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The Role of the Global Navigation Satellite System (GNSS) in Supporting Airport Surface Operations

RTCA DO-247
January 7, 1999

Prepared by: SC-159
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Foreword

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1. INTRODUCTION

1.1 Background

RTCA has undertaken a series of activities to explore the various operational applications for GNSS and to develop the associated GNSS performance standards. These activities are an outgrowth of the RTCA Task Force on GNSS Transition and Implementation [1]. The task force identified many potential benefits for aviation users resulting from the use of GNSS, and encouraged the early exploitation of GNSS capabilities to support key operational applications.

One of the planned applications is to use GNSS as an element of an advanced surface movement guidance and control system (A-SMGCS) to enhance airport surface operations. There is a need to improve guidance and situational awareness on the airport surface for air traffic controllers, pilots, and vehicle drivers so as to prevent runway incursions and provide greater efficiency in the surface movements. In this regard, RTCA has compiled material on various aspects of airport surface operations. These include classification of airports and aircraft/vehicles, compilation of operational requirements, description of postulated system architecture, identification of performance requirements ; and assessment of GNSS performance. It is intended that this material be used in the further development of performance standards applicable to GNSS subsystems and equipment for use on the airport surface. At this time, the performance requirements for airport surface operations have been developed primarily through analytical means and are considered to be of a preliminary nature with further validation required through planned demonstration programs. These validation efforts need to be completed before performance standards (MASPS and MOPS) can be finalized.

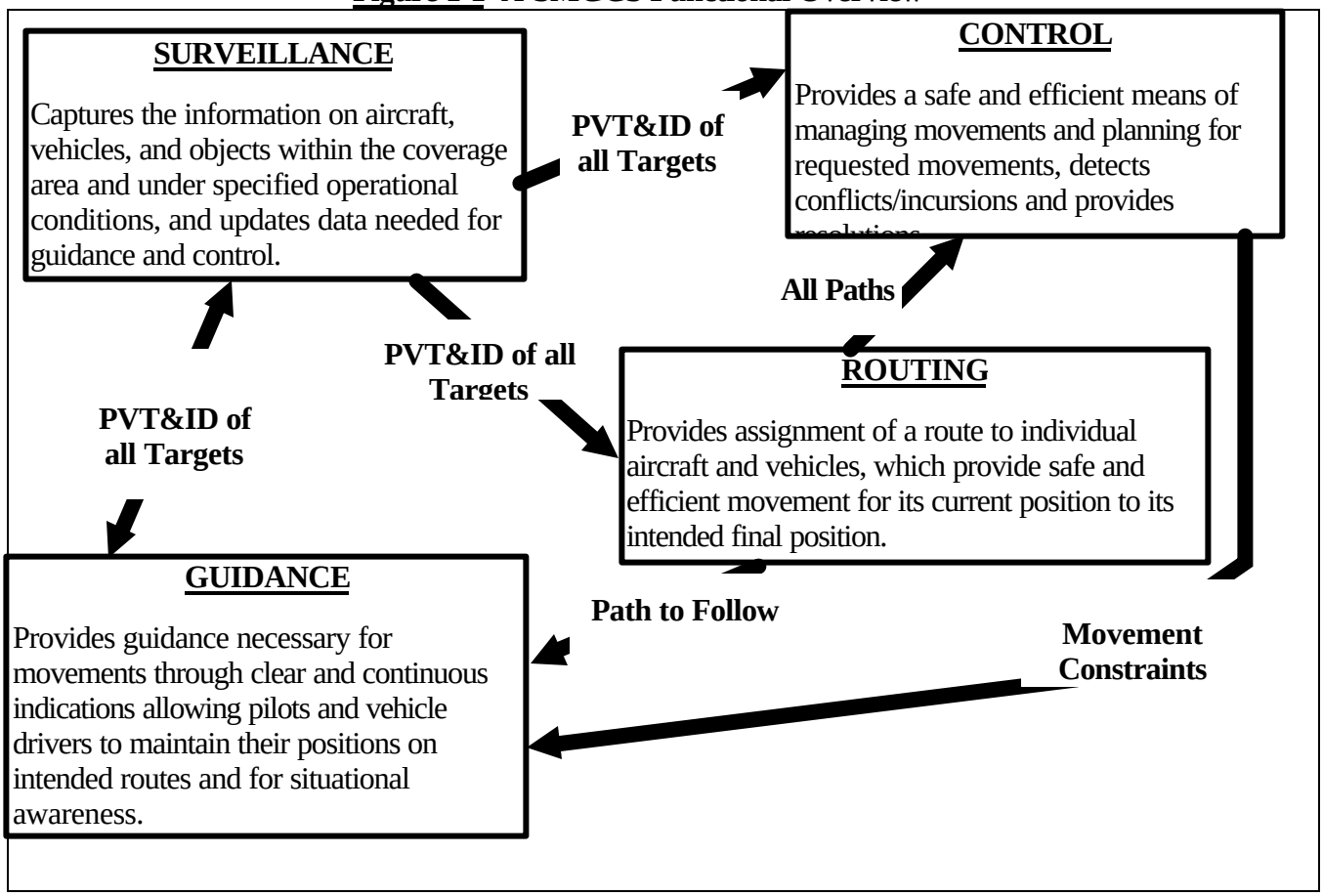
The purpose of this report is to present the material that has been compiled on airport surface operations and relate it to the use of GNSS. It is intended that the report provide background information for airport operators/users and equipment suppliers on the role of GNSS to support airport surface operations, and to provide guidance for the further development of performance standards.

1.2 Advanced Surface Movement Guidance and Control Systems

A viable A-SMGCS functional architecture (Figure 1-1) must support the primary functions of surveillance, routing, guidance and control. In addition, the architecture must provide for the timely exchange of operationally essential information between the various system elements and users. At any given airport, the development and implementation of a particular A-SMGCS architecture should take into consideration current and future operational goals. That is, the capability required in order to safely and efficiently support a given number of surface movements given the visibility and traffic density likely to be encountered, as well as the complexity and existing equipage of the airport itself.

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Figure 1-1 A-SMGCS Functional Overview



Depending on the technologies utilized, the responsibilities associated with each of the primary functions may be allocated differently.

In order to gain insight into how the technologies being utilized influence how an A-SMGCS is developed and implemented, the basic needs of pilots, vehicle drivers and air traffic controllers must be realized. Simply stated, the pilot needs to know the relative location of other aircraft, vehicles, and obstacles; the route to be followed and have a means to do so; and whether required approvals for specific movements have been authorized. Vehicle drivers have similar needs. Air traffic controllers need to know the location of all aircraft and vehicles; where to send or hold aircraft/vehicles; and whether aircraft and vehicles are doing what they have been instructed to do.

In their simplest form, current surface movement guidance and control systems rely on the "see and be seen" principle for supporting the guidance and surveillance functions. Routing and control functions are facilitated through voice and data communications. Pilots, vehicle drivers and air traffic controllers depend on visual observations for situational awareness. Guidance along assigned routes and the identification of intersections and holding points are accomplished through the use of visual aids such as lighting, signs and painted lines/markings. More advanced systems may employ switched taxiway or centerline lighting, stop bars, and visual observations may be

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augmented with display of surface movement radar data. In either case, the vast majority of the responsibility is assigned to the humans in the loop. For these systems, reduced visibility normally results in restricted movement rates, and as the visibility continues to decrease a point is reached where the "see and be seen" principle becomes impractical and surface operations must cease. In addition, the demand for increased capacity results in higher traffic density and more complex airport layouts, which provides the potential for an increase in incidents and accidents even during periods of good visibility.

Fortunately, new and emerging technologies, such as GNSS and ADS-B, can be used to overcome the limitations that exist with current systems. Where necessary, these technologies, used individually or in combinations, can provide precise guidance to pilots and vehicle drivers, as well as situational awareness for pilots, vehicle drivers, and air traffic controllers during low visibility conditions. At heavily utilized airports with complex traffic patterns, these technologies can be used to aid the monitoring and/or management of surface operations in an automated fashion. In this regard, specific capabilities may include conformance monitoring, conflict detection, collision avoidance, control of lateral and longitudinal spacing, real-time optimized routing, detection of restricted zone/runway incursions, and the control of switched stop bar lighting and runway status lights.

Before a new or emerging technology can be implemented as an element of an A-SMGCS, technology-related requirements and suitable human-machine interfaces must be available, and a reallocation of responsibilities must be accomplished. Also, it is realized that the diversity of user needs and airport environments will require a modular development and introduction of A-SMGCS elements, and that the implementation of A-SMGCS at most airports will be an evolutionary process. This modular approach will allow for the introduction of new elements as capabilities are improved and validated. However, it should be realized that sophisticated A-SMGCS are not required nor economically justifiable at airports where visibility, airport traffic pattern complexity, and traffic density do not present problems regarding the safe and efficient ground movement of aircraft and vehicles.

Satellite-based navigation systems such as GNSS are an emerging technology envisioned to be a key element of the future A-SMGCS. These systems can provide pilots and vehicle drivers with accurate position, velocity and time (PVT) information, as shown in Figure 1-1. PVT information is comprised of a GNSS compatible position and velocity component with a known time of applicability. The time of applicability defines the time for which the position and velocity are valid. This information, when combined with a suitable airport database and display, can be used to provide pilots and vehicle drivers with "limited" situational awareness and electronic guidance. That is, their position relative to runways, taxiways, intersections, maneuvering areas, and obstacles, and an indication of their deviation from a prescribed lateral track can be determined. When a data broadcast element (i.e., ADS-B) is added, pilots and vehicle drivers can now be provided with "complete" situational awareness by displaying the relative location of other aircraft and vehicles. In addition, utilization of the data broadcast element by air traffic controllers can augment visual observations, as well as provide situational awareness for participating aircraft and vehicles during low visibility

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conditions. Finally, the addition of a data fusion element and a data link element provide a means of augmenting, as well as automating, the monitoring and/or management of traffic flow on the airport surface. It should be noted that data/information processing is an inherent component of each of these elements, as well as the use of appropriate procedures. The application of these technologies to surface movement should provide an extension of the future CNS-ATM concept to the airport surface.

1.3 GNSS-Based Guidance and Surveillance

In the future, GNSS and ADS-B will play an important role in airport operations. GNSS and ADS-B will provide both guidance and surveillance capability to support terminal and surface operations. The global nature of this technology makes it attractive for deployment at large and small airports.

An A-SMGCS can utilize GNSS with augmentations for meeting the integrity, availability, position and velocity requirements associated with the guidance and surveillance functions. Accordingly, the material presented in this report focuses on the application of GNSS for supporting these two primary functions of A-SMGCS. The specific GNSS augmentation systems that are considered herein are the Local Area Augmentation System (LAAS) and the Wide Area Augmentation System (WAAS). These are safety critical systems designed to meet the requirements for both precision approach and landing, and departure operations in various visibility conditions. Consequently, the capability and availability of these two augmentation systems provides the motivation for their application as a means to support surface operations within a local airport environment.

1.4 Report Organization

The report is organized in the following sections:

Section 2 describes representative airport classifications in terms of complexity, runway/taxiway dimensions, current systems that support operations, and landing operational categories. Also, aircraft classifications are presented and related to runway/taxiway widths and obstacle free areas. Representative speeds are identified for the various phases of surface operations.

Section 3 presents a compilation of operational requirements applicable to airport surface operations. These have been extracted from the ICAO document titled “ICAO Operational Requirements for Advanced Surface Movement Guidance and Control” distributed by ICAO on 12 June 1998.

Section 4 introduces a postulated A-SMGCS architecture that utilizes GNSS and ADS-B as the principal technologies for supporting the guidance and surveillance functions. The major components required to support the four A-SMGCS functions are identified, and the GNSS/ADS-B architecture envisioned for supporting the guidance and surveillance functions is discussed in detail. The section concludes with a discussion of how this GNSS/ADS-B based architecture could be utilized to support surface operations during low visibility conditions.

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Section 5 defines the performance requirements that will be applicable to the GNSS and the associated augmentations. These have been derived from the operational requirements defined in Section 3.

Section 6 presents a preliminary assessment of GNSS performance in the airport surface environment. Performance issues unique to the airport surface environment are discussed.

Section 7 presents conclusions pertaining to the use of GNSS for airport surface operations, and identifies issues requiring further investigation.

Appendices are included covering the following topics: acronyms, explanation of terms, RF interference, example architecture, and references.

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