

# Cost Reduction and Better Management by Using An Intelligent GIS System For Tracking Pilgrims' Services: The Case of the National Tawafa Establishment For Pilgrims of South East Asian Countries (SEA)

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## Abstract

The study aimed to describe the design and application of an intelligent Geographic Information System (GIS) for pilgrims' services inspection from arrival to departure. The GIS technology was attached to a partial Enterprise Resource Planning (ERP) system that runs some of the main and support operations of SEA. SEA commenced using E-solutions since 2007 by building separate systems that run their operations. By 2014 a full ERP system was set to be built by mid 2015. The first version of GIS system was named "Najam". The proposed system "Najam" has an intelligent part for matching authorized inspectors' locations with inspected items locations to make sure that inspections were carried out. Najam runs in mobile platforms. It also records and computes real-time key performance indicators (KPIs) regarding service times such as buses movement and pilgrims' housing & food services. Najam system was introduced during the Hajj season of 2014. The system pilgrims' housing locations database, helped return lost pilgrims to their housing in record times. The system also provided better management and reduced penalties of camps (tents) faults by 85%. It was achieved by rejecting false inspections and by reporting all camps faults online to the concerned department and government offices. The system also tracks pilgrims services and movements through the GIS system until they reach their designated locations to ensure their safety and comfort.

**Keywords:** Enterprise Resource Planning, Key Performance Indicators, Geographic Information Systems ,Intelligent tracking and manufacturing, e-Business, e-Government , Tawafa, Pilgrims' Services

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## 1. Introduction

Geographic Information Systems (GIS) technology offers the users the ability to query and access information, map spatial data, and perform predictive modeling for targeting potential markets in a wide variety of industries and businesses [3]. GIS has matured and has been proven to be an enabling technology, one that is important to many disciplines. Location analysis is also a field that has matured and continues to evolve [14]. Location science has long been recognized as providing valuable support of planning processes and key to ensuring operational efficiency and competitive advantage in the provision of goods and services [14].

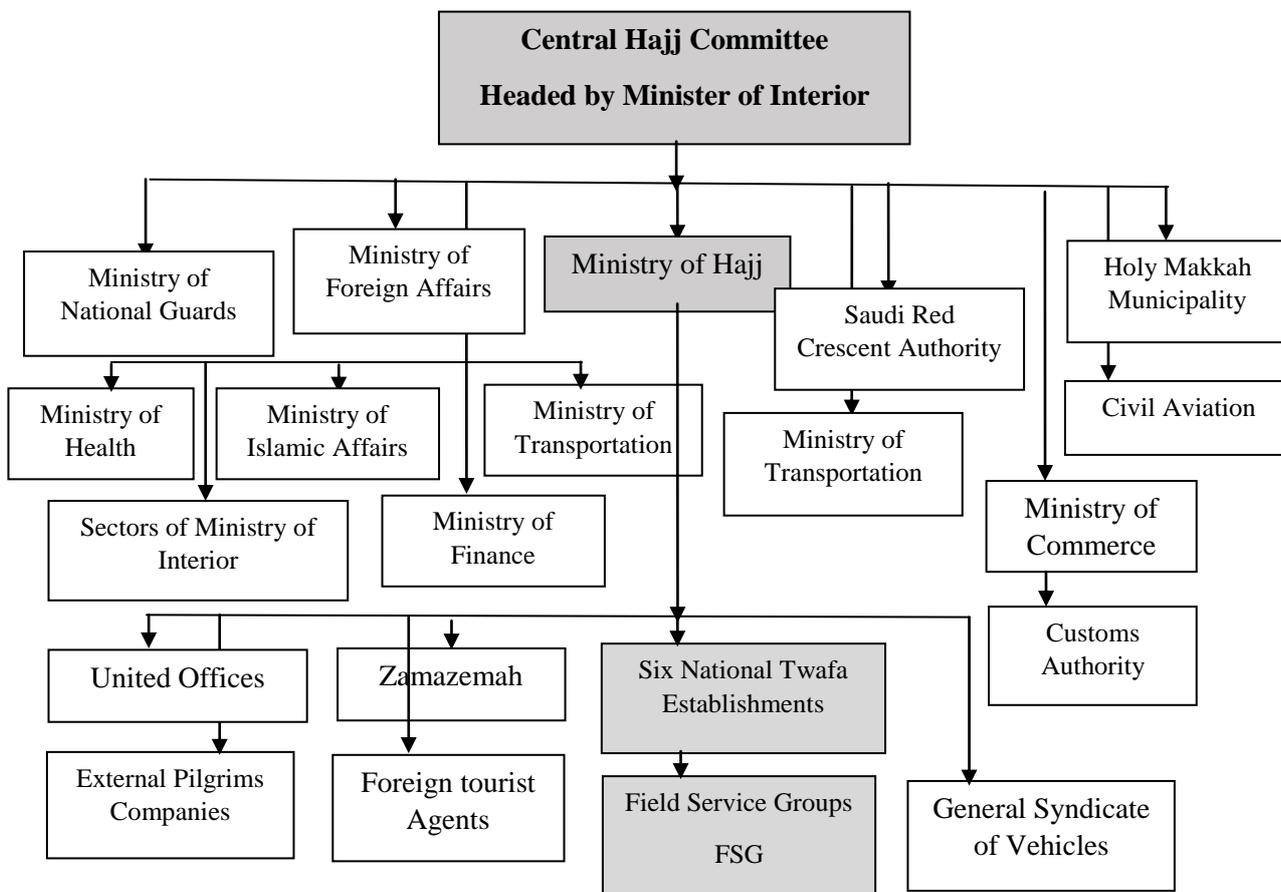
In telecommunications, companies engage in location analysis and modeling for citing central offices, placement of cellular towers and locating equipments for wireless broadband access [7, 4, 6]. Of course, there are a range of public sector efforts relying on location analysis and modeling as well. One example is citing fire stations, where potential calls for service, emergency response, and saving lives and property must be taken into consideration in location and staff decision-making [17,13]. Other applications include waste management, health care, school citing/closing and attendance, emergency warning siren citing, snow removal on roadways, public transit routing and scheduling [9, 16, 19, 10, 1]. Common to all of the above examples (and many others) is that location analysis and modeling is important for geographically citing one or more facilities that provide some sort of service, where operational efficiency is critical. Dawod *et.al* [2] applied GIS technology to investigate the spatial distribution of some selected public services over the municipal election areas within Makkah city in Saudi Arabia.

The city of Makkah and Madinah are the most sacred cities for Muslims around the world. Muslim population is about 2.08 billion and each one of them must perform Hajj ritual, pilgrimage to Makkah once in their life time, but only if they are physically and financially able to make the journey. Hajj is the fifth pillar of Islam and the most significant manifestation of Islamic faith and unity. Makkah Grand Mosque houses the Kabba, where all Muslims direct their daily prayers. Madinah, on the other hand, is the city of the prophet Mohammed (PBUH) where he lies in his grave at his Mosque. Muslims usually visit the prophet Mohammad's mosque (PBUH) before or after they perform Hajj.

## 2. History of Tawafa

Al Tawafah first appeared in Makkah as an aid offered to the Muslims who are not Arab, or to those who don't know the rituals and rites of Omrah and Hajj. It started first with individuals each called a 'mutawaf.' A mutawaf waited for the pilgrims ships so that they could assist them through their staying of performing Hajj or Omrah. They were responsible of finding the suitable accommodation for pilgrims and running their errands. To communicate and coordinate the pilgrims, Al Mutawaf got to speak many foreign languages. Actually, Al Tawafah was divided into the willing individuals or families, so that each one can assist a certain group from a certain country with their language.

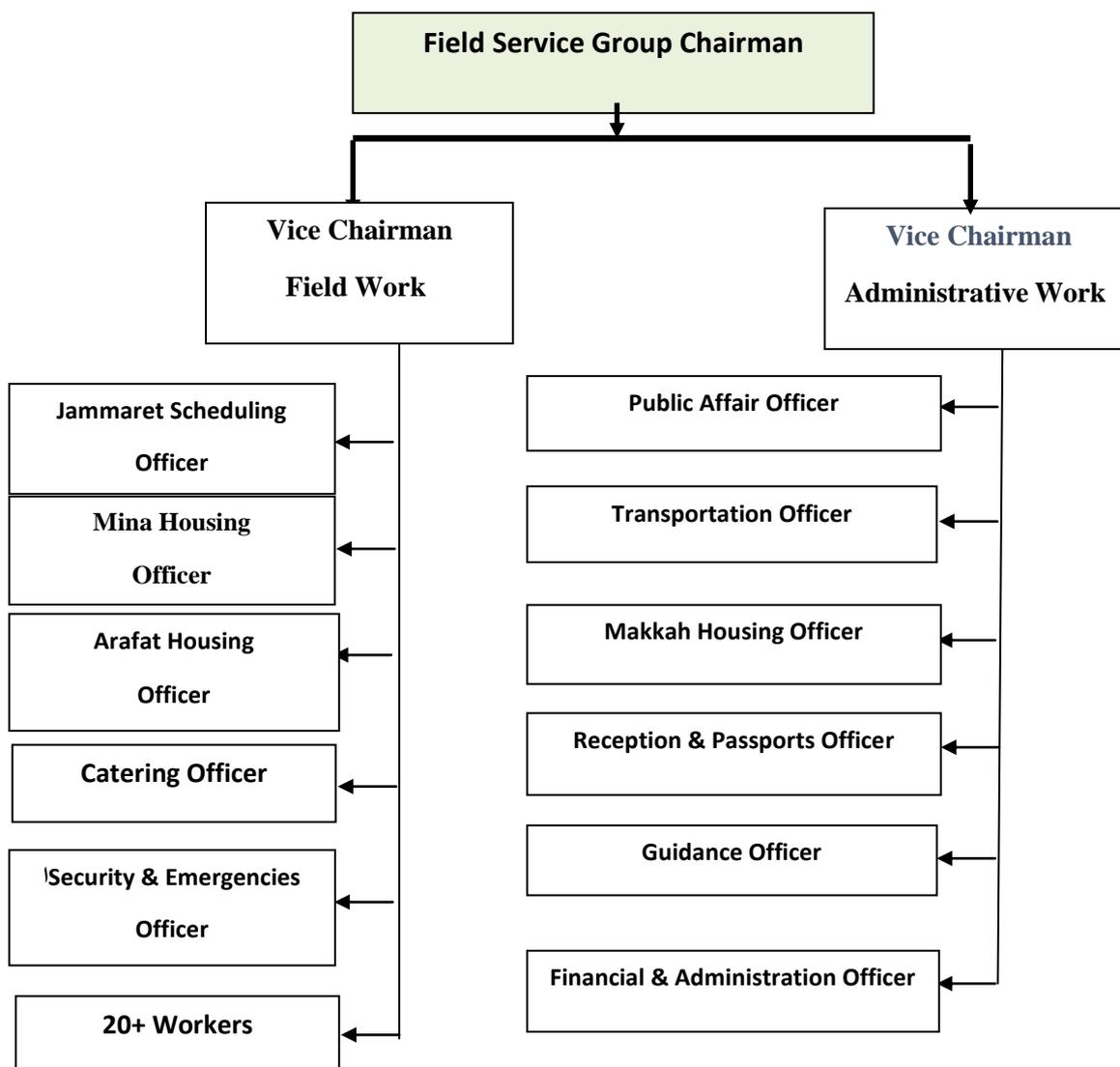
Serving the 1.8 million pilgrims from more than 64 countries around the world lies directly on the Ministry of Hajj and its six National Tawafah Establishments, the Zamazamah, who are responsible for zamzam drinking water for all pilgrims during their stay, and the United Offices who are responsible of collecting services fares. There are about 128 ministries and governmental offices who share the burden of serving pilgrims [11], [12] and [18] (Figure 1).



**Figure 1. Ministries and Governmental Offices Responsible of Pilgrims**

The National Tawafah Establishment for Pilgrims of South East Asia (SEA) serve the pilgrims coming from Indonesia, Malaysia, Singapore, China, Thailand, Philippines, Brunei, Hong Kong, North and South Korea, China Taiwan, Japan, Cambodia, and Fiji.

Each Tawafa Establishment selects the working team of each field service groups (FSG) to provide the direct services to the establishment's pilgrims. The number of field service group ranges from 70 - 104 offices. Each FSG has 13 members and more than 20 workers (Figure 2). The number of pilgrims in each FSG ranges from 2500 to 3000.



**Figure 2. Organization Chart of Field Service Group (FSG)**

The pilgrims arrive one month before hajj and stayed in Saudi Arabia for about two months. Their services started a few months before in their countries to require the hajj visa and to register for the required level of services.

### **3. Holy sites of Hajj**

Each year more than three million Muslims from every race and color perform Hajj, half of them come from other countries. The holy places of Muslims during Hajj are Makkah, Madina, Mina, Muzdalifah and Arafat.

The Saudi Government gave great attention to the development of facilities in holy places to serve the pilgrims. These sites were equipped with necessary drinking water systems and dissemination of lighting and the creation of the toilets. To facilitate the movement of pilgrims, the government set up an extensive network of streets, spacious longitudinal and transverse dotted with bridges in Arafat and Muzdalifah. The Government established bridges and tunnels through the mountains to regulate and facilitate traffic between Makkah and the holy sites and alleviate congestion during the Hajj season.

### **3.1 Mina**

Mina is located east of Makkah, just near the east suburb of Makkah, usually known as Tents City. In Mina, the Government built tens of thousands of tents to house Pilgrims during their stay at Mina. SEA alone was given about 25000 tents. Each Field Service Group (FSG) has 250 tents to house the Pilgrims under their contracted services. [ 5] (Pictures 1)



**Pictures 1 . Pilgrims Tents in Mina**



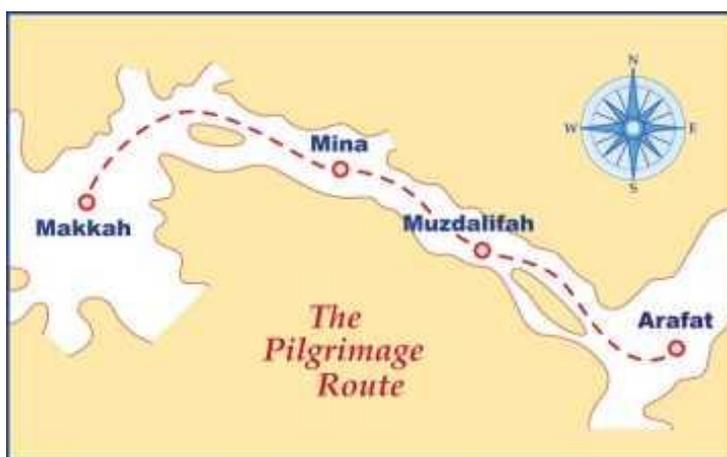
**Pictures 1 . Pilgrims Tents in Mina**

### **3.2 Arafat**

Valley of spacious room quarters, away from Makkah by 25 km to meet the pilgrims in the ninth day of the month of Dhul-Hijjah (Hidjri Calendar), and in Arafat, there are some places of interest such as the Mount of Mercy, Namira mosque, which had been expanded up to 14 thousand square meters.

### **3.3 Muzdalifah**

Muzdalifah is one of the holy sites which is located between Mina and Arafat. Pilgrims usually spend one night there or until midnight before settling in Mina [6] (Picture 2).



**Picture 2. The Pilgrimage Route**

#### 4. Summary of Hajj route

**step 1:** In the forenoon of the eighth day of month Dhul-Hijjah, Pilgrims go to Mina and there they pray Dhuhr (noon), Asr (afternoon), Maghrib (sunset), Isha' (evening) and Fajr (dawn), shortening their four unit prayers so as to make them two units each, without combining them. When the sun rises, 9th of Dhul-Hijjah, they go to Arafat and there they pray Dhuhr and Asr combined at the time of Dhuhr, making each one two units. Pilgrims remained in Namira Mosque until sunset, if possible. During that time, they remember Allah and make as many supplications as possible while facing the Kiblah (in Makkah).

**Step2 :**At sunset Pilgrims go from Arafat to Muzdalifah and there they pray Maghrib, Isha, and Fajr. If they are tired or have little water, it is permissible for them to combine Maghrib and Isha. If they fear that they will not reach Muzdalifah until after midnight, they should pray before they reach it for it is not permissible to delay prayer until after midnight. Pilgrims remain there, in Muzdalifah, making supplications till just before sunrise.

**Step3 :** Near sunrise, Pilgrims go from Muzdalifah to Mina where they stay until the 12th of Dhul-Hijjah . During their stay at Mina they perform the ritual of stoning Jamarat and other rituals.

**Step 4** If Pilgrims are in a hurry after stoning on the twelfth day, they leave Mina before sunset. But if they wish to prolong their stay, which is best, they can spend the night of the thirteenth in Mina.

**Step 5** When Pilgrims are ready to return to their countries, they make Tawaf Al-Wada' (farewell), which is seven circuits around the Kabba. After that Hajj is completed.

The following table (Table 1) illustrates the pilgrims services elements.

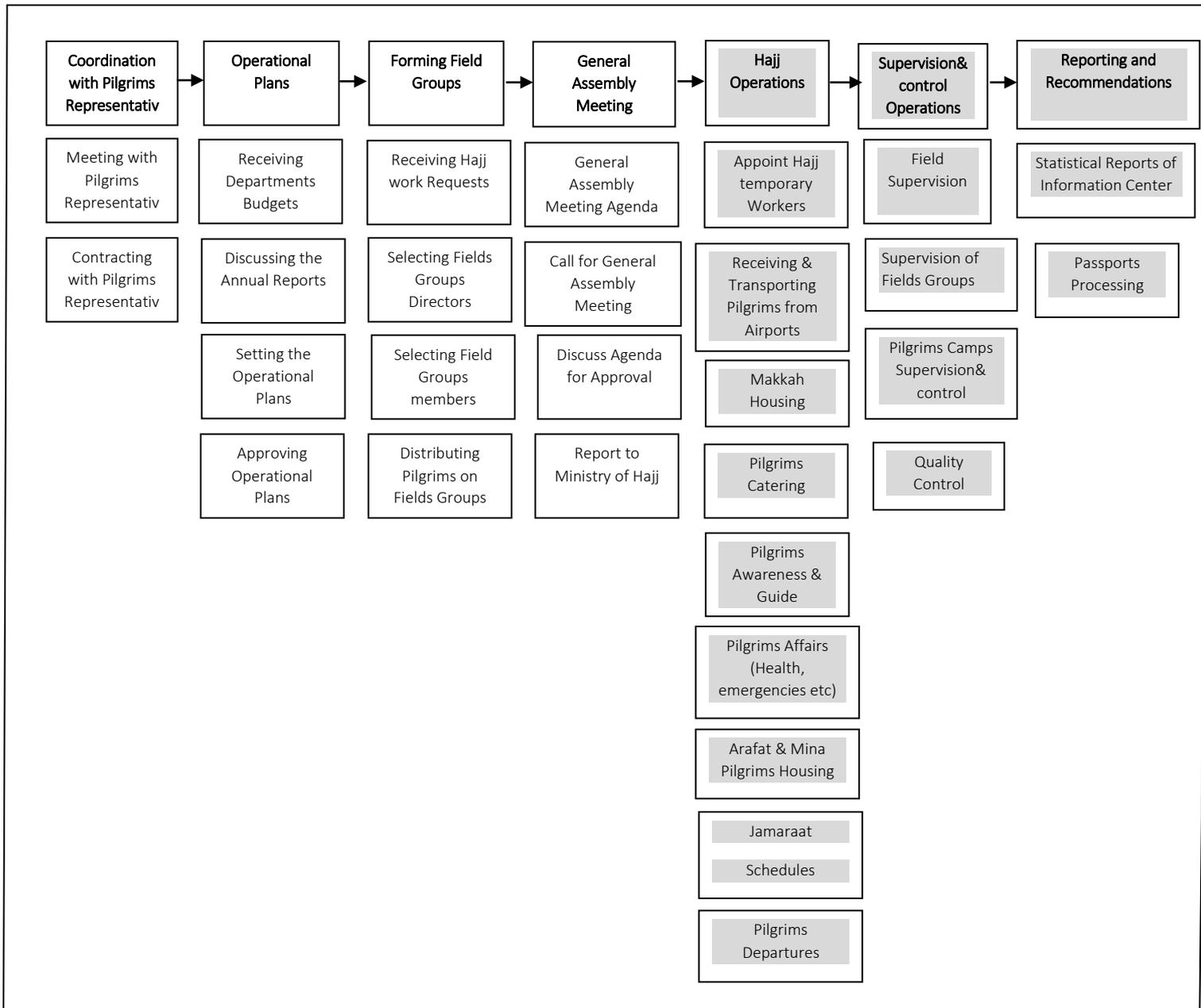
**Table1. Pilgrims Services Elements**

<b>N</b>	<b>Location</b>	<b>Services</b>	<b>Procedures</b>
<b>1</b>	<b>Makkah one month before Hajj</b>	Checking Pilgrims Housing	<ul style="list-style-type: none"> <li>• Inspecting Pilgrims' buildings in Makkah</li> </ul>
<b>2</b>	<b>Mina one month before Hajj</b>	Checking Pilgrims Tents and other services	<ul style="list-style-type: none"> <li>• Inspecting Pilgrims' tents in Mina</li> </ul>
<b>3</b>	<b>Ports of Arrivals Jeddah or Madinah</b>	Reception at Ports ( <b>United Offices</b> )	<ul style="list-style-type: none"> <li>• Welcoming Pilgrims</li> <li>• Finishing Arrivals Requirements ( customs, luggage and passports)</li> <li>• Collecting Services Fares</li> <li>• Issuing Transportation tickets of all trips</li> <li>• Grouping Pilgrims</li> <li>• Organizing Pilgrims departures dates</li> </ul>
<b>4</b>	<b>Ports of Arrivals Jeddah or Madinah</b>	Buses Departures ( <b>Buses Guidance Office</b> )	<ul style="list-style-type: none"> <li>• Collecting Pilgrims Passports for each bus</li> <li>• Loading Pilgrims on Buses</li> <li>• Sending Bus information to guidance centers</li> <li>• Provide guiders with proper maps to next service point</li> <li>• Unloading pilgrims with luggage and passports at service point</li> </ul>
<b>5</b>	<b>Makkah by Field Service Groups</b>	Reception	<ul style="list-style-type: none"> <li>• Welcome pilgrims</li> <li>• Collecting pilgrims passports</li> <li>• Distribute ID cards and bracelets to pilgrims</li> <li>• Distribute zamzam drinking water to pilgrims</li> <li>• Unloading pilgrims luggage to their assigned residences</li> <li>• Finishing pilgrims accommodations process</li> </ul>
<b>6</b>		Passports	<ul style="list-style-type: none"> <li>• Cross checking passports and numbers with arrived pilgrims to Makkah</li> <li>• Entering passports data to the proper computer system and locking passports in a safe</li> <li>• Providing the required passports for pilgrims departures (later on )</li> </ul>
<b>7</b>	<b>National Twafah Establishments SEA</b>	Housing	<ul style="list-style-type: none"> <li>• Cross checking availability all government regulations regarding pilgrims residences</li> <li>• Availability of water</li> <li>• Availability of safety, sanitation and security materials</li> <li>• Cross checking elevators safety</li> </ul>
<b>8</b>	<b>Field Service Groups</b>	Catering First meal	<ul style="list-style-type: none"> <li>• Provide first meal to pilgrims on time ( quality and quantity )</li> <li>• cross checking meals before serving</li> <li>• The proper serving of the meals</li> </ul>
<b>9</b>		Arrival Twaf at Grand Mosque	<ul style="list-style-type: none"> <li>• Grouping pilgrims</li> <li>• Provide guidance</li> <li>• Transporting pilgrims to Grand Mosque</li> <li>• Provide guide for Twaf ritual</li> <li>• Grouping pilgrims</li> <li>• Returning pilgrims their residences</li> </ul>

**Follow Table1. Pilgrims Services Elements**

<b>N</b>	<b>Location</b>	<b>Services</b>	<b>Procedures</b>
<b>10</b>		Health & Lost Affair sector	<ul style="list-style-type: none"> <li>• Readiness of health&amp; lost field teams</li> <li>• Provides cars &amp; communication equipments to field teams</li> <li>• Provides health&amp; lost centers with cars &amp; communication equipments</li> <li>• Provide enough and proper Ambulances</li> <li>• The presence of health teams in local hospitals</li> </ul>
<b>11</b>		Reception	<ul style="list-style-type: none"> <li>• Welcoming Pilgrims to holy places</li> <li>• Cross checking readiness of all services in pilgrims tents</li> </ul>
<b>12</b>	<b>Holy Sites</b>	Holy Sites Housing	<ul style="list-style-type: none"> <li>• Welcoming Pilgrims to their assigned tents</li> <li>• Cross checking readiness of all services in pilgrims tents ( sleeping mattress, water, light, cleaning teams and toilets )</li> </ul>
<b>13</b>	<b>Holy Sites By SEA and Field Service Groups</b>	Catering	<ul style="list-style-type: none"> <li>• Cross checking readiness of the kitchen and equipments, right food materials, quantities and quality</li> <li>• Washing water</li> <li>• Drinking water</li> <li>• Hot water</li> <li>• Right meals schedules</li> <li>• Cleanness of tents</li> </ul>
		Health & Lost Affair	<ul style="list-style-type: none"> <li>• Readiness of health&amp; lost field teams in holy places</li> <li>• Provides cars &amp; communication equipments to field teams</li> <li>• Provide enough and proper Ambulances</li> <li>• The presence of health teams in local hospitals</li> </ul>
	<b>Mina By SEA and Field Service Groups</b>	Jamarrat service ( stoning rituals)	<ul style="list-style-type: none"> <li>• Cross checking the jamarrat schedules</li> <li>• Grouping pilgrims into small groups</li> <li>• Provide guides to pilgrims</li> <li>• Provide written materials about stoning rituals</li> <li>• Provide enough teams for jamarrat schedules</li> </ul>

In order to provide the services to their Pilgrims, SEA is handling many operations. Figure 3 illustrates its main operations. The proposed system “Najam” helps in Hajj operations, supervision & control operations, total quality operations and in reporting & recommendation.



**Figure 3. SEA Main Operations**

## 5. Building “Najam” System

### Step1: Pilgrims’ Buildings & Tents Locations Data Base

1. Locations mapping of all Pilgrims buildings in Makkah are stored. Buildings detailed information, such as sizes and capacities, was attached to field Service Groups (FSGs).
2. Locations mapping of all Pilgrims tents in Mina are stored. Tents detailed information, such as sizes and blocks, was attached to field Service Groups (FSGs).

### Step 2: Matching Procedures

1. **IF** (location of authorize inspector, of certain FSG, within the coordinates of assigned tent) **then** inspection is True otherwise false. (See screen1).
2. **IF** (location of authorize inspector, of certain FSG, within the boundary' coordinates of assigned tents) **then** inspection is True otherwise system returns (crossing over other FSG tents).
3. Inspections of pilgrims' buildings in Makkah uses the same matching procedure of (1) and (2)

### Step 3: Attaching “Najam” system with other subsystems

Figure 4 illustrates how Najm system is attached with other subsystems.

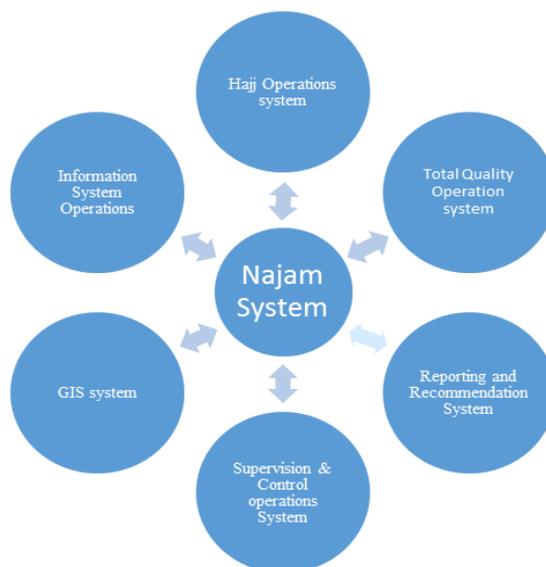


Figure 4. Najam Design

The following screens, translated to English, (screen1- screen 5) shows how Najam system works.

**(user name and password)**

Najam System shows name, date, time and tent coordinates

If user coordinate does not match with tent coordinate, Najam system reports false inspection to control

**( Field Service Group number)**

Najam System shows pilgrim nationality and type of services required

N	Item	available	unavailable	Remark
1	Electric Pipes inside Tents			
2	Tents Bases			
3	Interlocking tiles			
4	Stair & Bathroom handrails			
5	Metal fences in car parking			
6	Electric Pipes Check Boxes with covers			
7	Water Pipes check Boxes with covers			
8	Brick kitchen removal			
9	Stones clearance			
10	Concrete Plates at entrances			
11	General Sanitation			
12	Water Pipes for Restrooms			
13	Fences			
14	Fire Grates			
15	Floor Tarmac			
16	Camp ready and clear for housing			
17	Valley Gutters in roofs and walls			

Najam system send report to control and take user to Non conformity Form

Screen1. Tent inspection form (E-Form functional online on multiple platforms)

**(user name and password)**

Najam System shows name, date, time and arrivals location coordinates

If user coordinate does not match with arrivals location coordinate, Najam system reports false evaluation to control

**( Field Service Group number)**

Najam System shows pilgrim nationality and type of services require,

N	Item	Yes	No	Remark
	<b>Pilgrims Reception</b>			
1	Presence of one FSG leaders			
2	Presence of at least 5 members of FSG			
3	Members wear official clothes			
4	Members put their ID			
5	Welcoming Pilgrims into buses			
6	Distributing bracelets and ID cards			
7	Receiving Passports			
8	Presence of enough labors(10-15)			
9	Labors wear unified clothes			
10	Presence of mechanism of unloading luggage			
11	Distributing welcoming meals			
12	A Saudi Mutawaf to accompany pilgrims to Grand Mosque			
13	Helping Pilgrims in Twaf at Grand Mosque by FSG members			
14	Distributing gifts to pilgrims			
15	Delay in unloading Bus			

If there are any non-conformity, the system shows the non-conformity form for processing

Screen2. Evaluation form for pilgrims' reception at Makkah (E-Form functional online on multiple platforms)

**(user name and password)**

Najam System shows name, date, time and location coordinates

**(Building Number)**

If user coordinate does not match with building location coordinate, Najam system report false evaluation to control

**( Field Service Group number)**

Najam System shows pilgrim nationality and type of services required.

N	Item	available	unavailable	Remark
1	Availability of buildings permits			
2	Ensuring buildings safety ( fire exits, fire distinguishers, etc)			
3	Room furniture and lights			
4	Availability of buildings periodical visit form			
5	Availability of guide& information banners in buildings			
6	Availability of air-conditioner in every room.			
7	Availability of kitchens and kitchenware			
8	Availability of Security guards			
9	General Sanitation of rooms			
10	General Sanitation of bathrooms			
11	General Sanitation of entrances			
12	Availability of garbage cans			
13	Availability of coolers			
14	Availability of safe elevators			
15	Availability of Zamzam water in buildings			

If there are any non-conformity, the system shows the non conformity form for processing

Screen3. Evaluation form for pilgrims' housing at Makkah (E-Form functional online on multiple platforms)

**(user name and password)**

Najam System shows date and time

**( Kitchen Name)**

The system returns kitchen location, number of meals, types and other information.

If unauthorized user or user coordinate does not match with kitchen coordinate, Najam system report false inspection to control

**( Field Service Group number)**

Najam System shows pilgrim nationality and type of services required

N	Type of Service	Yes	No	Performance Evaluation			Remark
				Good	Fair	Bad	
1	availability of a kitchen supervisor						
2	availability of a chef and kitchen workers						
3	availability of kitchen tools and utensils						
4	availability of cleaning tools						
5	kitchen/tools sanitation level						
6	preparation room sanitation level						
7	availability of air ventilation and bug traps						
8	availability of enough workers						
9	availability of health certificate to all workers						
10	workers' commitment to unified uniforms						
11	workers' commitment to using gloves, masks and hairnets						
12	workers' health is in good shape						
13	sanitiation of loading and packing area						
14	swiftness of meal preparation						
15	availability of foam containers						
16	efficiency and temperature of meal						
17	meal is complete						
18	meal is out on time						
19	availability of meal delivery cars						
SUM							
%							

Najam system sends report to control and takes user to Non conformity Form .

Screen4. Kitchen Evaluation Form (E-Form functional online on multiple platforms)

**(user name and password)**

Najam System shows name, date and time

**(Field Service Group number)**

Najam System shows pilgrim nationality and type of services required

**(Bus Number)**

Najam system waits for number and enter key

**( Bus Company Name)**

Najam system returns selection to choose from

**(Arrival Time)**

Najam system waits for enter key

**(Departure Time)**

Najam system waits for enter key

**(Loading Time)**

Najam system shows difference and waits for enter key

**(Number of Pilgrims in Bus)**

Najam system waits for number and enter key

**(Number of Round)**

Najam system waits for number (1-7) and enter key

**(Name of Guide)**

Najam system waits for name and enter key

**Screen 5. Bus follow-up Form** (E-Form functional online on multiple platforms)

## **6. Discussions**

Najam also recorded and computed real-time key performance indicators (KPIs) regarding service times such as buses movements and pilgrims' housing & food services. The pilgrims' housings locations database, helped return lost pilgrims to their housings in record time. The system also provided better management and reduced penalties of camps (tents) faults by 85%. It was achieved by rejecting all false inspections and by reporting all camps faults online to the concerned department and government offices. Najam also tracked pilgrims services and movements through the GIS system till they reach their designated locations to ensure their safety and comfort.

In a survey during Hajj session 2014, a random sample of size 113, answered a question about Najam system (five points scale; bad, satisfactory, good, very good and Excellent). There was a general satisfactory (good) opinion about the system (Table 2).

**Table 2**

criteria	Weighted Average
Availability of “Najam” Training	4.03
Availability of WIFI	3.80
System Speed	3.70
Continuity of the System with no shutdowns	3.53
Time saving	3.53
Clarity of Geographic maps	3.17
System efficiency	3.16
Ease of Use	3.14
Clarity of system screens	3.12
Availability of technical support	3.02
General Satisfaction of the system	<b>3.23</b>

Furthermore the participants in the survey observed the following remarks in descending order:

<b>Remark</b>
Low Internet connection in prime times at holy sites
Users need more training
System does not support Apple platform
Slow maps downloading
Map zooming not supported
Need more technical support during prime times
Maintenance time should be in fixed time
Low system' bandwidth range
Not enough help screens
System hangs due to continuous update

As a result of this survey, SEA took many major measures to improve the system for the Hajj session of 2015. The new version of Najam supports Apple platforms, works online and offline, and attached to the newly developed ERP. Training contents and schedules are planned in advance to maximize its benefits.

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