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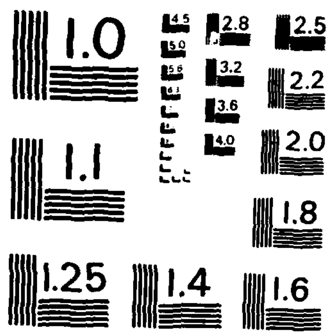

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Concepts for Terminal Area Configuration Management

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ABSTRACT

Terminal traffic flow management is concerned with the smooth and efficient flow of traffic in the terminal airspace and on the airport. The first element of terminal traffic flow management is to determine the available resources (e.g., runways, taxiways, airspace) and plan their optimal use to meet the given demand. Terminal Area Configuration Management provides this resource planning function of the terminal flow management process. The objective is to determine the best operating strategies within the terminal airspace and the airport to minimize total operating costs (delay and fuel). This paper presents Terminal Area Configuration Management concepts and discusses potential applications at major airports. A specific application is illustrated by the O'Hare Runway Configuration Management System developed by The MITRE Corporation under contract to the FAA Office of Systems Engineering Management.

This paper is based on the author's presentation at the sixtieth annual meeting of the Transportation Research Board in January 1981 at Washington, D. C.

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I. INTRODUCTION

Airport congestion costs have escalated rapidly in the past few years with the rising price of fuel. Annual delay costs experienced by the air transport industry have been estimated as high as $1 billion. The recent events related to the air traffic controller strike have temporarily constrained the demand imposed on the Air Traffic Control (ATC) system. This is, however, expected to be a transient phenomenon, with the demand increasing to its unconstrained free market level as the ATC system continues to recover its operating potential.

Expected technological advances and high capital investments can potentially provide long term relief to the congestion problem, but they require long lead times for implementation. Hence, there is a critical need for efficient and full utilization of the existing facilities to avoid excessive delays in the near term.

The Federal Aviation Administration (FAA) Office of Systems Engineering Management (OSEM) has recently initiated an Integrated Flow Management (IFM) program to address this issue. The three major elements of IFM are national flow management, en route flow management and terminal flow management (Reference 1). The primary goal of terminal flow management is to provide for the efficient use of terminal airspace and airport to minimize total operating costs (delay and fuel) in meeting the demand imposed on the existing ATC system. Terminal flow management is responsible for developing the best operating strategies within the terminal area that are consistent with the overall system constraints (e.g., national flow restriction directives) and that are responsive to contingency plans that allow for prediction uncertainties and unexpected perturbations.

The first element of terminal flow management is to determine the available resources (e.g., airspace, runways, taxiways, ATC equipment) and plan their optimal use to meet the given demand. The resource planning function is the foundation on which the traffic planning and control functions are based. Terminal Area Configuration Management is the element of terminal flow management which deals with this resource planning function. The resulting operational configuration of airspace, runways and airport surface traffic flow provides the environment for the tactical control of aircraft. The configuration selection in the terminal area environment is based not only on resource availability but also on several external constraints such as noise, curfews, adjacent airports, and restricted airspace. The problem of resource planning in the terminal environment is complex due to the dynamic changes in the operational environment. Unlike en route airspace where the traffic flow is primarily structured over fixed routes which do not change with time, the terminal airspace structure (which includes flight paths and designated fixes feeding specific runways) may change radically with changes in runway configurations and demand distributions. The complexity increases further due to higher traffic densities, a wide mix of aircraft, non metered traffic (e.g., popups, tower en route), interleaving of arrivals and departures, and shorter flight times in the terminal area (hence lower available controllability).

II. ELEMENTS OF AIRPORT OPERATIONS

Traffic flow in the terminal airspace and on the airport surface can be broadly divided into two categories (Figure 1). Airside Operations deal primarily with the movement of aircraft in the terminal airspace, on the runways, taxiways and aprons, and at satellite airports (if any). Landside Operations deal primarily with the movement of passengers, baggage and ground transportation from the aircraft gates and concourses, through the terminal building, into the parking lots, and across the access/egress system.

Terminal Area Configuration Management addresses the resource planning function of airside operations. The problem is one of utilizing the terminal airspace, runways, taxiways, aprons and satellite airports to best manage the movement of aircraft through the system. It is recognized that landside operations are also key elements of airport management and must work in unison with airside operations for the concepts to be effective.

III. FACTORS AFFECTING AIRSIDE OPERATIONS

It is critical for any application of Terminal Area Configuration Management to understand the diverse factors that affect each element of airside operations. Site specific applications are very much dependent on the individual nature and complexity of these factors at each airport.

a. Terminal airspace undergoes dynamic changes depending on the runway configuration in use (arrival and departure runways), nominal flight profiles for arrivals and departures, distribution of traffic over the arrival and departure fixes, and the structure of the airspace itself especially in multi-airport complexes.

b. Runway configuration selection is based on the operating environment (e.g., wind, weather, surface conditions), the available runway and equipment status, and the nature of the traffic demand distribution. In addition, other factors also affect the selection of runway configurations. These include noise, quota and curfew constraints, special restrictions on runway use, and controller staffing requirements.

c. Airport surface traffic flow is primarily governed by the geometry of available taxiways, runways in use, taxi patterns, aircraft gate locations, and the prevailing visibility.

d. Satellite airport operations are intimately connected to the airspace structure, the arrival and departure paths, and the coordination procedures for conflicting traffic, if any. At specific locations, satellite airport operations may be a major factor in the resource management functions at the primary airport.

In addition to assessing the effect of specific factors on airside operations, Terminal Area Configuration Management must have the ability to interface

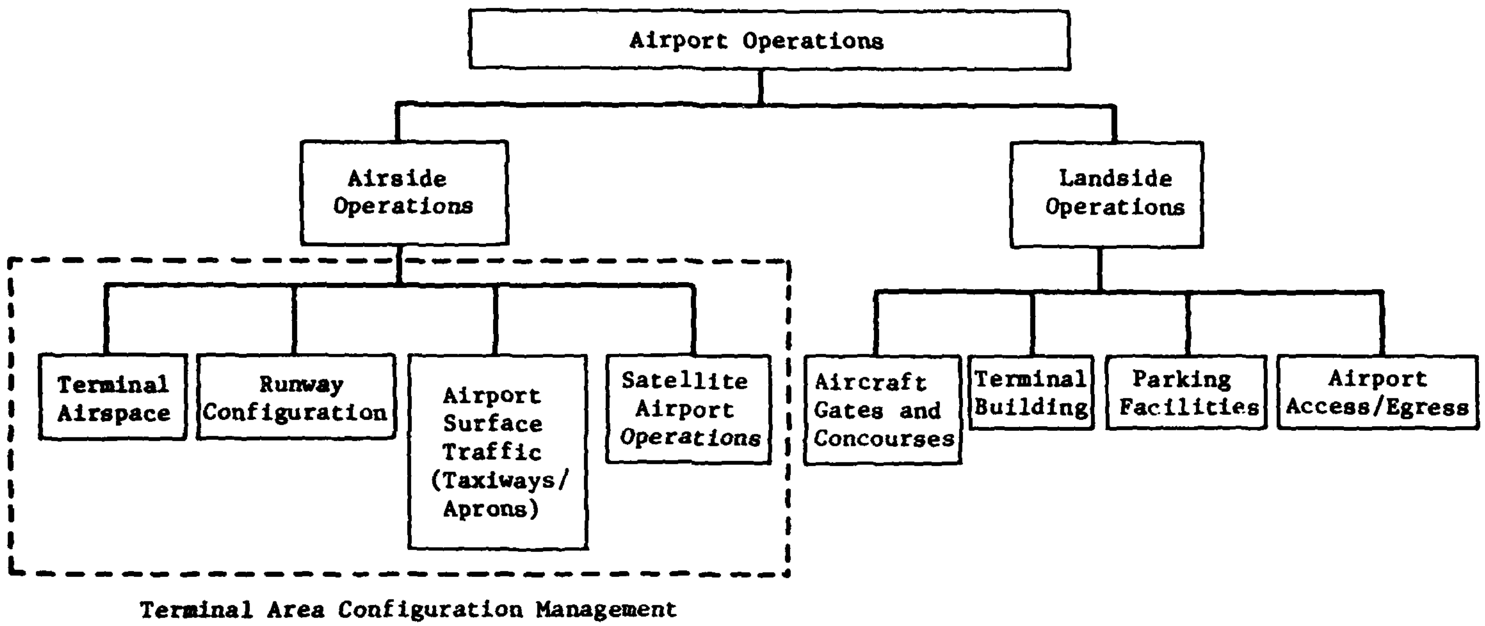

FIGURE 1
ELEMENTS OF AIRPORT OPERATIONS

with other ATC system elements for coordination and communication of current and predicted status of operational environments. The dynamic nature of operating conditions in the terminal area make it imperative to have the best available predictions for the success of plans resulting from Terminal Area Configuration Management. Recognizing the fact that there are prediction uncertainities, the resource planning function must develop robust plans for optimal utilization of the resources (airspace, runways, taxiways, etc.) that can withstand the fluctuations of the changing environment without significant loss in performance.

IV. APPLICATIONS AT SPECIFIC AIRPORTS

The application of Terminal Area Configuration Management to a particular site requires adaptation to the specific problems of that site. The major problem areas at each busy airport may involve airspace, runway configurations, or surface traffic flow depending on the site characteristics. The airport dependent nature of the resource planning function can be seen at many major airports. The following discussions illustrate the Terminal Area Configuration Management concept for three such high density airports.

Figure 2 shows the layout of Chicago O'Hare International Airport. In general, there are no major airspace or surface traffic flow problems at O'Hare. A four post arrival geometry allows a smooth flow through the terminal airspace from the arrival fixes to the runways. Departures are routed to the four major compass directions (N,S,E,W) with sufficient altitude separations from the arrival streams to preclude any major airspace conflicts. On the airport surface, the inner and outer taxiways provide a well regulated flow of taxiing aircraft between the active runways and their respective gates and concourses. The major problem at O'Hare is the selection of optimal runway configurations (i.e., selecting arrival and departure runway combinations) to minimize delay costs (Reference 2). With twelve major runway ends (not considering 18/36 which is used only during daytime by small general aviation aircraft), O'Hare has identified more than 70 runway configurations that can be used operationally. Consequently, the application of Terminal Area Configuration Management at O'Hare needs to address the question of runway configuration selection.

The New York Metroplex has three major airports in close proximity: J. F. Kennedy (JFK), La Guardia (LGA), and Newark (EWR). Management of airspace to optimize the flow to and from these airports is the main problem. An example of the interactions between airports is shown in Figure 3. When JFK is using instrument approaches to runway 13L, LGA may be forced to use instrument approaches to runway 13 due to winds, weather or potential traffic conflicts. The traffic to LGA landing on runway 13 overflies the airport at approximately 4000 feet and then loops around to land. As a result of this low altitude, LGA departures are prevented from using runway 4, and LGA is reduced to a one runway operation with a significant loss of capacity. There are a number of such interactions that must be accounted for by the New York Terminal Radar Approach Control (TRACON) operations. Hence,

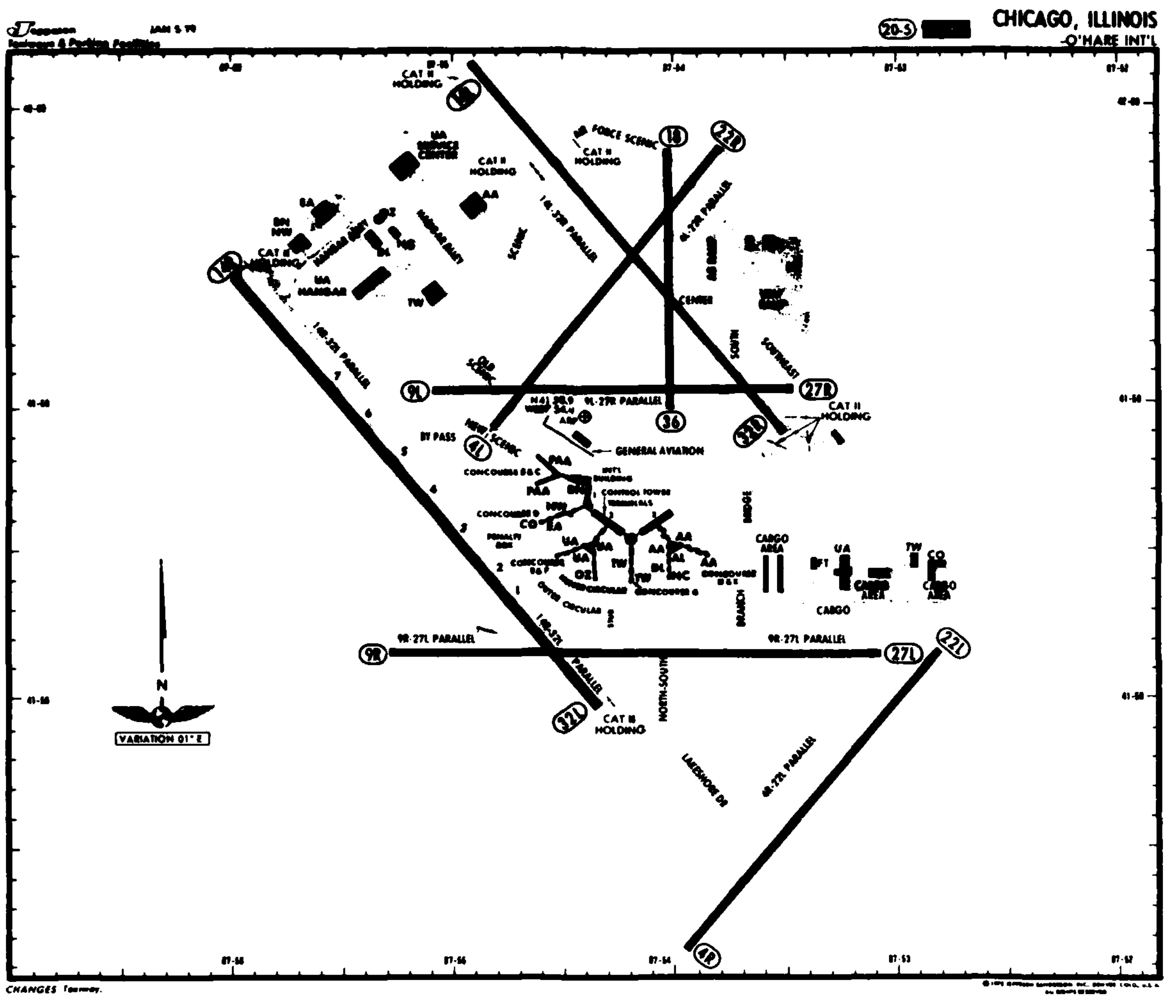

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FIGURE 2
CHICAGO O'HARE INTERNATIONAL
AIRPORT LAYOUT

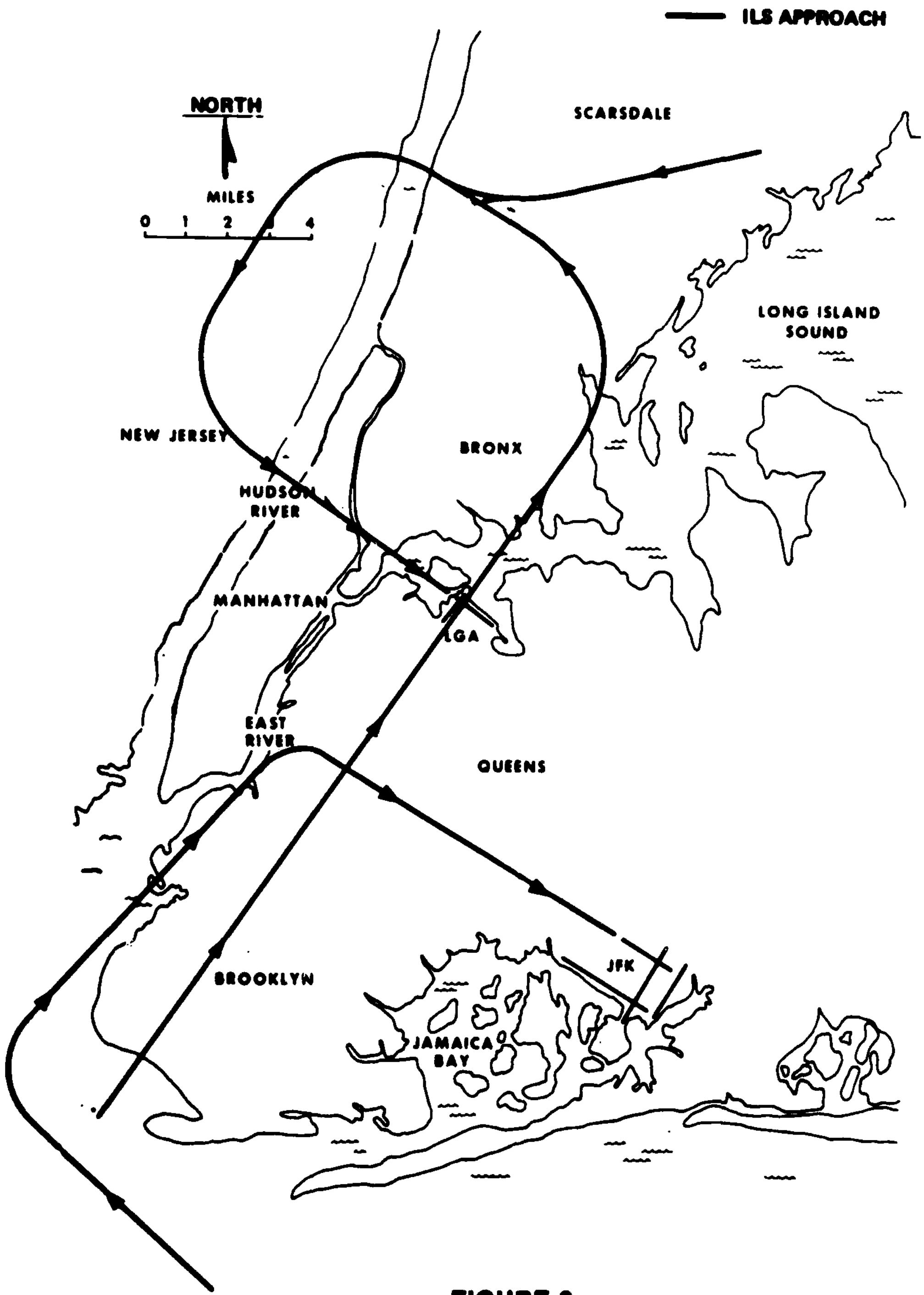

FIGURE 3
NEW YORK AIRSPACE
(ILS APPROACHES TO LGA 13 AND JFK 13L)

application of Terminal Area Configuration Management at New York must plan the use of the resources of all the airports and devise optimal strategies for the total complex, as well as account for the temporal noise distribution constraints imposed by the surrounding communities. Clearly, airspace management would be the primary emphasis in a New York implementation of Terminal Area Configuration Management.

The main problem at Atlanta, before the construction of the new terminal (Figure 4), was one of airport surface traffic flow and associated impacts on runways and airspace. The location of the old terminal required aircraft taxiing to and from the terminal to cross an active runway 8/26 in order to operate on the 9/27 runway pair. This imposed a penalty on the use of runway 8/26. Some of the problem has been eliminated with the construction of the new terminal between the runway complexes. However, ground flow problems have not been totally eliminated because the old terminal is still in use for limited operations. The old operating scenario at Atlanta illustrates a case where the primary emphasis of the resource planning function would be on airport surface traffic flow and its interaction with runway operations. In current operations, attention must be placed upon the avoidance of conflicting flows into and out of the gate areas.

Atlanta also has a tactical airspace management problem arising from runway assignments of individual aircraft. The arrival flight paths from the fix to the assigned runway can create complex airspace situations requiring crossovers from the north fixes to the south runways or from the south fixes to the north runway depending on the traffic load distribution. This type of airspace management problem is tactical in nature and differs from the New York situation which requires a more strategic planning. Thus, the application of Terminal Area Configuration Management at Atlanta would address the question of airspace as well as surface traffic flow.

V. DEVELOPMENT OF THE O'HARE RUNWAY CONFIGURATION MANAGEMENT SYSTEM

As discussed earlier, the resource planning problem at O'Hare is one of runway configuration selection. The O'Hare Delay Task Force Study (Reference 2) recommended the development of a system to select optimal runway configuration and estimated its impact to be a potential annual delay cost savings of $11-16 million at 1975 fuel prices. As a result, in support of FAA's Office of Systems Engineering Management, The MITRE Corporation developed the O'Hare Runway Configuration Management System (CMS) with the purpose of providing the means for a consistent selection of high capacity/low delay configurations.

In today's environment, the assistant chief (AC) of the shift on duty at the O'Hare facility has primary responsibility for making runway selection decisions. Such decisions are based on a diverse set of airport status and traffic demand indicators and generally require extensive coordination with team supervisors of both the tower cab and the TRACON. The O'Hare CMS is

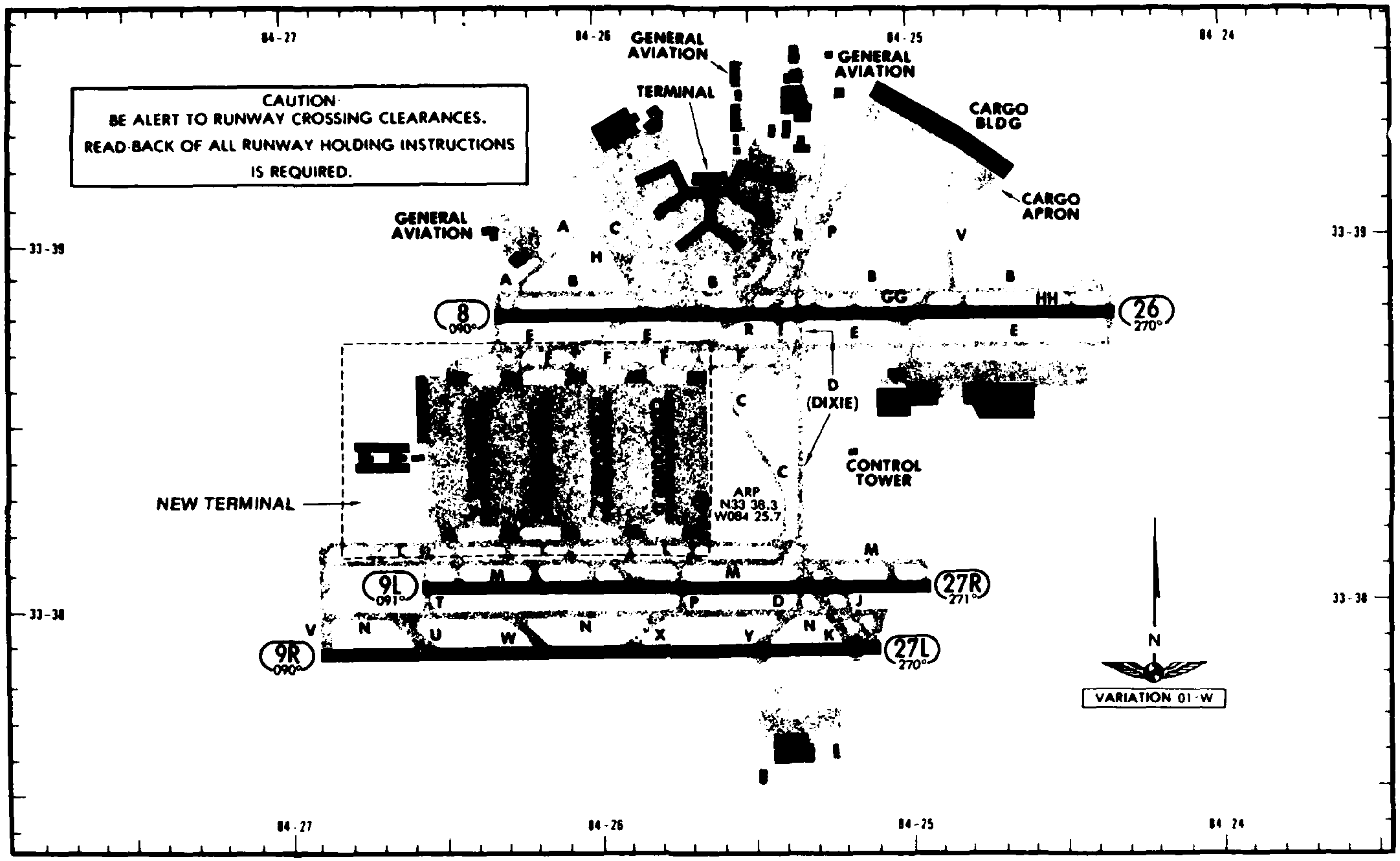

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FIGURE 4
ATLANTA HARTSFIELD INTE N. ,
AIRPORT LAYOUT

designed as an interactive computer algorithm that offers the means to consolidate and display information relevant to the decision process and to automatically integrate this information into a measure of capacity for evaluating alternative configuration choices (References 3 and 4). CMS also provides the AC with a powerful tool in planning transitions between the currently active configuration and those feasible in a forecast set of conditions.

The first step in runway configuration management is to define or update the current and forecast operational scenarios (e.g., winds, weather, equipment outages, runway closures). Based on these updated inputs, the next step is to determine the operational availability of individual runways for arrivals and/or departures within each scenario. Runway availability may be affected by construction, maintenance, excessive crosswinds or tailwinds, equipment outages, ceiling/visibility conditions, or noise constraints. The list of available runway configurations, composed of eligible runways, is then screened for configuration eligibility to check operational suitability (e.g., hold-short rules, non-parallel arrivals) within each scenario. The first level of output within each scenario is the capacity ordered list of eligible configurations under the current and forecast scenarios. The last element of the O'Hare CMS deals with the transition analysis which accounts for the impact of changing runway configurations from the current configuration to each eligible configuration in the forecast scenario. The final output is a capacity ordered list of transition strategies that assists O'Hare personnel in selecting optimal runway configurations.

The physical configuration currently envisioned for the implementation of O'Hare CMS is shown in Figure 5. The assistant chief (AC) has the responsibility of selecting runway configurations and hence, is the primary user of the system. He is supported by the Airway Facilities (AF) operations officer who maintains and provides the current equipment status and planned equipment outages (e.g., glide slopes, localizers, runway lights), and the tower cab supervisor who provides the inputs dealing with current/forecast runway availability and airport conditions (e.g., wind, weather, braking conditions). The AC utilizes the consolidated data base available to him in planning the selection of runway configurations. Provisions are made for additional computer terminals as desired (e.g, for TRACON team supervisor) for information transfer, and a printer to provide hard copies of desired information such as historical records of equipment outages, weather conditions and runway configuration usage.

In addition to fulfilling its primary purpose of providing an aid for consistent selection of high capacity/low delay runway configurations, the O'Hare CMS also provides a consolidated data base and improved information transfer among the three positions (AC, Cab, AF) which helps reduce the workload of these individuals. It also provides the means of generating historical records for use in equipment, Performance Measurement System (PMS) and facility logs required for record keeping.

The O'Hare system also provides accurate data of airport acceptance rates required by en route metering, and represents the first step of terminal flow

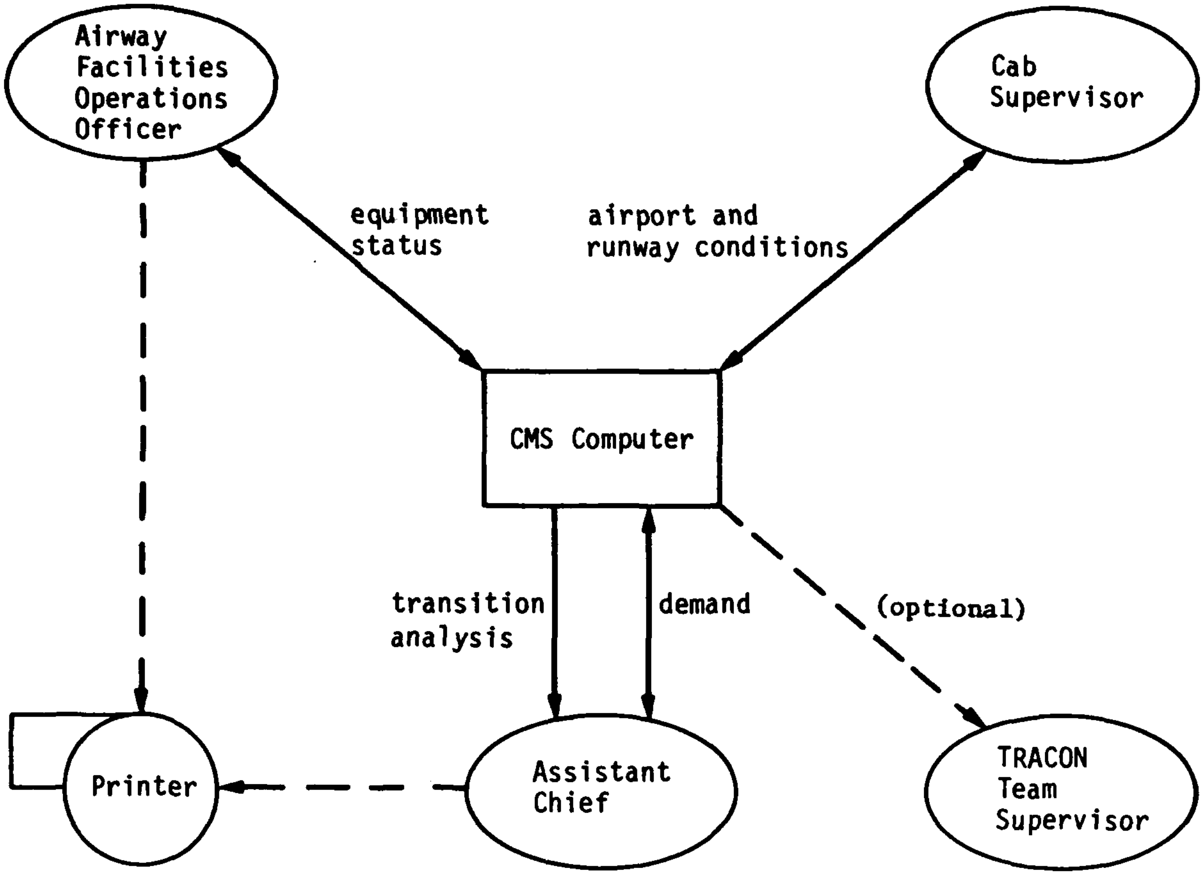

FIGURE 5
PHYSICAL CONFIGURATION OF CMS

management. It is also planned to interface with future automation systems such as Terminal Information Display System (TIDS).

While O'Hare CMS has been developed with a modular structure to facilitate site specific adaptation, it should b noted that the transfer of the O'Hare CMS to other airports is only appropriate if the major emphasis is on runway configuration selection. Additional features must be incorporated if airspace and/or ground flow problems are to be included.

VI. SUMMARY

Generalized concepts of Terminal Area Configuration Management have been discussed in the role of a resource planning function. The scope covers airside operations while recognizing the need for compatible landside operations. This resource planning function is the foundation of the terminal flow management process which is an element of the Integrated Flow Management program.

Applications of Terminal Area Configuration Management to individual airports require an insight into the nature of the site specific problems and may emphasize different elements as illustrated by airspace management in New York, surface traffic flow at Atlanta, and runway configuration management at Chicago.

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