhelming amount of general aviation and freight traffic. Major airports will likely face capacity problems again soon.

With congestion already a major concern, airports clearly need more capacity and must complement this with greater efficiency. They must handle aircraft as quickly and cost-effectively as possible, while ensuring optimum safety. Owing to space and budget constraints, this is rapidly becoming a challenge the world's major airports must face.

Advanced Surface Movement Guidance and Control Systems (called Airport Surface Detection Equipment in North America) potentially can solve the airport capacity bottleneck while maintaining at least the current safety level.² A-SMGCS is becoming increasingly sophisticated and plays a major role in avoiding runway incursions.³ To investigate the

feasibility of phasing in new technology to ease airport operation, the European Commission has funded several research projects. The latest project, called Vision, aimed to apply all the technologies developed in previous projects, including A-SMGCS, to a set of real airports.

System technology

Traditionally, air traffic controllers have relied on position reports from pilots to maintain aircraft separation on the ground. Controllers can use A-SMGCS to monitor and safely direct aircraft and service vehicle movements on runways and taxiways. This traffic appears on radar screens in the tower, letting controllers monitor vehicles and aircraft to ensure that they maintain the proper distance from other traffic. The system determines aircraft and vehicle positions and relative speeds, improving the safety and efficiency of airport operations. The system is especially useful during peak periods or conditions of poor visibility—due to fog, precipitation, or darkness, for example—when traffic cannot be clearly seen from the control tower. The system also has an automatic safety alert capability known as the Runway Inursion Monitoring and Conflict Alert System, which detects potentially hazardous situations. For example, an approaching aircraft headed for an occupied runway will generate visual and audio warnings with enough time to ensure that controllers can take proper action. Additionally, the system can control lead-on and lead-off lights and automatically activate stop bars at runway entry points.

Vision

The Vision project ran from 1 January 1998 to 31 December 2000 under the European Commission—DG

XIII 4th R&D Framework Program. The overall cost was 3,445,711 euros, of which the commission contributed 50 percent.

The project's main objectives were to

- Demonstrate the capabilities of A-SMGCS, including its modularity and adaptability
- Assess the possible increase in airport capacity under various visibility conditions
- Assess safety while increasing capacity
- Evaluate the workload on air traffic controllers
- Stimulate cooperation in Europe between the 13 project partners (see the sidebar)

The Vision demonstrator consisted of several software components running on a Silicon Graphics O2 workstation. The system provided the basic A-SMGCS functions:

- Surveillance
- Situation monitoring and conflict alert
- Aircraft guidance to or from its assigned stand

The project consortium first analyzed user requirements, then defined the system and designed the subsystems. The consortium partners integrated the various components into the Vision demonstrator and installed it at four high-volume test sites:

- Frankfurt, the second-largest airport in Europe,^{4,5} had 49 million passengers and 458,000 movements (takeoffs or landings) in 2000.
- Palma de Mallorca, the third-busiest Spanish airport, had 19 million passengers in 2000.
- Oslo Gardermoen, one of the newest European airports, had 20 million passengers and 200,000 movements in 2000.
- Paris Orly, eighth in Europe and second in France, had 25 million passengers and 243,000 movements.

The information fusion from the test airports' different sensors and databases fueled the traffic display. The consortium tested several sensors, including surface movement radar (SMR), approach surveillance radar, the Differential Global Positioning System (DGPS), Secondary Surveillance Radar Mode-S multilatera-

Project Partners

The Vision project coordinator was Navia Aviation (Norway), now a part of Park Air Systems. Twelve other companies and organizations also participated:

- Seatex (Norway), www.seatex.no
- Oslo Airport (Norway), www.osl.no
- AENA (the Spanish Civil Aviation Administration), www.aena.es
- Airsys Air Traffic Management (Germany)*
- Frankfurt Airport (Germany), www.fraport.de
- Airsys Air Traffic Management (France)*
- Aeroports de Paris (France), www.adp.fr
- ISDEFE (Spain), www.isdefe.es
- Syseca Belgium (Belgium)*
- Syseca (France)*
- Airsys Navigation Systems (Italy)*
- Polytechnical University of Madrid (Spain), www.upm.es

* now part of Thales (www.thalesatm.com)

tion, and docking sensors. Airport technical staff tested the system's functionality on-site, making sure it performed according to specifications and caused no harm to existing airport equipment. Certified controllers tested its operation and provided subjective feedback on the system's usability, performance, and value to their jobs.

Results and achievements

The project partners obtained several significant results, and most of their objectives were met. Along the way, they gained significant experience and made important relationships. For example, the project fostered cooperation and communication among partners from different countries and business competitors.

The Vision A-SMGCS improved the traffic flow and showed potential for significantly increasing capacity during poor visibility and peak periods. The traffic display provided full situational awareness, which reduced the need for vocal communication and lowered air traffic controllers' stress levels.

The consortium developed several new functions in the framework of the Vision project, including

- SMR and Mode-S multilateration data fusion for locating and identifying airport ground traffic⁶
- An A-SMGCS routing function, which designates routes for aircraft within the movement area, and a guidance function, which clearly indicates

assigned routes and allows pilots to follow them^{7,8}

- Data fusion algorithms based on radar
- Automatic dependent surveillance measurements for air traffic control application⁹

Increased capacity

The evaluation does not confirm categorically that an A-SMGCS makes it possible to handle increased traffic. However, some air traffic controllers participating in the evaluation quantified the benefits on the basis of previous experience. Oslo Gardermoen, an airport with bad visibility during much of the year, showed an increase from 20 to 30 movements per hour without A-SMGCS (monitors turned off) to 55 to 60 or more with A-SMGCS. This means a profit increase of 100 percent in terms of traffic capacity under low visibility. The Orly controllers confirm this experience, although no figures are available, and further confirm that the advantage of an A-SMGCS increases as traffic increases. Benefits were not as significant during low-traffic periods.

Increased safety

The evaluation confirms that the combination of cooperative sensors available with an A-SMGCS improves controllers' situational awareness, particularly in difficult weather situations and in combination with operations on the runway such as snow cleaning and runway inspections. Controllers can detect possible conflicts and take corrective actions to avoid them (see Figure 1).

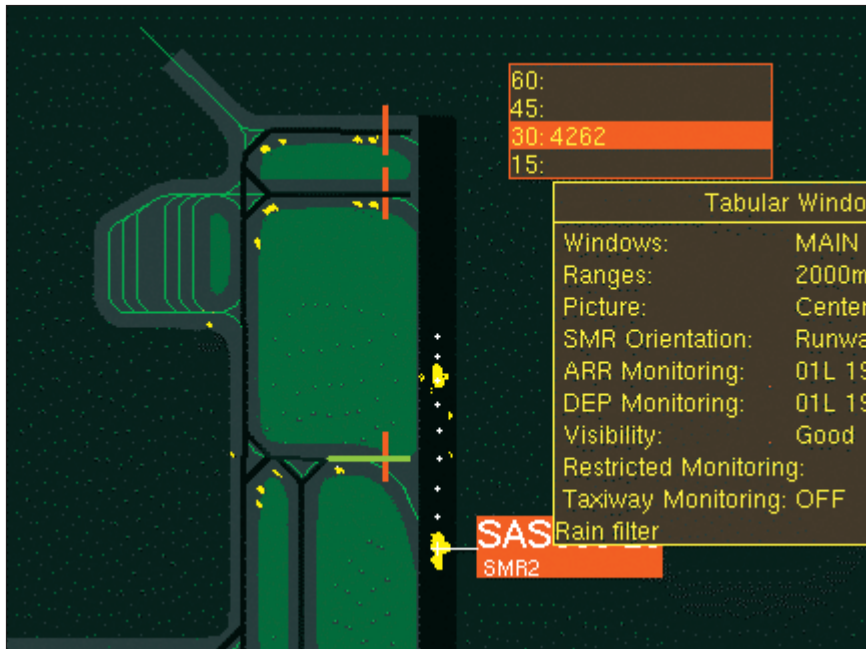


Figure 1. A conflict alert shown on an air traffic controller's screen. The SAS departing flight was in conflict with an arriving aircraft not shown. The approaching plane is identified on-screen by its secondary surveillance radar code, 4262, in the window near the runway threshold. In this case, a red alert was set to trigger when the approaching aircraft was 30 seconds or less from the runway.

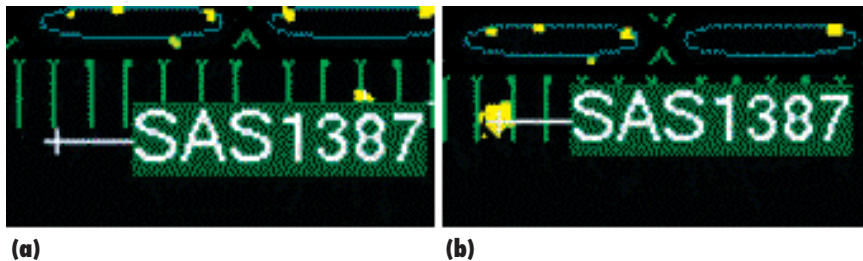


Figure 2. Automatic labeling: (a) Docking sensor data is fused with the gate management system, and the call sign is attached to the target. The docking sensor now tracks the target. (b) The target has been pushed back from its parking position to the taxiway and is now visible to both the surface movement radar and docking sensor.

Reduced vocal communication

A reduction in the amount of vocal communication can lead to improved controller efficiency and reduce the possibility of communication errors. Experiences at Oslo Gardermoen showed that an A-SMGCS could reduce the need for vocal communication to determine aircraft position by approximately 50 percent. This is under certain visibility conditions, when the controller does not have visual contact with the aircraft. This benefit does not arise in other visibility conditions.

Data fusion

Several sensors, including SMR, Mode-S multilateration, approach radar, and docking sensors, provided data for the tracking function, although the sensor suite differed among the test airports. Fusion of this data was one of the major functions tested. Fusion at Frankfurt and Palma was performed with the tracker from Universidad Politecnica de Madrid, which required more powerful processors. Fusion at Gardermoen was performed with the tracker supplied by Park Air Systems. Both trackers provided reliable target reports in real

time. Tests also demonstrated the system's modularity—it could use any tracker module with only a little modification.

Automatic labeling

The Vision A-SMGCS demonstrated automatic labeling, enabled by data fusion, of both arriving and departing aircraft. It used data from SMR, the DGPS vehicle tracking system, docking sensors, and the gate management system to assign and lock labels on various targets (see Figure 2). The system required no controller input.

Vehicles fitted with transponders appear automatically on the screen with call signs and target classifications (“vehicle”). This makes identification of vehicles faster and safer, even when they are alongside the runway, outside the radar coverage area.

Routing and guidance

The evaluation concluded that the routing and guidance functions provide a useful service to pilots, particularly in bad weather, but do not significantly improve efficiency or capacity. Figure 3 shows three targets. D:300 is a departing flight following a given route, shown by the lit centerline lights. FIN659N is an arriving Finnair flight following a given route, also shown by the lit centerline lights. BRA587 is a Braatens flight that has just left the gate for the runway. The two surface movement radars (SMR1 and SMR2) and the docking sensor are tracking it at its present location.

Adaptability

When the project partners installed the Vision demonstrator, each site used the same main software components. Only the maps and sensor interfaces needed development and configuration.

Lessons learned

The project partners discovered a few significant problems during system installation and testing.

Hardware platforms

In the initial project phases, the partners developing the system used their own platforms, which were either SGI or Sun workstations. They installed the final product on SGI platforms. Each platform contained different library versions, development tools, operating systems, and so on. This presented a serious handicap as soon as

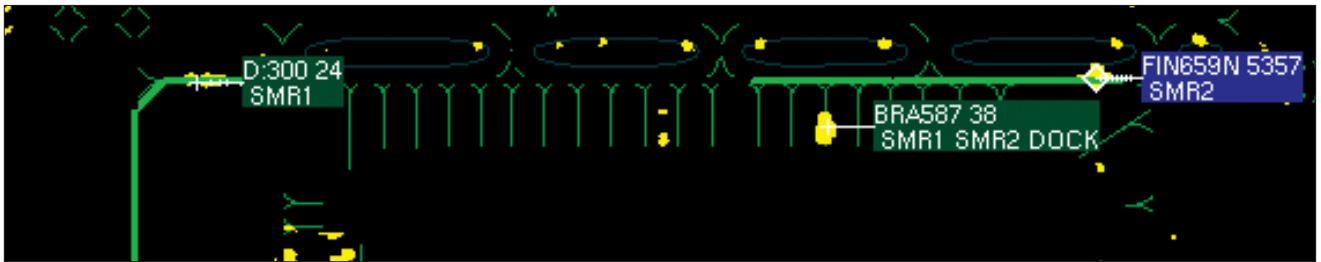


Figure 3. Three targets with extended labels (debug mode). The screen shows the tracking sensors for each target at the bottom of the label. The system's guidance function lights the segments in front of the targets on-screen.

component integration started. Partners using the Sun environment had to “translate” software from Sun to SGI, and sometimes from SGI to Sun, to ensure that it worked correctly. During installation and testing, the partners found additional problems, because it was difficult to reproduce the conditions of a system working in a different platform.

Lack of debug tools

The project lacked tools to analyze and debug the system, isolating all the elements in the chain from the sensor interfaces to the objects displayed on the screen. So, a detected malfunction was apparent only on the screen, and a costly, exhaustive debug procedure was required to infer where the problem actually was.

Performance

Focusing on performance is important when designing the various components, especially when all processes run on a single computer. In particular, performance problems were discovered when the demonstrators were installed at Frankfurt and Gardermoen. For example, the Spanish tracker module required more processing power.

Limited time for validation

Owing to the tight program schedule, there were only a few weeks for validation and demonstration, especially regarding user and controller feedback. This time frame was too small to achieve a broader perspective on operational system use. Future system testers should ensure that enough time is available for validation.

The Vision project confirmed that A-SMGCS is a mature, viable technology that can significantly contribute to the efficien-

cy and safety of airport operations. Under certain conditions, use of an A-SMGCS can increase traffic handling capacity by 100 percent while reducing controller workload. Safety aspects of A-SMGCS, particularly the conflict alert capability, can significantly reduce the risk of runway incursions and traffic conflict situations. This technology is available in Europe thanks to the European Union research efforts, although the US is still lagging. (The American ASDE-X program, which hopes to develop data fusion, Mode-S multilateration, color displays, and a vehicle tracking system, was still in the definition phase as of November 2001.)

Most major airports in Europe have or will soon have a modern A-SMGCS, whether they will be updating current equipment or installing the system from scratch. Although the Vision demonstrator will not be used directly in other projects, reuse of the design concept for several software components, including the routing, guidance, and conflict alert functions, is already planned. Additionally, other European Commission projects such as BETA (Operational Benefit Evaluation by Testing an A-SMGCS) will continue to explore the benefits and possibilities of the system in an operational environment. ■

References

1. R. Heitmeyer, “Biometric ID and MRTDs Will Help Generate Future Airport Capacity,” *Int'l Airport Rev.*, vol. 5, no. 1, 2001, pp. 60–63.
2. C. Bernabei, “Air Traffic Jam: European Commission Research Activities Searching for Solutions,” *Int'l Airport Rev.*, vol. 4, no. 2, Summer 2000, pp. 21–24.
3. *The Future Airport Surface Movement Safety, Guidance, and Control System: A Vision for Transition into the 21st Century*, Federal Aviation Administration, Washington, D.C., 1993.
4. “Strong Growth at Spanish Airports,” *Jane's Airport Rev.*, vol. 13, no. 2, Mar. 2001, p. 32.
5. “European Airports Break All Records,” *Jane's Airport Rev.*, vol. 13, no. 3, Apr. 2001, p. 40.
6. J. Garcia Herrero et al., “ASDE and Multilateration Mode-S Data Fusion for Location and Identification on Airport Surface,” *Record of the 1999 IEEE Int'l Radar Conf.*, IEEE Press, Piscataway, N.J., 1999, pp. 315–320.
7. E. Piazza, “A-SMGCS Routing and Guidance Functions” (part one), *IEEE Aerospace and Electronic Systems*, vol. 15, no. 7, July 2000, pp. 15–23.
8. E. Piazza, “A-SMGCS Routing and Guidance Functions” (part two), *IEEE Aerospace and Electronic Systems*, vol. 15, no. 11, Nov. 2000, p. 34.
9. J.A. Besada et al., “Data Fusion Algorithms Based on Radar and ADS Measurement for ATC Application,” *Record of the 2000 IEEE Int'l Radar Conf.*, IEEE Press, Piscataway, N.J., 2000, pp. 98–103.



Enrico Piazza is a development engineer with Park Air Systems, Norway. He is developing algorithms for the NOVA 9000 Advanced Surface Movement Guidance and Control System in the European Commission's Vision and BETA (Operational Benefit Evaluation by Testing an A-SMGCS) research and development projects. He received his Laurea in electronic engineering and his PhD in methods and technologies for environmental monitoring from the University of Florence. He is a member of the IEEE and founder of the Associazione Dottorandi e Dottori di Ricerca Italiani (the Italian PhD association).

Contact him at Park Air Systems AS Division Nova, PO Box 145, 3191 Horten, Norway; e.piazza@no.parkairsystems.com; www.parkairsystems.com.