



ABU DHABI EMIRATE, UAE, SYSTEM FOR SEISMIC RISK MONITORING AND MANAGEMENT

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ABSTRACT

To assure and maintain sustainable development of the Emirate of Abu Dhabi, UAE, in general, of Abu Dhabi Municipality and Abu Dhabi City in particular, and disaster free living environment for its citizens, the Abu Dhabi Municipality Town Planning Department initiated project "Assessment of Seismic Hazard and Risk in Abu Dhabi - ADSHRA". During the conceptual design of the system and development of the Tender document, the primary concept and territorial coverage of the project have been enhanced ending up into "Emirate of Abu Dhabi System for Seismic Risk Monitoring and Management – AD SRMMS". This paper, in necessary details, presents the Project structure, its objectives and scope and some crucial aspects of the system implemented.

1. INTRODUCTION

To assure and maintain stable development of Abu Dhabi Emirate, disaster free living environment for its citizens and targeted quality of life, the Municipality Abu Dhabi City in 2008 initiated conceptualization of the Project "Assessment of Seismic Hazard and Risk in Emirate of Abu Dhabi (ADSHRA)".

Endeavoured in creating the Abu Dhabi System for Seismic Risk Monitoring and Management (AD SRMMS), the Project is primarily focused on seismic sector. Being under the implementation over the last 24 months, the Project, in most effective and technically and scientifically consistent manner, integrates the state-of-the-art know-how, technology and data for developing a sound strategy and superior policies for protecting the current and planned development against adversity of potential environment impacts.

The Project meets national seismic safety goals by assuring consistent, technically sound and economically justified inputs for:

- Prevention, Regional and Development Planning
- Urban Planning and Land Development
- Mitigation, Emergency Preparedness and Response
- Engineering and Development, and
- Promotion of Public Awareness, Risk Prevention Culture, and Public Safety.

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ADSHRA objectives have been designed along the Hyogo Framework for Action 2005-2015 (HFA 2005-2015) strategic goals, in particular the first one:

<< The more effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction >>

as well as are in full conformity with HFA priorities for action:

1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation
2. Identify, assess and monitor disaster risks and enhance early warning
3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels
4. Reduce the underlying risk factors
5. Strengthen disaster preparedness for effective response at all levels.

As such, ADSHRA fully complies and are in support of Abu Dhabi Municipality vision: To ensure a superior quality of life and a sustainable environment for Abu Dhabi residents.

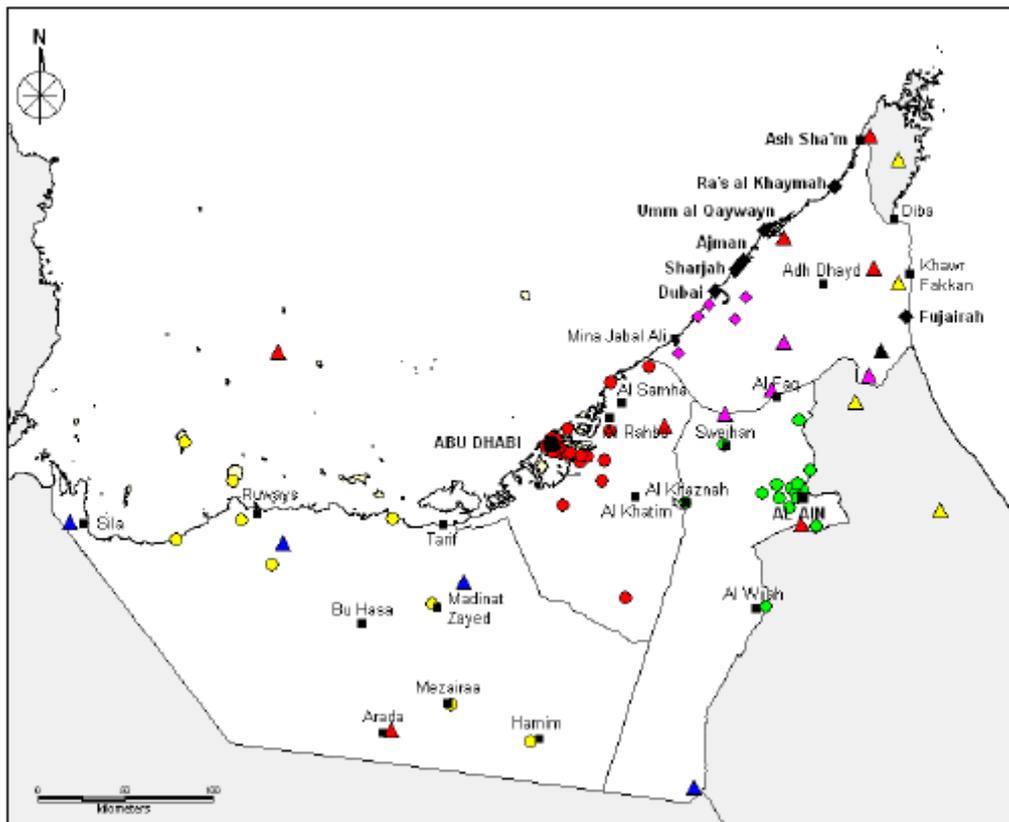


Figure 1. ADSHRAs' Permanent Accelerograph (yellow, red and green solid circles) and Seismic Monitoring (blue solid triangles) Networks.

/Red solid triangles: NCMS Seismic Monitoring Stations, Yellow solid triangles: Part of Omani Seismic Monitoring Network, Pink solid triangles: Dubai Municipality Seismic Monitoring Stations; Pink rhomboids: Dubai Municipality Permanent Accelerograph Network/

2. PROJECT STRUCTURE

The Project consists of 20 tasks and 69 deliverables. Fifteen (15) tasks and fifty nine (59) deliverables of technical nature are related to qualitative and quantitative understanding of:

- Seismic environment the Emirate of Abu Dhabi is exposed to

- Potential consequences if the Emirate in general, and Abu Dhabi, Al Ain and/or Western Region Municipalities in particular, are exposed to a major earthquake event from surrounding high energy seismic zones
- Performance and seismic risk inherent to current and planned building stock, and selected critical importance lifeline systems
- Installation of seismic monitoring systems (accelerograph network, seismic monitoring network and structural health monitoring systems) for research, engineering, planning and emergency management needs
- Establishment of disaggregated AD Seismic Risk Monitoring and Management Center (AD-SRMMC) consisting of two (2) Data and five (5) Display Centres, and
- Definition of parameters for deciding nationally feasible and economically justifiable levels of seismic protection, i.e. – economically acceptable level of seismic risk.

Three (3) tasks and seven (7) deliverables are related to coordinated activities, the Project promotion, validation and creation of public awareness and training, one (1) task and one (1) deliverable to post implementation phase maintenance and one (1) task and one deliverable (1) are related to BOT services that will enable Client to rapidly start offshored operations, and within a period of 3 (three) years, to take ownership of the offshored developed center (AD-SRMMC Center) as its own subsidiary.

Fourteen (14) tasks and twenty-six (26) deliverables shall be performed at Abu Dhabi Emirate level, while six (6) tasks and forty-two (43) deliverables are municipality specific and shall be conducted either within or for selected urban areas and critical1 and/or unique2 structures in Abu Dhabi, Al Ain and Western Region Municipalities.

3. ACCOMPLISHMENTS

During the Implementation Phase ADSHRA accomplished:

1. Qualitative and quantitative assessment of:

- Seismic Hazard and Seismic zoning of the UAE, and
- Microzoning of areas defined by Abu Dhabi Urban Planning Council (UPC) Urban Structure Framework Plans:
 - o "Plan Abu Dhabi 2030"
 - o "Plan Al Ain 2030", and
 - o "2030 Al Gharbia (Western Region) Plan";

2. Installation of Seismic monitoring for emergency management and disaster risk reduction by deploying:

- Permanent accelerograph network of fifty (50) stations (150 channels, Figure 1), and
- Structural Health Monitoring Systems (204 channels in total, Figure 2) in unique structures selected within the urban areas of:
 - o Abu Dhabi Municipality (5 structures, $3 \times 36 + 2 \times 24$ channels = 156 channels), and
 - o Al Ain and Western Region Municipalities (2 structures, 2×24 channels = 48 channels);
- Seismic monitoring (Figure 1) for development and maintenance of 3D Seismic Simulation Model for simulating long-period seismic waves and triggering the Permanent accelerograph network by deployment of:
 - o A network of four (4) stations consisting of three-component broad-band sensors and triaxial accelerometer unit (4×6 channels = 24 channels)

3. Establishment of UAE Ground Shaking Map (UAE-GSM) System

4. Establishment of the Seismic Design Parameters Web in a support to earthquake resistant architectural and structural design and construction practice

5. Seismic risk and loss assessment of:

- Two, out of four foreseen by ToR v2.0 Critical Infrastructural Systems, and
- Urban built environment

6. Development of reliable seismic data base as a major instrument for seismic risk monitoring and management

7. Establishment of disaggregated AD Seismic Risk Monitoring and Management Centre (AD-SRMMC) consisting of:

- Two (2) Data (Figure 3) Centers, and
- Five (5) Display (Figure 4) Centres, in fact emergency decision making posts established in: (1) Abu Dhabi City Municipality /ADM/; (2) Al Ain City Municipality /AACM/; (3) Western Region Municipality /WRM/; (4) National Centre of Meteorology and Seismology /NCMS/; and (5) Abu Dhabi Police (ADP-GHD).

Table 1. Summary on ADSHRAs Site Characterization Field and Laboratory Investigations

#	Site Characterization Investigation Type	Quantity
A.	Boreholes and Borehole Related Investigations	
1.	30 meter Deep Exploration Boreholes	70
2.	30 meter Deep Instrument Installation Boreholes	5
3.	3 meter Deep Instrument Installation Boreholes	40
4.	SPT Measurements	72 boreholes
5.	PS Suspension Logging Tests	70 boreholes
6.	Perssuremeter (Elastmeter) Tests	3 boreholes
7.	Sampling for Soil Laboratory Testing (SLT)	72 boreholes
8.	Sampling for UCST Testing	47 boreholes
9.	Sampling for G-g & D-g Dynamic Soil Laboratory Testing (DSTL)	72 boreholes
10.	Sampling for Liquefaction Potential Testing (DLPT)	34 boreholes
B.	Other in-situ Investigations	
11.	Geophysical (Shallow Surface Refraction) measurements; 2 orthogonal 100-120m profiles	70 borehole associated 5 stand alone
12.	1 month long Ground Noise Measurements	68 borehole associated 7 stand alone
C.	Soil Laboratory Testing	
13.	UCST Tests with Deformation Measurements	85 Samples
14.	DSTL G-g & D-g Tests	142 Samples
15.	DLPT Liquefaction Potential Tests	42 Samples

ADSHRA was conceptually not aimed in generating, but utilizing the abundance of existing data. However, at 70 selected locations (Table 1) ADSHRA implemented detailed field (30 meter deep boreholes, borehole sampling, PS suspension logging, Elastimeter testing, geophysical shallow refraction and one month long ground noise measurements) and laboratory (soil index and engineering properties, UCST and dynamic soil testing) geotechnical studies aimed in defining parameters and relations that will assure implementation of existing soil data for seismic geotechnical engineering studies.

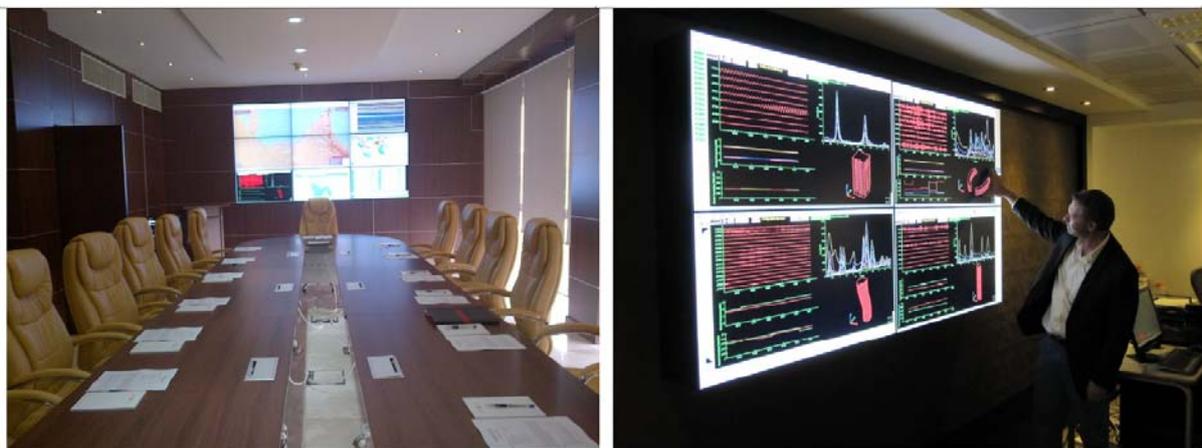
While the predominant number of ADSHRAs' accomplishments is publically invisible, embedded in institutions, structures or scattered within the Abu Dhabi Emirate remote areas, the Seismic Zoning Map of UAE, presently under the final stage of adoption, is a product of high visibility that will shape Abu Dhabi Emirate design and construction practice as well as safety and security of its citizens.

All ADSHRA products are stored and mirrored in Data Centres (Figure 5), including:

- All metadata accumulated during the project performance
- Data qualitatively and quantitatively defining the seismic environment of Abu Dhabi Emirate and its neighbourhood
- Geotechnical data and data related to seismic zoning and Microzoning
- Spatial data for assessing urban (buildings) and infrastructure (4 Critical Importance lifelines) seismic performance and generated results
- Other geo-spatial data



Figure 2. Buildings Equipped with 24 (4) and 36 (3) Channel Structural Health Monitoring Systems



- Simulation models and expertise generated for various ADSHRA needs and subsequent simulations
- Specialized client's oriented software products
- Related GIS shelled databases, and
- Other achievements pertinent to spatial seismic qualification and quantification of the territory of Abu Dhabi Emirate and neighbouring regions, process of regional urban planning, development and preventive seismic protection of existing and planned construction.

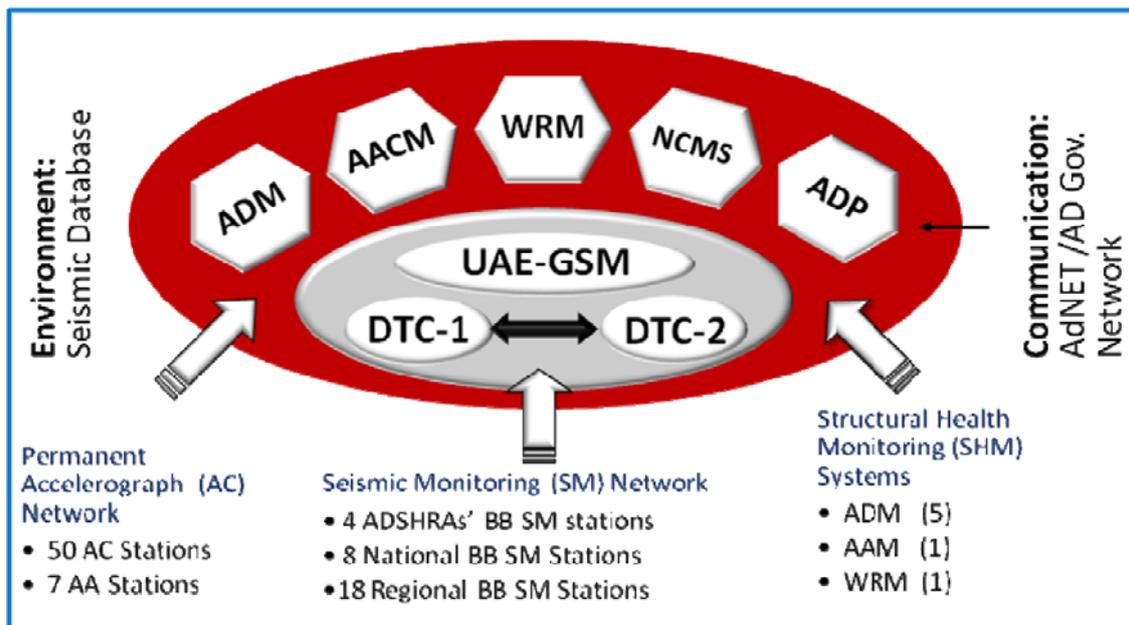


Figure 5. Conceptual Layout of ADSHRAs Disaggregated Seismic Risk Monitoring and Management Center, AD-SRMMC

In essence the AD-SRMMC technological Platform (Figure 6) is highly redundant system that:

- Supports implementation of installed capacity in daily activities/work of strategic and other stakeholders
- Catalyses and integrates cooperation in the fields of hazard, risk and emergency/disaster management among different national entities (ADSIC¹, NCMS², UAEU³, other Universities, PI⁴, ADNOC⁵, ADWEA⁶, EAD⁷, other), the decision making authorities (DMA⁸, Municipalities / ADM⁹, AAM¹⁰ and WRM¹¹), Emergency systems ADP¹², NCEMA¹³), Critical infrastructure operators (power and water supply, gas and oil transportation), and other interested in potential stakeholders
- Efficiently bridges the gap between professionals of various proficiencies and decision making authorities

¹ ADSIC: Abu Dhabi System and Information Center

² NCMS: National Center for Meteorology and Seismology

³ UAEU: United Arab Emirates University

⁴ PI: Petroleum Institute

⁵ ADNOC: Abu Dhabi National Oil Company

⁶ ADWEA: Abu Dhabi Water and Electricity Agency

⁷ EAD: Environmental Agency – Abu Dhabi

⁸ DMA: Department of Municipal Affairs

⁹ ADM: Municipality of Abu Dhabi City

¹⁰ AAM: Al Ain Municipality

¹¹ WRM: Western Region Municipality

¹² ADP: Abu Dhabi Police

¹³ NCEMA: National Crisis and Emergency Management Authority

- Assures and maintains real-time decision making process among major emergency and crisis management stakeholders (DMA, ADM, AAM, WRM, ADP and NCEMA), and
- Integrate the worldwide state-of-the-art in the fields of: (1) Geosciences, (2) Engineering and earthquake engineering, (3) IT & communication, (4) Emergency decision making process, and (5) other related scientific, technical and decision making domains.

AD-SRMMC is seen as a seed and the backbone of an Integrated Abu Dhabi Multi Disaster Management System. Although at this very moment it is conceptually designed and implemented based on potential seismic threats the Emirate could be exposed to, due to its modular structure and integrated GIS shelled data bases, it is easy upgradable for including any other disaster agent jeopardizing safety, security and quality of life of Abu Dhabi Emirate citizens.

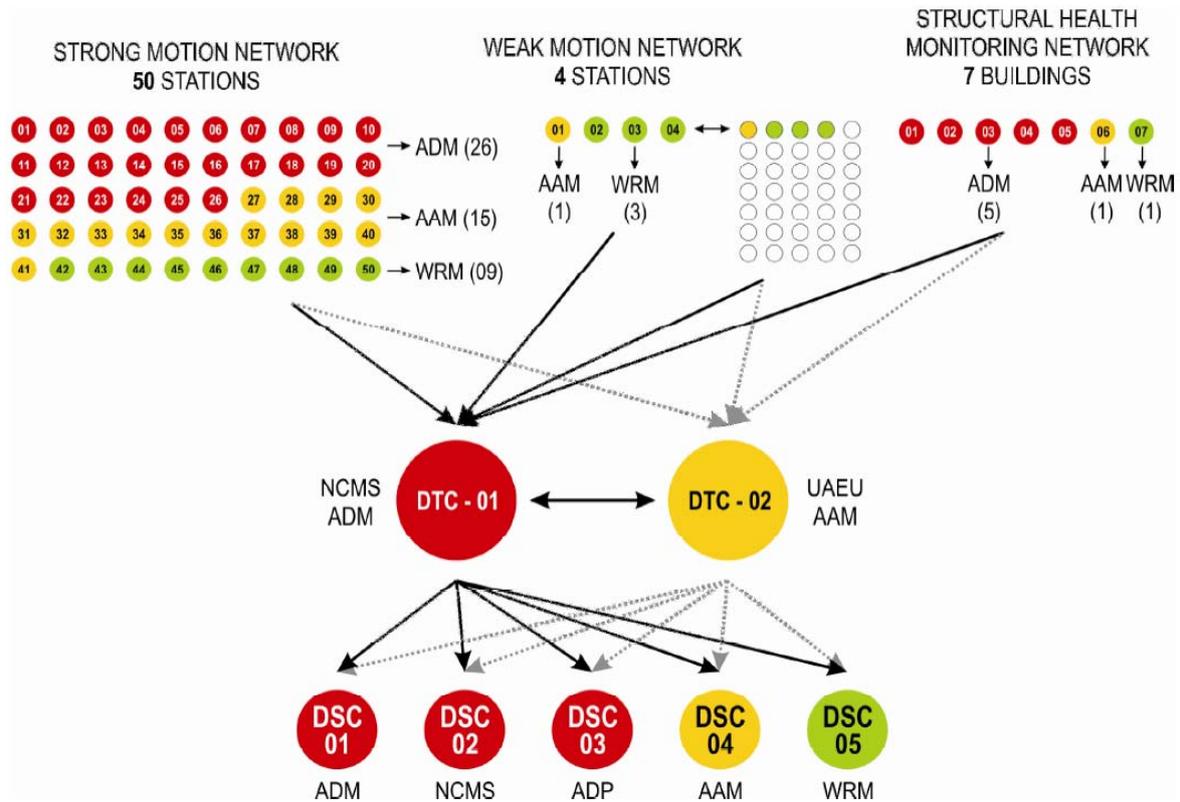


Figure 6. AD-SRMMC Cyber Platform

Such strategic achievements are made possible by recent worldwide advances in seismic monitoring instrumentation, real-time computational, data transmission and communication technology, as well as the data accumulated, databases developed and established GIS systems for monitoring and management of urbanization processes in major urban areas of Abu Dhabi Emirate.

4. ADSHRAs' STAKEHOLDERS

ADSHRA products and outputs cover mandates and needs of broad number of stakeholders, among which the following are dominating:

- Governmental authorities
- Emergency response systems & Emergency Managers
- Engineering & scientific community (Seismologists, Architects, Structural and Earthquake engineers, Geologists, etc.)
- Regional & Urban planners
- Land developers

- Operators of critical infrastructure
- Owners and/or operators of infrastructure and public utilities
- Owners of structures
- Businesses
- Media
- General public; etc.

5. TRAINING AND INTERNATIONAL VALIDATION

During the course of its implementation, ADSHRA incorporated a strong training component implemented in terms of:

- Hands-on trainings designed to develop and improve national capability to operate, maintain and use the system for various technical, planning, research and emergency needs; and,
- Purpose oriented trainings designed for training of decision making authorities and other relevant professionals to familiarize with system outputs and develop skills to efficiently implement them in decision making process.

ADSHRA organized three International workshops to present its achievements, position them with respect to worldwide state-of-the-art, receive comments and, if viable, incorporate them in the final products:

- Workshop 1: Seismic Hazard Assessment, Seismic Zoning and Microzoning
- Workshop 2: Strong Motion Instrumentation and Structural Health Monitoring
- Workshop 3: Seismic Risk and Loss Assessment National and international feed-backs have been obtained from a number of national, regional and international conferences.

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- UAE Ministry of Energy
- Department of Municipal Affairs (DMA)
- Al Ain Municipality (AACM)
- Western Region Municipality (WRM)
- National Centre for Meteorology and Seismology (NCMS)
- United Arab Emirate University (UAEU), Faculty of Science, Geology Department, Al Ain
- Petroleum Geosciences Department, the Petroleum Institute, Abu Dhabi, and
- Abu Dhabi Municipality, Building Permit Directorate

and with full support of the Abu Dhabi Municipality, Town Planning Sector, Spatial Data Directorate – the initiator of the Project.

Consultant expresses his gratitude to Technical Committee for continuous assistance, support and encouragement during the course of conceptual design of the system and its 24 months implementation.

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