Visitor Management and Carrying Capacity at World Heritage Sites in China

17-19 May 2013
Mogao Grottoes, Dunhuang

Compiled and edited by
Neville Agnew and Martha Demas

Extended Abstracts of the International Colloquium

Visitor Management and Carrying Capacity at World Heritage Sites in China

17-19 May 2013

Mogao Grottoes, Dunhuang

Compiled and edited by

Neville Agnew and Martha Demas

The Getty Conservation Institute works internationally to advance conservation practice in the visual arts, broadly interpreted to include objects, collections, architecture, and sites. It serves the conservation community through scientific research, education and training, model field projects, and the broad dissemination of the results of both its own work and the work of others in the field. And in all its endeavors, it focuses on the creation and dissemination of knowledge that will benefit the professionals and organizations responsible for the conservation of the world's cultural heritage.

Front cover: Visitor crowds in front of the Fengxian Cave Temple at Longmen Grottoes during the peak season (Courtesy Longmen Grottoes Academy)

Contents

Other Case Studies

Introductory Remarks

Opening Address at the International Colloquium on Visitor Management and Carrying Capacity at World Heritage Sites in China

Tong Mingkang
Chair, ICOMOS China

Distinguished experts, friends, ladies and gentlemen,
I feel honored to attend the International Colloquium on Visitor Management and Carrying Capacity at World Heritage Sites held in beautiful Dunhuang, together with the experts and scholars. First of all, please allow me, on behalf of ICOMOS China, to extend a warm welcome to all the guests, in particular our international counterparts who came from afar.

Since 1972 when the UN adopted the *Convention for the Protection of World Cultural and Natural Heritage*, 962 cultural and natural heritage places from 157 countries and regions globally have been inscribed on the World Heritage List. The increasing number of World Heritage sites and the rising fame of heritage sites spur the development of world tourism. According to the World Tourism Organization, 2013 will witness even greater development of tourism worldwide, with the overall number of tourists exceeding 1 billion. It is expected that the tourism industry will be able to provide 296 million job opportunities between 2013 and 2019. Besides, tourism has accounted for over one third of the trade volume of world service industries, ranking as the leading industry among all service industries.

In 2010, tourism in GNP in France and US accounted for over 7% and 2.7% of GNP respectively, creating 2 million and 7.5 million job opportunities either directly or indirectly. China became the third largest world tourism destination, next to France and the US. Its tourism was responsible for over 4% of GNP, creating over 76 million job opportunities directly or indirectly.

China now boasts forty-three World Heritage sites. According to statistics from the China National Tourism Administration, in 2012 the total number of tourists in China was 2.96 billion and China generated 2.27 trillion yuan in revenue from domestic tourism. Inbound tourism had 132 million visitors and the foreign exchange earnings were 48.5 billion dollars. It is expected that the number of domestic tourists in 2013 will be 3.25 billion and the revenue will reach 2.55 trillion *yuan*.

In general, the development of tourism increases the employment rate, improves the income of local residents, promotes the development of other related industries and propels the economic development of the whole region. Besides, tourism revenue provides partial funding for heritage conservation.

No doubt tourism also brings problems: with the rapid increase of tourists from both China and abroad and under-developed management some heritage sites have been operating beyond their capacity, which violates the principle of sustainable development. Firstly, for heritage destinations themselves and the surrounding environment, overloading will be detrimental to their protection, especially those with vulnerable cultural and ecological environments, on which the impact might be disastrous; secondly, for residents in the heritages sites, although more tourists can bring more job opportunities and revenues, on the other hand, it disrupts their original life style and order and causes environmental deterioration, traffic congestion, and rising living costs; additionally, for the tourists themselves, too many visitors will undermine the quality of their experience and even put their safety at risk.

Due to the above mentioned problems, recently China has paid great attention to the relationship between heritage sites and sustainable tourism. Some of you here attended the International Seminar on Advancing Sustainable Tourism at Natural and Cultural Heritage Sites held in Dunhuang in 2009. This seminar was co-hosted by the State Administration of Cultural Heritage, the government of Gansu Province, the Department of the Environment, Water, Heritage and the Arts of Australia and the Getty Conservation Institute and organized by ICOMOS China and the Dunhuang Academy. About 100 experts and scholars from 21 countries participated in the discussion. The report, which included the proposal for amending the *Operational Guidelines for the Implementation of the World Heritage Convention*, was submitted to the 34th session of the World Heritage Committee meeting for discussion. During this meeting, the principles for sustainable tourism at world heritage properties were set in the conclusive document, so as to guide sustainable tourism.

China has carried out research on the carrying capacity and visitor management in multiple heritage sites, such as Dunhuang, the Palace Museum in Beijing and the Potala Palace in Lhasa and reaped some achievements. The central government followed the process closely. At the end of last year, the State Council released: *Opinions on Improving the Protection of Cultural Relics in Construction and Development Activities relating to Tourism* and proposed to

properly determine standards concerning the carrying capacity of cultural heritage sites and required relevant departments to compile, coordinate and implement the plan for protecting cultural relics and the plan for tourism development by giving top priority to the safety of heritage and tourists. In February this year, the State Administration of Cultural Heritage and National Tourism Administration jointly released: *Notice on Implementing the Opinions on Improving the Protection of Cultural Relics in Construction and Development Activities relating to Tourism*, and required localities to conduct self-inspection, in particular to study how to set proper standards of carrying capacity of tourist venues and properly deal with the relationship between the protection of cultural relics and tourism development. At the national level, the supervision and inspection work has entered the stage of implementation.

In recent years, various heritage sites have taken a series of bold measures and attempts to manage tourists efficiently. The Potala Palace was one of the first World Heritage sites to introduce a reservation system, embracing 4000 tourists at most per day and only 100 tourists every 20 minutes for no longer than one hour. Last year, the Potala Palace installed electronic display to give information about tickets. This year, it is expected to realize online booking of tickets. Since last year, the Palace Museum has voiced its willingness to cooperate with tourism management agencies, with a view to gradually implement the reservation system, design various visiting routes and properly limit and divert tourists. This year, new measures for limiting visitors will be unveiled, for example tour groups visiting at different hours and limiting tourist number at different hours for some vulnerable spots, such as the imperial garden. Additionally, from April 1st, the Palace Museum will be closed for half day every Monday afternoon so that it can get necessary maintenance.

In order to improve visitor management at China's World Heritage Sites and take advantage of the opportunities as well as deal with the challenges created by the development of China's economy and culture, to improve the ability and awareness of both government departments and site management responsible for heritage in balancing the needs of conservation with visitation, and to avoid trial and error, there is a need for China to become engaged, to undertake research and study and to draw on advanced international conservation theories, methodologies and management experiences. Under such circumstances, this international seminar co-hosted by the Dunhuang Academy and the Getty Conservation Institute and ICOMOS China is of demonstrable significance and value.

Introduction to the Colloquium

Neville Agnew[1] and Fan Jinshi[2]

[1] Getty Conservation Institute, U.S.A.
[2] Dunhuang Academy, China

Background

In 1987 China nominated its first six sites to the World Heritage List of UNESCO. Among these was the Mogao Grottoes (also known as the Dunhuang Caves) near Dunhuang, Gansu Province, in far northwestern China. The site, on the ancient Silk Road, comprises nearly 500 Buddhist grottoes cut into a cliff face and dating from the 4th to the 14th centuries CE. It speaks to the national importance of this site that it was selected, together with the Forbidden City, the first Emperor's tomb at Xi'an, the Great Wall, Mount Tai, and the Peking Man site, by the Chinese authorities for such recognition. The Mogao Grottoes was put forward under all six cultural criteria—only Mount Tai (a natural and cultural site) also met all the cultural criteria. Today China has some forty-three sites inscribed on the List, and many of these, certainly the Forbidden City, the Great Wall, and the Xi'an Warriors are iconic sites, known throughout the world.

China's domestic and international tourism, on the way to becoming the largest in the world, continues to burgeon and has long been focused on these iconic sites and many others of World Heritage status and national importance. Because of its relative geographical remoteness, the Mogao Grottoes had escaped overwhelming pressure from tourism until recently. In 1979 when the grottoes were opened to visitors there were 26,000 visitors. As of 2013, visitors to the caves numbered over 800,000, the great majority being domestic. Most visitors come during the summer months (May through October) creating particularly severe pressure on the site during peak holiday periods. Progressively the Dunhuang Academy (the statutory authority) has experimented and developed measures to cope with visitation pressure. Visitor management today clearly complies with and even leads other sites in terms of industry standards of guide quality and professionalism. And yet, the site has continued to face severe challenges caused by excessive numbers of visitors.

The visitor management challenges faced by the Mogao leadership over the last decade and more are mirrored at other World Heritage sites in China and

in many other countries. It was the goal of the colloquium to share these challenges and the solutions being developed at Mogao and other sites and to learn from each other. The impetus for the colloquium was the culmination of a multi-year visitor capacity study for the Mogao Grottoes undertaken by the Dunhuang Academy (DA) and the Getty Conservation Institute (GCI). This seemed an appropriate time to disseminate the methodology and results of this study, as well as the comprehensive visitor management initiatives undertaken by the DA, more widely in China and to hear from site managers and specialists within China and internationally who are grappling with these problems. As will be seen from the presentations, the challenges faced at these sites of accommodating so many visitors and protecting the resource are truly enormous.

A colloquium format was chosen for the meeting, with a limited number of invited participants, in order to maintain a high degree of focus in the presentations and discussions and facilitate exchange of information (Figs 1-2). The colloquium was attended by thirty-four delegates from China, representing national institutions and World Heritage sites, as well as the organizers and staff from the Dunhunag Academy, and fifteen international participants. In addition to the sessions over three days, visits to the grottoes and surrounds were arranged by the DA for the delegates. A considerable part of the colloquium was devoted to case studies, mainly from China, but also representing a wide spectrum of heritage sites from Cambodia, the U.S., Europe, Jordan, and Australia. Simultaneous translation of papers and discussion during the colloquium was done by Peter Barker, June Mei and Li Bohong.

Organization of the Colloquium
The colloquium was jointly organized by the Dunhuang Academy (DA), the Getty Conservation Institute (GCI) and ICOMOS China, with funding provided by the China Dunhuang Grottoes Conservation and Research Foundation and the U.S. Dunhuang Foundation. The GCI has collaborated with the DA since 1989 on site stabilization and wall painting conservation, master planning, research, and visitor management and capacity studies. The DA (http://enweb.dha.ac.cn), established in 1943, is the legal entity responsible for the protection and preservation of the Mogao Grottoes, research on the history and art of the site, and interpretation and visitor management.

Dissemination of the colloquium presentations to a wider audience is the goal of this compilation, which will be available in English and Chinese versions. Extended abstracts and selected images from their powerpoint presentations

were requested from participants (translation of Chinese abstracts into English was undertaken by Yuanjing Jessica Du, Po Ming Lin and Peter Barker). While this method does not allow for details of the talks to be presented, we hope it will shed light on the tourism challenges being confronted by managers of cultural heritage sites in China and elsewhere and the many efforts being developed to address them. In particular, for the non-Chinese audience we believe this compilation provides a rare window onto the emerging trends in China, including those of a technological nature, to deal with the issues of preserving cultural heritage in the face of mass tourism.

Fig 1. Opening day speakers at the Colloquium, with Tong Mingkang (center) delivering Opening Address.

Fig. 2. Sessions of the Colloquium were held in the Conservation Institute of the Dunhuang Academy

Issues and Approaches to Managing Tourism

Tourism to the Mogao Grottoes: Overview of Conservation Challenges and Countermeasures

Fan Jinshi
Dunhuang Academy, China

The Mogao Grottoes are located at the eastern face of the Mingsha Mountains, 25 km southeast of Dunhuang city in westernmost Gansu Province. Construction of the caves began in 366 CE and continued for a thousand years. At present, 735 caves have survived on the 1700 meter long cliff face, housing 45,000 square meters of wall paintings and more than 2000 painted statues in addition to 50,000 historical documents and artifacts from the Library Cave (Figs. 1, 2).

The paintings and painted statues of the Mogao Grottoes as well as the historical documents and artifacts discovered in the Library Cave not only bear witness to the construction throughout one thousand years, but also constitute an unsurpassed record of Buddhist art creation and great achievements in China. These are the flowering and cultural achievements of a gradual confluence and blending of Sino-foreign religions, art, cultures as well as ethnic religions over that period. The Mogao Grottoes site is not only a cultural heritage one, but also comprises an important part of modern social life, providing an indispensable cultural resource for social progress, economic development and academic research. In March 1961, it was listed among the first group of nationally protected key cultural heritage sites by China's State Council owing to its historical, scientific and artistic value. The Mogao Grottoes site meets all six criteria that identify World Heritage sites, and it was inscribed onto the World Heritage List in November 1987 by the UNESCO World Heritage Committee. This testifies to its universal and outstanding value.

The 492 caves at the southern area of the Mogao Grottoes were originally constructed for worshipping Buddha or as family temples instead of as a public cultural center. Now the site is open to the public as a museum. The caves and the paintings and painted statues are cultural relics that cannot be modified.

Most caves have a limited physical capacity, that is, the number of people who can safely and comfortably occupy the cave. Only 18 caves have a floor

area of 100 square meters or larger, 21 caves are 50-100 square meters, 41 caves are 25-50 square meters, 123 caves have 10-25 square meters, and 289 caves are less than 10 square meters. The last type accounts for 58.7 % of the caves. The paintings and painted statues are made of fragile materials such as mud, straw, wood and pigments. Some caves have collapsed and have been ruined due to human activities and natural elements over the centuries. A lot of deterioration of paintings such as detachment of plaster, deep loss, disruption, and flaking has also developed in extant paintings and painted statues (Fig. 3). As time passes they will gradually deteriorate further. The caves are connected with one another by narrow external walkways on the cliff face (Fig. 4).

Visitor numbers at the Mogao Grottoes have been increasing inexorably since 1979 when the site was first opened, and the numbers have grown rapidly in the 21st century as a result of the national strategy of Western Regions Development. Tourist numbers were a little more than 10,000 when the site officially opened in 1979, 100,000 in 1984, 200,000 in 1999, 300,000 in 2001, 400,000 in 2004, 500,000 in 2006, and reached a peak of nearly 800,000 in 2012. One of the aspects of tourism to the site is the seasonal and time-dependent character. Tourists increase in the summer peak season and decrease in the winter off season. Take the case of 2012 for example, when the tourist number was nearly 800,000. The number in the peak season (from May to October) was 726,000, accounting for 91.39%, while the number in July, August and September was 469,000, accounting for 64.63% of the tourist total in the peak season (Fig. 5). The second characteristic is that the current maximum daily visitor carrying capacity is 3000, which is verified by researching the current conditions and characteristics of the caves. However, the number of the days when the daily tourist number goes beyond 3000 in the peak season has increased year by year. In 2012, there were 100 days when the daily tourist number was beyond 3000. And tourist numbers during the 'Golden Week' holiday, around national day, have reached a record: there were four days when the daily tourist number went beyond 10,000; the tourist number on 3rd October was 18,660, six times the maximum daily visitor carrying capacity.

Since the 1990s, we have adopted a variety of ways to solve the contradiction between protection and opening to tourists, in order to achieve the goal of good protection, while ensuring the quality of visitor experience (Figs 6-10). The Gansu provincial government promulgated the 'Regulations on Protection of Dunhuang Mogao Grottoes.' Dunhuang Academy, together with organizations from both home and abroad, have developed the 'Master Plan

for Protection of the Mogao Grottoes' and 'Tourism Planning.' In addition, protection measures have been implemented, such as daily maintenance and management of caves, conservation of a number of seriously deteriorated caves, walkway renovation, and alternative opening of caves. Basically, the cave wall paintings have been made safe to open to the public.

Additionally, the Dunhuang Academy has co-operated with the Getty Conservation Institute in developing a visitor capacity study to determine the damage to the caves by tourists, and the maximum visitor capacity of the grottoes. Moreover, a variety of tourist services have been adopted to promote the visitors' experience. With the rapid economic development of recent years, we expect a continuing increase in tourism to Mogao Grottoes. Thus, the Dunhuang Academy plans to increase the daily capacity of Mogao Grottoes through scientific research, adoption of modern technology to improve management methods and efficiency, and the utilization of a new visitor center to buffer tourist flows. Meanwhile, the digitization of wall painting images will be improved, and we will make use of modern communication technologies and exhibitions to display the caves' art and culture. In addition, multi-disciplinary research will be developed on a larger and fresh perspective to provide more exciting presentations. It is hoped that the maximum carrying capacity of Mogao Grottoes will be written as an appropriate regulation to ensure the opening of the caves more scientifically and on a legal basis. The main problem that will remain a focus is the conflict between the fragile caves, the limited area available for visitation in the grottoes, and increasing tourist numbers. To sum up, Dunhuang Academy will strengthen preventive protection of the Mogao Grottoes, establish protective systems, study various issues between tourism access and cave protection, and solve the contradictions by use of the scientific strategies and methods.
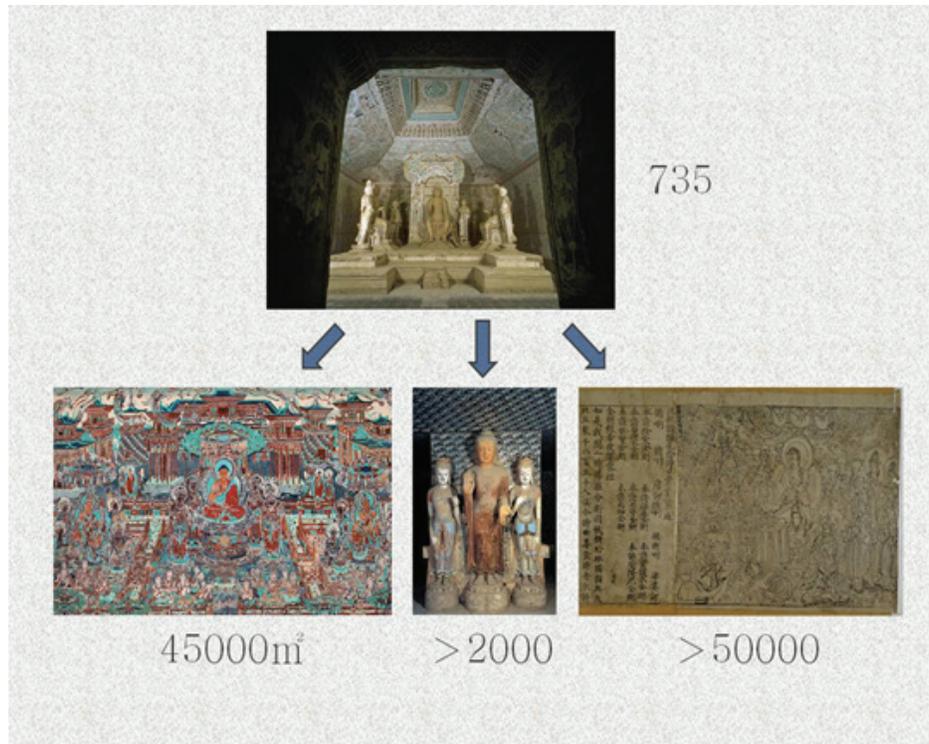
Fig. 1. Caves at the Mogao Grottoes were constructed and decorated over a thousand years, beginning in 366 AD, resulting in 735 caves, 45000m^2 of wall painting, over 2000 statues, and more than 50000 artifacts that survive today.

Fig. 2. Elements of the Mogao Grottoes: sculpture, wall paintings, cave paintings, cave temples, pagodas, and artifacts from the Library Cave.

Fig. 3. Deterioration conditions of wall paintings include mold, flaking, detachment, disruption, and color loss.
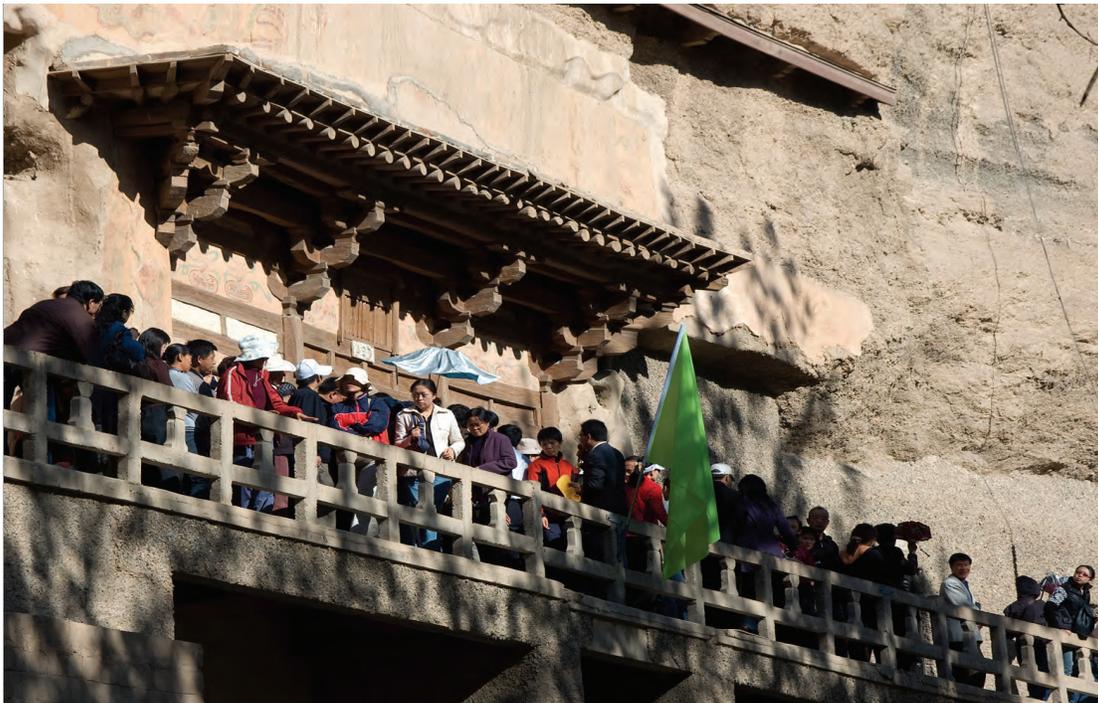
Fig. 4. Visitors crowded on the walkway during the Golden Week holiday.

Fig. 5. Visitor numbers increased rapidly starting in 1979, reaching 800,000 in 2012 (upper graph). Visitor numbers differ significantly between high season (July, August, September, and October) and low season (December, January, February, and March) (lower graph).

Fig. 6. Visitors inside the Library Cave Exhibition Center, the restored temple where the Daoist monk Wang Yuanlu, who discovered the Library Cave, lived.

敦煌石窟保护研究陈列中心

Fig. 7. Visitors inside the Mogao Grottoes Exhibition Center.

敦煌研究院院史陈列馆

Fig. 8. A room of the Dunhuang Academy History Exhibition Center, which presents the history of the Academy; shown here is the reconstituted office of the first director, Chang Shuhong.

Fig. 9. Views of Dunhuang exhibitions in Beijing (upper left), London, UK (upper right), Shenzhen, China (lower left), and Nice, France (lower right).

Fig. 10. Examples of publications about the grottoes, most published by the Dunhuang Academy.

UNESCO World Heritage and Sustainable Tourism Programme

Peter DeBrine
UNESCO World Heritage Center, Paris, France

Context

If undertaken responsibly, tourism can be a driver for preservation and conservation of cultural and natural heritage and a vehicle for sustainable development. But if unplanned or not properly managed, tourism can be socially, culturally and economically disruptive, and have a devastating effect on fragile environments and local communities.

The overarching goal of the World Heritage Convention is the protection of cultural and natural properties of Outstanding Universal Value (OUV). This cultural and natural heritage in turn represents resources for economic activities such as tourism and the accrual of benefits for the local communities living in proximity to or associated with the World Heritage property.

Therefore, in order to achieve long-term economic, environmental and social sustainability, heritage values and associated assets—tangible and intangible—should be considered by State Parties as significant cultural capital which needs to be preserved and maintained through appropriate and responsible tourism in order to fulfill the ultimate responsibility set out by the World Heritage Convention.

In addition to the nomination and inscription of heritage properties to the World Heritage List, there are also the more technical challenges of monitoring and measuring impacts from tourism and using this to set parameters for property planning, development and management.

However, whilst at a high level UNESCO and the World Heritage Convention are widely recognised, the concept and significance of the OUV of World Heritage properties is less well understood. Making tourism stakeholders aware of and appreciate the heritage values is key to presenting the World Heritage properties.

For tourism there is a need to communicate these values in a way that is readily understood and explains its significance within a local, national and

international context. An informed appreciation of OUV and the implications of potential adverse impacts through tourism on heritage values are essential to decision-making by a broad range of tourism stakeholders. It is within this context that the World Heritage and Sustainable Tourism Programme takes place and that an appropriate definition of World Heritage sustainable tourism identified.

Tourism Stakeholders
- States Parties wishing to establish and implement policies and strategies to realise development objectives and long-term benefits for local and other communities
- The tourism industry wanting to realise long-term commercial profits;
- Visitors seeking full appreciation of the World Heritage, guidance to appropriate behaviour, and a potential incentive to contribute towards their maintenance and protection
- Local communities seeking improved quality of life while maintaining the integrity of and access to their natural and cultural heritage representing their history and identity

Opportunities and Challenges
World Heritage properties attract significant tourism interest and form important tourist destinations. They may represent key vehicles for economic development and as public goods provide value for everyone. However, the full and potential long-term value of tourism is not always realised for local communities or benefit the properties themselves. Inadequately managed tourism can have severe consequences compromising the OUV of the properties, depriving the local communities of benefits and potentially degrading the destination itself.

Opportunities
- The mechanisms of the World Heritage Convention provide incentives to place conservation of OUV at the centre of policy orientations and management systems;
- Established networks and well-developed relationships exist representing powerful opportunities to influence policies and ensure property-level implementation;
- A range of existing initiatives and strategies provide frameworks for support;
- Opportunities exist for new partnerships and collaboration to use the World Heritage Convention to advocate for sustainable tourism and raise awareness amongst stakeholders;
- The ability to engage at a decision-making level provides opportunities to support change at a national level;

- The regional approach to monitoring and reporting within the context of the World Heritage Convention provides a platform for sharing of good practices in related contexts.
- Local communities seeking improved quality of life while maintaining the integrity of and access to their natural and cultural heritage representing their history and identity.

Challenges

- Failure to thoroughly analyze, comprehend and take into account longer term costs of damage to World Heritage due to lack of awareness of heritage values and the concept of OUV;
- Policy formulation/development not adequately taking sustainability issues into account, and/or lacking support and consideration for local communities;
- Institutional arrangements failing to fully support a sustainable destination management approach which is key to realising the full value from tourism and visitation;
- Lack of ownership by local authorities and civil society;
- Lack of capacity to implement measures for sustainable tourism in planning, development, management and administration;
- Lack of understanding and consideration of the different stakeholder needs, and/or lack of dialogue between stakeholders;
- Difficulties in changing the tourism model and economic approach once investment decisions are made may contribute to unsustainable tourism development;
- The complexity of local systems, histories and competing values that challenge attempts to manage sustainable development;
- The need for appropriate and context specific values based planning processes;
- The political nature of all decision making processes.

Background

The work undertaken to develop the World Heritage and Sustainable Tourism Programme responds to the Decision 34 COM 5F.2 of the World Heritage Committee at its 34th session in Brasilia in 2010, which "requests the World Heritage Centre to convene a new and inclusive programme on World Heritage and Sustainable Tourism, with a steering group comprising interested States Parties and other relevant stakeholders, and also requests the World Heritage Centre to outline the objectives and approach to the implementation of this programme".

The Steering Group comprised of States Parties representatives from the six UNESCO Electoral Groups (Germany (I), Slovenia (II), Argentina (III), China (IV), Tanzania (Va), and Lebanon (Vb)), the Director of the World Heritage Centre, the Advisory Bodies (IUCN, ICOMOS and ICCROM), the United Nations World Tourism Organization (UNWTO) and the Swiss Government as the donor agency.

The programme development process was enriched by an outreach to representatives from the main stakeholder groups including the tourism sector, national and local governments, property managers/coordinators and local communities and further developed at an Expert Meeting in Sils/ Engadine, Switzerland October 2011. The Programme was approved by the World Heritage Committee at the 36th session in St Petersburg, Russia Federation.

A New Paradigm

The new World Heritage and Sustainable Tourism Programme will seek to contribute to a new paradigm that is guided by the World Heritage Convention and whereby the conservation, presentation and transmission of World Heritage properties is fully served by tourism and the potential opportunities and challenges are harnessed and mitigated for the purpose for sustainable development.

Overall, this will require a clear vision, appropriate policies and frameworks, an open dialogue with the tourism sector (industry and government administration) and an emphasis on local community development.

The new programme will take a holistic and strategic approach to World Heritage properties and destinations that will include bottom-up as well as top-down measures to ensure sustainability that reflects not only high-level goals but also local needs and the ability to attain these goals.

Vision and Mission

Vision

World Heritage and tourism stakeholders share responsibility for conservation of our common cultural and natural heritage of Outstanding Universal Value and for sustainable development through appropriate tourism management.

Mission

Facilitate the management and development of sustainable tourism at World Heritage properties through fostering increased awareness, capacity and

balanced participation of all stakeholders in order to protect the properties and their Outstanding Universal Value whilst ensuring that tourism delivers benefits for conservation of the properties, sustainable development for local communities as well as a quality experience for visitors.

Vision and Mission: Key Aspects
- An interpretation and implementation of the World Heritage Convention that embraces sustainable tourism;
- National, regional and local governments have policies and frameworks that recognise sustainable tourism as an important vehicle for managing their cultural and natural heritage;
- All stakeholders are aware and committed to sustainable development, and have the capacity to manage tourism sustainably;
- Local communities take pride in and have a sense of responsibility and empowerment towards the World Heritage properties and contribute to property conservation and the sustainable management of tourism at the World Heritage destinations;
- The tourism sector values World Heritage and engages in its preservation while ensuring that its activities based at World Heritage properties are responsible, and support social and economic development;
- Visitors understand and gain an appreciation of the meaning of Outstanding Universal Value of World Heritage and adopt responsible behaviours.

Programme Methodology

The new World Heritage and Sustainable Tourism Programme will create an international framework for the cooperative and coordinated achievement of shared and sustainable outcomes related to tourism at World Heritage properties. The Programme will take a strategic approach in its implementation, working in partnership with the key stakeholders (States Parties, property management/coordinators, tourism sector, destination management organisations and local communities) to achieve its objectives. Opportunities to create synergies and add value to existing initiatives will be part of the overall approach.

The Programme is coordinated through the World Heritage Centre and will work extensively through UNESCO's regional and country offices in close collaboration with the UNWTO, the Advisory Bodies and other UN Agencies, and with the support of the World Heritage related Category 2 centres. The

Programme will furthermore work with existing regional bodies that represent World Heritage networks and information sharing mechanisms and platforms.

The Programme methodology features:

a. The use of the mechanisms of the Convention: The mechanisms of the Convention (the nomination process, Reactive Monitoring and Periodic Reporting etc.) represent opportunities for identifying cases where tourism may represent a threat to the heritage values (OUV) and where tourism is having a positive impact.

b. A focus on early intervention: Typically there are greater opportunities to institute sustainable management practices at an early stage, and preferably already in the nomination process and before inscription. An early stage intervention approach provides an opportunity for the Programme to promote sustainable tourism without excluding benefits to the already inscribed properties.

c. Strengthening the enabling environment: Having the right enabling environment that sets out policies, legislative and regulatory frameworks and development strategies is critical for the realisation of sustainable tourism at and around World Heritage properties. Implementation of these policies, frameworks and strategies often depends on having the adequate institutional arrangements and capacities.

d. Co-operation and partnership with the tourism sector: The Programme will seek close alignment and open dialogue with the tourism sector and promote sustainable tourism at World Heritage destinations with focus on developing, promoting and providing quality products and services for the visitors as well as a contribution to the long-term viability and conservation of the World Heritage properties.

e. A destination approach: A World Heritage destination is a geographical space in which the entire tourism experience takes place. For World Heritage destinations this encompasses the World Heritage property itself and the surrounding area. As World Heritage properties are primary drivers of tourism, to realise their full value requires a broader destination approach that reflects local conditions and needs. Efficient collaborative partnerships involving key stakeholders are needed to enhance a destination's sustainability. The Programme will therefore encompass ways of guiding destination development towards preservation of heritage values (OUV), acting as an impetus for interventions in favour

of conservation and the enhancement of heritage values both within and outside the protected properties and to ensure that the tourism development does not compromise the value and potential contribution of World Heritage to sustainable development in the long term.

Central to this approach will be planning for tourism development that involves and benefits the local communities. In addressing this objective the Programme will seek to support the development and implementation of tourism development plans that consider the destination as a whole and the heritage values that exist outside the World Heritage property. Key in this will be to create good quality experiences for visitors at World Heritage destinations which are based on sustainable tourism products and services that enable better understanding and appreciation of World Heritage values (OUV) and conservation of the tangible and intangible heritage at the destination.

f. Capacity development: Addressing the challenges and taking advantage of the opportunities requires that property and destination managers have the appropriate capacities. The Programme will therefore seek to identify capacity building, training and education needs, raise awareness, develop and support learning and exchange platforms, as well as supplement and distribute tools and resources in relation to sustainable tourism. Capacity building activities of the Programme will aim to benefit a range of stakeholders.

Objectives

The Programme is designed to benefit a number of stakeholders. The following set out the objective of the Programme.

Programme Objectives
- Integrate sustainable tourism principles into the mechanisms of the World Heritage Convention.
- Strengthen the enabling environment by advocating policies, strategies, frameworks and tools that support sustainable tourism as an important vehicle for protecting and managing cultural and natural heritage of Outstanding Universal Value.
- Promote broad stakeholder engagement in the planning, development and management of sustainable tourism that follows a destination approach to heritage conservation and focuses on empowering local communities.

- Provide World Heritage stakeholders with the capacity and the tools to manage tourism efficiently, responsibly and sustainably based on the local context and needs.
- Promote quality tourism products and services that encourage responsible behaviour among all stakeholders and foster understanding and appreciation of the concept of Outstanding Universal Value and protection of World Heritage.

Strategy and Direction

Overall, the UNESCO WH+ST Programme seeks to encourage responsible behavior among all stakeholders, and foster an understanding and appreciation of the concept of Outstanding Universal Value and protection of World Heritage. The WH+ST Programme provides World Heritage stakeholders with the capacity and tools to manage tourism efficiently, responsibly and sustainably based on the local context and needs. Key features include:

Key Strategic Components
- Catalyze investment and projects that demonstrate a new sustainable approach to tourism development in key regions.
- Develop partnerships and communication initiatives with the tourism industry to identify, design and implement alliances that leverage the strengths of the sector on behalf of the World Heritage promotion and conservation.
- Assess, develop and disseminate good practice approaches and other mechanisms to promote, recognize and incentivize sustainable tourism practices and products at and around World Heritage sites.

People Protecting Places

An online learning and communication platform called *People Protecting Places* has been developed to drive this effort forward. The platform serves as the primary public interface for the WH+ST Programme (Fig. 1).

Fig. 1. Protecting people and places communication platform

Establishing a Monitoring and Warning System and Tourism Impact Analysis and Management for World Cultural Heritage in China

Qiao Yunfei

China World Heritage Monitoring Center, Chinese Academy of Cultural Heritage

Profile of China's World Heritage Monitoring Center

On November 17, 2012, at the 'Conference on Work relating to China's World Cultural Heritage' convened by the State Administration of Cultural Heritage (SACH), Li Xiaojie, Vice Minister of Culture and Director of SACH, handed over the Center's official signboard signifying that the China World Heritage Monitoring Center, based at the Chinese Academy of Cultural Heritage (CACH), was now officially operational. SACH has designated this center as a national research center and general platform responsible for the monitoring and conservation of World Cultural Heritage in China.

The center will be responsible for drawing up technical standards, norms and systems; the organization of major projects and key research into related technologies; the establishment and maintenance of monitoring and warning systems for World Cultural Heritage in China; issuance of warnings; reactive monitoring; provision of technical support and professional consultation for monitoring programs at sites; promotion of pilot monitoring programs; compiling an annual report on the monitoring of World Cultural Heritage in China; collaboration and academic exchanges with international organizations on the monitoring of World Cultural Heritage Sites; and the organization of training programs.

CACH believes that monitoring of World Heritage is one of its most important functions and has on many occasions financially sponsored conferences on monitoring related issues such as the 2013 Conference on the National Pilot Program for the Monitoring of Cultural Heritage (2013 Annual Conference of China World Heritage Monitoring Center).

Major Achievements

Achievements at the center to date include: completion of the 2013-2020 Plan for the Establishment of a Monitoring and Warning System for World Cultural Heritage in China; preparatory research for the establishment of a national-level platform for the monitoring of China's World Heritage as well as completing the preparatory work needed to develop such a platform; actual

monitoring of the Grand Canal through the establishment of a monitoring platform and an archives center for the site. (Two of these aspects are briefly mentioned with greater focus on the visitor related components).

2013-2020 Plan for the Establishment of a Monitoring and Warning System for World Cultural Heritage in China
The plan aims to achieve good conservation and improve conservation practices and management of World Cultural Heritage in China through the establishment of a world-class monitoring and warning system suited to conditions in China. It is a comprehensive plan for the overall configuration of the platform as well as putting in place the systems required to establish a monitoring and warning system in the next ten years. The plan also specifies what areas will require further capacity building and technical support in the future.

The plan's overall objectives are to establish or improve on management practices in each jurisdiction so that the monitoring and warning system integrates World Heritage sites at national, provincial and site levels. The technical platform created to undertake these tasks must use the latest technology which is centralized, highly efficient, interconnected and shares information on a site's conservation so that accurate, comprehensive and dynamic information on a site's state of conservation is provided along with information about monitoring warnings to support management in their decision making processes.

Research into the establishment of a general platform for the monitoring of World Cultural Heritage in China
The overall objective is to establish a dynamic monitoring and warning system for China's World Cultural Heritage that is based on a 'two-tiered platform at the national and site levels with a three-tiered management structure;' overall improvement in the management of World Heritage Sites, with a preventive approach to conservation; and promotion of the appropriate use of World Heritage sites to create World Heritage sites that we all can 'see and experience'.

Functions of the national-level platform are: automatically acquire monitoring data from heritage sites according to monitoring criteria and be able to receive completed data forms from sites; develop and undertake dynamic remote sensing of the development of heritage sites; issue warnings to sites well in advance; establish a website portal for the center; provide the public with information and establish a channel through which they can participate in aspects of the project.

Analysis of Visitor Impact and its Management and Monitoring

1. Current Condition of Visitation at Heritage Sites

Heritage conservation should go hand-in-hand with the development of tourism at heritage sites. Conservation can be a powerful tool for the development of cultural tourism. The development of tourism at sites is also an excellent way for people to fully understand the significance of World Heritage sites and secure the financial funding needed to conserve a site. In recent years, the development of cultural tourism at World Heritage sites has led to an enormous increase in visitation numbers at sites creating a whole series of conservation and management issues that need to be dealt with by site management. These developments have also impacted some site's conservation.

1.1 Dramatic Increase In Visitor Numbers

Heritage sites are important destinations for cultural tourism and many sites suffer from an excessive number of visitors. An example is the Palace Museum which can have more than 100,000 visitors in one day. Vast numbers of people visiting a site can create enormous challenges for a site's conservation.

1.2 Inappropriate Visitor Behavior

Visitors may trample vegetation, litter a site or write graffiti on a site's fabric; this sort of inappropriate behavior negatively impacts a site and its setting.

2. Impact of Visitation on Heritage Conservation

Visitation mainly impacts a site and its setting but may also have an impact on local traditions, culture and arts and crafts. If a site becomes commercialized over a period of time local culture is gradually influenced by foreign cultures which may negatively impact on the local community. Large numbers of visitors flooding into the local community may also disrupt what was once a quiet and peaceful way of living and may have some impact a site's stakeholders.

Mass tourism and inappropriate visitor behavior can create enormous challenges for the conservation of a site and its setting and emphasize the uneasy relationship between tourism and conservation. Conservation of the site itself is not by and large directly impacted by tourism. However, the development of tourism at heritage sites is an issue that demands our immediate attention. Through various management and monitoring measures a site should be able to manage and guide the development of tourism so that is a positive force, not a negative one.

3. Management and Monitoring of Tourism

3.1 Monitoring measures

Most sites already provide annual and monthly visitor statistics. The provision of daily statistics is possible in some sites. Tourism-related commercial activities are tracked in some heritage sites to further identify the impact of tourism on heritage sites.

• Tourism monitoring in the Summer Palace

Monitoring records and statistics are kept for the total number of visitors and ticket-holding visitors on daily and weekly basis. Monthly average and annual average numbers are compiled into a general report for comparative purposes. Peak visitation days are calculated on the basis of using hourly visitor number. These reports are handed on to the Palace's senior management. Foxiang Pavillion and Wenchangyuan can experience high levels of visitation; when numbers reach a certain level the monitoring system will issue a warning and measures can be taken to reduce visitor flows to these areas.

• Monitoring of Activities Associated with Tourism in Ancient Town of Lijiang:

Monitoring of visitor flow

- Aspects monitored: entry/exit number, entry/exit time, impact assessment
- Monitoring method: manual counting, assessment and analysis
- Assessment criteria: established visitor carrying capacity of the historic town
- Actions: issue warnings to senior management for their review and action.

Monitoring of commercial activities

- Aspects monitored: changes in shops
- Monitoring method: regular and irregular patrols, visual observations
- Assessment criteria: *Plan for Conservation of Traditional Business Culture of the Ancient Town of Lijiang*
- Actions: issue warnings to senior management for them to action

3.2 Management measures

• Analysis of monitoring data

Visitor monitoring data is reviewed and analyzed on a year to year and year on year basis to discover changes in previous trends and be able to be proactive in dealing with changes. Visitors are managed, dispersed around the site and dispatched to various locations

based on the research and calculation of the site's carrying capacity (overall and place specific). By controlling visitor numbers and visitor flows the site is able to take a scientific approach to organizing and managing visitor behavior thereby reducing their impact on the site.

• Other management measures

Restriction of access to certain areas open to the public: adopt various methods to prevent visitors from physically touching historic fabric and artifacts; fragile areas can have a buffer zone between them and visitors to isolate the area or barriers or shields made from Perspex or glass may be used.

Adopting a scientific approach to operations: encourage visitation during the low season through the provision of promotional materials and the use of a site's website or lower admission fees.

Tourism-related Contents of China World Cultural Heritage Monitoring Platform

1. Monitoring
- Goals: better conservation of World Cultural Heritage and ensure the safety of rare and precious sites, effective visitor management at sites.
- Method: installation of security and condition monitoring equipment.
- Monitoring details: visitor flow, visitor behavior, visitor routings, vehicle flow and safety, what visitors belongings are brought onto a site, special areas.
- Report

2. Monitoring criteria

The criteria used for China World Cultural Heritage Monitoring and Warning consists of the following two parts:
- Monitoring and warning indexes for the physical components of the site and its setting defined by heritage categories; frequency of different components determined by site management according to the sites specific conditions of properties.
- Degree of impact, conservation and management behavior, safety monitoring and warning indexes are all determined centrally along with their frequency which may be on a daily, monthly, annual basis as well as real-time monitoring of impacts and measures designed to deal with these impacts. Daily, monthly and annual monitoring should be undertaken on a regular basis and real time monitoring on an ad hoc basis.
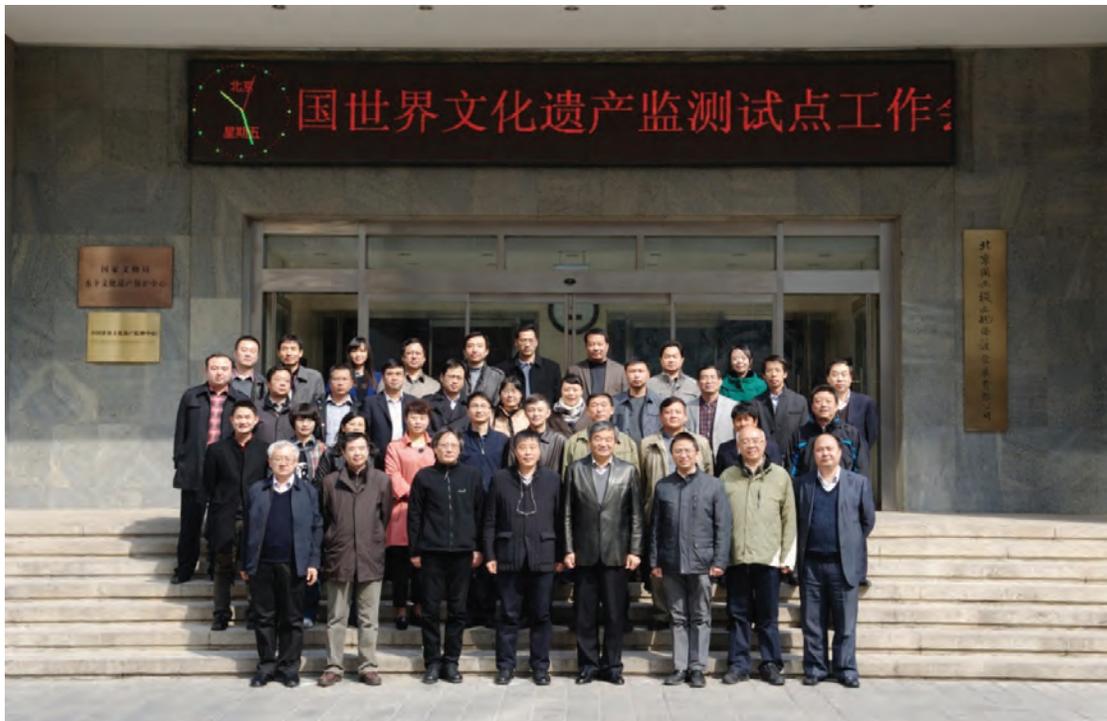
Fig. 1. Representatives of 2013 Work Conference on National Pilot Program for Monitoring of World Cultural Heritage
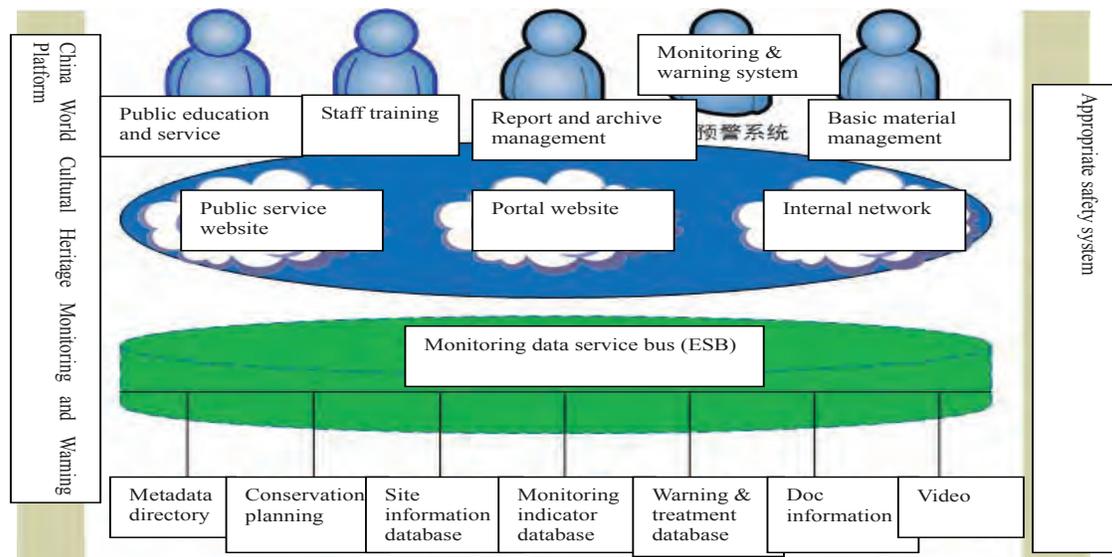
Fig. 2. Technical chart of the national-level platform

Carrying Capacity as a Tool for the Management of Tourism Pressures on Heritage Sites

Harry Coccossis
University of Thessaly, Greece

Tourism is globally a leading and growing economic activity providing opportunities for development but also creating pressures in many destinations. Heritage sites are particularly vulnerable to such pressures often as an outcome of the number of visitors in combination with the particular characteristics, constraints or limitations of the heritage site or broader community related social, economic and environmental concerns in destinations. A growing number of heritage destinations experience tremendous negative impacts as a consequence of their growing attraction to tourists-visitors. Overcrowding, noise, traffic congestion physical degradation of monuments and many other types of impacts are typical in many cases, affecting the heritage itself and/or the experience of visitors. In cultural heritage sites and places there is a need to take such impacts seriously into consideration in planning, policy making and the management of destinations.

A key question in this context is 'how much tourism' or 'how many visitors' can be accepted in order to avoid such undesirable impacts. Carrying capacity is a conceptual (and occasionally an operational) tool for managing tourism pressures in heritage sites. In the case of heritage sites carrying capacity is expressed as 'the number of people visiting the site without causing irreversible damage to its natural and built environment and without decreasing the quality of the experience gained by the visitors'. Carrying capacity can be expressed in terms of real or perceived limiting factors expressing obstacles, threats or risks in physical, social or economic terms, such as natural resource, infrastructure or built-structure limits, crowding or critical local socio-cultural attitudes, costs of living or maintenance, etc. It can provide a sense of 'measure' (a threshold) for local communities or site managers in stimulating consensus building among key stakeholders for taking action towards the management of tourism growth in heritage sites.

Carrying capacity has to be considered in the context of heritage and/ or destination management plans. Thus it can be an intrinsic part of community planning involving key stakeholders in a democratic process seeking complementarities, synergies and coordination of actions. The

process of identifying carrying capacity involves several steps such as analysis of constraints and opportunities in the functioning of the heritage site/destination, identification of critical factors, analysis of scenarios for future development, identification of goals and objectives, development of strategy, implementation of actions and monitoring and evaluation as a means for a feedback. Whether explicitly or implicitly taken into consideration, several heritage sites adopt policies and concrete measures to control tourism pressures on the basis of carrying capacity. In this respect some examples from European sites can highlight some characteristic actions taken.

Case studies reveal the type and range of measures and policies adopted and may be useful as best practices to be considered. To a great extent the specific and broader institutional, social and cultural contexts have an important role. The spatial scale of reference is also an important issue. In towns and cities capacity issues bring often social, cultural and broader economic concerns over tourism/visitor impacts affecting entire communities often leading to conflicts. In some cases such as in the cities of Salzburg, Toledo, Venice, and Bruges, tourism dynamics often act as the main source of conflict between the benefiting stakeholders and the residents or the rest of the community. In many urban areas/heritage sites which suffer from tourism pressures capacity issues are at the center of community consultations towards specific actions to be taken. In an urban context, local measures may focus on the protection of heritage sites from traffic congestion, air pollution, intense development of human activities, etc. but they are also often complemented with regional level measures of land-use planning to reduce the negative impacts of urbanization.

In most heritage destinations visitor and traffic congestion are key issues. The first is normally taken care of through site specific actions while the second often involves broader community planning actions. Typical responses involve spreading opportunities for visits (i.e. incentives to extend the peaks over the season) or providing alternative means of access (i.e. off-center parking and public transport, virtual tours) or constraints (i.e. limits of access, charges, etc.) or a combination. In some cities, a policy to manage traffic congestion has been implemented in the form of a park and ride system in the town's periphery, often in combination with a new traffic plan. In the cities of **Bruges**, **Oxford** and **Salzburg**, the pressures from day-visitors has been eased by means of controlling incoming excursionist buses, which are easy to spot and thus to divert. Similar management schemes are being implemented in the smaller Spanish art cities of **Toledo**, **Granada** and **Segovia** to face 'capacity issues' regardless whether these have been explicitly stated as such. In some cases, tools using geosciences and spatial information have proven useful in order to

provide information on the risk and of overburdening the carrying capacity in heritage sites at a local and regional level. In *Algarve*, a predictive toolkit for urban heritage in relation to urban cultural endangerment has been developed in order to analyze the urban growth potential and threats to the abundant presence of archaeological heritage in the area.

Venice is world famous for its preserved architecture, romantic atmosphere, the gondolas, St Mark's Plaza, its museums, Carnival and the Biennale of Arts. It is estimated that around 200.000 people visit the city on peak days leading to a 'competition' between residents and visitors for the use of public space. The main characteristic of tourism in Venice is that it involves mostly excursionists or visitors who stay in the suburbs and therefore, measuring carrying capacity has become very difficult. In order to tackle such issues and provide the city with the expected benefits of tourism, local management tools have been introduced such as the Venice card. Its aim is to attract people to stay in Venice hotels and book their visits to the city in advance. Visitors receive in exchange a "Venice Card" which offers them a series of special advantages and possibilities not accessible to other visitors such as secured entry to key sites or opportunities to visit extra places. Thus it is possible to manage visitor numbers and seek a more balanced number of visitors throughout the year. The number of cards issued equals the restrictive carrying-capacity defined and adopted for Venice by the community. In order for such a system to work, however, cooperation is necessary between the various stakeholders and users of the system.

In specific heritage site destinations, responses to capacity issues become part of a destination specific site management program concentrating on organizational and technological actions towards managing visitor numbers and flows.

Lascaux Caves is the setting of a complex of caves in southwestern France famous for its Paleolithic cave paintings. Because of the many people visiting the site each day, already in 1960, an air conditioning machine was placed to renew the air to breathe. The condensation and humidity on the painted walls endangers cave paintings. The appearance and development of green algae provoked the closing of the cave to visitors in 1963. This led to restriction of access to the real caves to a few visitors every week, and the creation of a replica cave for visitors to Lascaux. In 2001, the authorities in charge of Lascaux changed the air conditioning system which resulted in regulating better the temperature and humidity. When the system had been established, an infestation of a white mould began spreading rapidly across the cave ceiling

and walls. In January 2008, authorities closed the cave for three months even to scientists and preservationists. A single individual was allowed to enter the cave for 20 minutes once a week to monitor climatic conditions. Now only a few scientific experts are allowed to work inside the cave and just for a few days a month but the efforts to remove the mold have taken a toll, leaving dark patches and damaging the pigments on the walls. The problem is ongoing, as are efforts to control the microbial and fungal growths in the cave. The fungal infection crises have led to the establishment of an International Scientific Committee for Lascaux and to rethinking how, and how much, human access should be permitted in caves containing prehistoric art.

Stonehenge is another example of a site under pressure as a result of a large number of visitors in combination with traffic and the development of leisure and recreation activities. The area's physical environment has proven to be unable to withstand such pressures and therefore strict management measures have been implemented. These include the provision of a low cost and sustainable visitor experience along with the provision of 'sustainable' accessibility to the site. More specifically, visitors are guided to vantage points from which to view the panorama of the site, and then be forwarded to the visitor centre where the visitor experience starts with interpretative and audio-visual displays of the site and then walk to the actual site. Therefore, immediacy is delayed and through tour itineraries and access by coaches (who require access close-by and a controlled time-monitored experience), Stonehenge can be, and often is, visited in 10 minutes. There is also a provision of a fast and free visit through which visitors pay nothing and look through the fence.

Whether in cases of a specific site or an entire town (or part of it) capacity issues are often central for several European destinations and in many cases actions have been already in place to manage, control, diffuse (in space and time) visitors. Carrying capacity can serve as a framework of reference for various purposes depending on the particularities of place (size, characteristics of the site, community, tourism and visitors) and capacities of the local system (institutional, economic, social and cultural) to adopt and implement visitor management policies and programs. Such a process is not always easily implemented. Capacity issues have often a strong political and economic dimension as they affect perceptions about growth prospects and bring considerations of economic costs and community impacts. In spite of these difficulties, capacity issues can provide a useful platform to seek broader consensus towards common action. Thus, carrying capacity can stimulate community action or become a key operational tool—a threshold value—for guiding management decisions.

A Systematic Aproach to Managing Recreation and Tourism in U.S. National Parks and Related Areas: Development and Application of Management Matrices

Robert E. Manning[1] and Laura E. Anderson[2]

[1] University of Vermont, U.S.A..
[2] University of Wisconsin – Stevens Point, U.S.A.

Parks and protected areas, including world heritage sites, are becoming increasingly important in contemporary society. Parks are vital to people in many ways: they offer open, green spaces in our ever-developing world; they're retreats from the hectic lives that many people lead; and they protect wildlife and other elements of biodiversity, as well as historical and cultural resources that are important markers of society. And, of course, tourism and outdoor recreation are also important, offering healthy and satisfying leisure activity; intimate contact with the out-of-doors; opportunities to build family solidarity; enjoyment and appreciation of the natural environment and our cultural heritage; employment and economic development to local people and communities; and a myriad of other benefits.

Because of their importance, parks and protected areas have been established across the globe. Formally designated national and international protected areas now number over 150,000 and include more than 24 million square kilometers of land and water and cover more than 12% of the surface of the earth (IUCN and UNEP-WCMC, 2011; IUCN and WCMC, 2012). Tourism and outdoor recreation have also grown exponentially (Balmford et al. 2009). For example, visits to the U.S. national parks now number nearly 300 million. Worldwide tourism has been estimated to account for 10% of gross domestic product and outdoor recreation makes up one of tourism's fastest growing sectors (Goodwin, 1996; Mastny, 2001; Davenport et al., 2002; World Travel and Tourism Council, 2007).

While we should celebrate the popularity of these areas, increasing visitation also presents a number of mangement challenges. For example, research documents a number of potential impacts of recreation/tourism, and these impacts include resource degradation and declining quality of the visitor experience (Hammitt and Cole, 1998; Manning, 2011). However until now, there has been little systematic information on how to manage recreation/ tourism in ways that protect park resources and the quality of the visitor experience. This paper develops a series of matrices that can be used by

managers to think systematically and creatively about a range of management practices that can be used to address potential environmental and experiential problems casued by excessive or inappropriate recreational use.

This paper begins with development of classification systems of 1) recreation/ tourism-related impacts and associated problems, and 2) management strategies and practices that can be used to address these problems. Management problems include impacts to park resources (soil, vegetation, water, air, wildlife, historical/cultural resources, soundscapes, night skies), impacts to the quality of the visitor experience (crowding, conflict, depreciative behavior), and impacts to park facilities (trails, campsites, attraction sites, roads/parking lots, and interpretive facilities/programs). Management strategies include limiting use, increasing the supply of recreation/tourism opportunities, reducing the impacts of visitor use, and hardening park resources and the quality of the visitor experience. Management practices include information/education, rationing/allocation, rules/regulations, law enforcement, zoning, and facility development/site design/maintenance.

These classification systems can be combined into a series of matrices that can be used to help guide recreation/tourism management. There are four management matrices, one for each of the four management strategies (outlined above). Each of the four management matrices have 96 cells, one for each of the interactions between the 16 management problems (outlined above) and the six management practices (outlined above). The management matrix for the strategy of limiting use is shown in Figure 1 as an example. In this example, cell one represents the ways in which the management practice of information/education can be used to limit use in order to minimize impacts to soil. In the interactive version of the matrix, the user would «click» on cell one and the ways to apply information/education in this context would appear. Or the user might «click» on one of the management problems (impacts to soil, for example), and the ways to apply all six of the management practices would appear. Or the user might «click» on one of the management practices (information/education, for example), and all of the ways in which this management practice might apply to all of the management problems might appear. Use of the management matrix approach encourages systematic and creative consideration of all possible management strategies and practices for all categories of management problems.

Case studies are drawn from the U.S. National Parks to illustrate use of the management matrices. For example, one of the case studies addresses management of the Colorado River in Grand Canyon National Park, a World

Heritage Site. The Colorado River is the heart of Grand Canyon and offers visitors a world-class whitewater river trip. However, increasing use of the river was causing impacts to the limited number of campsites along the shore (Impacts to Campsites), many of the areas iconic side canyons and other attraction sites (Impacts to Attraction Sites), and some of the Canyon's archeological and historical sites (Impacts to Historical/Cultural Resources). The growing amount and diverse types of use were also causing crowding at campsites and on the river (Crowding) and conflict between motorized and nonmotorized boaters (Conflict). A new management plan was prepared by the U.S. National Park Service applying the strategies of Limiting Use and Reducing the Impact of Use (Fig. 2). A coordinated suite of management practices was employed to advance these strategies, including spatial and temporal zoning of the river (Zoning), regulation of the number and type of boating trips (Rules and Regulations; Rationing/Allocation), ranger patrols to enforce regulations (Law Enforcement), a lottery system to allocate permits to noncommercial boaters (Rationing/Allocation), and an intensive program of public education (Information/Education) (Fig. 3).

Another case study addresses visitor use of Arches National Park which has grown dramatically in the past few decades and now exceeds a million visits annually (Fig. 4). This recreational use has had several important impacts in the park, including trampling of fragile soils and vegetation (Impacts to Soil; Impacts to Vegetation) and crowding on trails and at attraction sites (Crowding) (Figs 5 and 6). The National Park Service developed and applied its Visitor Experience and Resource Protection framework to measure and manage visitor capacity at Arches (Manning, 2001). The resulting management regime includes division of the park into a series of spatial zones (Zoning), visitor education about when and where to visit and appropriate visitor behavior (Information/Education), sizing of parking lots to limit crowding and fencing to discourage walking off maintained trails (Site Design, Facility Development, Maintenance), regulation and enforcement of overflow parking (Rules/Regulations; Law Enforcement), and mandatory permits for use of some park attractions (Rationing/Allocation).

Development and application of the management matrices outlined in this paper has been more fully described in a new book for practitioners and students, Managing Outdoor Recreation: Case Studies in the National Parks (Manning and Anderson, 2012). The book is divided into three parts. Part 1 includes five chapters and describes and discusses development of the management matrices. Part 2 presents twenty case studies of successful management of recreation/tourism in the U. S. National Parks and that

illustrate use of the management matrices. These are exemplars of recreation/ tourism management in national parks and related areas. Part 3 presents a series of principles of recreation/tourism management in parks and related areas based on development and application of the management matrices.

References

Balmford, A., J. Beresford, J. Green, R. Naidoo, and M. Walpole et al. 2009. A Global Perspective on Trends in Nature-Based Tourism. *PLoS Biol* 7(6): e1000144. doi:10.1371/journal.pbio.1000144.

Davenport, L., W. Y. Brockelman, P. C. Wright, K. Ruf, and F. B. Rubio del Valle. 2002. Ecotourism Tools for Parks. *In*: Terborgh, J., C. van Schaik, L. Davenport and M. Rao (Eds.). Making Parks Work. Washington, DC: Island Press, 279-306.

Goodwin, H. J. 1996. In Pursuit of Ecotourism. *Biodiversity Conservation* 5:277-291.

IUCN and UNEP-WCMC. 2012. *The World Database on Protected Areas (WDPS): February 2012*. Cambridge, UK: UNEP-WCMC.

Manning, R. 2001. Visitor Experience and Resource Protection: A Framework for Managing Carrying Capacity in the National Parks. *Journal of Park and Recreation Administration* 19: 93-108.

Manning, R. and L. Anderson. 2012. *Managing Outdoor Recreation: Case Studies in the National Parks*. Wallingford, UK: CABI Publishing.

Mastny, L. 2001. *Treading Lightly: New Paths for International Tourism*. Washington: Worldwatch Institute.

World Travel and Tourism Council. 2007. *The Global Travel and Tourism Summit*. London: World Travel and Tourism Council.

Management Practices	Problems														
Strategies Practices	Impacts to Resources								Impacts to Experience			Impacts to Facilities/Services			
Limit Use	Soil	Vegetation	Water	Wildlife	Air	Soundscapes	Night Sky	Historical/Cultural	Crowding	Conflict	Depreciative Behavior	Attraction Sites	Trails	Campgrounds/Campsites	Roads/Parking	Interpretive Facilities/Programs
Information/Education	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85	91
Rationing/Allocation	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86	92
Rules/Regulations	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93
Law Enforcement	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
Zoning	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
Facility Development/ Site Design/Maintenance	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96

Fig. 1. Management matrix for the strategy of limiting use

Fig. 2. The amount of visitor use on the Colorado River in Grand Canyon National Park has been limited to protect the park's natural and cultural resources.

Fig. 3. A system of temporal zoning on the Colorado River in Grand Canyon National Park has been implemented to reduce the conflict between motorized and non-motorized use.

Fig. 4. Arches National Park features impressive sandstone formations, including a collection of natural stone arches.
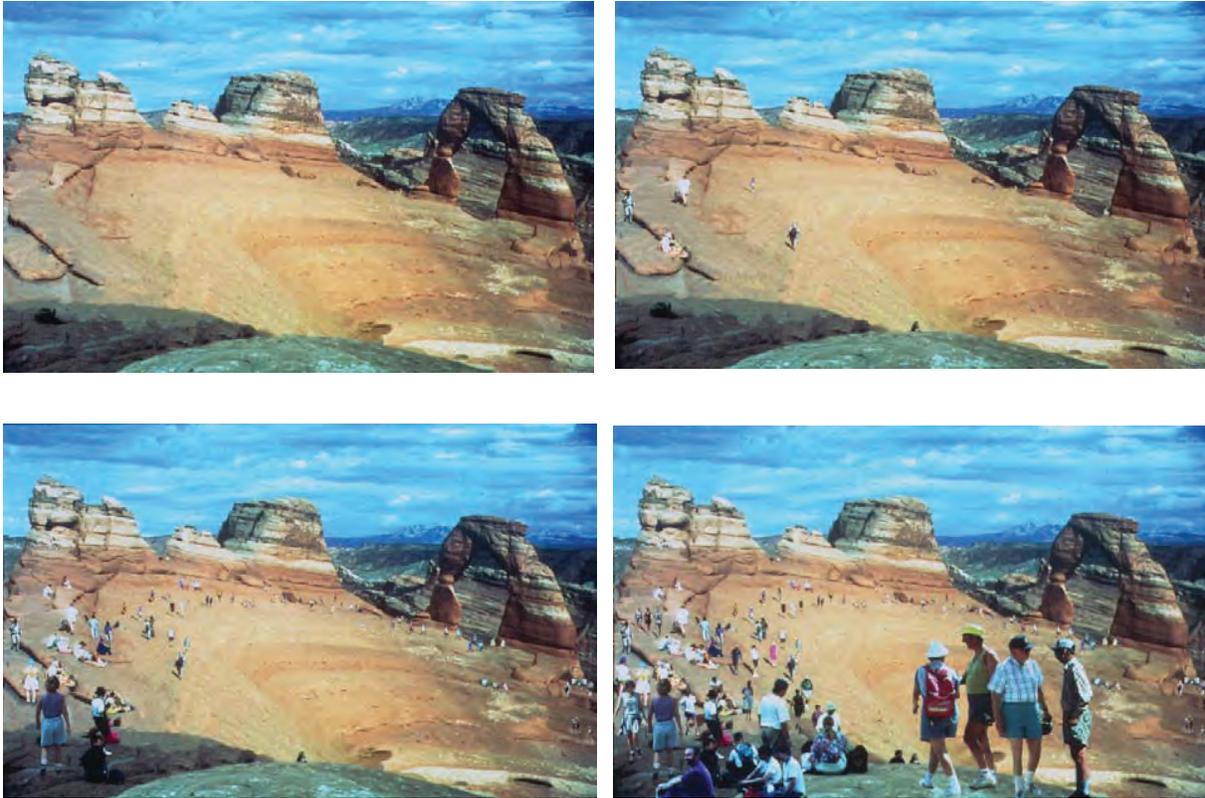
Fig. 5. Visitors to Delicate Arch, an iconic park attraction, were shown a series of photos depicting a range of visitor use levels as part of a visitor survey. Respondents were asked to rate the acceptability of these photos to help determine a threshold for crowding in the park. This figure shows four of the sixteen study photos.
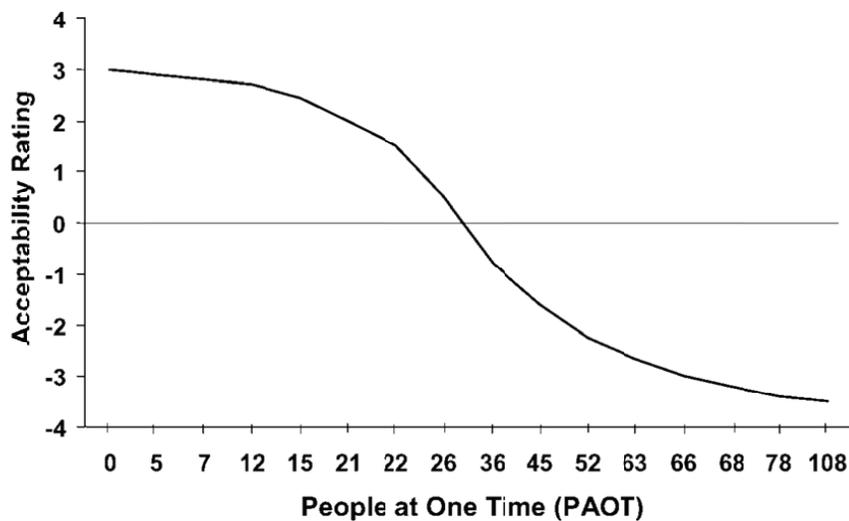
Fig. 6. Mean acceptability ratings of respondents show that the threshold for crowding at Delicate Arch is about 30 people-at-one-time (this is the point at which average ratings fall out of the acceptable range and into the unacceptable range). The park is managed (through restrictions on parking) to ensure that this threshold is not violated.

Application of Visitor Management Strategies to World Heritage Sites

Overview of the Methodology and Results of the Visitor Study for the Mogao Grottoes

Neville Agnew[1] and Martha Demas,[1] Fan Jinshi[2] and
Wang Xudong[2]

[1] Getty Conservation Institute, U.S.A.
[2] Dunhuang Academy, China

Introduction

China's rise as an economic power, higher living standards, and a national policy that identifies tourism as a pillar industry has led to great increases in domestic tourism to heritage sites. At the Mogao Grottoes the rapid rise in visitor numbers since 1979 when the site opened has threatened to lead to an unsustainable situation for management, an unsafe and unsatisfactory experience for visitors, and irreparable damage to the fragile art of the caves. A multi-faceted visitor study began in 2001 as a joint undertaking of the Getty Conservation Institute and the Dunhuang Academy to determine, on the one hand, the impact of visitation on the painted caves and on the other, sustainable visitor numbers such that, once implemented, the threats would be eliminated. Succinctly stated, the goal has been to determine maximum visitation numbers compatible with no damage to the caves and their art while ensuring a safe and enjoyable experience for the visitor. The study, which responds to one of the principal objectives of the Mogao Master Plan, is part of a larger collaboration with the Dunhuang Academy to apply the *Principles for the Conservation of Heritage Sites in China* at the site.

This presentation provides an overview of the research components that together comprise the methodology of the visitor study, which forms part of a comprehensive visitor management system described in other presentations of this panel (see Wang Xudong, Li Ping, and Su Bomin et al.).

Methodology

The methodological framework of the study is based on the VERP (Visitor Experience and Resource Protection) model used by the U.S. National Park Service. It involves identifying the main issues impacting the site, the indicators to monitor change, and the desired conditions for the site, defining the limiting conditions for visitation and, finally, developing long-term monitoring and management strategies and tools (Fig. 1). This method and others such as the LAC (Limits of Acceptable Change) depends upon a clear understanding of the relationship between visitation and impacts. From this understanding

and use of indicators and monitoring, management responses are developed. Within this basic framework the Mogao study established parameters and priorities (Fig. 2). The grottoes themselves constitute the principal significance of the site and are the baseline for determining limits on visitation. The study was therefore focused on the Grotto Zone of the site where the 492 painted caves are located. The objective was to maximize visitor numbers without adverse effect on the grottoes, and without compromising visitor safety and satisfaction. The larger Visitor Use Zone is part of an ongoing comprehensive plan developed by the DA for visitor facilities, exhibition spaces and interpretation, and flow and distribution of visitors throughout the site (see presentations by Fan Jinshi, Wang Xudong, and Li Ping).

Research and Assessment Strategy

A major research and assessment component was developed to address the main issues impacting the grottoes and the visitors and constitutes the core of the visitor study. The specific issue identified for the wall paintings is ongoing deterioration, in which the mechanisms leading to decay can be activated under conditions of elevated humidity. The research design required, foremost, investigation of the causes and mechanisms of deterioration of the wall paintings and the impact of visitation on cave microenvironments to establish whether there is a link between visitation to the caves and deterioration. The research strategy integrated analytical investigations in the laboratory; environmental monitoring and research; deterioration monitoring (field testing); and assessment of condition and visitation potential for 112 priority caves. The main visitor issues were overcrowding in the peak summer and holiday seasons and bad air quality in many of the caves (an unpleasant cocktail of high carbon dioxide [CO_2] levels, heat and body odors). To address these the study assessed the prevailing visitor management conditions and established safe CO_2 limits and physical space requirements for visitor health and comfort.

The presentations by Shin Maekawa et al. and Lori Wong et al. elaborate on the research and assessment related to humidity and carbon dioxide in caves and the assessment of the 112 priority caves, respectively.

The research resulted in a conceptually integrated body of information about the presence, types, and distribution of active deterioration in the caves; the conditions activating this deterioration; the role of natural air exchange with the outside in accelerating or mitigating deterioration through its influence on relative humidity and on CO_2 buildup; the impact to the wall paintings from visitation, and to visitors from high CO_2 and crowding; the potential of

individual caves to be visited, based on level of risk, significance, size, safety and access limitations; and the principal management conditions that affect the daily visitor capacity of the grotto Zone.

From the research, three categories of limiting conditions were defined and applied to 112 priority caves (Fig. 3): (1) conditions that eliminate caves from visitation (low significance, safety issues, less than 13 square meters physical capacity, and an unacceptable level of risk to the wall paintings); (2) conditions that may restrict visitation (CO_2 not to exceed 1500 ppm and relative humidity not to exceed 62% in caves at risk from salt-induced deterioration); and (3) management conditions (duration of cave visit and maximum group size of 25 persons). These limiting conditions provide the basis for setting provisional visitor capacities for individual caves.

Strategies for Responding to the Limiting Conditions

Development of monitoring and management tools that incorporate these limiting conditions and simulation models to test visitation scenarios allow site managers to create tours responsive to changing conditions and varied visitation demands on a daily or seasonal basis (see Ali Kiran et al.). Operational changes and constraints will be required to maximize visitor loads (e.g. longer opening hours, reducing the number of tours offered and the number of caves per tour, and removing bottleneck caves - among the most popular - from tours). Such changes and constraints represent management challenges, but with the ability to plan and explore options, which the tools provide, and experimentation based on long experience with visitors (see e.g. Li Ping), they can be met during periods of peak visitation.

Constraints on tours to the Grotto Zone are a necessary concession in order to achieve very high visitor capacity, but they need not result in a diminished visitor experience. Interpretive programs, improved presentation of caves, exhibitions, films, virtual cave tours, and other options currently in development will diversify and enhance the visitor experience and will dovetail with changing visitor demographics and patterns of travel that are already making themselves felt at Mogao (Fig. 4).

The new visitor center outside the boundaries of the site, scheduled for completion in late 2014 (see Wang Xudong presentation), will serve an important orientation and interpretation function and allow management to control heavy visitor loads. It will be the point of departure for all visitors to the grottoes and will include a film about the history of the site and virtual tours of caves that may not be open to the public or be able to be seen by all visitors.

For research such as the present study to be effectively applied requires that it be embraced not only by site authorities but also by the tourism industry. In China to date there has been little evidence of collaborative partnership in this area. Needless to say, studies such as this need also be validated, refined and updated as required. Failure to do so will relegate the work to the dusty shelf that is the final home of so many other reports and site master plans.

A bilingual report, *A Systematic Methodology for Sustainable Visitation at the Mogao Grottoes, China*, disseminated at the Colloquium, provides comprehensive information on the study. The full publication of the study is forthcoming (Martha Demas, Neville Agnew and Fan Jinshi. 2014. *Strategies for Sustainable Tourism at the Mogao Grottoes of Dunhuang, China*. Springer Briefs in Archaeology. Archaeological Heritage Management. New York: Springer)

Methodology of the visitor study

Phase One:

Assessment and Analysis

1. Define the parameters of the study and management objectives

2. Identify issues impacting the site & visitors

3. Identify key indicators to monitor change

4. Define desired conditions

5. Design and implement a research and assessment strategy

   5.1 Analytical investigations
   5.2 Visitor analysis
   5.3 Environmental investigations
   5.4 Field testing
   5.5 Cave assessments

6. Define limiting conditions

Phase Two:

Response

1. Set visitor capacities of individual grottoes

2. Develop monitoring and management tools and strategies

3. Define management actions to respond to monitoring

Fig. 1. Methdology of the Mogao visitor study, based on the Visitor Experience and Resource Protection model of the U.S. National Park Service.

Parameters of the Visitor Study

Use zones: The one kilometer long Grotto Zone (dashed red line) and the Visitor Use Zone, where facilities and exhibition buildings are located. The study is focused on the Grotto Zone.

Values to be protected: The primary cultural values of the site are the wall paintings and sculpture of the 492 decorated grottoes, representing the artistic and religious development of Buddhism in China over a thousand years.

Visitor health & safety: The health and safety of the visitors are the first priority of management and need to be ensured as a baseline condition of the visitor experience.

Fig. 2. The main parameters defining the visitor study were the use zone, values to be protected and visitor health and safety during the time of greatest threat (May through October).

Limiting conditions

Eliminating conditions

Significance

Physical capacity: minimum physical capacity of 13 square meters

Safety & accessibility

Unacceptable risk: Risk Level 4 caves cannot be opened to visitation

**Restricting conditions**

CO_2 capacity
CO_2 capacity of caves (based on a not-to-exceed limit of 1500 ppm) allows for a preset number of group visits per hour using projected Air Changes per Hour

Risk Level 3
Risk Level 3 caves are vulnerable to deterioration from influx of humid air requiring closure when the external humidity reaches 62% RH

Management conditions

Tour group size
Tour group size is limited to 25 persons, based on what guides are capable of handling.

Duration of cave visit
Duration of a cave visit is set at five minutes on average per cave.

Fig. 3. Based on the research carried out in the visitor study, the conditions that would limit visitation were defined and applied to each of the 112 priority caves.

Enhancing diversity

A new Visitor Center outside the boundaries of the site, scheduled for completion in 2013, will serve an important orientation and interpretation function for visitors and will allow management to control heavy visitor loads.

Methods of improving presentation of the caves are being developed. Following conservation of Cave 85 by the DA and GCI in 2009, presentation and interpretation involved a raised platform to allow better viewing of the ceiling painting, LED lighting, and interpretation panels explaining conservation issues. This model is being adapted for other caves.

The Exhibition Hall, built in the 1980s, is one of several exhibition spaces on site. It houses hand-painted replica caves that allow visitors to explore the art more intimately and at their leisure. New and changing exhibits provide greater depth of interpretation and the efforts to preserve the site.

Fig. 4. To address the challenges of increasing visitation, the DA is implementing strategies to enhance and diversify the visitors' experience while also limiting direct access to the art of the caves.

Modeling Impacts of Visitation on the Cave Environments for the Visitor Study

Shin Maekawa,[1] Xue Ping,[2] Zhang Guobin,[2] Hou, Wenfang,[2] Zhang Zhengmo[2]

[1] Getty Conservation Institute, U.S.A.
[2] Dunhuang Academy, China

Introduction

Wall paintings of the Mogao Grottoes have survived for a millennium in the dry and stable cave environment of the northwestern desert of China, but opening of the caves to visitors since 1979 has subjected the wall paintings to greater stress. As part of the Getty Conservation Institute – Dunhuang Academy visitor study (see Agnew et al. presentation) extensive investigations were carried out to better understand the impact of visitation on the cave environment.

Conservation and Indoor Air Quality Requirements

The Mogao Grottoes' conglomerate bedrock contains hygroscopic salts. The largest threat to the wall paintings with high concentrations of hygroscopic salts is elevated humidity levels at or above their deliquescent humidity, 67% RH. This environmental condition causes the deliquescence and subsequent re-crystallization of the salt mixture resulting in damage to the paint and plaster. Cycling over large humidity variations physically stresses wall paintings even if they do not contain hygroscopic salts. This cyclic stress can result in the mechanical failure of paint surfaces. Therefore, for protection of the wall paintings, the highest allowable humidity was set to 62% RH, 5% RH below the deliquescence value, in order to provide a margin of safety.

Indoor air quality (IAQ) requirements have to be maintained in the caves for visitor comfort and safety. The carbon dioxide (CO_2) concentration, one of the major IAQ markers, in the ambient air is 350–400 parts per million (ppm). Higher than 3000 ppm has been recorded in heavily visited caves, such as Caves 16, 328, and 148. Although recommended limits vary widely (1000–3000 ppm), depending on the type of space and length of exposure as well as sources of the recommendation, 1500 ppm was selected for caves of the Mogao Grottoes, considering the short exposure time and a museum-like viewing space.

Environmental Monitoring

Monitoring of the site climate and environments in several caves has been conducted at the Mogao Grottoes since 1989. Climate data shows normally cold and dry winters and hot and dry summers. However, several prolonged rain or humid weather events were recorded in summer months and some snow in winter (Fig. 1). Temperature in caves, approximately 5°C in winter and 18°C in summer, followed the site climate with reduced short and long-term variations. Cave humidity, which averaged from approximately 10–20% RH in winter to 40–50% RH in summer, is highly influenced by weather conditions and by visitation. Cave environments, which have been recorded in visited, non-visited, small, medium, and large caves, showed impacts of visits as temperature and humidity spikes (Figs 2 and 3).

Analysis of Cave Environments

Humidity in a visited cave is a mixture of humidity emitted by visitors and humidity of the infiltrated outside air. When the outside air is dry, the dry air dilutes humidity emitted by visitors. On the contrary, the infiltrated outside air during prolonged rainy or warm and humid weather becomes the major source of cave's humidity (Fig. 4). Therefore, numbers of visitors, the outside humidity, and rates of air infiltration determine the humidity in the cave.

Similarly, the cave's CO_2 concentration is a result of the CO_2 emission by visitors and dilution by the infiltrated outside air. Therefore, visitor numbers and air infiltration rates determine the CO_2 concentration in the cave.

Air Infiltration Rates

As described the above, air infiltration rates of caves are the important factor in determining caves' environments. The rate is influenced by architectural features of the cave as well as climatic conditions of the site, but especially by whether the door to the cave is open or closed (Fig. 5). Considering the complexity in modeling the rate, air infiltration rates were measured for a variety of caves during a range of climate conditions (Fig. 6). Empirical relationships between the cave size and the measured rate were established.

Modeling of Cave Environment

Mathematical models were developed for simulating humidity and CO_2 concentration in caves. The models use known human physiological emission rates for humidity and CO_2 as well as measured air infiltration rates of various caves. Models' predicted 24-hour trends for humidity and CO_2 concentration, which were verified using monitoring data collected in several caves (Fig. 7).

The above models were used to compare impacts of visitations on the cave environment. During prolonged rain or hot and humid weather events, whose dew point temperature remained above 13°C, humidity in caves exceeded 62% RH, the critical humidity, under continuous occupation by 25 visitors. This result indicated that caves with a high concentration of hygroscopic salts should be closed to visitation on rainy or hot and humid days. In the normal hot and dry summer condition, humidity remained below the critical humidity with the same visitation scenario. However, the CO_2 concentration exceeded 1500 ppm. This indicated that only the IAQ issue should be considered during normal hot and dry summer days.

Establishment of CO_2 Capacity

Finally, the CO_2 capacity, which is the maximum number of groups per hour during normal hot and dry summer days, while limiting the CO_2 concentration to less than 1500 ppm, was calculated for each cave using the CO_2 model as a determining factor in visitor capacity. The size of group and visit duration were also fixed to 25 person per group and the viewing duration of five minutes per cave, respectively. Resulting CO_2 capacities were then forwarded to a visitor management system for simulating the cave-tour operation during peak periods.

Conclusions

The main results from the environmental investigations were:

- The main source of moisture in the caves is outside weather. This means that for caves with high salt content doors should be kept closed during rain and high humidity (dew point temperature higher than 13°C) - that is, no visitation at these times. During warm and dry days, however, keep doors open to ventilate visitor-generated humidity and CO_2.

- CO_2 capacities were calculated for each of the 112 priority caves based on:
  - Group size (25 persons)
  - Duration of visit (5-minutes)
  - CO_2 limits (1500 ppm)

These results were integrated into the overall visitor study in order to determine a visitor capacity for the grottoes.
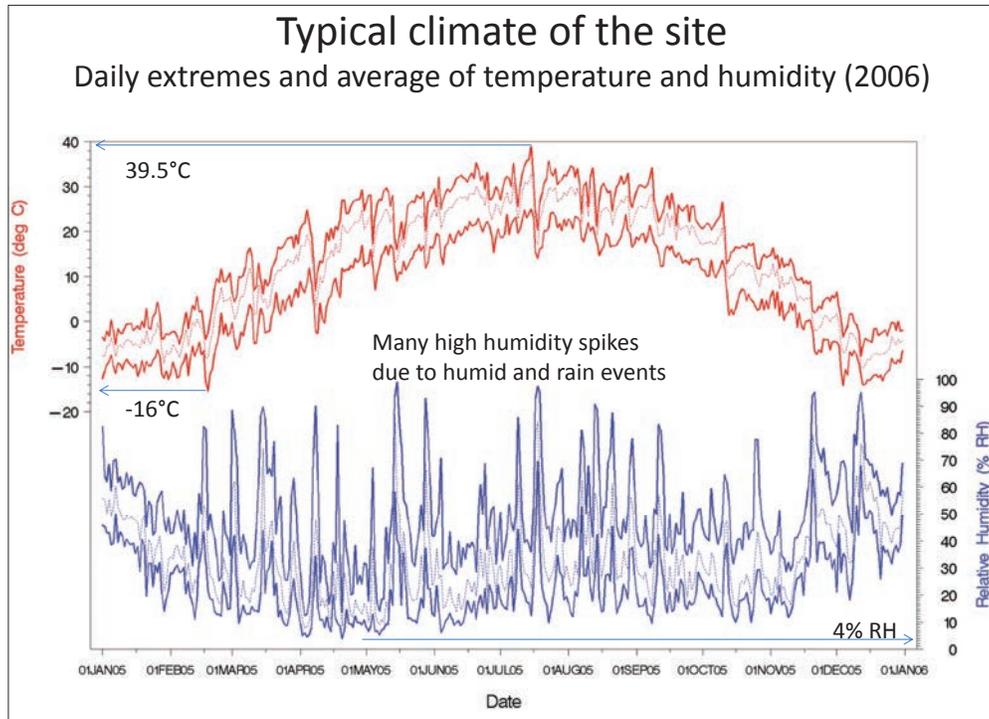
Fig. 1. The site's annual range of temperature and humidity is very wide, 56° C and 100% RH, with many high humidity spikes due to rain or weather fronts.
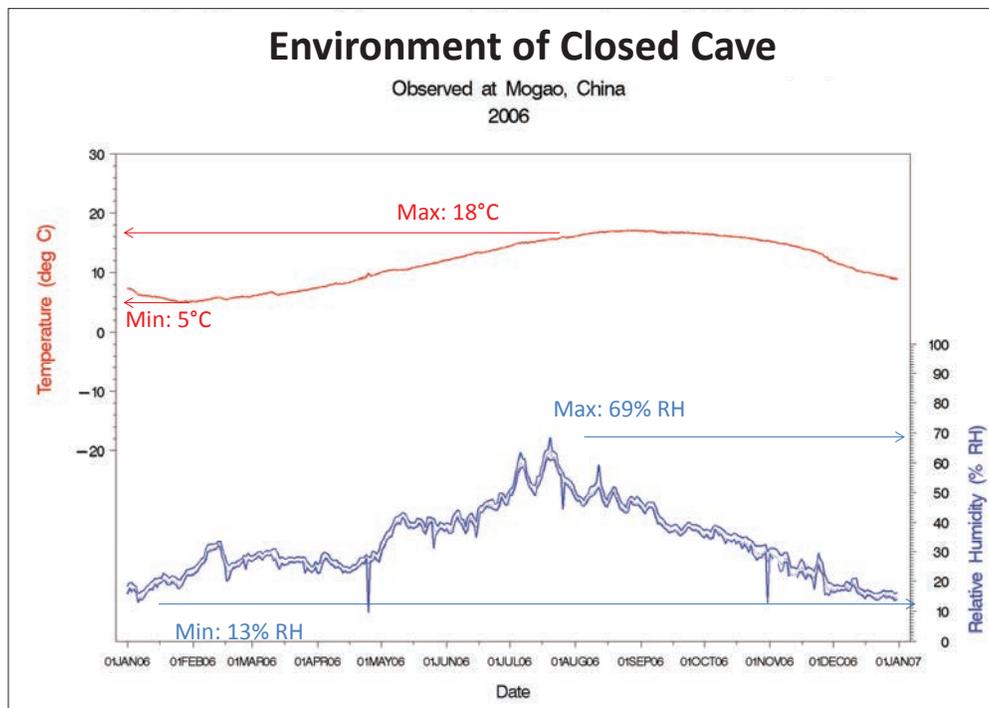

Fig. 2. Within a cave with closed doors, i.e., an unvisited cave, temperature and humidity are considerably buffered, and the annual range is around 23° C and 56% RH due to the thermal mass of the rock and closed doors.
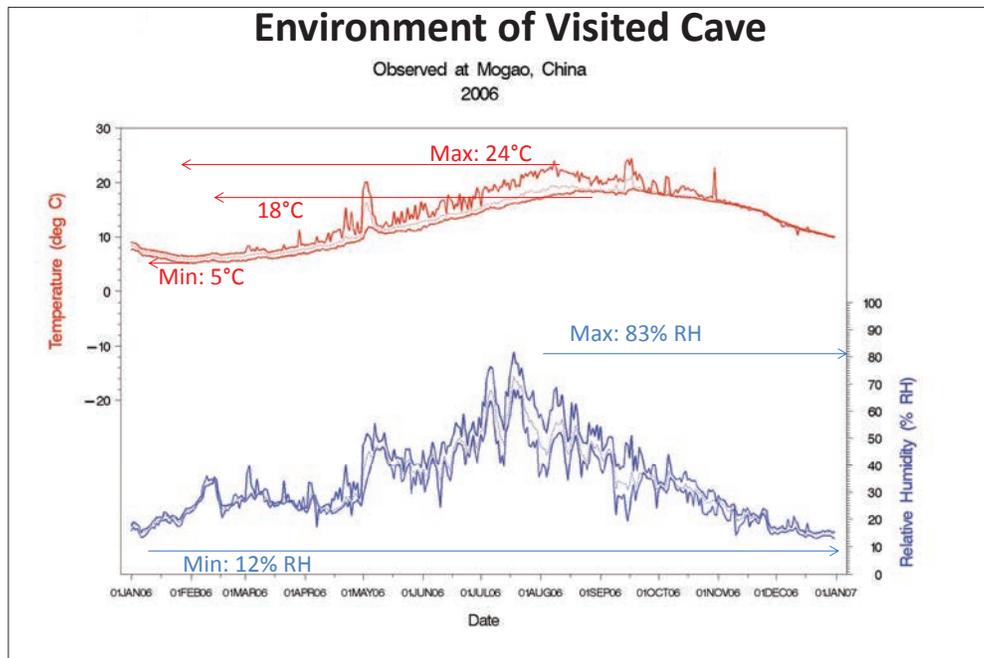
Fig. 3. By contrast with a closed cave, opening and closing a cave to visitors has a large effect on the interior microclimate due to exchange of air with the exterior.
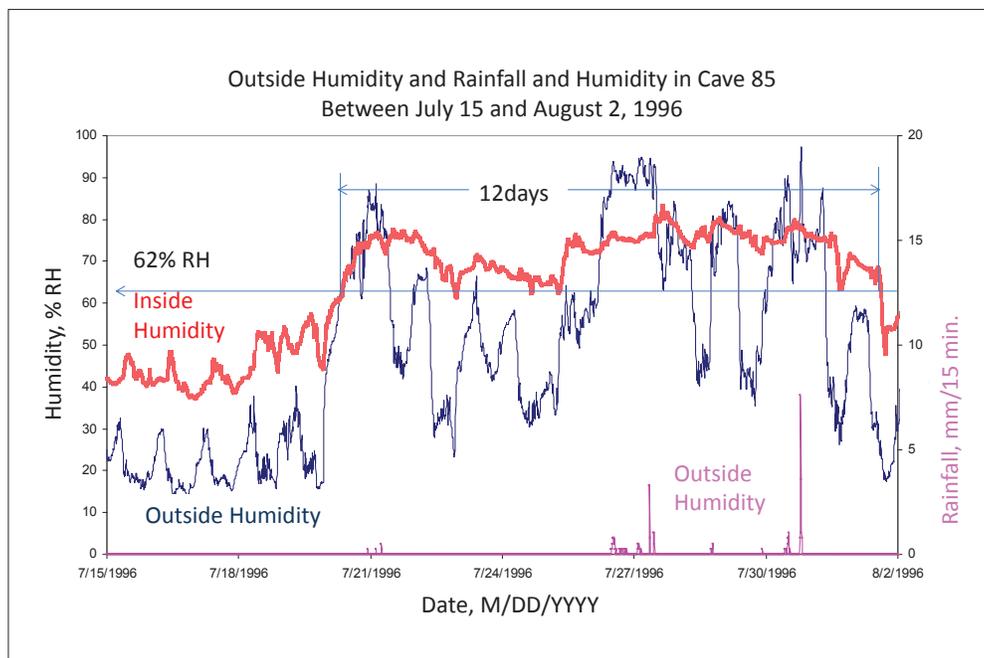

Fig. 4. In Cave 85 in 1996, 12 days of rain events led to sustained high RH within the cave as the exterior moisture infiltrated through frequently opened doors.
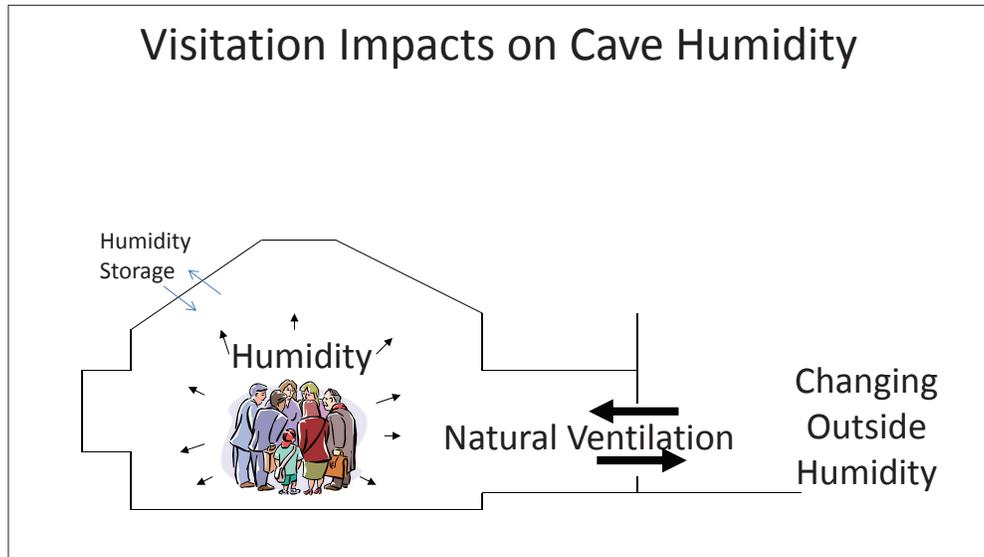
Fig. 5. Visitors generate humidity, heat, and carbon dioxide in a cave. With doors opened for visitor access, natural ventilation removes most of the CO_2 and humidity other than that absorbed by the cave walls and salts in them. If the external RH is higher than that in the cave the intrusion of humid air may raise the threshold above the not-to-be-exceeded value of 62%RH.

Fig. 6. Natural ventilation is measured by mixing a tracer gas (SF_6) with cave air and measuring its dilution over time. The rate depends on a number of factors (open or closed doors; outside temperature and wind, cave size and configuration).
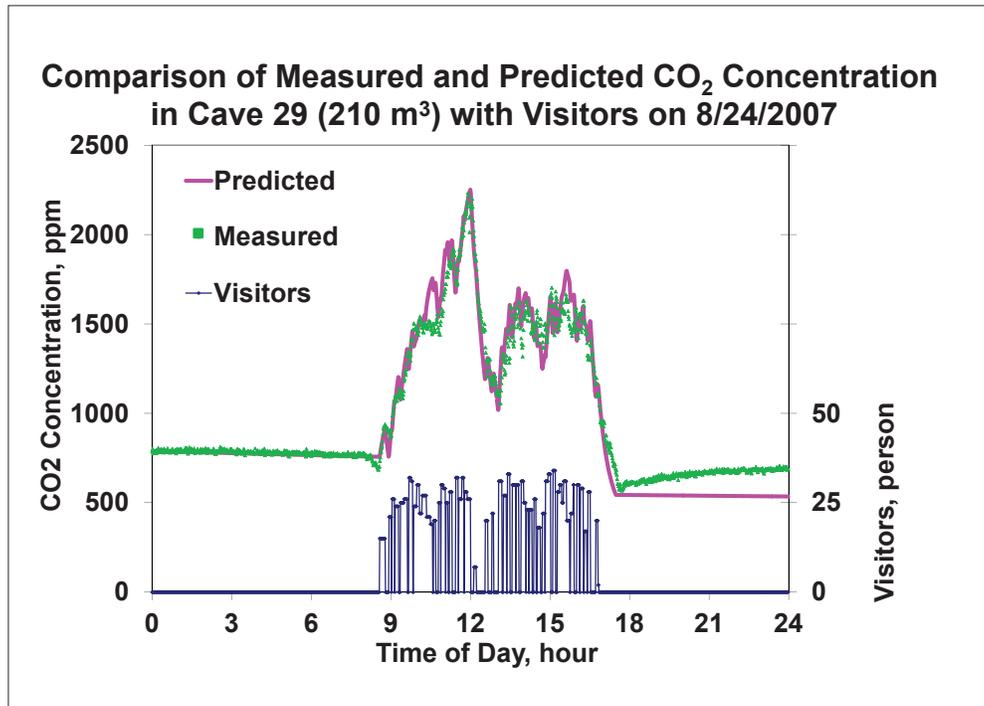
Fig. 7. This figure shows the measured effect of visitors on CO_2 concentration. The predicted values correlate closely and validate the model.

Assessment of Cave Condition and Visitation Potential for the Visitor Study

Lori Wong,[1] Wang Xiaowei,[3] Kiernan Graves[2] and Chen Gangquan[3]

[1] Getty Conservation Institute, U.S.A.
[2] Getty Conservation Institute, Consultant
[3] Dunhuang Academy, China

Introduction

Since the opening of the Mogao Grottoes to visitors in 1979, a total of some 112 caves have been open to the general public or special groups at various times. As a component of the visitor study research, outlined in the presentation by Agnew et al, an assessment of cave condition and visitation potential was undertaken by the Dunhuang Academy (DA) and the Getty Conservation Institute (GCI) for each of the visited caves (Fig. 1). The principal objective was to determine which caves could be opened to visitation based on their physical condition and their visitation potential.

The Assessment Process

The assessment is composed of two parts: physical condition or risk to the wall paintings and sculpture from possible visitor-related deterioration and damage; and, visitation potential which includes aspects important to the visitor experience such as significance, safety and access, physical capacity and CO_2 capacity for each cave (Fig. 2).

A protocol for systematic condition assessment and recording was developed to determine the potential physical risk to the wall paintings and sculpture from visitation. This process includes four steps: information collection, a preliminary assessment, an in situ assessment and report compilation (Fig. 3). From this, a risk level between 1 and 4 was assigned to each of the 112 caves and recommendations for the opening or closing of caves to visitation. At Mogao, the assessment of risk focuses on caves that are affected by salt-related mechanisms of deterioration. These caves, determined to be Risk Level 3, require temporary closure under specific exterior conditions of high humidity to prevent deterioration. Other risks from visitation to the wall paintings and sculpture include the potential impact of humidity fluctuations on fragile flaking paint layers, light and humidity on pigments and colorants susceptible to color change, and damage from visitors touching the paintings. Caves found to be at imminent risk of loss are placed in a Risk Level 4 group and are recommended to be closed to visitors.

Visitation potential was assessed by factoring in the significance ranking (A–D) for each cave determined by the age and rarity of dynastic representation, integrity (degree and extent of preservation of the paintings and sculpture), artistry, Buddhist iconography, and inscriptions. Also, safety and access issues related to the walkways or within a cave were identified, useable visitor space (defined as one meter from the cave walls, to decide whether a cave meets the physical capacity threshold for a standard group) was measured, and CO_2 capacity determined from air change rates as discussed in Maekawa et al.

Results

The assessment process provided key information on the condition and visitation potential for the 112 priority caves (Fig. 4 and 5). Results from the assessment—specifically, significance, safety and access, physical capacity, and risk level (Fig. 6)—were incorporated into the limiting conditions, along with other data from the visitor study such as CO_2 capacity, and integrated in the Visitor Management System developed by Kiran and Qware under contract to the Dunhuang Academy.

The resulting assessment data also serves other important roles including providing the most current information on the state of preservation for each cave which can be used as baseline documentation for condition monitoring, to help identify areas that require further investigation and recommendations for conservation planning. Taken together these serve as a basis for prioritizing conservation needs at the site.

Fig. 1. The assessment of physical condition and visitation potential is one component of the research and assessment strategy of the Mogao Grottoes Visitor Capacity Study.

Fig. 2. The cave assessment is composed of two parts: physical condition and visitation potential.
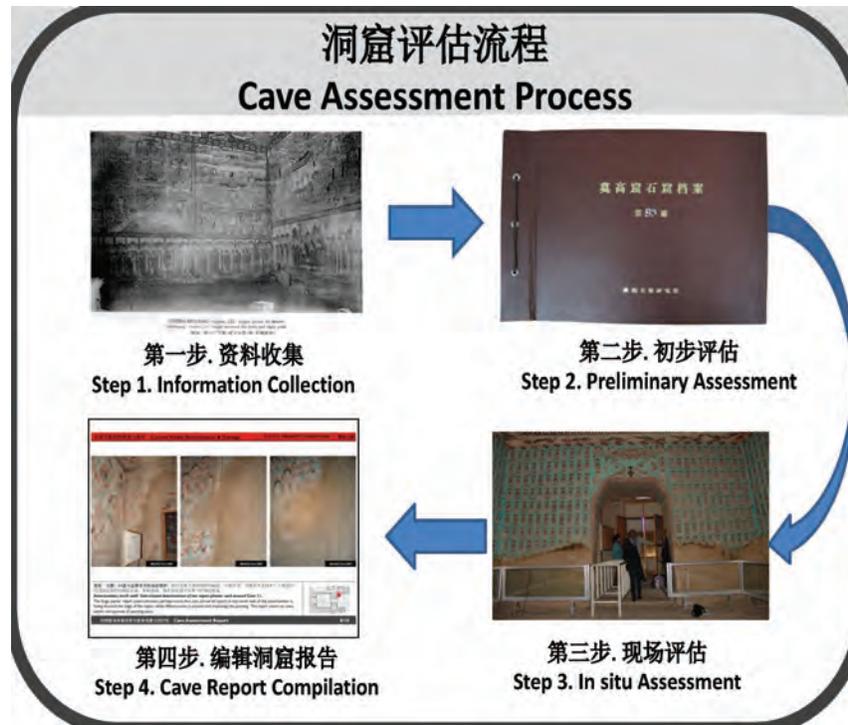
Fig. 3. The cave assessment process includes four steps: information collection, a preliminary assessment, an in situ assessment and report compilation.
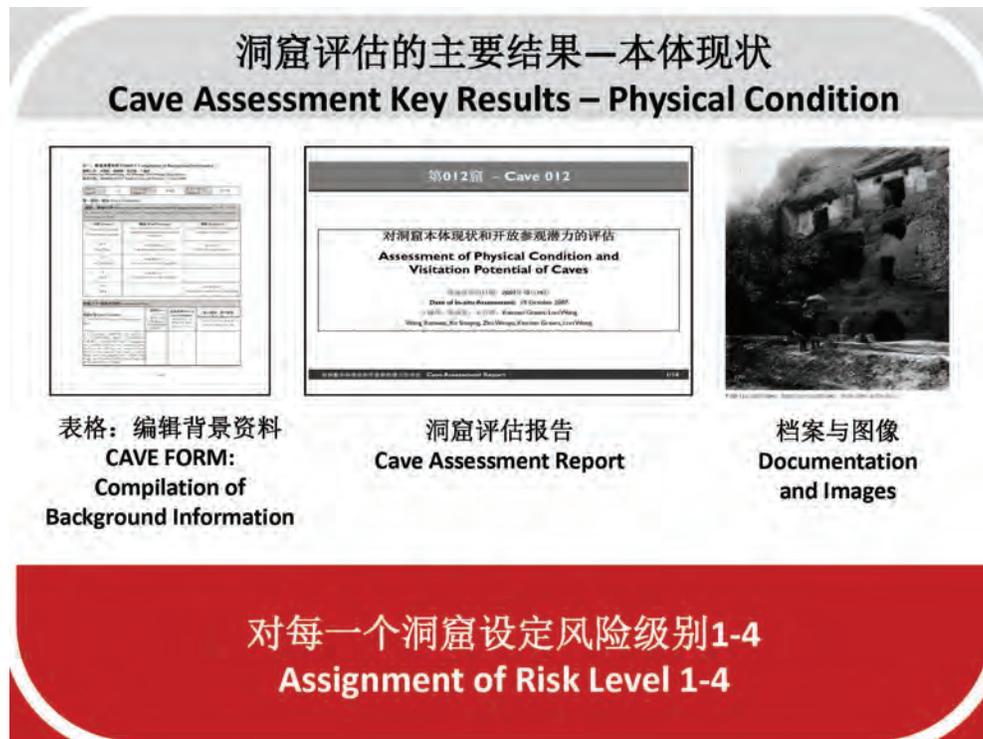
Fig. 4. Key results of the cave assessment include assignment of a Risk Level 1-4, a cave form that contains background information, a cave assessment report and documentation and images for each of the 112 caves
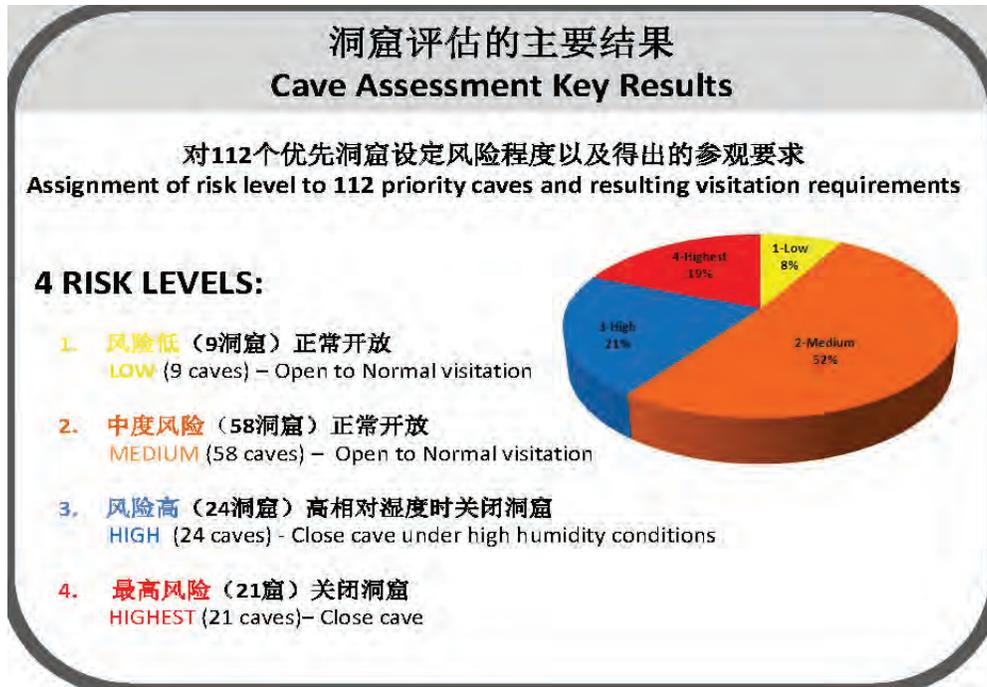
Fig. 5. Risk Level results for the 112 priority caves.

Fig. 6. Example for Cave 85 showing how results of the assessment of visitation potential and physical condition indicate whether or not a cave can be safely open to visitation.

Incorporating a Visitor Center into the Mogao Grottoes Visitation Model

Wang Xudong
Dunhuang Academy, China

According to forecasts, the number of visitor to the Mogao Grottoes will grow at an annual rate of 15%. It is of great urgency to limit the number of visitors in order to protect the fragile wall paintings and polychrome statues. However, we also have to meet the needs of tourists, to provide them with a good visitation experience. With the application of digital technology to show the arts of Mogao at the new visitor center, visitors can obtain most of the information about the Mogao Grottoes before visiting the caves. This will change the present visitation model, which carries out all interpretation provided by staff guides inside the caves. Utilizing this new visitation model interpretation at the visitor center will achieve a win-win relationship of conservation and visitation.

The Dunhuang Mogao Grottoes visitor center presently under construction and scheduled to open on September 10, 2014 is located at the northern boundary of the grottoes protection zone approximately 15 kilometers from the heart of the site (Figs 1 and 2). The center's primary function is to fully interpret through the use of digital technology the natural, historic and cultural conditions under which the caves were created and the Buddhist art of key caves from different historic periods. Prior to visiting the actual caves, visitors will gain basic background information thereby reducing the amount of time guides need to spend interpreting the caves in situ. This in turn will reduce the amount of time visitors spend in the caves and enable the daily visitor carrying capacity of the site to increase from approximately 3,000 visitors at present to a maximum of 6,000 visitors.

Results from the visitor capacity study and simulation modeling for the Grotto Zone (see Agnew et al. and Kiran et al. presentations) were used in the design of the visitor center with a daily capacity of 6,000 visitors. With the new center in place there will be dramatic changes to the visitation model. All visitors need to plan ahead of time before visiting the site and will be required to pre-book their visits over the internet or by phone. For special groups, such as senior citizens, experts and scholars, appropriate numbers of tickets will be set aside to meet their needs. Of course, we also need to

consider different operational models for the off-season, peak season and major festivals.

After the official opening of the visitor center (Fig. 3) in late 2014, prior to visiting the actual caves all visitors will watch two 20 minute long movies, a high definition digital movie 'The Millennium of Mogao' and 'The Dream of the Buddha Temple' to appreciate the historical and cultural background and profound Buddhist art of the grottoes (Figs. 4 and 5); then they will board a vehicle (operated by the DA) and proceed to the grottoes; every 15 minutes up to 200 people will be arriving at the grotto site. During the trip visitors in groups will be handled differently than individual visitors. Guides will take a group of 25 visitors through the site on pre-determined routes and the total amount of time that visitors spend in the caves will be reduced to half that of the present visitation model. After visiting the caves, the visitor can self-guide to the Exhibition Center, Museum of the History of the Dunhuang Academy (in the Upper Temple and Middle Temple), while in the future, self-guided tours of caves in the northern grottoes will also be available (Fig. 6). At the end of the visit visitors will board vehicles and return to the visitor center for souvenir shopping or dining. The entire visit to the site will extend the 120 minute period that visitors presently spend at the site to 150–180 minutes. However the total amount of time that visitors spend inside the caves will be reduced to approximately 60 minutes, but the advantage will be their access to more information.

In order to ensure smooth implementation of this visitation model, the following requirements must be met: a strict reservation system; apart from special holidays the maximum number of visitors at the Mogao Grottoes must be controlled at less than 6,000; through a variety of media, such as television, newspapers, the Internet, mobile Internet, outdoor advertising etc., to fully inform the public of the visitation management model in a timely manner, and thereby obtain their understanding and support; last, use of good software and scientific operation and management of the site visitor center.

This model reduces the potential threat posed by visitation to the fragile wall paintings and statuary in the Mogao caves as well as providing a more diversified and enhanced visitor experience. Moreover, the visitation model will allow us to reach our goal of providing cultural tourism to the international community in a responsible manner.
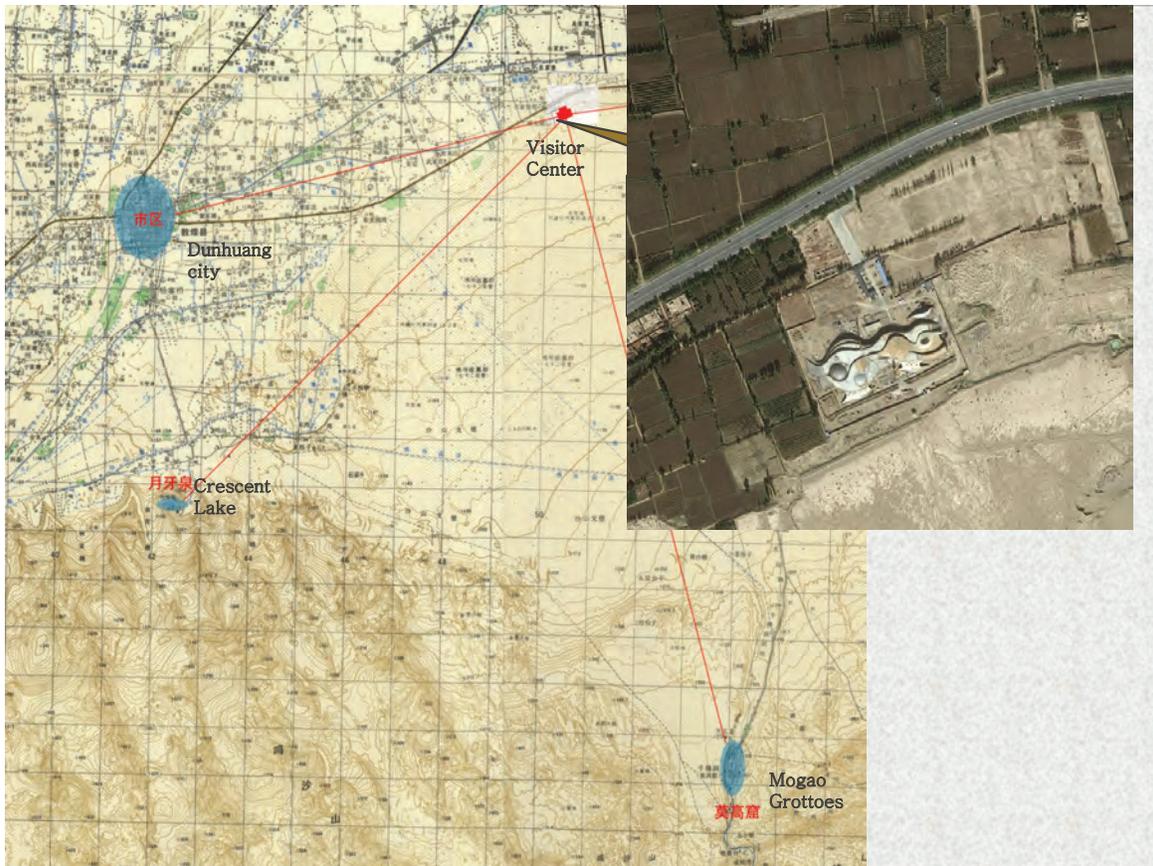
Fig. 1. Location of the Mogao Grottoes visitor center (red dot) in relation to Dunhuang city (big blue dot), the Mogao Grottoes (mid size blue dot), and the Crescent Lake (small blue dot) with aerial view of the Visitor Center inset.

Fig. 2. View of the Mogao Grottoes visitor center during final construction.
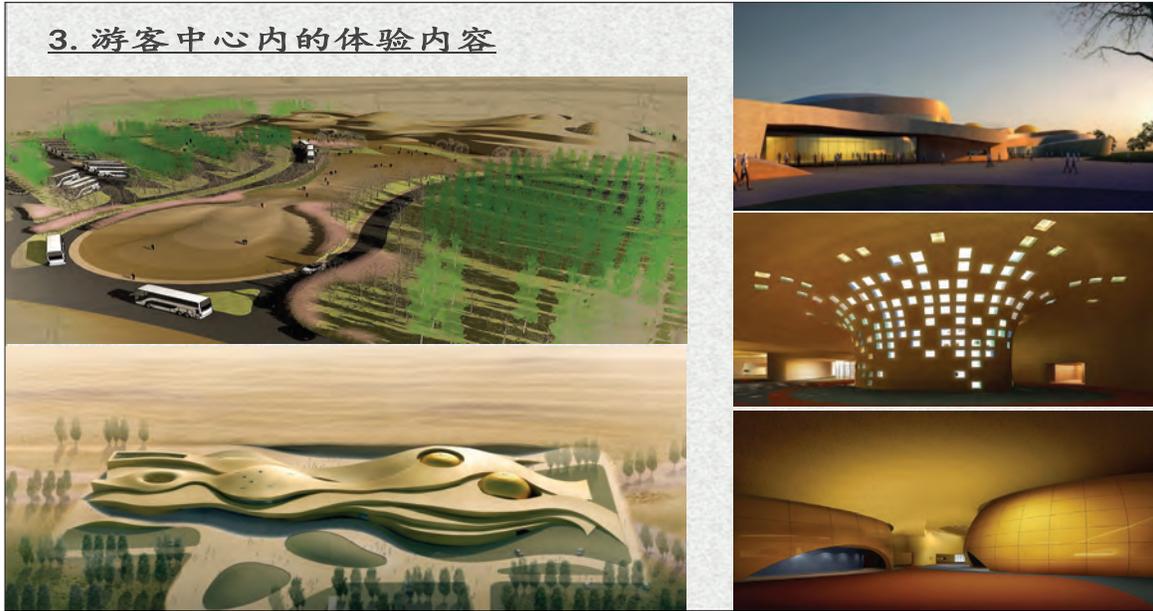
Fig. 3. Computer renderings of the exterior and interior of the visitor center when complete.

Fig. 4. Computer rendering of the interior of the digital theater.
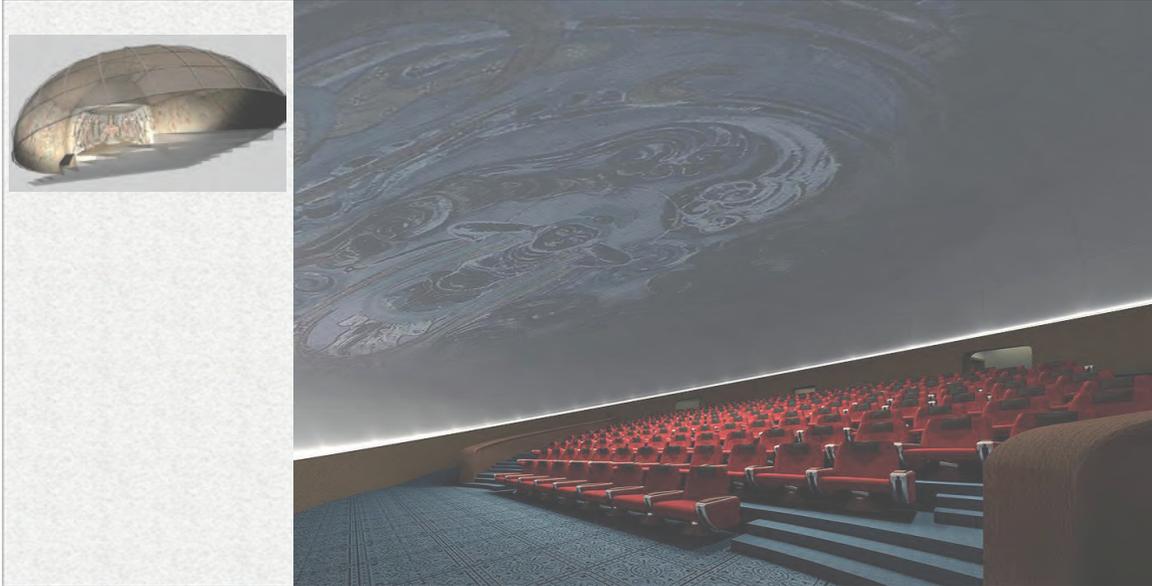
Fig. 5. Computer renderings of the interior of the dome theater.

Fig. 6. After visiting the caves, visitors will be free to walk around the Exhibition Center, Academy History Museum, and the Northern Grotto area.

Exploration and Practice of Visitor Management at the Grottoes

Li Ping
Dunhuang Academy, China

Visitation at the Mogao Grottoes is limited by the following two factors: visitation is highly seasonal with the vast majority of visitors concentrated in a very short period (Figs. 1 and 2) and physical space available for visitation is extremely constrained. How do we balance these constraints of the time and space?

Use of a booking system

Implementing a booking system: in peak tourism seasons we have implemented a booking and visitor number forecasting system. The booking system was originally done manually by booking on the telephone. We then gradually implemented an online booking system and a SMS service. We have also set up a dedicated booking center in the Dunhuang central business district. We aligned booking times of both groups and individual visitors to cater better for their preferences while at the same time achieving a more even spread of visitor numbers over the entire day.

Outcomes of implementing a booking system:
- In the high seasons the booking system plays an important role in regulating visitor flow evenly throughout the day over the full range of time slots available (Fig. 3).
- Provides a great deal of information about visitors.
- Has developed into becoming an effective means of monitoring the micro-environment of the caves.

Issues that need to be resolved:
- In 2005, 95% of visitors who made reservation were from tour groups; but individual travelers still present a problem for the Reception Dept. of the Dunhuang Academy.
- Individual tourist numbers have grown significantly since 2010, while tour groups have decreased dramatically. The number of visitors from tour groups comprised 68% of the total numbers of visitors in 2006; that number dropped to 33% in 2012. The number of individual tourists was 32% of the total numbers of visitors in 2006; that number

increased to 67% in 2012. Figure 4 shows the increasing number of visitors yearly.

Time slots: We devised a plan for the allocation of time slots for the following day based on the number of group bookings that were received for that day: we find that if we multiply the numbers of visitors who made group bookings by 2.5 then we obtain a reasonably accurate estimate of the number of individual travelers we can expect to receive. Improving group bookings and a major adjustment to time slots allocated to group bookings opens up more time slots that then can be allocated to individual travelers.

Space: We open as many caves as possible to visitors: 40 open caves + 20 optional caves + ten special caves. Dispersing visitors across the entire site through two separate routes each running in a single direction assists visitor flow.

Strategies for coping with a sudden unexpected surge in visitor numbers
During peak seasons visitor management uses past experience to continually adjust and improve visitor flows so that there are no bottle-necks or unreasonable delays (Figs. 5 and 6). During peaks, especially on days when we can expect a large surge in visitor numbers, visitors need to be effectively dispersed across the entire site to reduce the pressure on the caves. This is done by an increase in the number of routes.

In 2012 we started to implement a system of dividing the Grotto Zone into separate areas each with two continuous separate routings running in a single direction (Fig. 7). Visitors enter the Grotto Zone either from the south entrance or the north entrance which we have found is effective in regulating the congestion problem on days with a sudden spike in numbers. Visitors who enter the grotto zone from the north entrance visit the caves on the upper tier tour route while those who enter from the south entrance visit the caves on the lower tier tour route. This separation has decreased tour crossover points and has shortened waiting times to enter the grottoes. It has also reduced pressure on the caves and has improved the micro-climate inside the caves.

Visitor throughput capacity is limited to about 3000 people in the Grotto Zone in the high season and visitors are dispersed on the upper and lower tier tour routes by using the pathways outside the caves. Caves that are open to visitation have a micro-climate monitoring system installed (see Su Bomin

and Dong Yabo presentation) and caves can be closed and others opened with little reorganization should environmental conditions established by the visitor capacity study be reached (see presentations of Agnew et al and Maekawa et al.). For example: Caves 172, 328 and 419 are typically open only half a day, and other caves may have to be closed temporarily during the course of the day because of low CO_2 capacity.

Strategy for dealing with the very high visitor numbers during the National Day (October 1) Holiday Week

Two continuous separate routes running in a single direction and 20 open caves with staff guides stationed inside the caves rather than taking groups around individually and providing continuous narration. Strict controls are place on the number of visitors allowed to enter the Grotto Zone at different time slots both for the safety of visitors and the protection of the site.

Monitoring visitor flow at the two entrances and the key sections in the Grotto Zone in real-time and restricting the number of visitors in the Grotto Zone to 2000-2400 people means that each tour route has a capacity of about 1000-1200 people (this includes visitors in the Library Cave Exhibition Hall, lining up to enter the Grotto Zone at the two entrances and visitors walking on the walkways outside the caves).

Management strategies for must-see caves in the Grotto Zone

We have set up interpretive panels outside the "must-see" caves. Guides give the commentary outside these caves. The visitation experience for these caves is akin to a quick walk around (Fig. 8) rather than a detailed visit which shortens visitation time (from 5 minutes to 3 minutes) and improves the microclimate in the caves.

Fig. 1. Excessive number of visitors during the Golden Week holidays in October 2012 caused long queues and waiting time to enter the Grotto Zone.

Fig. 2. Visitors queuing for the 'must see' Cave 148 during the Golden Week in October 2012.

莫高窟实施预约制前后游客流量对比 Visitor flow pattern before and after applying the reservation system								
	8—9	9—10	10—11	11—12	12--13	13--14	14--15	15--16	16-17
2004年9月22日	133	396	630	400	131	1387	635	284	136
2005年9月11日	596	653	874	580	734	711	374	513	261
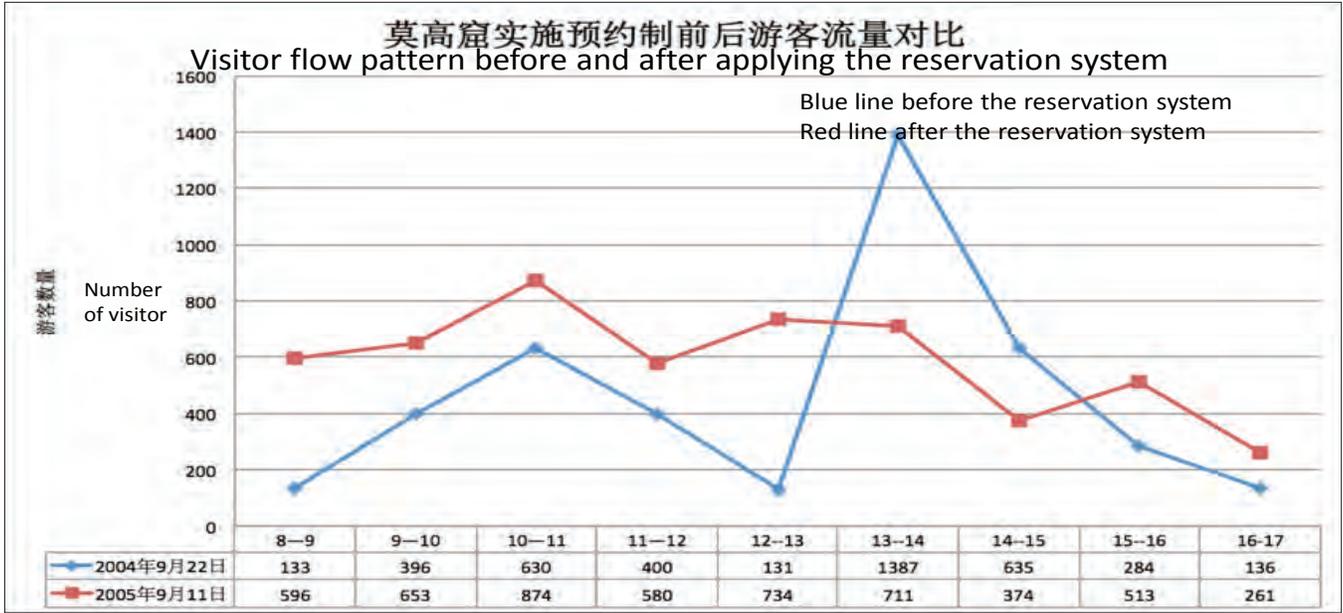
Fig. 3   Graph shows the daily flow of visitors before (blue line, September 22, 2004) and after (red line, September 11, 2005) a reservation system was implemented, resulting in a reduction in the peaks and troughs throughout the day.
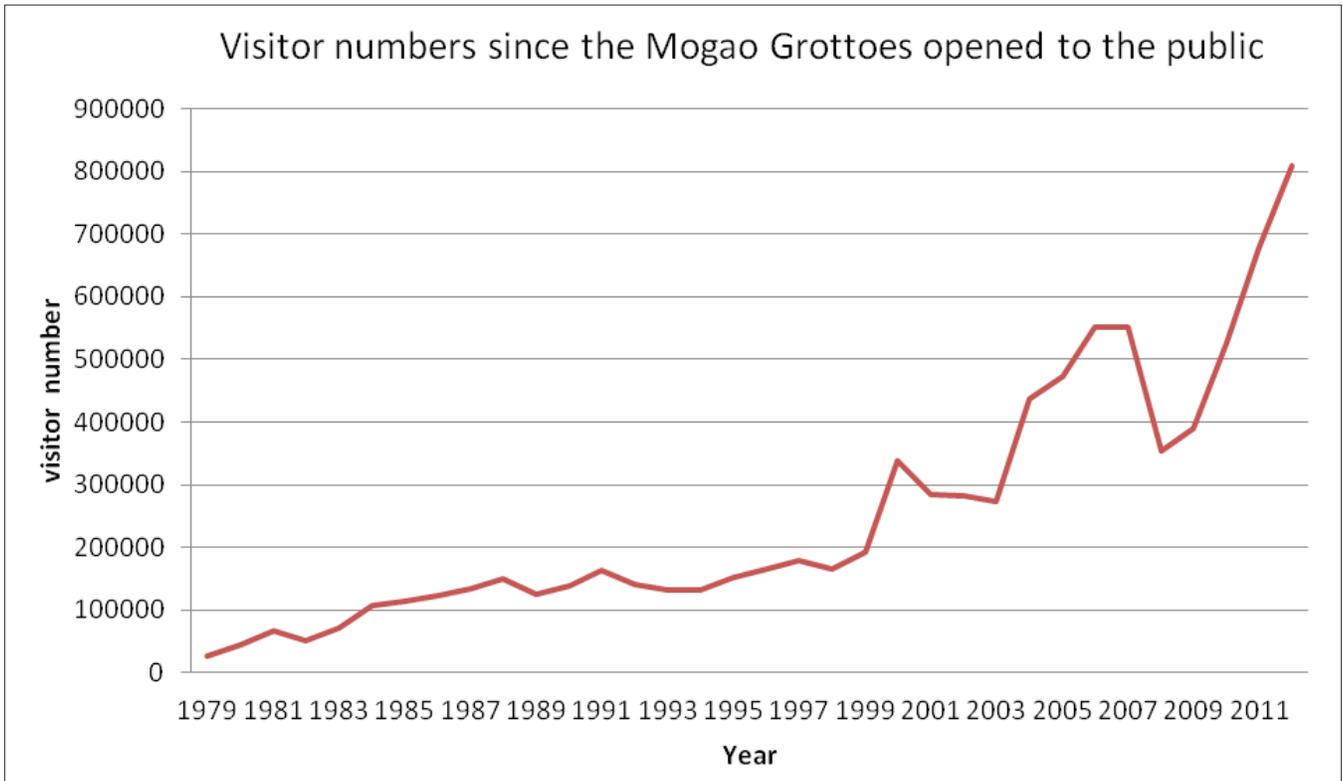
Fig. 4. Visitor numbers since the Mogao Grottoes opened to the public. Temporary declines in numbers in 2003 and 2008 are due to SARS and global economic downturn respectively.

Fig. 5. Dunhuang Academy staff member wearing a shirt with 'ASK ME' written on it to encourage visitors to ask for help.

Fig. 6. Dunhuang Academy staff conducting a visitor satisfaction survey

Fig. 7. During peak periods one-way tour routes are implemented to ease congestion on the walkways and stairs.

Fig. 8. Visitation to the 'must see' Cave 148 with the Nirvana Buddha, which has a long, narrow chamber, is changed to a continuous single-file flow pattern when daily visitor numbers exceed 4000.

IOT*-based Risk Monitoring and Control System

Su Bomin[1] and Dong Yabo[2]

[1] Dunhuang Academy, China
[2] Zhejiang University, China

Wall paintings at the Mogao Grottoes face various risk factors such as environmental deterioration in the caves caused by visitation, moisture from the rock and air, and erosion of the cliff rock body caused by wind and sand abrasion (Figs 1–5). Among all such factors, the change of micro-environment such as air temperature and humidity in the caves is one of the most important causes of mural degradation (see Agnew et al. and Maekawa et al. presentations). To effectively protect the art and balance the contradiction between conservation and utilization, we must adopt methods of preventive conservation. Through real-time monitoring of the surrounding environment, and microclimate in caves, the condition of the paintings and tourist numbers, we can effectively regulate and control the cave micro-environment and visitor numbers, which can help to slow down degradation and assure long-term conservation.

However, because the caves are of various size and shape, it is not allowed to deploy cables in the caves and traditional wired monitoring techniques cannot be used. Furthermore, traditional wireless monitoring devices are not reliable in the long-term because of the power supply and signal attenuation problems.

In view of the special requirements for the mural conservation, we are designing and developing an IOT-based monitoring and control system (Figs 5–9). Through the integration of an existing automatic meteorological station and a sandstorm monitoring system, we are establishing an enhanced meteorological monitoring system. In the near future we will develop an early warning system for flood disaster by monitoring the water flow of the Daquan River.

---

*"Internet of Things" refers to a network of real-world objects linked by the internet and acting through on-line services.

The micro-environmental monitoring system in caves consists of low power wireless sensors, wireless gateways and data service management software. The low power wireless sensors are responsible for collecting micro-environmental parameters such as air temperature, humidity and carbon dioxide, transmitting the data to the wireless gateways deployed outside the caves by means of a wireless ad-hoc network, which can overcome signal blocking problems caused by the various shapes of caves. The wireless sensor can work continuously more than one year powered by two AA batteries, which dramatically reduces the maintenance cost. The wireless gateway uploads monitoring data to the data service management software, which provides visual functions such as data analysis and storage, inquiry statistics, warning of cave micro-environment, and also the live management of monitoring devices. Management staff can thus know the situation in the caves and respond without delay.

Excessive visitation is a great risk for murals and also the health of tourists. Because of this, we established a real-time tourist monitoring system based on 25 persons per tour group. The system adopts an active RFID technique to locate the site guides in real time to obtain accurate data on tour groups entering and leaving a cave, through which the accurate number of tourists in each cave and the distribution of tourists in the whole site can be instantaneously known. This information is necessary for an intelligent visitor route scheduling system, to be implemented in the near future.

Normally the change resulting from wall painting deterioration is a relatively slow process. To build a long-term monitoring base, we established an image monitoring system through regular photography of selected areas and archiving. Changes provide support for conservation and study. Furthermore, we will develop wireless image sensors and an image matching software system to improve the automation of monitoring and the accuracy of identifying changes.

To reduce the influence on micro-environment in caves caused by the meteorological environment and visitors, we are developing a micro-environment automatic adjustment system. Previous research has proved that the clean and relatively dry air is favorable for preservation of the murals. However, visitors and rainfall both increase the air humidity in caves. For such conditions, it is necessary to separately increase or decrease the air exchange rate to ensure that the micro-environment in caves can quickly reach or maintain a reasonable range. Thus, the micro-environment automatic adjustment system should determine the optimal air exchange rate according

to the data from environmental monitoring inside and outside of caves, and automatically adjust the vent opening and fan speed to actively regulate the air exchange rate, in order to accomplish stabilization of the micro-environment.

Next we will further improve the Mogao Grottoes environmental and image monitoring system. On the basis of the accumulation of massive monitoring data, we will carry out a multidisciplinary crossover study. Through the study of techniques such as intelligent data analysis processing, massive data mining and reduced-order modeling under conditions of incomplete sampling, and in combination with material science research, we will try to reversely establish the model between the murals physical condition and various risk factors, revealing the evolution of cultural relics condition and the internal and external reasons for deterioration, thus laying the theoretical foundation for the preventive conservation of cultural heritage.

Fig. 1. Main risk factors including natural forces and manmade activities threaten the Mogao Grottoes.

Fig. 2. Sand migration and pile up at the Northern Grottoes.

Fig. 3. Big chunk of stone blocks separated and fell from the cliff face rock body.

Fig. 4. Visitors crowd inside and outside of caves and flood impacts the site.
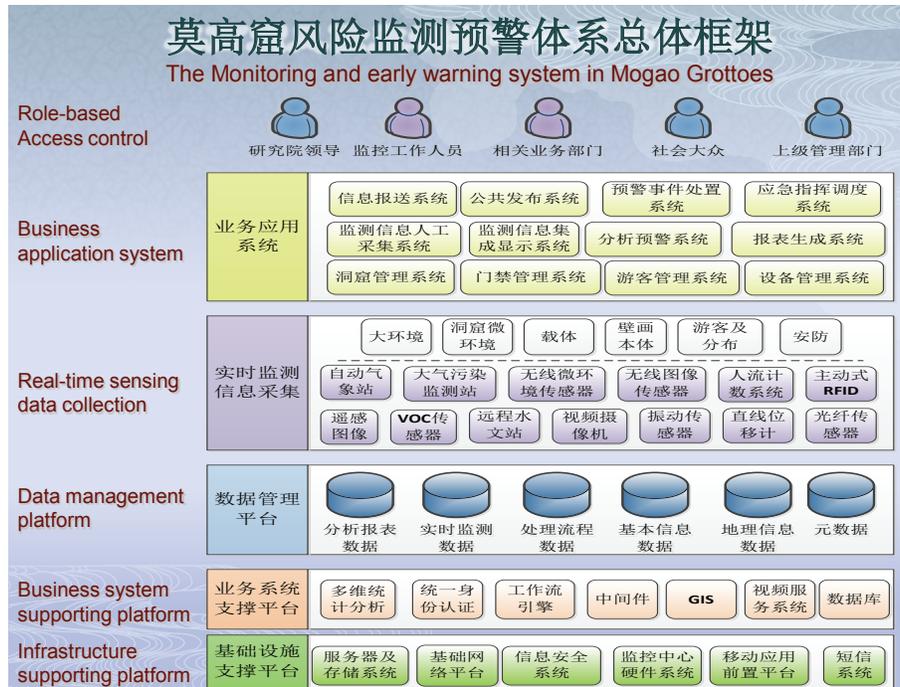
Fig. 5. The framework of the monitoring and warning system which may be implemented at the Mogao Grottoes includes business application system, real–time sensing data collection, data management platform, business system supporting platform, and infrastructure supporting platform and can be accessed by stakeholders.
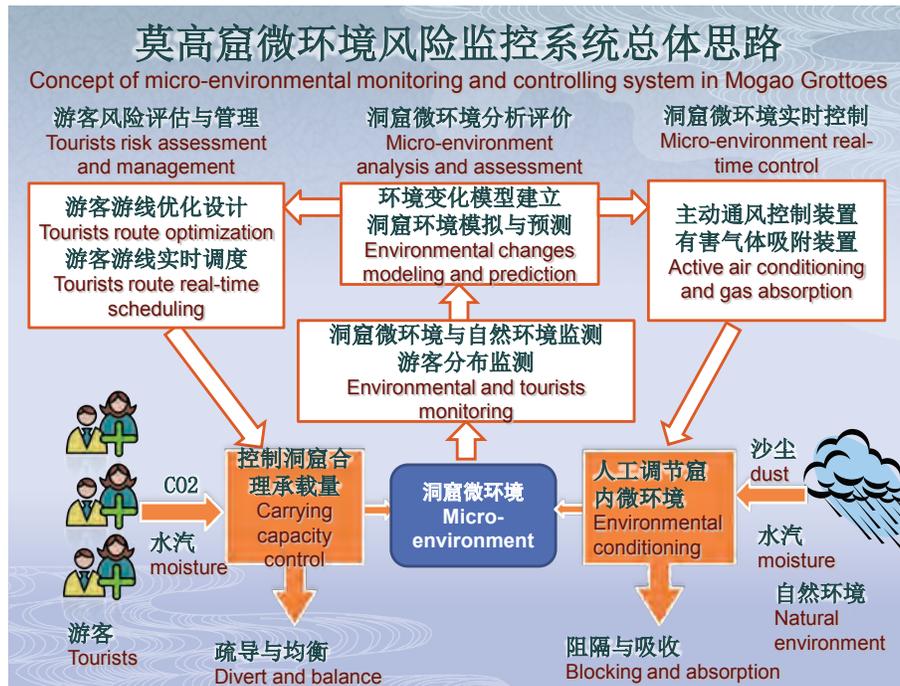
Fig. 6. Concept of micro-environmental monitoring and controlling system at the Mogao Grottoes
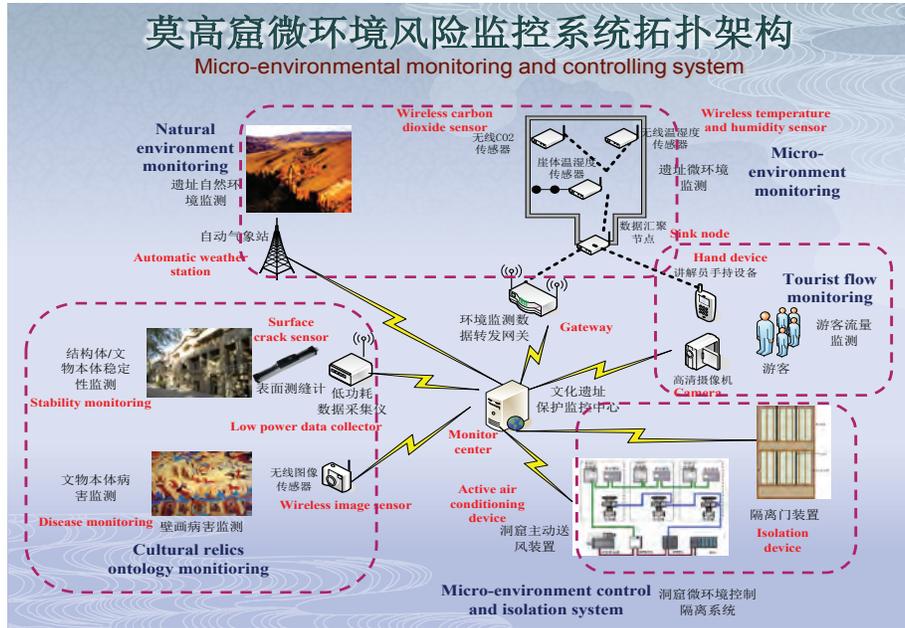
Fig. 7. The framework of the micro-environmental monitoring and controlling system at the Mogao Grottoes
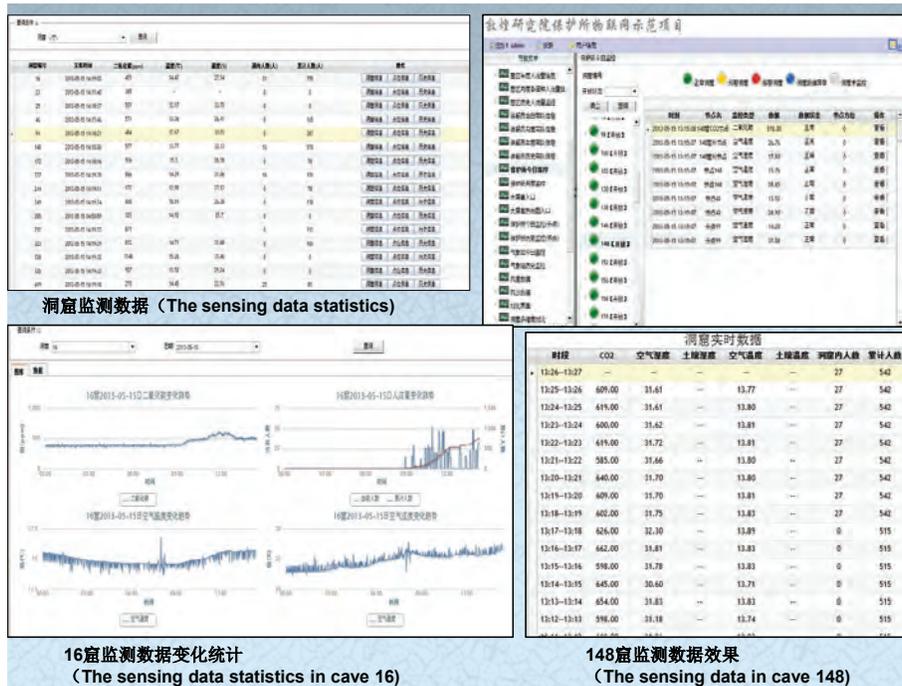
Fig. 8. Data showing on the monitoring screen at the Conservation Institute. The upper left shows real-time cave temperature, humidity, carbon dioxide, visitor number and accumulated visitor numbers of each cave. The lower left shows the same data in Cave 16. The upper right shows real-time data reading from each sensor at Cave 148. The lower right shows the real-time average environmental data at Cave 148.
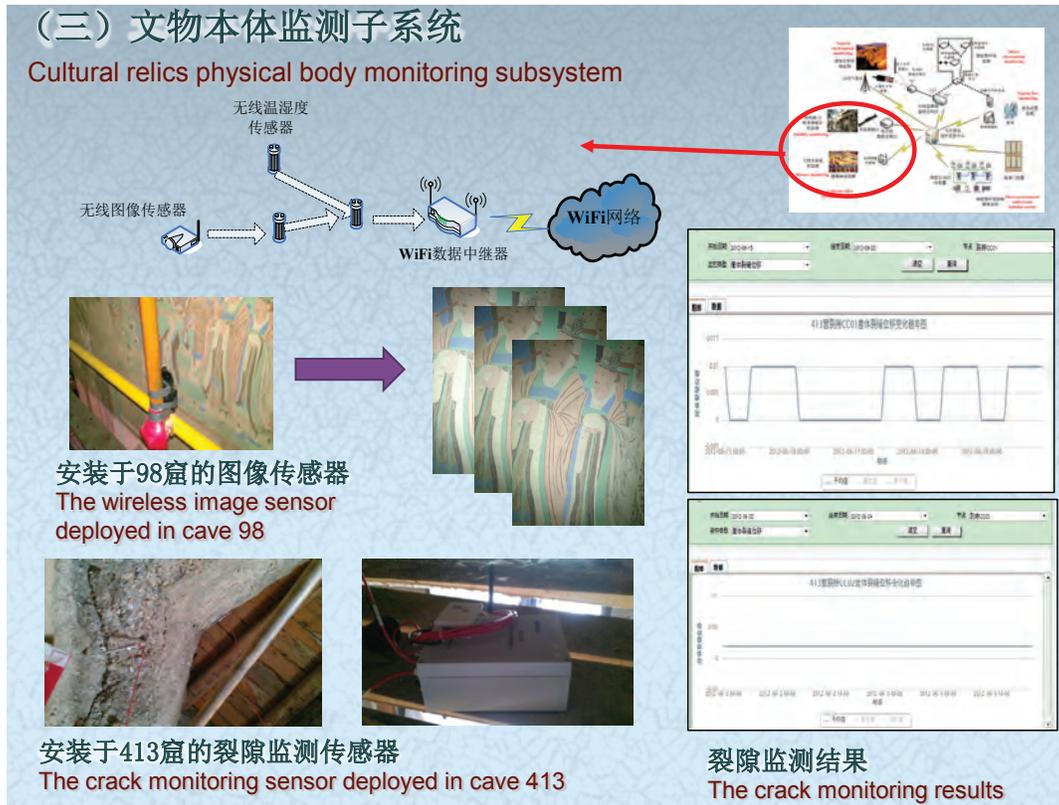
Fig. 9. The grotto monitoring system including painting condition and crack movement monitoring systems.

An Integrated Visitor Management System for the Mogao Grottoes

Ali S. Kiran,[1] Celal Kaplan[1] and Jiang Ping[2]

[1] KIRAN Consulting Group, San Diego, California, U.S.A.
[2] QWARE, Hangzhou, China

Introduction

The new Integrated Visitor Management System (IVMS) was developed for the Mogao Grottoes, Dunhuang by KIRAN Consulting Group and QWARE (the team) for management of the day-to-day visitor activities. This presentation explains the functionality and benefits of this integrated approach to the visitor flow issues.

The system has four modules:
- Ticketing and Reservations
- Forecasting
- Tour Creation
- Simulation/Tour Optimization

The visitor center management system is an integral part of the construction of the Visitor Center. Through implementation of this system, the following objectives will be achieved:

1. Regulation of visitor arrival volumes between the peak and off seasons
2. Effective distribution of visitor arrivals throughout the day so that the site's visitor carrying capacity will not be exceeded during any part of the day
3. Ensuring that the flow of visitors is smooth and organized after completion of the Visitor Center
4. Offering visitors complete and comprehensive service
5. Optimizing the tours to minimize visitor's environmental impact on the site
6. Monitoring of the cave conditions and alerting operation managers to insure conservation of the fragile caves

The IVMS not only handles the basic functions such as reservations and ticket sales but also integrates the cave monitoring systems and visitor tour optimization capabilities. In order to protect the caves, it is necessary to ensure that the carbon dioxide and humidity levels inside the caves stay below the safety thresholds and that the cave's static carrying capacity is not

exceeded. This requires integration and utilization of the visitor flow systems and cave monitoring systems. At the heart of the system is a unique cave tour optimization model which ensures cave preservation in terms of exposure to environmental factors such as carbon dioxide, while maximizing the visitor experience by covering a wide range of cave types and minimizing the wait times. The system incorporates data from the Getty Conservation Institute-Dunhuang Academy visitor study (see Agnew et al. presentation).

The project team, comprised of Dunhuang Academy, KIRAN Consulting Group and QWARE experts, performed a detailed visitor flow analysis in order to design and develop the optimization software to demonstrate different visitor traffic scenarios.

Due to the high variation of visitor traffic between the peak and off seasons in Dunhuang, the visitor reservation system's main goal was to increase the number of visitors per day during the off-season and to therefore improve resource utilization and reduce costs. Different management models for the different peak and off season scenarios were then developed as follows:

1. Peak season (4000-6000 visitors)
2. Midseason (1000-4000 visitors)
3. Off season (< 1000 visitors)
4. High-peak season (> 6000 visitors)

Once the Visitor Center is complete in late 2014, up to 6,000 visitors will arrive at the Mogao Grottoes daily, during the peak season. In addition to the existing attractions, the Mogao Grottoes Tour will feature a Reception Hall, Digital Movie Theaters, Theme Theaters and several other attractions including rides, interactive exhibition halls and other optional tours. Compared with the existing visitor experience, the complexity of operations will be greatly increased.

The Integrated Management System will help the Visitor Center managers effectively manage and organize the tourists and optimize the visitor experience while minimizing the costs and environmental impact on the caves.

Ticketing and Reservations
The ticketing and the reservation system distributes visitor arrivals throughout the day so that the site's visitor carrying capacity will not be exceeded during any part of the day. The module ensures that the flow of visitors will be

smooth and organized after completion of the Visitor Center.

Forecasting Module

The forecasting module forecasts visitor traffic through the year. Its use will provide for maximum Tour Guide utilization and ensure that congestion and overcrowding of the Visitor Center does not occur.

The system incorporates the following factors to generate accurate forecasts:
- Year-to-year trends
- Seasonality, weekly changes in the demand
- Weekday, day-to-day changes in the demand
- Hourly arrival patterns within a day

The module continuously updates the above factors as new data arrives by giving higher weight to the newest data and keeps the model up-to-date. The system is integrated with the reservation system, tour creation and optimization systems.

Tour Creation

Tour creation is the most critical component of the integrated system where the main intelligence lies.

A tour is defined as a sub-group of caves that a visitor group visits in a set-sequence. The tour creator generates a number of tours that can be assigned to different visitor groups. When creating the tours, the system considers the environmental risk factors to the caves (humidity levels) and the visitor health (CO_2 levels), as well as the factors below, all simultaneously:
- All the tours include the "must-see" caves, that is, the caves that all the visitors want to see.
- All tours include caves from every major historical period (early, mid and late dynasties).
- Ensures that the caves have sufficient physical capacity (area) to handle the target visitation levels.
- Walking distances are minimized. Caves that necessitate extensive walking or the use of stairs are not included in the same tour, if possible.

Minimizing walking distances is considered a difficult problem (NP-Complete) in the operations research field. Additional constraints compound the difficulty of the problem. The team used an Artificial Intelligence based search algorithm (Ant-Colony System) to generate near optimal solutions to the problem.

The tour creation module has two major groups of inputs:
- Cave information (Fig. 1): Cave information that the model uses was compiled through years of research by the Getty Conservatory Institute in conjunction with the Dunhuang Academy as part of the visitor capacity study (see Agnew et al presentation)
- Path Networks (Fig. 2): Once all the inputs and target visitation levels are entered, the module creates tours.

Simulation/Optimization Module

Once the tours are created, the simulation module tests tour performance under either the actual visitor reservations or the target demand and predicts the system performance. The module also has the capability to optimize the tour steps based on the actual cave state and generates an optimized tour sequence for individual groups (Fig. 3).

This system can be adjusted to simulate only the grottoes area or the whole system including transportation to and from the Visitor Center. The user can omit or adjust the use of the environmental factors through the user interface. Once the program is run, the results are uploaded onto the Oracle database, and a number of reports are generated.

Run Time:	5/17/2013 14:36				
Number of Groups:	280				
Average Visit Time:	167.65				
Maximum Visit Time:	235.31				
Average Wait Time:	51.90				
Maximum Wait Time:	113.62				
Average Walk Time:	114.58				

Cave No	Average Wait	Maximum Wait	Number of Groups	Average CO2 Level	Maximum CO2 Level
16	0.16	2.45	280	586	1,035
23	-	-	17	414	1,846
79	0.58	5.50	63	529	1,684
94	0.12	3.37	280	535	810
100	0.03	1.63	86	807	1,109
103	-	-	-	-	-
130	0.06	3.24	280	1,168	1,308
138	-	-	-	-	-
146	-	-	-	-	-
148	46.94	103.86	280	1,499	1,535

As shown in the sample simulation table, the results reveal the cave congestions, wait times and the CO_2 levels. When the CO_2 levels are used as a constraint, the system will always keep the CO_2 levels under the target level, and reveal the resulting wait times (Fig. 4).

Besides the above, a number of detailed reports that list the individual group movements, shuttle requirements and tour guide requirements are generated. Using the tool, the Academy can make adjustments to its operations and enhance the visitor experience by;

• Reducing the visitation times in the most critical caves.
• Eliminating some of the must-see caves under the extreme demand periods.
• Adopting a continuous visitor flow through a bottle-neck cave such as 148, as described in Li Ping presentation.
• Using technology to improve the air circulation to reduce CO_2.

Conclusion

IVMS is an integrated system that utilizes sophisticated planning tools combined with valuable years of research in cave preservation. By using the system, Dunhuang Academy will be able to conserve the Mogao Grottoes, a UNESCO World Heritage site and ensure a positively enhanced world class visitor experience. This solution, pioneered at the Dunhuang Academy, is a technologically state-of-the-art model adaptable to other World Heritage sites on the globe.

Fig. 1. Cave information that the model uses was compiled by the Getty Conservation Institute in conjunction with the Dunhuang Academy.
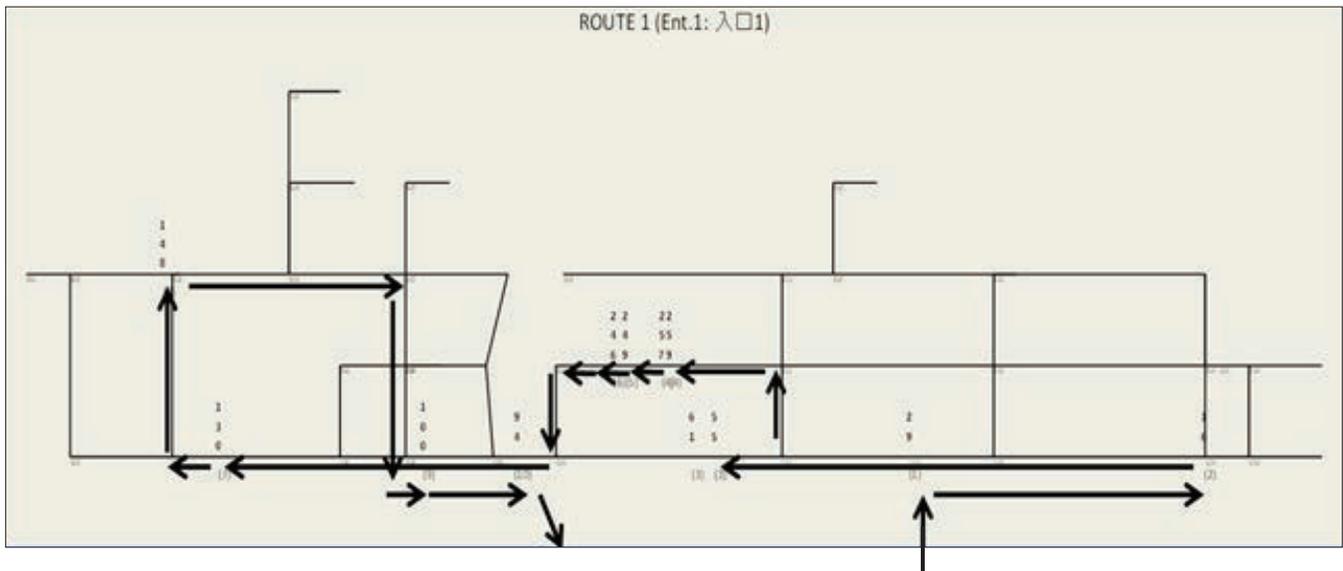
Fig. 2. A Sample Tour of caves (numbered) overlaid on the visual representation of the Path Network.

Fig. 3 Simulation interface.
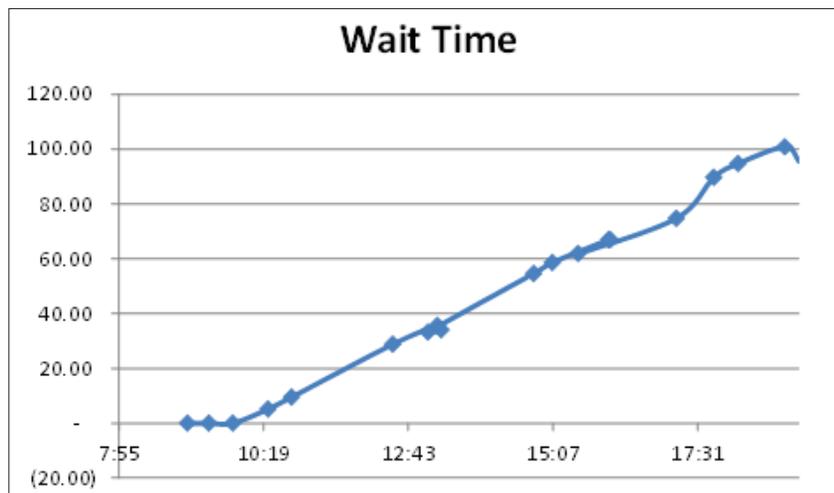
Fig. 4. Wait times for 'must-see' Cave 148 under a heavy visitation day scenario.

Petra as Bellwether World Heritage Site

Douglas C. Comer

Cultural Site Research and Management, Inc., U.S.A.

The number of visitors to the Petra World Heritage Site (Fig. 1) in southern Jordan has increased from about 40,000 per year at the time of its inscription on the World Heritage List in 1985 to almost 1,000,000 per year in 2012. Inscription was the central and essential factor in this dramatic increase; other factors included highway construction, massive tourism campaigns (sponsored in large part by USAID), and the use of Petra as a backdrop in movies. Petra is now an important economic engine, accounting for the lion's share of Jordan's tourism revenue, with tourism in most of the past ten years generating more income than the other leading industrial sector in Jordan, mineral extraction. I review here the damage done to irreplaceable and non-renewable archaeological materials as a result of what has become mass tourism, the physical processes that have produced this damage, and the reasons for the absence of effective management that have set these processes in motion. I also suggest a strategy and a specific project that might slow or arrest the further deterioration of cultural resources within the Petra World Heritage Site.

Unregulated development around Petra has altered the hydrology of the region by introducing large areas of impervious surfaces. Because of this, rainfall, which is slight on a yearly basis but sporadically heavy, is channeled into the ancient city. The water carries salts that disaggregate the sandstone in which the famed tombs of Petra were carved. It also finds its way into small fissures in tomb facades, which spall away as water freezes and thaws. Flooding also washes away subsurface archaeological remains. Insufficiently regulated visitor flow through the site has produced fluctuations in temperature and humidity that also disaggregates sandstone. In the absence of effective visitor management, tourists abrade sandstone and topple ancient walls by climbing and sitting on them (Fig. 2). Vandalism and looting have also taken a toll on archaeological materials.

Admitted 13 years after the 1972 World Heritage Convention, the Petra nomination dossier consisted of a few hurriedly prepared pages, which did not address management capacity. The site was inscribed despite the fact

that an ICOMOS reviewer urged that it not be admitted until, at the least, the boundaries of the site had been firmly established. A buffer zone around the site was an afterthought, and that which was established a few years ago was too late to prevent development of impervious surfaces upslope from the site. Also, by then, numerous structures that visually intrude upon the ancient city had been erected.

Ever larger numbers of visitors (Fig. 3) are seen as cause for celebration by international aid organizations that have worked to embed Petra firmly in global consciousness as a must-see destination. As a result, management capacity has lagged far behind tourism development. The scale and pace of the destruction of archaeological materials at the site is suggested by, for example, sequential inventories of stonemason dressing marks. The first, done in 1990, found that 15–20% of the surface of the theater displayed these marks, the second, in 2005, found that only 5–10% of the theater displayed these marks.

I argue here that the first priority at Petra should be the development of a highly precise digital terrain model which, along with an existing inventory of ancient water control, could provide the basis for an engineering solution to the hydrological cause of accelerating deterioration of subsurface sites and the original fabric of tombs and standing structures (Fig. 4). The overall site management strategy at Petra should much more resemble that of a museum than a recreational park. As at a museum, the environment must be controlled, in this case, at the scale of a landscape. In addition, as at a museum, visitors should not be encouraged to come into contact with ancient materials.

Petra can be considered a bellwether site in our thoroughly globalization world, one in which international industries and corporations are as much players on the global stage as are nations. International industries easily overwhelm states that have limited domestic sovereignty. The tourism industry has so far offered only products branded "ecotourism" and "sustainable tourism," brands that are often as misleading as food products labeled "organic." The system of World Heritage sites was modeled closely on the national park system in the United States, a model that assumed a level of administrative capacity and access to scientific data and trained personnel that exists in few nations. For decades, sites were admitted to the World Heritage List with no regard to the capacity to adequately manage fragile archaeological resources. Consequently, we have seen marked deterioration not only at Petra, but also at many other preeminent archaeological sites including Angkor, Machu Picchu, and Pompeii, where regional development

and visitor flow are inadequately controlled. Even now, sites are admitted to the World Heritage List despite the fact that effective site management is clearly not in place. The lesson that can be drawn from Petra is that careful research, planning, and management on a regional scale, much larger in scope than simply establishing a buffer zone around a site, must be done in advance of attracting large number of visitors in order to prevent great injury to all World Heritage Sites.
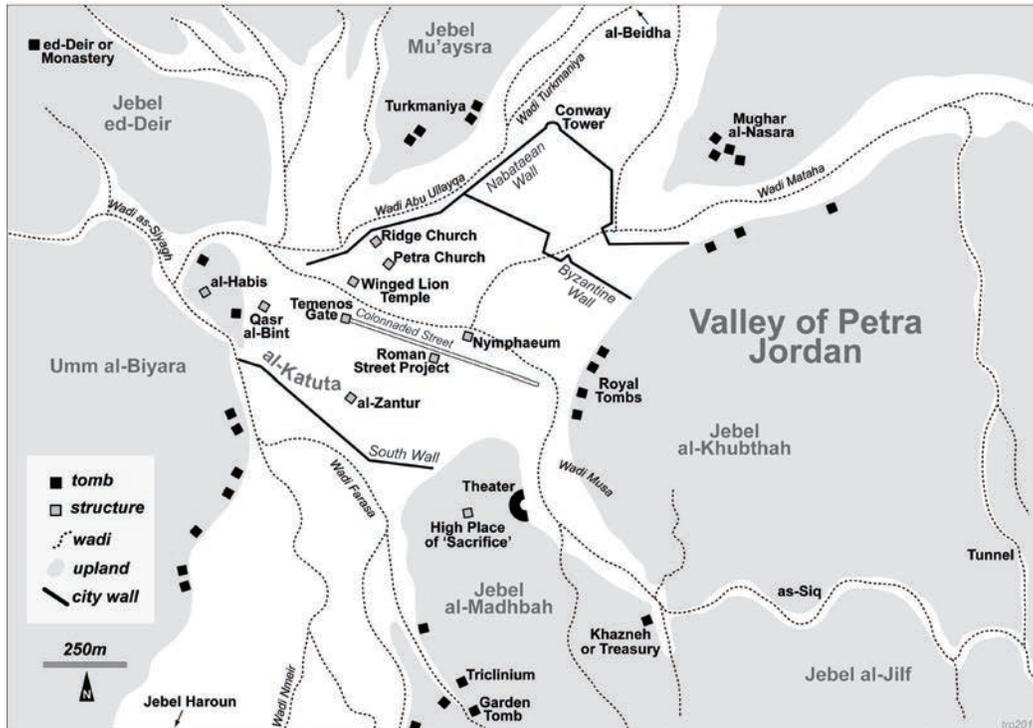
Fig. 1. Schematic map of core area of Petra World Heritage Site.

Fig. 2. Steps carved from native sandstone by Nabataeans 2,000 years ago have been almost completely destroyed in some places by the hooves of donkeys that take tourists to one of Petra's most famous tombs, Ad-Dayr.
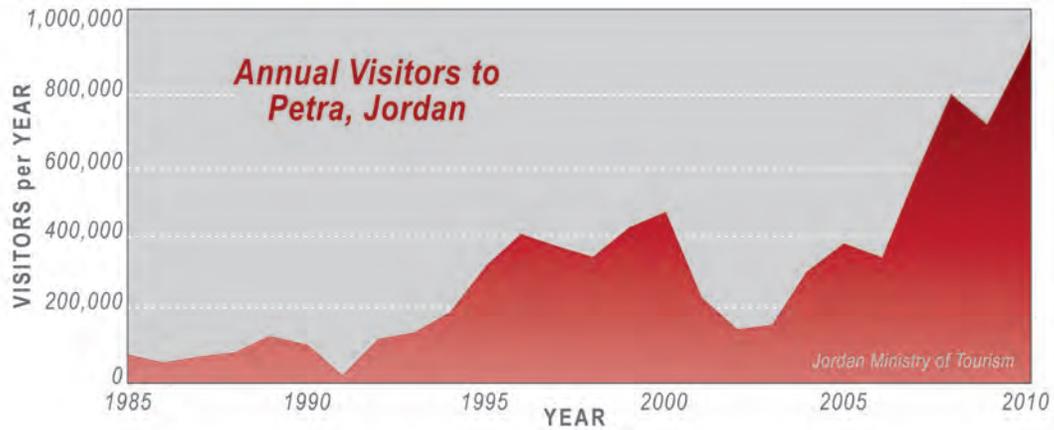
Fig. 3. Visitation dropped sharply in the early 1990s with the Intifada and after 9/11, but then resumed with a dramatic increase.

Fig. 4. The Royal Tombs, seen here are among the best preserved at Petra, but display the characteristic 'key-hole' deterioration at ground-level entrances. This is produced by salt-laden flood waters that are absorbed by the sandstone from which the tombs are caved.

Analysis of the State of Visitor Management at the Palace Museum, Beijing

Di Yajing
Palace Museum, Beijing, China

The Palace Museum, also known as the Forbidden City, located in the heart of Beijing, covers an area of 720,000 m2 with a building floor space of 150,000m^2. The past few years has seen an incredible increase in visitors and in 2012 visitor numbers broke through 15 million for the first time (Fig. 1). During the 2012 extended public holiday periods (the so-called "Golden Weeks"), and the summer vacation when there is a concentration of visitors, daily numbers have reached 180,000, a new record and far in excess of the site's visitor carrying capacity limits (Fig. 2). In order to deal with crowding and bottlenecks caused by such large numbers the Palace Museum undertook an initial assessment of visitor impacts which resulted in the establishment of a series of systems to deal with issues such as security, visitation and first aid. A contingency plan was also written. However these measures were only able to deal with basic general order rather than extreme situations. A practical solution based on scientific assessment of the situation was later drawn up that restricted visitor flows and limited visitor numbers. These are measures that are required to conserve this World Heritage site and ensure visitor safety. The Palace Museum plans to put forward further technological and managerial measures to ensure better visitor management.

Firstly, we need more convincing data on the carrying capacity of the Palace Museum through in-depth study of visitation characteristics. Experience in the visitor capacity of domestic heritage sites lacks practical guidance, instructions, and specifications. In accord with the Regulations and Master Planning for Scenic and Famous Landscapes, the Palace Museum draws on research methods from both home and internationally, combined with the ongoing plan to study the visitor carrying capacity. Hopefully, these results for the 'at one time' carrying capacity, the daily capacity, and the annual capacity can be completed in the initial 2–3 years of research. This requires statistics on visitor numbers and length of visit. In 2013 the Palace Museum established a ticket checking system as well as a visitor monitoring system (Figs 3–5).

Secondly, exploration of the possibility of a more extensive visitor management regime is a crucial element in managing numbers both in the short and long terms. The Palace Museum is situated at China's political center, an extremely sensitive location. Daily visitor numbers are high and there is an uneven distribution of visitors throughout the day and at different seasons. The entrances and exits of the Palace Museum are quite narrow and the site has its own unique visitation characteristics. Research is required on how to control visitor flow both inside and outside the site to ensure an appropriate amount of space for visitation. The Forbidden City began a trial on restricting visitor numbers to the Imperial Garden in April 2013. This is providing an opportunity to gradually acquire experience in improving our capabilities in visitor management.

In the near future, the Palace Museum's development plan will be based on scientific assessment of the visitor carrying capacity and the reservation system will be gradually established. By these means it is hoped to control the daily visitor capacity. These measures will be implemented through an improvement of the service levels by an increase of the visitation area, improvement in the ability to respond to emergencies, a strengthening of social advocacy, and conducting visitor surveys to achieve scientific and detailed management rationally, beneficially, and systematically.
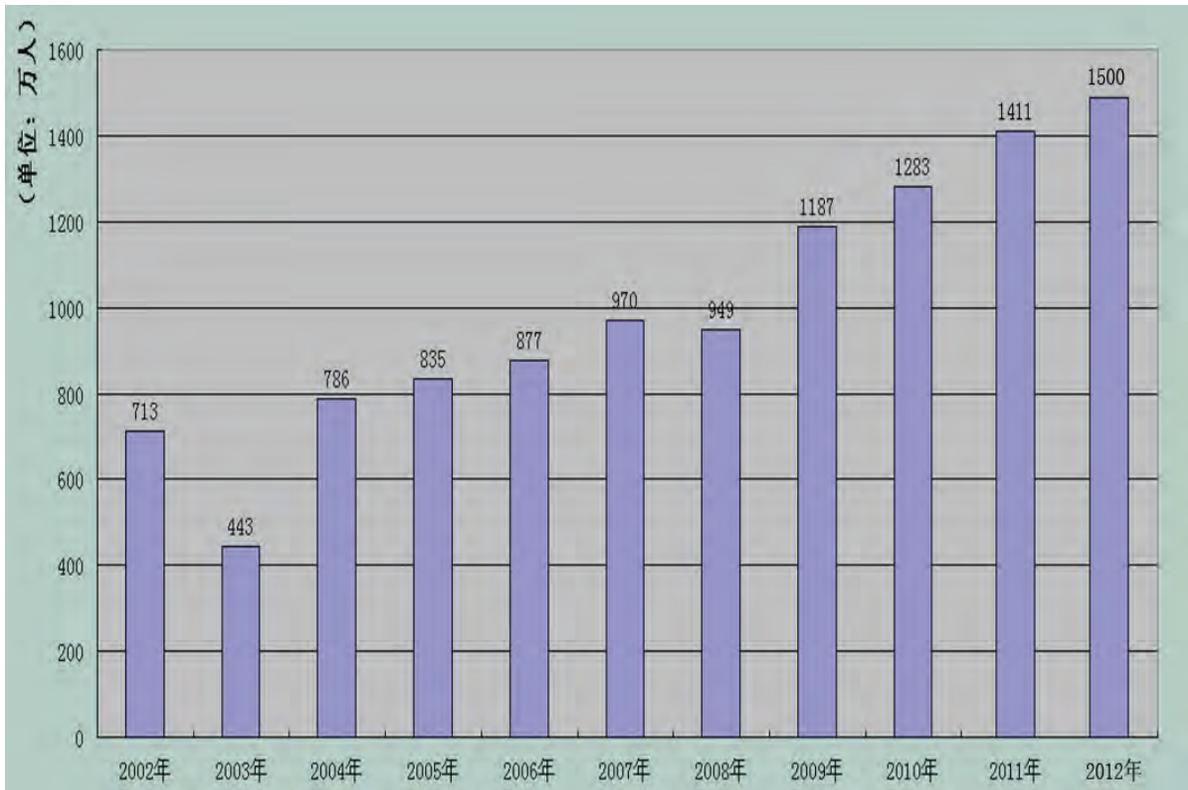
Fig. 1. Numbers of visitors between 2002 and 2012 (unit: ten thousand).

Fig. 2. Visitors crowded in front of ticket office at Qingming festival in 2012.

Fig. 3. Thirty new ticket sale windows at Duan Gate.
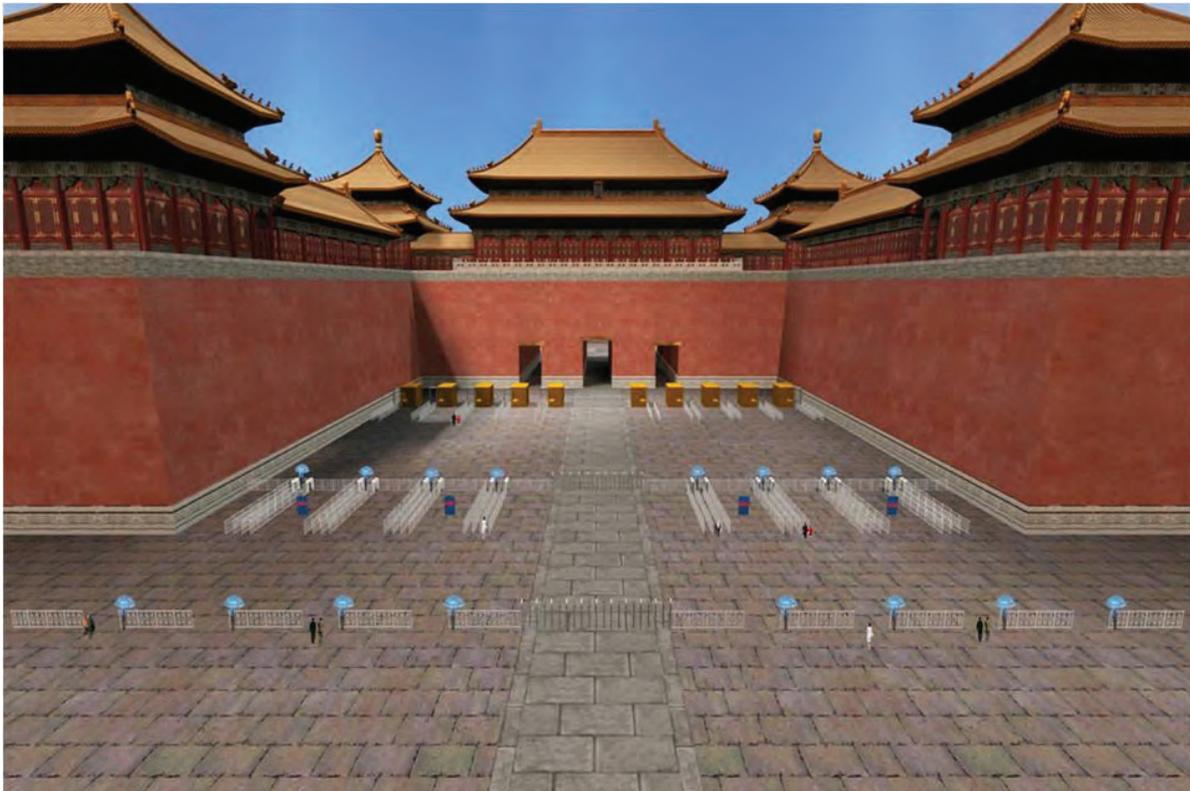
Fig. 4. New facilities for checking security and ticket at Wu Gate (computer rendering).
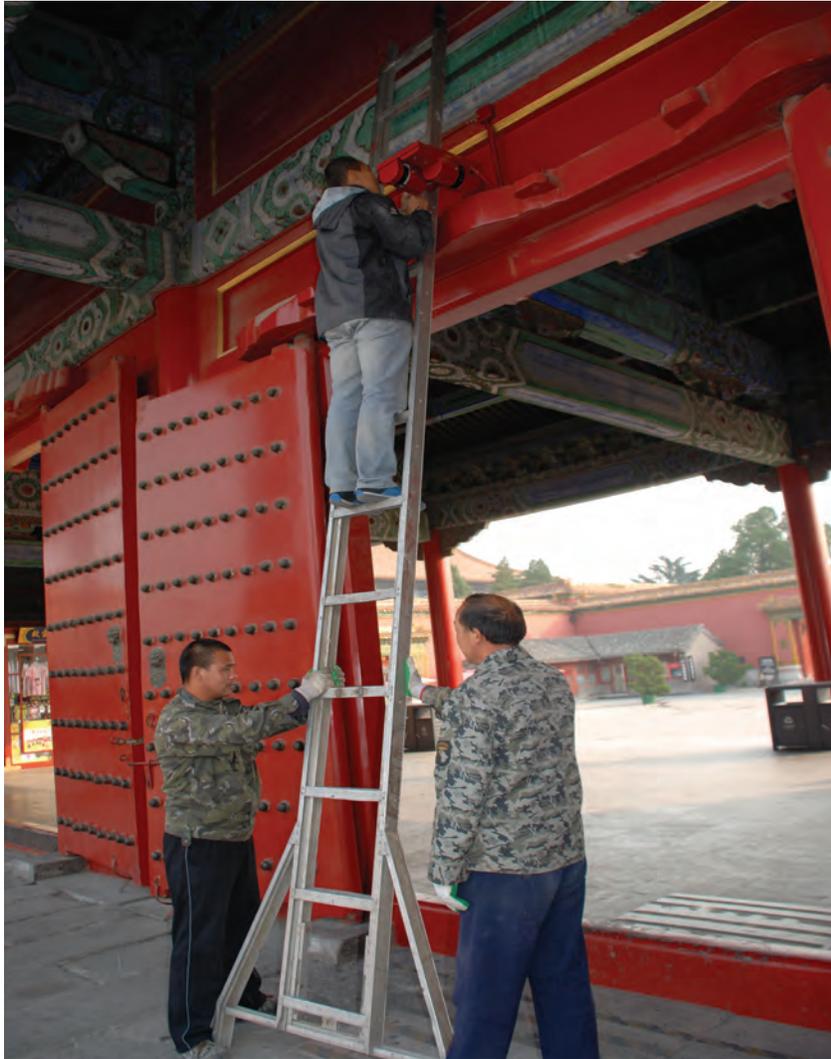
Figure 5. Installing visitor monitoring system in 2013.

The Challenge of Tourism at Angkor

Sharon Sullivan[1] and Richard Mackay[2]

[1] Sullivan Blazejowski & Assoc., Australia
[2] Godden Mackay Logan Heritage Consultants, Australia

The World Heritage site of Angkor contains the remains of the one of the largest pre-industrial cities in the world. Angkor includes spectacular temples, vast hydrological works, and a network of archaeological sites (Figs 1–2). While the World Heritage Site comprises around 40,000ha the total Angkor site is much larger. More than 100,000 modern Khmer live traditional village lives within the Angkor World Heritage Park (Fig. 3). These are the descendants of Angkor's creators, and they still have significant spiritual connections to the site. Angkor has universal aesthetic, scientific, historic, and social value (Fig. 4). These values are as significant as those for which the Dunhuang Grottoes are internationally famous, but are on a much larger geographic scale.

The Royal Cambodian Government, assisted by a strong international effort has made great strides in the past twenty years in rescuing Angkor from the status of a World Heritage property in danger, to one with an enviable conservation record and a strong management authority.

In part because of this success Angkor now faces tourism challenges which are comparable to those of the Mogao Grottoes: the pressure of tourism is overwhelming the site and threatens to damage the values for which it is renowned.

Angkor is a symbol of the Cambodian nation and the major drawcard for tourists to Cambodia, making the site a major source of foreign income in a still very poor country. The increasing stability and development in Cambodia, successful marketing by the Cambodian Ministry of Tourism and the awakening of the global community to the wonders of Angkor have created an ever-growing stream of visitors. Tourism is rapidly expanding. Visitor numbers are now approaching 3 million annually. Many inter-related and sometimes conflicting issues affect tourism at Angkor. While considerable and commendable efforts in visitor management have been made by the authority responsible for managing the site (the APSARA National Authority or 'APSARA'), rapidly growing tourism now threatens World Heritage values, environmental sustainability, revenues and the visitor experience.

Some of the major issues of Angkor include:

- **Rapidly increasing, uncontrolled visitor numbers**: The Angkor Park contains more than 100 ancient temples and associated hydrological works. It is theoretically large enough to cope with increasing visitor numbers. However, 3 million visitors concentrate around four or five "must see" temple complexes at certain times of day especially in the high season, causing severe congestion and fabric damage (Figs 5–6).

- **Site and values impacts**: Ongoing impacts to the Angkor site (as uncontrolled tourism increases) include damage to monuments and environmental degradation, traffic congestion, littering and inappropriate parking, and degraded pathways. Local communities also have concerns about the integrity of some traditions and cultural practices, inappropriate and disrespectful behaviour, and displacement, as foreign visitors increasingly dominate the cultural landscape (Fig. 7).

- **Visitor experience, behaviour and safety** are severely compromised by visitor numbers and patterns. Risks for visitors include lack of readily available first aid services, the height and stability of some monuments, and harassment from touts and other visitors. Management of tourism at Angkor is currently not directed at responding to different market needs. Conflicts can arise where different market sectors using the same locations at the same time have different expectations and requirements. While some visitors appear to thrive in noisy crowds others suffer distress or discomfort in these circumstances. In any case the visitor experience of the site and their understanding are severely compromised in these circumstances. Many management staff, guides and operators are not currently trained or motivated to give visitors a good level of information, and guidance on acceptable behaviour, so that many visitors are experiencing a less than optimal experience, and affecting the site fabric, while at the same time the intangible values of the site are threatened.

- **Lack of recognition of some natural and cultural values**: Some of the heritage values of Angkor are well known internationally. However some important values are unrecognised and are not conveyed to tourists. In particular, the ancient Angkorian temples retain their religious significance for local Khmer but this is unrecognised by many tourists, guides, and operators. Similarly there is little recognition of the wider cultural landscape values of Angkor. This limits the experience of visitors and endangers these values.

- **Infrastructure and transport:** Current infrastructure does not meet the needs of growing visitor numbers and there is a need to further manage transport flow and reduce traffic congestion. Improved infrastructure is needed within and around temple enclosures such as visitor management and facilities areas (parvis), toilets, bus, car and auto-rickshaw (remork) parking, walkways, steps and rest areas.

- **Regional development pressures:** Other cumulative impacts of the rapidly increasing visitor numbers include increasing population growth in local villages and the City of Siem Reap, problems such as waste management, unsustainable long-term effects on water quality and supply, and inadequate transportation systems leading to greater airborne pollution.

- **Stakeholder engagement:** Relationships between participants in tourism at Angkor—the Government, the tourism industry and the community—are not strong. Mutual lack of communication is a constant problem. This makes attempts at reform and change problematic.

- **Governance:** APSARA is a strong organisation with dedicated and highly skilled staff who recognise the need for change. However the challenges of increasing tourism have arisen swiftly and threaten to overwhelm efforts to solve the problem. Management of tourism through good governance requires organisational reform, improved allocation of resources and consistent and systematic enforcement of regulations. Both human and other resources need to be strengthened for effective management of tourism pressures.

- **Uneven distribution of the profits of tourism:** Gate takings are increasing rapidly but resources available to APSARA to manage the site and deal with the pressures of increased visitation are not increasing at a comparable rate. Many of the profits of tourism are retained by non-Cambodian tourism operators. Although APSARA undertakes community participation projects to assist local communities, many local communities are not afforded some of the economic or other opportunities that arise from tourism at Angkor and Siem Reap remains one of the poorest provinces in Cambodia despite massive tourism related business and infrastructure. There are opportunities to utilise revenue derived from tourism to ensure the protection, conservation and management of Angkor and to alleviate local poverty (Fig 8).

These issues are complex and interconnected. They require understanding and strong cooperation between all stakeholders, including UNESCO, international missions, the Royal Cambodian Government, APSARA, the tourism industry, and the local community. Therefore any plan to address these issues effectively needs to be values-based and must actively involve all stakeholders in its development and implementation.

Tourism issues at Angkor are part of a wider group of issues relating to the site's overall management. The Tourism Management Plan (see Mackay and Sullivan presentation), fast-tracked in response to the crisis in tourism at Angkor has been developed to sit within an overall Heritage Management Framework which addresses the complexities of managing this huge site and provides an essential platform for the institutional capacity necessary for its implementation.

Fig. 1. Angkor: Angkor Wat.

Fig. 2. Angkor: Angkor Thom.

Fig. 3. The Angkor Park is home to more than 100,000 people the majority living traditional life styles.

Fig. 4. Angkor is still a sacred landscape for the Khmer descendants of the original temple builders (Photo: Im Sokrithy).

Fig. 5. Sunset at Phnom Bakeng: Significant overcrowding is damaging many values and degrading the visitor experience.

Fig. 6. Overcrowding is apparent in the long queues to climb the Bakan at Angkor Wat.

Fig. 7. Visitor behaviour is often potentially dangerous and destructive.

Fig. 8. Khmer produce good quality traditional handicrafts
but make small profits and remain impoverished.

The Angkor Tourism Management Plan

Richard Mackay[1] and Sharon Sullivan[2]

[1] Godden Mackay Logan Heritage Consultants, Australia
[2] Sullivan Blazejowski & Assoc., Australia

The Royal Government of Cambodia, UNESCO and the Australian Government have together supported the preparation of a Tourism Management Plan (TMP) for Angkor (Fig. 1). The TMP has been developed collaboratively by the APSARA National Authority (APSARA), UNESCO and Australian Consultants GML Heritage, with the crucial agreement and engagement of key stakeholders including the tourism industry and the local community. This plan has been endorsed by the Royal Government and is now in the process of being implemented. The development of the plan and its implementation require significant cultural change among key players and is a harbinger of further change.

The TMP provides a basis for managing and coordinating the rapidly-growing tourism industry at Angkor through an assessment of values, analysis of issues, and development of six key policy initiatives:

1. promoting positive visitor experiences
2. reducing site impacts
3. partnering with industry
4. providing benefits for local people
5. improving governance
6. engaging with stakeholders.

1. Positive Visitor Experiences
Visitors will have a positive experience of Angkor's extraordinary natural and cultural heritage through effective delivery of information about the place, its sacred nature and its living traditions, access to different opportunities and a level of service that exceeds their expectations (Fig. 2).

2. Reduced Site Impacts
The cumulative effects of tourism growth will be proactively managed to remove or minimise adverse impacts on the values of the Angkor World Heritage Area through both encouragement and regulation.

3. Partnership with Industry

The tourism industry and government will collaborate, as partners in the sustainable management of tourism at Angkor World Heritage Area, through clear and consistent communication and transparent and timely decision making (Fig. 3).

4. Benefits for Local People

The social and cultural values of the Cambodian local communities in and around the Angkor World Heritage Area will be recognised, conserved and enhanced and these communities will have a fair share of the economic and other benefits that flow from tourism at Angkor (Fig. 4).

5. Governance

In accordance with Principle 8 of Principles for Sustainable Tourism at World Heritage Properties, Cambodian Government agencies will ensure that, as tourism revenue grows, institutional structures and available resources reflect the requirements for effective management of tourism at Angkor, including implementation of the TMP (Fig. 5).

6. Stakeholder Engagement

There will be an agreed vision for management of tourism at Angkor arising from effective communication, consultation and collaboration between and within government, industry, NGOs and local communities at Angkor World Heritage Area.

Major Initiatives

The TMP also includes proposals for significant changes which will require the support and involvement of government agencies and the tourism industry. These include, for example, major new initiatives in the areas such as:

- **Integrated Management at Individual Temples:** Many of the issues and challenges at Angkor relate to the day-to-day operation of a few major temples. At these temples, there are opportunities to improve management by deploying existing resources so that there can be a more responsive approach customised to particular circumstances at each temple (Fig. 6). The appointment of temple managers at some major temples is an important component of this initiative.

- **Visitor Flow Management:** At present, there are relatively few restrictions on where visitors at Angkor may go and what they may do. Given the rapid

and continuing growth in visitor numbers, this approach is unsustainable and it is essential that both government and industry accept the need to introduce limitations and to manage visitor flow more actively.

- **Transport System:** Arising from the inevitable need to manage visitor flow within the Angkor Park, an overall transport system is required. Such a system should be designed and implemented consultatively with industry. The system needs to address the vehicle and non-vehicle routes, modes of transport, directional flow and visitor numbers. A long-term objective is to remove buses and coasters from Angkor Park; in the short term from Angkor Thom (Fig. 7).

- **Visitor Orientation:** Visitor management at Angkor requires a common core orientation. Such an orientation could present both a briefing on appropriate visitor behaviour and basic information about the history and significance of the Angkor World Heritage Area and thematic circuit options, as well as introducing an Angkor visitor code.

- **Tourist Guide Re-training:** The reputation of Angkor and the current visitor numbers warrant urgent attention to guiding standards and a collaborative approach between guide associations, industry and government. An important element in improving tourist guide training will be the 're-training' of existing guides.

- **Industry Relationship and Communication:** Tourism at Angkor is a partnership. It cannot happen without both government and industry. Industry has demonstrated its eagerness to engage with government; to learn more, to provide feedback and to embrace opportunities to invest in new tourism products at Angkor. A new collaborative approach, continued willingness from government, and improved communication are all needed for this partnership to work effectively.

Spreading the Visitor Load

A prerequisite for the development and implementation of the TMP has been recognition by all stakeholders of the need to change the present trajectory of visitor flow and experience, if conservation of values and sustainability are to be achieved. Effective and well-implemented regulation, which is clearly communicated to visitor and tour operators, is an important first step. However, additional strategies which do not simply seek to limit visitor numbers or regulate every visitor's experience are also required. The TMP uses careful research, market segmentation, visitor education and the development of a

range of new and different opportunities for visitors – thereby spreading the visitor load.

Case Study: Best Angkor Sunsets

The Angkor TMP encourages tourism operators and visitors to change their behaviour because they perceive alternatives to existing arrangements and destinations as better for them. An example is provided by the 'Best Angkor Sunsets' initiative, which uses simple strategies to deliver useful and inspiring online and published information; thereby changing behaviour and reducing congestion (Fig. 8).

The experience of watching the sunset is a key attraction for visitors to Angkor. The vast majority of visitors visit the Phnom Bakheng temple for this experience. In recent years growing numbers have also been watching the sunset from the Pre Rup temple. The large visitor numbers at Phnom Bakheng and Pre Rup contribute to congestion, reduce the quality of visitor experiences and create physical pressure on significant features. There are also safety concerns for visitors at these sites especially when they are climbing down from the monuments following sunset.

The crowded sunset experience at Phnom Bakheng is particularly problematic. Phnom Bakheng is a highly significant temple, close to the entrance to the Angkor World Heritage Park. The temple mount is at the top of a steep hill and is relatively small, but most evenings there are hundreds and sometimes thousands of visitors watching as the sun sets in the opposite direction from Angkor Wat. In the post-sunset twilight, surging visitors can prove dangerous for both people and monuments. Consultation with industry operators reveals that one reason that Phnom Bakheng is so popular is not necessarily the quality of the monument itself nor the sunset view, but its proximity to the park exit —which enables all the operators to take advantage of late-afternoon free entry and some operators to take their visitors to an additional gift shop on the way home—and then to make the early dinner sitting at the hotel. In other words, this temple is visited at sunset because it is convenient for tourism industry operators and because it is promoted, not because it provides a good sunset experience.

The "Best Angkor Sunsets" project has evaluated and analysed alternative sunset options, so as to match potential experiences with tourism market segments. Available sunset experiences have also been identified and analysed —ranging from easy-access broad-scale, mass-market offers, to more distant, intimate niche offerings.

The project strategy seeks to match types of visitor with types of experience and to change the behaviour of tourists and operators by drawing their attention to alternatives that better suit their particular needs. This in turn reduces impact on individual sites, improves visitor experiences and could potentially increase revenues.

The vast Angkor World Heritage site offers a huge range of potentially enthralling and appropriate vantage points for memorable sunset experiences. For example, experiences such as watching the sun set across the lake at Sra Srang or from the Angkor Thom wall are already possible and enjoyed by some visitors. In other cases the vantage points exist, but work would be required to create a view or to ensure safety. In other cases, a new sunset experience can be 'created' through provision of new infrastructure. The West Baray, a very large historic reservoir (approximately 8 km long) offers one exemplar new venue for visitors to experience a memorable sunset. The APSARA National Authority Department of Water Management has recently undertaken work to restore the walls of the West Baray and has installed some viewing platforms for visitors.

Having 'matched' markets to potential experiences, the final element of the strategic approach involved engagement with industry, through roundtable discussions and feedback aimed at ensuring that available sunset experiences also met industry requirements.

The results have been summarized in a simple matrix, which has been used to develop an interactive website, and informative brochure, and as the basis for an information strategy involving internet-based content, industry familiarization visits and direct approaches to tourism industry publishers. It is too early to tell whether the Best Angkor Sunsets initiative will be successful, but it is already demonstrating the value in diversification through market segmentation and focused visitor experience, rather than rules and regulations.

Conclusion

At Angkor, a combination of rules and encouragement will assist in conserving the values of the site, while improving visitor experience, in a way that does not impact on overall revenue but which also provides more economic benefits for the local community.

Fig. 1. The Angkor Tourism Management Plan uses a values-based approach to determine six policy programs and a series of major initiatives and priority areas.

Fig. 2. Providing a range of positive visitor experience opportunities creates diversification, thereby spreading the visitor load and impact across the Angkor World Heritage Area.

Fig. 3. The tourism industry must be included as partner in the conservation and management of Angkor; through collaboration, industry participants can benefit and site impacts can be reduced.

Fig. 4. The tourism management plan seeks to provide benefits for local people, rather than having them marginalised and excluded from access to their own heritage.

Fig. 5. Improving governance through integrated site management is an important element of the Angkor Tourism Management Plan.

Fig. 6. Assessment of carrying capacity and the introduction of a visitor management system at popular temples are important initiatives for managing increasing congestion.

Fig. 7. Angkor Thom requires a new transport management system.

Fig. 8. The 'Best Angkor Sunsets' initiative informs visitors and industry about alternative sunset opportunities,' demonstrating how visitor behaviour can be influenced through information as well as regulation.

Tourist Capacity Management and Control at West Lake Cultural Landscape, Hangzhou

Yang Xiaoru,[1] Hua Fang,[2] and Sun Kaixuan[2]

[1] World Heritage Site Monitoring and Management Center of West Lake
at Hangzhou, China
[2] Hangzhou Municipal Urban Planning and Design Academy, China

In recent years, with the increase of the protection efforts of the scenic resource, and the improvement of the quality of the environment, the tourism at West Lake (Figs. 1 and 2) in Hangzhou is rising each year. The annual reception is around 23 million, making it one of the most popular scenic areas in China. The difficulty of tourist flow management is greatly increased due to the open access of the West Lake Cultural Landscape, which naturally integrates with the downtown district of Hangzhou (Fig. 3). It results in the uneven distribution of tourists congregating in specific locations during specific periods. The purpose of this paper is to examine the tourist capacity management of the West Lake Landscape, against the background of daily growing tourism after the site was nominated to the World Heritage list.

Basic guidelines of tourist management

Tourists are always congregated in specific locations, seasons, and times in a day, which makes a lot of pressure in heritage protection and tourist safety (Figs 4–6). The basic guideline of management is to adhere to the principle of "tourism development subject to heritage conservation," taking the means of distributing visitors, eliminating obstructions and bottlenecks and enhancing traffic flow to calculate and control the visitor flow effectively. We start from changing the pattern and structure of tourism so that visitors are not just seeing one aspect or feature but have options.

Eliminating obstruction means to avoid visitors lingering around sensitive or narrow areas. Distributing involves guiding visitors from the beginning by changing their choice of destination, to adjust the distribution of the visitor numbers in space and time, so that we can build a balanced tour system. Enhancing traffic flow means to increase the capacity of scenic roads and improve internal turnover rate through traffic control.

Basic strategy of regulating visitor flows

First, the basic strategy focuses on increasing the internal scenic spots' capacity in combination with external tourist flow distribution; increasing the

capacity of urban tourism in order to reduce the pressure on the heritage area; distributing tourism through the whole heritage area while reducing the pressure on popular scenic spots.

Secondly, the popular scenic spots should be combined with promotion of tourist capacity at relatively less popular ones. By doing so, the visitor flow at the hot scenic spots can be controlled to achieve the goal of preservation and maintaining an appropriate atmosphere. In this way some relatively less popular scenic spots could enhance their own value and share the burden of tourist pressure.

The last measure aims to regulate the entry permission by reducing obstructions and distribution of visitors at entry points and duration of visit at popular spots, while providing free tickets, coupons, and other enhancements to encourage visitation to other areas.

Evaluation and management system

Design of effective tourist management requires analyzing tourist behavior, designing an evaluation system, and establishing a response system. Tourist behavior analysis is a study method that is based on the area calculation method of visitor capacity which is proposed in the "Scenic Spots Planning Criteria," focused on the investigation of tourist attractions and the popular tour routes. It determines that the purpose of the tour is to experience the Chinese landscape's natural beauty and harmony and indicates the heritage value of the West Lake landscape as well. It also develops the standards for per capita tour area for three types or visitors to the area: casual visitors; sightseeing tourists; and passers-by from the city.

Fig. 1. Panoramic view of the West Lake area

Figs. 2. The serene beauty of the lake and landscape as captured during four seasons of spring, summer, fall, and winter.
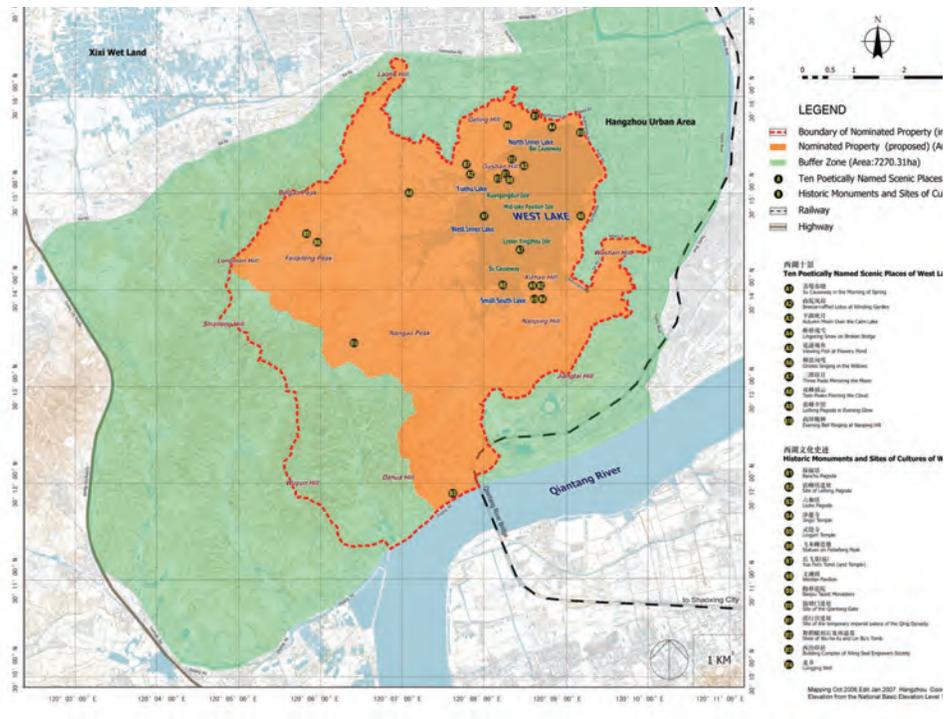
Fig. 3. Boundaries and buffer zone of the West Lake scenic site.
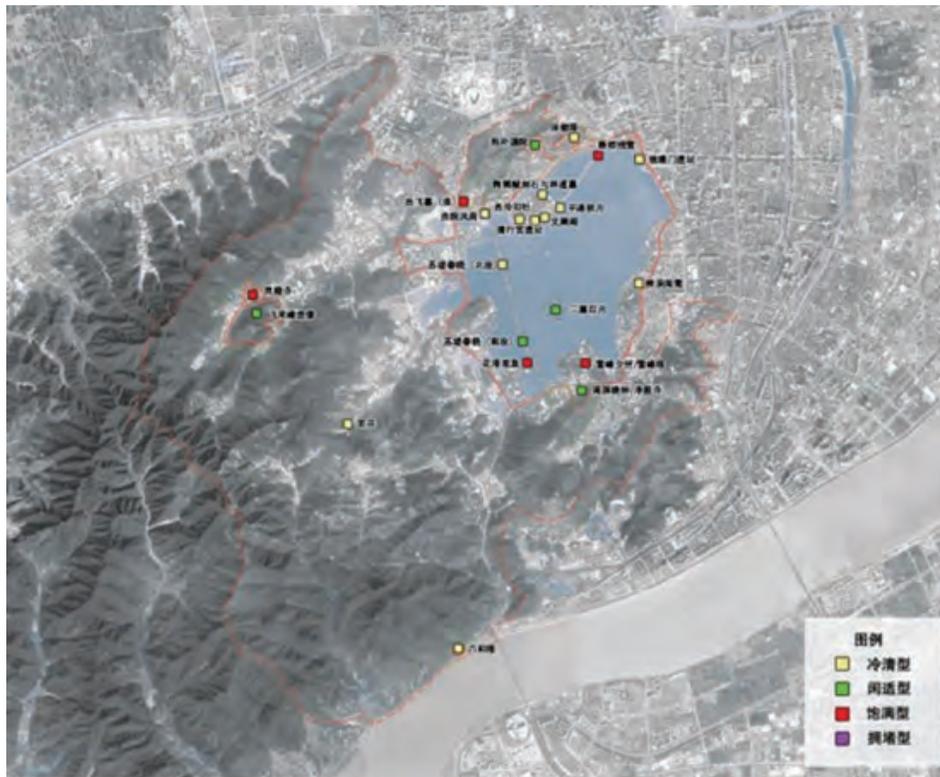
Fig. 4. Mapping of visitor impacts at major attractions during normal visitation: yellow represents a quiet situation; green represents a pleasant situation; and red represents a crowded situation.
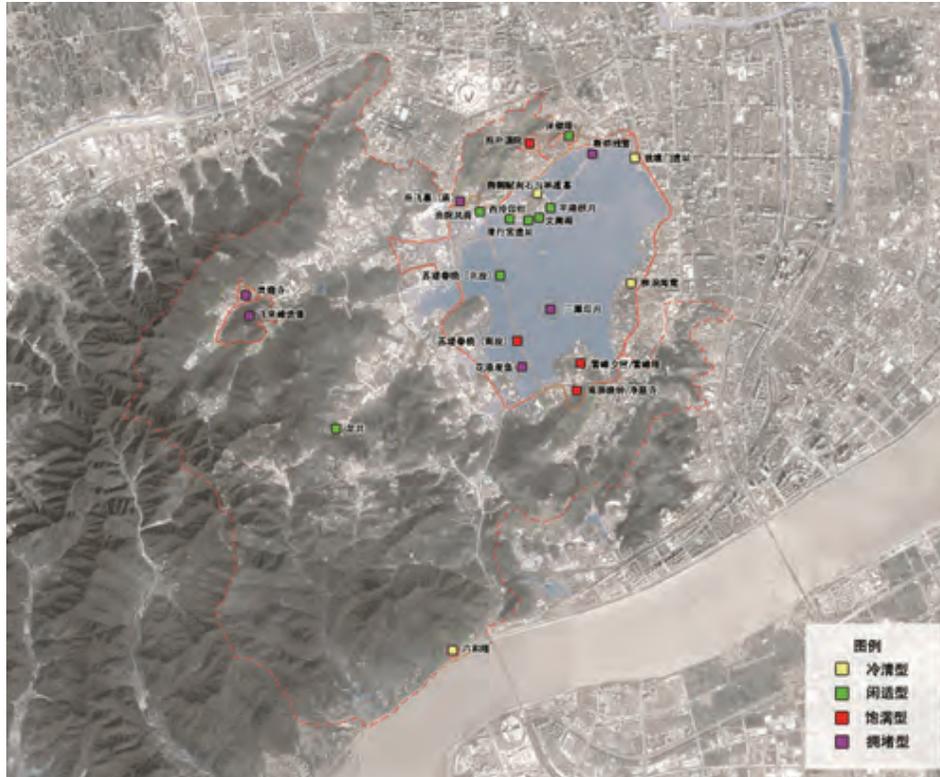
Fig. 5. Mapping of visitor impacts at major attractions during a peak season: yellow represents a quiet situation; green represents a pleasant situation; and red represents a crowded situation; and purple represents a saturated situation.

Fig. 6. Visitor crowd at the West Lake during the October Golden Week celebration National Day.

The Road to Sustainable Development based on Visitor Management at the Classical Gardens of Suzhou

Cao Fengjiao, Wang Qinran and Lu Feifei
Suzhou Conservation and Monitoring Center for the Classical Gardens
of World Cultural Heritage, China

The classical gardens of Suzhou are renowned for their long history and exquisite and elegant design (Fig. 1). The Chinese concept of idealism has been expressed in the design and form of classical gardens. The gardens come close to representing the universe and were designed with great care. They are a profound reflection of a close relationship with nature while at the same time transcending nature. In 1997 the gardens of Suzhou were inscribed on the World Heritage list as being representative of Chinese gardens (Fig. 2). There has been rapid development of tourism in China over the past few years and there are new issues and challenges facing the conservation of the classical gardens of Suzhou. These include finding a balance between tourism and conservation. This is required if we are to reach a level of sustainable development at heritage sites. Sustainable development is the primary issue that requires an urgent solution for site managers.

This paper summarizes the development of tourism, visitor numbers (Fig. 3) and distribution characteristics and trends in tourism at the gardens over the past few years, and analyzes current issues in the development of tourism at the site. These include visitor numbers exceeding the site's capacity, deficiencies in visitor management, inappropriate visitor behavior and a lack of qualified personnel in the field of tourism management. The paper presents an analysis of the impact of these various issues on the site. In conclusion it presents practical proposals for sustainable management based on research undertaken in recent years.

Currently, the problems of tourism to the classical gardens are the following:
- First, a serious imbalance in the distribution of tourists: some gardens carry an overload of tourists (Figs. 4 -6);
- Second, the loss of the garden infrastructure is increasing, including the effects of the local humid climate on brick constructions, leading to the loss of building integrity, as well as the free standing stone stele, furniture, and other infrastructure (Fig. 7);
- Third, the garden environment is getting worse, specifically damage to plants, ground surface erosion, the problems of the rockeries caused by

125

attrition and natural weathering, water damage and soil erosion, visitors, and noise pollution from the loudspeakers and guides during peak hours and seasons (Fig. 6).

• Fourth, management of the buffer area needs to be strengthened: most of the garden is in the downtown area of the city and the surrounding environment is complex, so that the skyline surrounding the area and the view-shed is affected by the presence of various types of buildings. In addition, some tourists do not pay attention to environmental protection with serious effects on the overall image of the Suzhou gardens (Fig. 8).

• Fifth, there is a need for tourism management talent.

In response to these problems, some measures have been taken by the garden management authority, and the following solutions have been proposed:

1. Establishment of monitoring and warning systems: after nearly three years of effort, the Suzhou pilot project of the China World Heritage dynamic information, monitoring and early warning system was passed on March 28, 2013 by the Chinese Academy of Cultural Heritage (CACH), which is a solid first step for the construction of the national systems (Figs 9-10).

2. Development of protection methods for free standing stone stele, stele mounted on walls, and other infrastructure: the first concerns assembling files and preservation records; the second to take measures to protect the integrity, and prevention of natural and man-made hazards; the third to develop deterioration monitoring methods, analyze the physical characteristics of the stone inscriptions, predict potential damage arising from the interaction with the environment; and the fourth to improve protection study methods.

3. Use of advanced technology to abate noise pollution through providing self-guided devices and mobile phone self-help systems for visitors at some gardens and scenic spots; and for groups wireless microphone systems, as well as other new means to reduce noise pollution.

4. Strengthen management of the buffer area by close monitoring of landscape and involving participation of relevant departments at all levels in order to establish appropriate intervention mechanisms.

5. During peak season two things need to be well done: tourist security and heritage protection. First is to activate contingency plans, adapt protection measures to prevent visitors' bad behavior that could cause

damage; second, to improve the frequency of monitoring inspections of the entire garden, but particularly of areas where more tourists gather, and the rockery and bridge where visitors typically stay longer. Thirdly, improve security of movable relics.

6. During the off-season, Liu Yuan Garden management department undertakes monitoring and maintenance of buildings, structures, rockery, and banks. Ancient trees are pruned and protected; enhanced security and the general monitoring system is reviewed and reorganized. The East Garden management department implemented three-dimensional mapping of the entrance area of Ou Yuan Garden prior to completion of the ancient city walls restoration project. The Zhuozhengyuan Garden management department has checked and maintained 46 items of furniture in the garden according to the monitoring plan.

To sum up, the following has been proposed or implemented for the sustainable development of Suzhou classical garden tourism:
1. Improve laws and regulations.
2. Improve responsibility and reporting, prevention and control network.
3. Diversion of visitors to ease the heavy load on the gardens.
4. Enhance the role of tour guides in World Heritage education.
5. Strengthen efforts to deal with bad behavior.
6. Strengthen staff recruitment and training.

Fig. 1. Montage of the features of the Suzhou gardens.

Fig. 2. The Suzhou Ancient Gardens historic district includes nine distinct gardens: Zhuozheng Yuan, Shizi Lin, Liu Yuan, Yi Pu, Huanxiu Shanzhuang, Ou Yuan, Canglang Ting, Wangshi Yuan, Tuisi Yuan, each marked by a World Heritage symbol on the map.

Fig. 3. Graph shows the total visitors for the Gardens between 2008 and 2012 (unit for visitor number is ten thousand).

Fig. 4. Graph shows distribution of visitors at each garden between 2008 and 2012: red is Zhuozheng Yuan, the most visited garden; purple is Shizi Lin; yellow is Liu Yuan; and blue is Yu Yuan (unit for visitor number is ten thousand).

Fig. 5. Graph shows visitor distribution pattern during the Golden Week holidays: red is the first day; green is second day; blue is third day; yellow is fourth day; dark green is fifth day; dark red is sixth day; and brown is seventh day (unit for visitor number is ten thousand).

Fig. 6. Overload of visitors during peak periods impacts the gardens and their features.
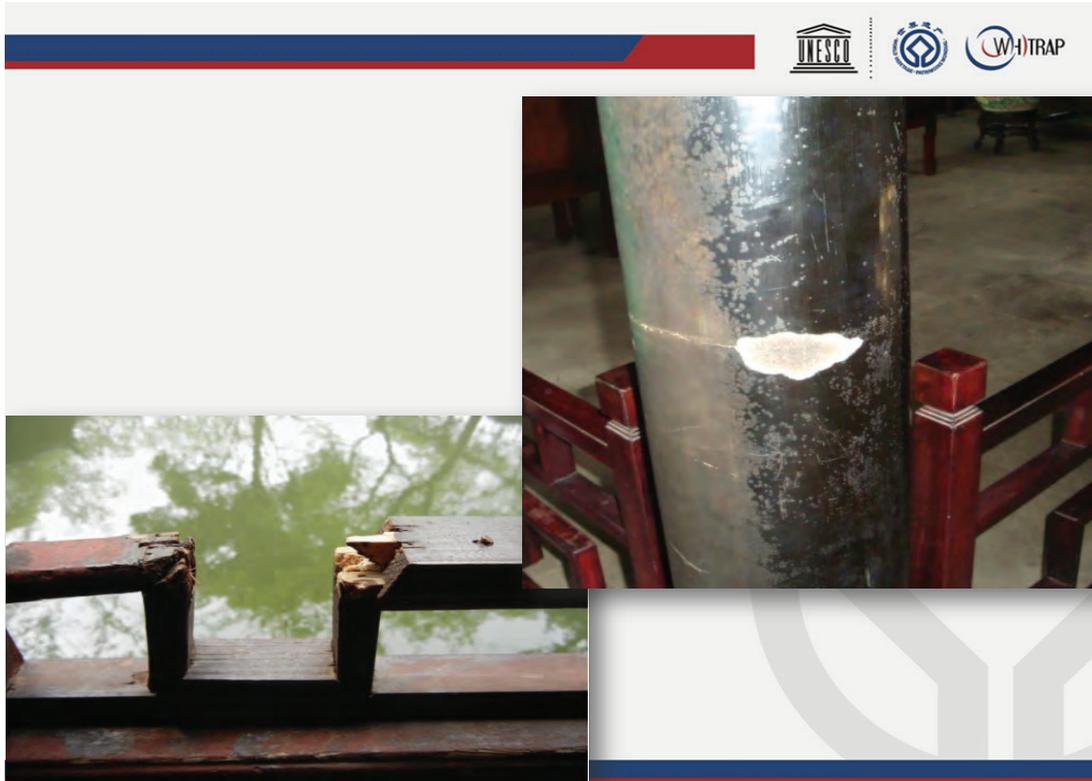
Fig. 7. Architectural elements in the gardens damaged due to excessive visitation.

Fig. 8. Inappropriate behavior by visitors causes damage to the plants and features.

Ticket system

Video & audio

Infrared warning

Fig. 9. Equipment installed in the gardens to improve visitor management includes video and audio monitoring system, automated ticket checking system, and infrared warning system.

二、苏州古典园林游客管理措施

园林	开放面积（m²）	可容面积（m²）	人均停留时间（小时）	计算开放时间（小时）	日饱和人数
拙政园	45012	22578	1.25	8	14500
留园	19175.69	13939.4	1	8	11200
狮子林	11002.21	5557.09	0.67	8	6700
沧浪亭	11800	2631.4	0.5	7	3700
艺圃	3356.53	2580.22	0.75	8	2800
网师园	6500	2125.5	0.5	7	4000
耦园	5954	4458	0.83	8	4300
虎丘	202101	65625	1.5	8.5	37500

表：预警标准研究

Fig. 10. Parameters and standards for each garden's warning system include area of garden, usable area, average time of stay, daily opening hours, and daily maximum capacity.

Alcatraz: People and Place. A Quality Tourism Destination with Growing Numbers of Visitors

Greg Moore

Golden Gate National Parks Conservancy, U.S.A.

Alcatraz Island is a national park and a national historic landmark in San Francisco Bay (Fig. 1). This famous island has a varied history – as a military fort, as a lighthouse and as a federal prison. Its location provides spectacular views of the San Francisco skyline and the Golden Gate Bridge – and its rocky cliffs provide nesting habitat for many species of sea birds (Fig. 2).

Alcatraz opened to the public as a national park in 1974. Since then, its popularity has consistently grown. In its first year of operation, Alcatraz was visited by 40,000 people. Today, this 9-hectare island hosts 1.5 million visitors each year.

This growth has required careful management by the National Park Service, the government agency that manages this historic site, and its nonprofit partner (NGO), the Golden Gate National Parks Conservancy (Parks Conservancy), which serves visitors on the island. There have been many challenges over the years:

- How to respond to the public demand to see Alcatraz without damaging the island's resources or the quality of the visitor experience
- How to try new approaches to telling the island's story that allowed for more people and improved the educational value of an island visit
- How to monitor and review the quality of the visitor's experience and have measures of crowding and the island's capacity
- How to ask visitors about their experience and use that information to improve their visit
- How to care for the island—and provide the revenue needed to preserve and restore historic buildings and grounds

The National Park Service and Parks Conservancy use five tools to answer these questions:
   1. Advance Planning
   2. Adaptive Management
   3. Visitor Research and Visitor Surveys

4. Application of Visitor Research Surveys Results and

5. Preservation through Partnerships.

Advance Planning has been very important to balancing the visitor experience with the protection of park resources. Early planning studies evaluated the historic and natural resources of the island to determine which features needed to be preserved and which features were central to telling the island's story to visitors. With these planning studies completed, measures were taken to designate the island as a National Historic Landmark and identify key buildings and resources needing protection. Over the decades, additional planning studies provided more information about cultural landscape features, marine bird habitat, archaeological features and zones of visitor use. Together, these studies have helped guide the design of the visitor experience and the preservation of the island's resources.

Adaptive Management is the system used to design, implement and test new ways of managing the growing number of visitors. When Alcatraz opened, park rangers guided all visits to the island. Within the first decade, it was clear that this approach to visitation had many problems, especially because it limited how many people could visit. Over the years, new ways to manage visitors were planned, analyzed, tested and implemented. These have included an audio tour, evening tours, self-guided tours, volunteer-guided tours and the opening of new areas on the island to handle more visitors and relieve crowding (Figs 3-6).

Visitor Research and Surveys: Changes in the numbers of people permitted to visit the island needed to be guided by research about crowding and visitor capacity, by surveys of park visitors, and by studies of visitor flow throughout the island (Fig.7). These studies were critical to understanding the proper levels of visitation and how visitors felt about the quality of their experience on Alcatraz. A particular research and survey effort by an expert in visitor capacity at national parks, Professor Robert Manning of the University of Vermont, provided important information about some of the most critical issues of crowding and visitor experience (see Manning presentation). The National Park Service and Parks Conservancy used this research to make decisions about the visitation to the island.

Applying Visitor Research and Surveys: The prime visitor attraction on Alcatraz is the historic Cell House—where prisoners lived during Alcatraz's years as a federal penitentiary (Fig. 8). Specific research, visitor surveys, and studies of visitor flow have guided the design of the visitor experience and the levels of

people visiting the island. With this background research, steps are continually taken to monitor and improve the visitor experience on the island. This has included redesigning the audio tour, opening new areas of the Cell House and the island, adding international languages to the audio tour and improving educational exhibits and signs on the island.

Preservation through Partnerships: Central to effectively managing Alcatraz Island is preserving its historic, cultural, natural and scenic resources. This requires good knowledge of preservation requirements as well as the funding to implement preservation, projects. It also requires the partnership of the government (National Park Service), a nongovernmental organization (the Golden Gate National Parks Conservancy) and a private company (Alcatraz Cruises) working together to manage visitors, secure revenue to invest into the island's care and plan for the future. A strong partnership has been critical to day-to-day management as well as planning for future visitor enjoyment and resource preservation.

Today, Alcatraz welcomes 1.5 million people each year. Ninety eight percent of these visitors rate their visit as "outstanding." Revenue from ferry transportation, a park admission fee, audio tours and retail sales are being invested into the island's ongoing maintenance and operation (Fig. 9). A new partnership plan is being developed to address the most expensive preservation projects needed to maintain the island's many historic buildings. Visitor surveys continue to inform park management about the quality of the visitor experience on the island.

The "Alcatraz Model" is one example of how to continually plan and respond to the challenge of growing visitation. Through monitoring, research, experimentation, innovation and revenue management, Alcatraz has been able to welcome increasing numbers of visitors while preserving historic and natural resources and ensuring a high-quality visitor experience.

Fig. 1. Aerial view of Alcatraz island, with more of the Golden Gate National Parks and Golden Gate Bridge in the background.

Fig. 2. Snowy Egret nesting in Alcatraz island's ornamental shrubs (Photo Mason Cummings, 2013).

Golden Gate NRA, Park Archives, Richard Frear Photograph Collection, 1979-1980, GOGA 18326 (P89-030-03)

Fig. 3. NPS Ranger Ruth Lawrence leads a youth group on tour through an Alcatraz cell block, interpreting The Rock's use as a Federal penitentiary (Golden Gate NRA, Park Archives)

Fig. 4. NPS Ranger Marcus Koenen leads a tour of the Alcatraz gardens, stewarded by volunteers from the San Francisco community (Photo Mason Cummings, 2013).

Fig. 5. Alcatraz night tour, a popular behind-the-scenes look at the history of the island, provided by the Golden Gate National Parks Conservancy.

Fig. 6. The first stop on the Alcatraz Cell House Audio Tour, available in English, Spanish, German, French, Italian, Japanese, Dutch, Mandarin, Portuguese and Korean.

Fig. 7. Typical crowd at the Alcatraz landing dock, the first stop for visitors to this National Park site (Photo Ben Fash, 2013).
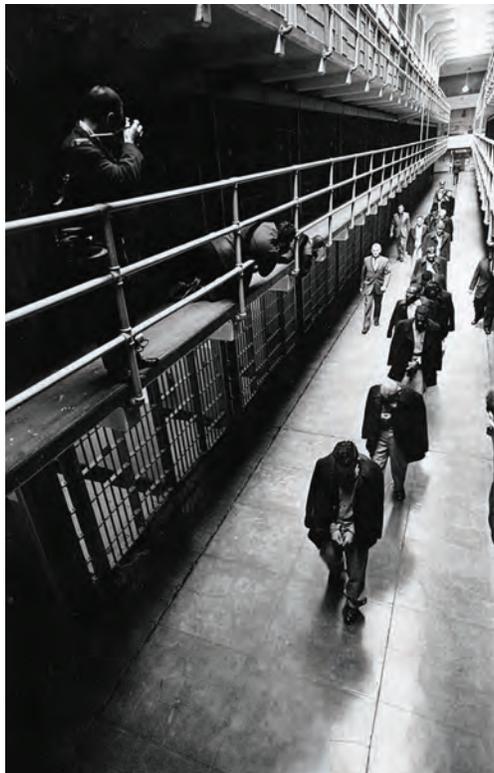
Fig. 8. In this historic photo, prisoners are taken to their cells at Alcatraz Federal Penitentiary (Golden Gate NRA, Park Archives).

Fig. 9. The Alcatraz store, featuring interpretive and commemorative items for purchase after the Cellhouse Audio Tour (Photo Ben Fash).

Estimating Carrying Capacity of Alcatraz Island

Robert E. Manning
University of Vermont, U.S.A.

This paper describes a program of research to help estimate and manage carrying capacity of Alcatraz Island (Fig. 1). The island is a historical/cultural site in California and is part of the U.S. National Park System. It is a heavily visited tourist attraction that is widely known for its history as a federal prison for incorrigible criminals. This history has been romanticized and popularized in several books and movies. Consequently, demand to visit Alcatraz is high, and there is concern that visitation may exceed carrying capacity. Visitors must purchase a ticket and access the island by ferry from San Francisco; the number of visitors allowed on the island each day is controlled by the National Park Service. The prison cellhouse is the primary visitor attraction and nearly all visitors tour this site by means of an audio tour.

The program of research conducted at Alcatraz was designed to support application of Visitor Experience and Resource Protection, a management-by-objectives framework developed by the U.S. National Park Service to manage carrying capacity in the national park system (National Park Service, 2007; Manning, 2001; Manning, 2007; Manning, 2009). The framework is based on three primary steps: 1) formulation of management objectives and associated indicators and standards of quality, 2) monitoring of indicator variables, and 3) implementation of management practices designed to maintain standards of quality. Indicators of quality are measurable, manageable variables that are proxies for management objectives, and standards of quality define the minimum acceptable condition of indicator variables (Manning, 2011). Carrying capacity is recognized as having two primary components, resource and experiential. The resource component addresses potential impacts of recreation/tourism on natural and historical resources, while the experiential component addresses maintaining the quality of the visitor experience.

The program of research was aimed primarily at the experiential component of carrying capacity and was conducted in two phases (Manning et al., 2002). First, qualitative and quantitative surveys were conducted of visitors to Alcatraz to help identify indicators and standards of quality. Based on the visitor surveys, the number of people-at-one-time (PAOT) in the prison cellhouse was

determined to be an important indicator of quality. For example, many visitors reported that PAOT at iconic sties in the prison cellhouse affected the quality of the visitor experience. Respondents were shown a series of visual simulations (computer-generated photographs) of a range of PAOT at an iconic location (called "Michigan Avenue") within the prison cellhouse (Fig. 2). Respondents rated each photograph on a scale of -4 ("very unacceptable") to +4 ("very acceptable"). Average acceptability ratings for the study photographs were graphed to form an acceptability curve (Fig. 3), and the point at which the curve fell out of the acceptable range and into the unacceptable range (44 PAOT) was considered a standard of quality, or the minimum acceptable condition for PAOT (called the "acceptability" standard of quality). Respondents were also asked to report the photograph that showed the PAOT condition they preferred to see (25 PAOT; called the "preferred" standard of quality) and the photograph that showed the maximum PAOT that the National Park Service should allow (44 PAOT; called the "management action" standard of quality).

The second phase of the study developed a computer-based simulation model of visitor use of Alcatraz Island. The primary purpose of the model was to determine the relationship between the number of visitors to the island and PAOT on Michigan Avenue. In this way, carrying capacity could be estimated in relationship to crowding-related standards of quality for the prison cellhouse. Model input was based on detailed visitor counts and observations, including number of visitors per ferry, frequency of ferries, length of time between debarkation of visitors on the island and their arrival into the cellhouse audio-tour ticket line, time spent in the audio-tour ticket line, and time spent touring the prison cellhouse. The resulting model estimated the maximum number of visitors that can be allowed on Alcatraz Island each day without violating the PAOT standard of quality at Michigan Avenue. The model estimates that 2,560 visitors can be allowed on the island per day without violating the "preference" standard of quality and that 4,800 visitors can be allowed on the island per day without violating the "acceptability" and "management action" based standards of quality. The simulation model was also used to test the efficacy of alternative ferry schedules. The ferry currently departs for Alcatraz Island every half hour. If the schedule were reduced to every hour, then the daily carrying capacity for the "acceptability" based standard of quality would fall to 3,200 visitors (because of greater clustering of visitors). However, more frequent ferry service would result in only minor increases in carrying capacity.

References

Manning, R. 2001. Visitor Experience and Resource Protection: A Framework for Managing the Carrying Capacity of National Parks. *Journal of Park and Recreation Administration* 19(1): 93-108.

Manning, R., B. Wang, W. Valliere, S. Lawson, and P. Newman. 2002. Research to Estimate and Manage Carrying Capacity of a Tourist Attraction: A Study of Alcatraz Island. *Journal of Sustainable Tourism* 10(5): 388-404.

Manning, R. 2011. *Studies in Outdoor Recreation: Search and Research for Satisfaction*. Corvallis, Oregon: Oregon State University Press.

Manning, R. 2007. *Parks and Carrying Capacity: Commons without Tragedy*. Washington, DC: Island Press.

Manning, R. 2009. *Parks and People: Managing Outdoor Recreation at Acadia National Park*. Hanover, New Hampshire: University Press of New England.

National Park Service. 1997. *VERP: The Visitor Experience and Resource Protection (VERP) Framework – A Handbook for Planners and Managers*. Denver, Colorado: Denver Service Center.

Fig. 1. Alcatraz Island, California, is a unit of the U.S. National Park system and is known for its history as a federal prison for incorrigible criminals. The prison was closed in the 1960s.

Fig. 2. As part of a survey conducted at Alcatraz Island, visitors were shown a series of study photos depicting a range of visitor use levels in the prison cellhouse. Respondents were asked to rate the acceptability of these photos to help determine a threshold for crowding on the island.
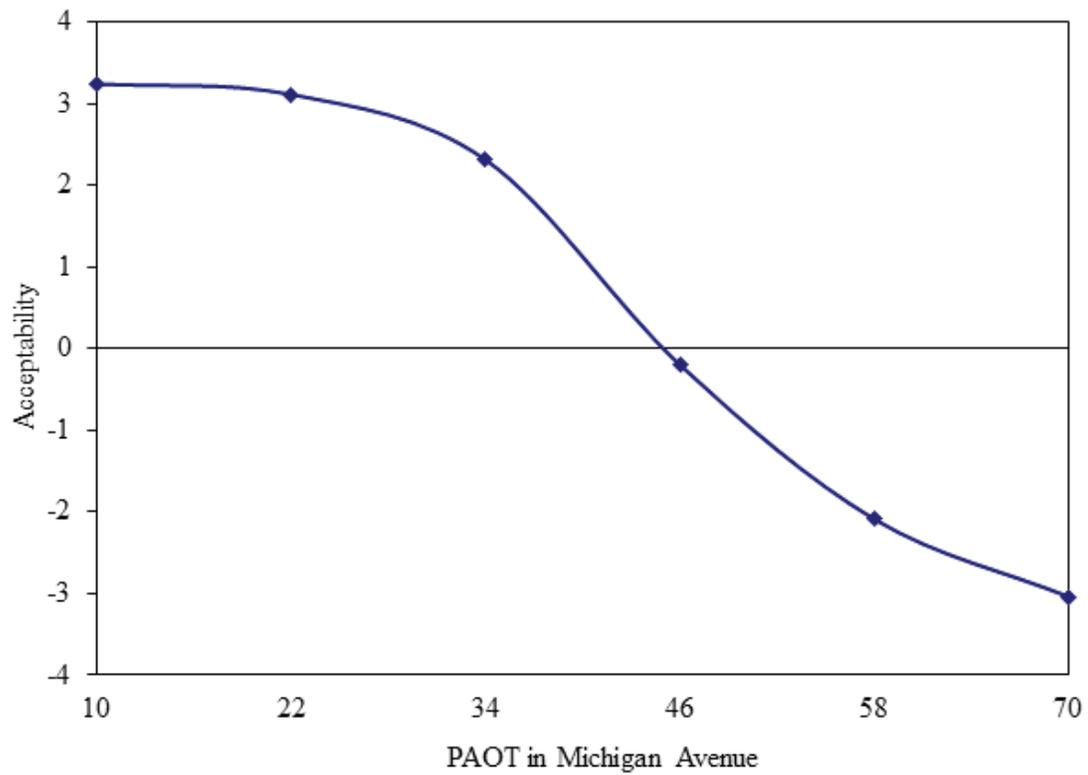
Fig. 3. Mean acceptability ratings of respondents show that the threshold for crowding in the prison cellhouse is about 44 people-at-one-time (PAOT) (this is the point at which average ratings of the study photos fall out of the acceptable range and into the unacceptable range). The National Park Service limits the number of visitors to the island to ensure that this threshold is not violated.

Visitor Management at the Longmen Grottoes

Ma Chaolong and Li Suisen
Longmen Grottoes Academy, China

Longmen Grottoes is located 12 kilometers south of Luoyang in Henan Province, one of the eight ancient capitals of China. The site includes some 2,300 extant niches and nearly 110,000 statues (Fig. 1). Together with Dunhuang Mogao Grottoes, and Datong Yungang Grottoes, they are called the three outstanding Buddhist art treasures of China. Longmen Grottoes was inscribed in UNESCO's World Heritage List in November 2011. With this strong attraction, and convenient transportation in central China, a large number of tourists visit Longmen. A total of 2.48 million visitors in 2012 broke historic records, and the daily number reached 62,000 (Fig. 2).

The following issues are relevant:

Increase in visitor numbers over a specific period
1. Rapid growth. The number of visitors grew from 650,000 in 2003 to 2,480,000 in 2012.
2. Peak period is concentrated, and the seasonal distribution is uneven.
Visitor numbers during April to October in 2012 were 2.05 million, which is 82.6% of the total of 2,480,000 (Fig. 3). The daily peak number reached 62,000, which is overloading the site. The main reason for this increase is due to the Luoyang Peony Festival in April, but also the Golden Week holiday in October (Fig. 4).

Overloading at Longmen
1. Impact on the heritage. When environmental conditions of the setting change there is likely to be a negative impact on preservation of the site.
2. Environmental pollution. Atmospheric pollution affects the scenic environment of the mountain, vegetation, water, as well as the historic material itself.
3. Visitor safety and satisfaction issues. Overcrowding and decreased safety have reduced the visitor's experience and satisfaction level (Figs 5-6).
4. Interference to the local residents and their social activities. Excessive visitors cause traffic congestion, with parking scarcity for the surrounding

area, and this affects the normal life of residents.

5. Service facilities cannot meet the needs of visitors and staff is overloaded with work.

Visitor management methods at Longmen

As a consequence of growing daily tourist numbers, the Longmen Grottoes Research Institute has adopted the following measures to deal with heritage preservation and visitors in order to secure the safety of both heritage and visitors and to create sustainable heritage preservation and tourism development, thereby achieving a more satisfying condition.

1. Study of the environment and tourist capacity of Longmen Grottoes scenic zone. Aspects of visitor capacity at Longmen Grottoes include:
   • Ecological capacity
   • Physical capacity
   • Tourism resource capacity
   • Social environmental capacity
   • Tourists' psychological capacity

Preliminary estimate on the daily social environmental capacity is 15,000, while the site reaches saturated conditions at 70,000.

2. Measures in response to the increasing numbers of visitors

   a. Enlarging the scenic zone framework increases the capacity for tourism: Some scenic spots have been included within the Longmen scenic zone; these are a heritage museum and exhibition museum, a wetlands park, and other new attractions. The scenic zone has expanded, and the tour environment increased.

   b. Enrich content and extend opening hours: Opening hours have been extended by completing the night tour project, so that the visitor flows can be distributed, and the visit enriched (Fig. 7).

   c. Strengthen management, and improve service levels: Strengthen measures to keep scenic sites clean and orderly; and enhance tour guides' management and training. Allow tour guides to adjust tourists' distribution in the scenic areas and redesign the visit routes to reduce congestion.

   d. Upgrade infrastructure in order to increase visitor capacity: Provide convenience for visitors by expanding parking area, increasing the number of electric cars (Fig. 8), provide boats, reconstruction of trails, and reinforcement of sightseeing paths.

   e. Standardize and guide visitor behavior through use of public media: Through media presentations on the site's values visitors can be educated to meet standards of behavior while appreciating

the culture of Longmen Grottoes, without harm to the World Heritage site.

f. The establishment of an early warning mechanism system: In the peak season, an early warning mechanism is needed at the ticket office and main entrance when the numbers of visitors approaches saturation and environmental capacity numbers, to control visitor's entrance time and speed, so as to relieve scenic zone pressure and adjust distribution.

Conclusions

Since different types of heritage have their own characteristics in terms of integrity, history and space, location and environment, carrying capacities are different. Even though heritage types may be the same, they can be distinguished by behavioral types, resource sensitivity, spatial distribution and management methods, which could have an effect on the heritage resources. Tourist capacity can be changed with environmental and other targeted changes. It requires a great amount of basic data to support, and it is built on long-term monitoring of key indicators. The data must be checked, modified and optimized by practice, so that the appropriate and real value of the heritage environment capacity can be determined.

Fig. 1. General view of the Longmen Grottoes.
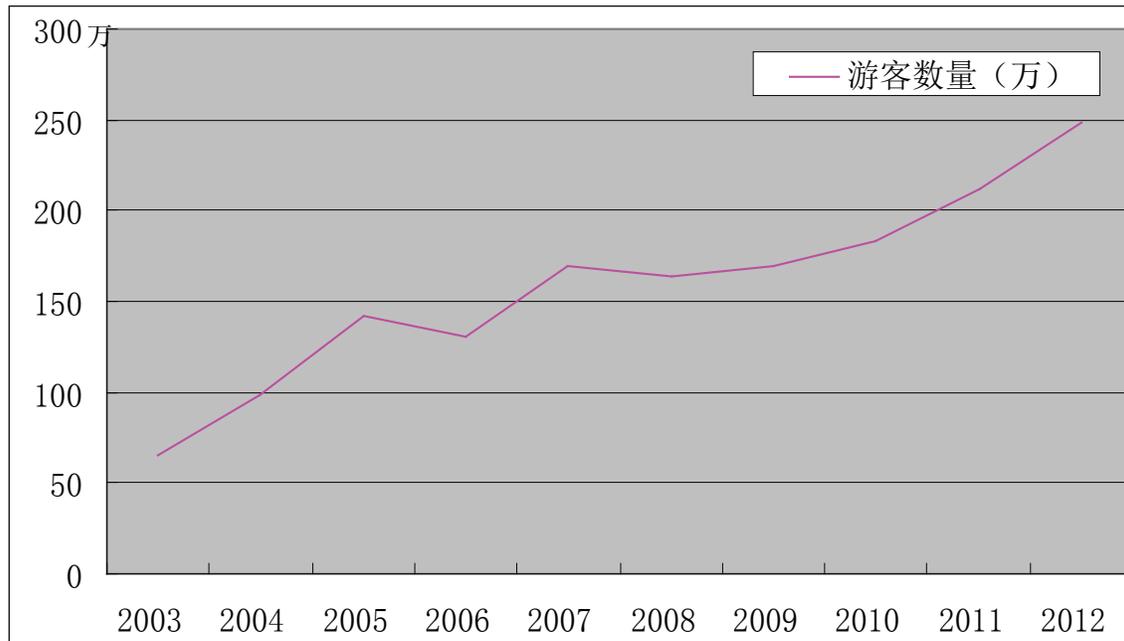
Fig. 2. Graph shows number of visitors between 2003 and 2012 (unit: ten thousand).
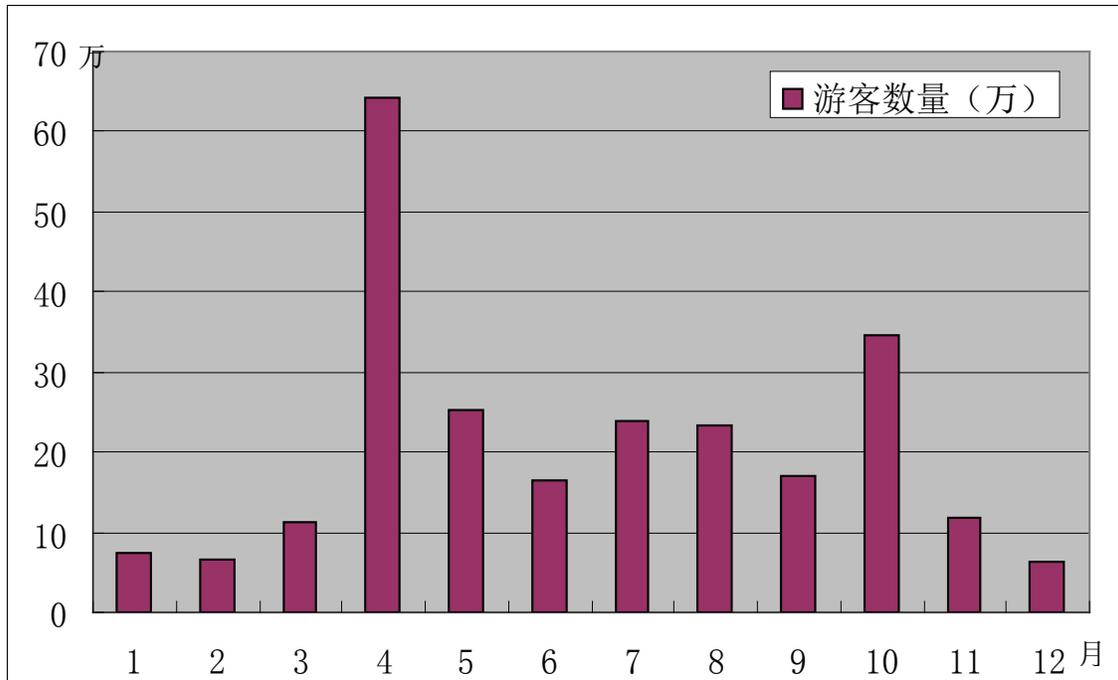
Fig. 3. Graph shows number of visitors in 2012. The highest peak in April was due to the Peony Festival at Luoyang and the next highest peak in October was due to the Golden Week holidays (unit: ten thousand).

Fig. 4. Visitors crowded in front of Fengxian Cave Temple at Longmen Grottoes during the peak season.

Fig. 5. Excessive overload of visitors at Longmen Grottoes during the peak season.

Fig. 6. Henan Cultural Heritage days on November 26 and 27 in 2005 drew a huge number of visitors to the Grottoes since it was free to enter.

Fig. 7. Longmen Grottoes at night.

Fig. 8. Visitors entering the grottoes on foot and by shuttle on an ordinary day.

Visitor Management Issues at the World Heritage Site of Port Arthur, Tasmania

Stephen Large
Port Arthur Historic Sites, Australia

The Port Arthur Historic Sites are extremely important in terms of Australian Heritage and we were honoured in July 2010 to be inscribed on the UNESCO World Heritage List as part of the Australian Convict Sites nomination which was a serial listing involving eleven sites from Tasmania, New South Wales, Western Australia and Norfolk Island.

In terms of significance, briefly, the Port Arthur Historic Sites are three of 11 convict sites that together represent an exceptional example of the forced migration of convicts and an extraordinary example of global developments associated with punishment and reform. The sites are places of outstanding heritage value and together form a complex set of landscapes, the primary layers of which relate to the convict era. An additional layer of tragic significance occurred when a gunman on 28 April 1996 took the lives of thirty-five people and wounded many others.

PAHSMA (Port Arthur Historic Sites Management Authority) has the responsibility for managing three of these sites. Port Arthur, the Coal Mines Historic Site and the Female Factory Historic Site (a former women's prison in Hobart); however the focus here is on the Port Arthur site (Fig. 1), a place that despite a troubled history is one of much beauty.

Following the massacre in 1996 the Australian Government provided funding for a visitor centre which was completed in 1999 and as such has helped in handling the large volume of visitors coming to the site (Fig. 2). I should add that, in the context of what the Dunhuang Academy is currently doing with its new Visitor Centre, after 14 years we are still learning how to get the best value out of this building.

All visitors arriving by road are required to go through the visitor centre and on arrival get a ticket which is a two day pass and includes a 40 minute guided tour, access to the Interpretation Gallery, a Harbour Cruise and access to approximately 40 buildings and the impressive grounds of the site (Fig. 3)

The Centre with the Interpretation Gallery downstairs is designed to prepare visitors for their experience and occurs just before the Guided Tour. Visitors can also purchase an audio tour or app if they would like to do their own self guided tour. Interpretation and the message we want to convey to visitors is very important and we spend a lot of effort in training and assessing our guides to ensure this is done effectively. This tour and the time spent with individual guides providing a short overview of the site is both welcomed and valued by visitors (Fig. 4).

We also have guides in three of the houses and the Separate Prison to provide visitors with interpretation. The Authority also conducts a number of activities and events on the site on a regular basis, together with an education program to keep our younger visitors occupied. We take seriously our feedback from visitors and endeavour to survey them on a regular basis. Many of their constructive suggestions have been taken on board as we continually enhance the visitor experience.

Unlike many overcrowded sites we are eager for more visitors to come to the PAHSMA sites. The high Australian Dollar, Australians holidaying overseas in record numbers and the global financial problems being experienced in some of our key markets have meant the last few years have been a challenge for us in terms of declining domestic tourism. However Chinese visitors to the Site have increased threefold in the last two years. We expect, and are hopeful this will continue to increase and we hope more Chinese visitors will come to Tasmania in the near future.

Visitation to Tasmania and Port Arthur is seasonal with nearly two thirds of visitors coming between late December and the end of April. This can be problematic if say there is a wet day in the busiest month of January. When, for example, this happens visitors tend to stay longer in the Visitor Centre making the building very crowded and not providing the sort of experience we want visitors to have.

Another management issue for us is cruise ships which is a market PAHSMA has been actively pursuing for some years. Most cruise ships come in the peak summer period and sometimes have in excess of two thousand passengers which in addition to visitors who come by road creates logistical challenges, particularly around the jetty which has much activity anyway with passengers taking a harbour cruise as part of the site entry package (Fig 5).

We are presently extending the jetty infrastructure to provide more room and better access for cruise ship visitors and have introduced a number of other initiatives to accommodate the large numbers of visitors, for example setting up a ticket booth next to the jetty rather than bringing passengers up to the Visitor Centre.

Another recent occurrence at the site which had significant visitor management consequences was a major bushfire in south east Tasmania in January this year. The extent of the blaze resulted in closure of the only road in and out of the area leaving 700 visitors stranded on the site. The site was turned into an evacuation centre for 5 days until police allowed cars back on the highway. We had to accommodate, feed and look after all these stranded people. A difficult situation resulted with no power, no computers, no internet and limited mobile phone coverage for quite a period of time. The site was in fact closed for ten days during our busiest time of the year which has significant financial ramifications. This situation had not been planned for but management certainly learnt a lot and on the whole visitors despite the adversity appreciated how they were accommodated and cared for during this period.

Whilst PAHSMA as an organisation has not done the carrying capacity studies that other sites have, if numbers continue to increase substantially this is clearly something that will need to be done, particularly with our more fragile buildings. For the moment, congestion resulting from cruise ship arrivals, which are however scheduled, and adverse weather during peak times comprise the main visitor management challenges.

Fig. 1. Aerial view of the Port Arthur site.

Fig. 2. Visitor Center at Port Arthur.

Fig. 3. Views of harbor, gardens and buildings that form part of the visitor tour.

Fig. 4. A wide variety of interpretation programs and exhibits are available for visitors.

Fig 5. Cruise ships and resulting queues are a challenge for managing visitors to the site.

Visitor Management at the Potala Palace, Lhasa, Tibet

Ding Changzheng
Potala Palace, Tibet Autonomous Region, China

The central government has always attached great importance to the protection of the Potala Palace, a national cultural heritage site (Fig. 1). On December 17, 1994, the Potala Palace was inscribed on the World Heritage List. In November 1997, the Tibet Autonomous Region People's Government promulgated the "Measures for the Administration of the Potala Palace."

According to statistics, the annual tourist numbers to Potala Palace are greatly increasing. The number in 2000 was 290,000, and this number increased to 1 million in 2012, which indicates an increase of more than three times (Fig. 2). The average daily number of visitors increased from 800 in 2000 to 2,900 in 2012. In the peak period, the daily visitor numbers increased from less than 2,000 in 2000 to 5,000 in 2012.

As tourism has developed and visitor number increased, this has created many difficulties for conservation and management. From the Potala Palace's perspective, the opening up of Tibet, the construction of a railway line from Qinghai to Tibet and the new Linzhi Airport has led to strong development in the tourism industry resulting in the increase in visitors. This increase has has created new problems for the site (Figs 3 and 4), particularly in the debate over conservation of the palace versus the development of tourism and use of the site. The issue of how to effectively conserve the palace heritage buildings and the site itself, while satisfying visitor demands in the face of mass tourism, is of particular concern and one of the hardest issues for site management to deal with.

Control of visitor numbers during peak periods

The Potala Palace is a large structure and has undergone renovation and extensions several times over its long history. The structures are complicated and vary from one to the other. They also suffer from varying degrees of damage. In particular immovable heritage components such as the Linta, Buddha niches and the Scriptures Wall have enormous loads to bear, let alone the additional load caused by visitation and pilgrims which is contributing to the damage. The autonomous region's government and the Cultural Heritage

Bureau for the Autonomous Region have therefore called for a limit in daily visitor numbers during peak seasons.

Research methodology for the carrying capacity

At present there is no scientific data available for an understanding of the extent of the damage or impact on the structures caused by visitation. We also do not have any accurate idea about the visitor carrying capacity that could be reasonably borne by the structures. For these reasons, we appointed the Civil Engineering School of Beijing Jiaotong University to undertake a monitoring study of the Potala Palace. This will provide a thorough understanding and an accurate determination of the extent of change and potential danger that exist throughout the site's structures (Fig. 5). It should allow a solution to conservation of the site's physical components and ensure that future visitation and use of the Potala Palace is appropriate and safe. The monitoring study uses an advanced numerical value modeling and analysis approach to structural capacities of the buildings and will provide us with accurate data which can be used to control visitor flow in a scientific and appropriate manner. The study will also provide scientific data for strengthening, stabilization and routine maintenance in the future. We have already completed phase one of the project (which mainly consisted of surveying crucial locations in the main structure of the palace) and are still at the stage of data collection.

Main measures to deal with tourism peaks

Visitor statistics from 2005 to 2012 at the Potala Palace showed a steady increase in visitor numbers over this period. We have adopted the following measures to assist with visitor management at peak periods.

1. Implemented a reservation system where visitors must pre-purchase their tickets one day in advance. Visiting times are controlled and allocated by the site (Fig. 6).
2. Different entrances to the Palace. The local community, pilgrims, individual visitors and tour groups enter the Palace at different entrances.
3. In order to speed up visitor flow inside the palace we have closed off or only allow viewing or worship from outside in narrow passageways or areas where bottlenecks frequently occur. We have limited the amount of time guides spend with tour groups and have prohibited photography in certain scenic locations outside the main buildings to reduce congestion.

Issues facing visitor management

Visitor management consumes large amounts of human and material resources. There were also gaps in the area of ticket sales which could not be addressed. It was for the above reasons that we decided to implement a reservation system for the purchase of tickets. Firstly, we developed our own software for the ticket reservation system and have automated and used electronic means for tasks that were originally manually undertaken by site staff. This has increased the amount of funding on maintenance. We also have fixed locations and dedicated staffing for ticket reservations and inspection.

Secondly, we have put arrangements into place to disperse visitors more evenly across the site while ensuring that the site is still adequately protected. To ensure a more rapid visitor flow has required more staff supervision. Thirdly, the problem in buying an entrance ticket during the peak season has created opportunities for individuals to make a profit by scalping tickets which harms the legitimate interests of visitors.

Fig. 1. General view of the Potala Palace.
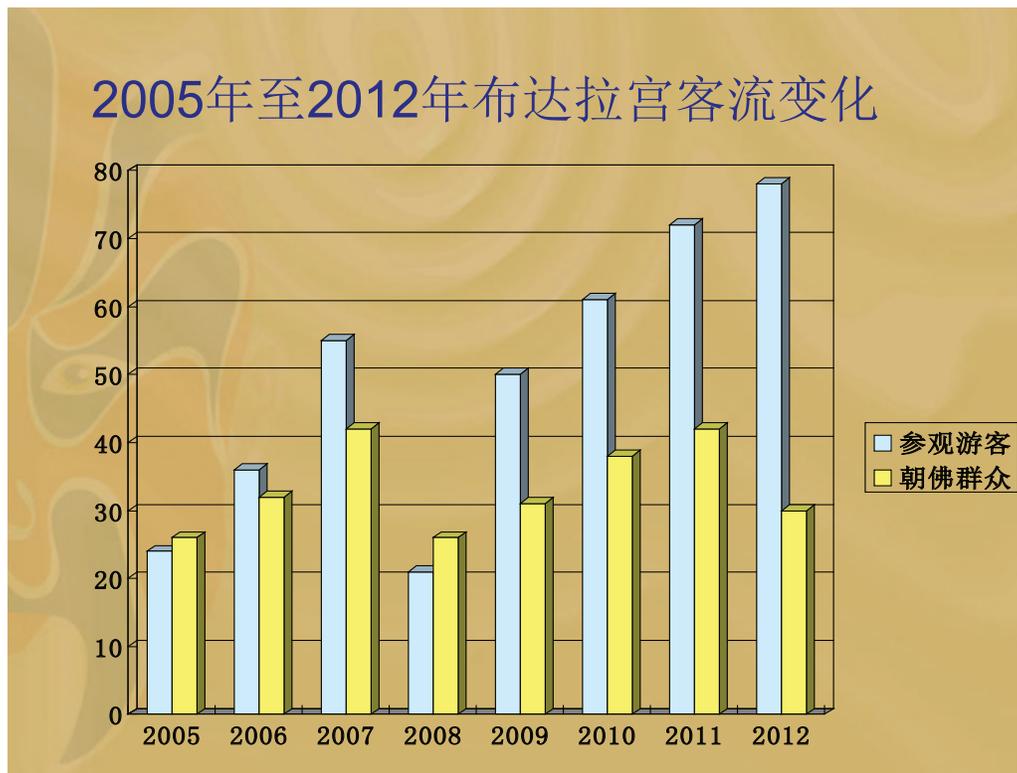
Fig. 2. Graph shows the number of visitor (in unit of ten thousand) between 2005 and 2012. The light blue bar is number of ordinary visitors and the yellow bar shows the number of religious pilgrims. In 2008 both groups declined, likely due to economic downturn.

Fig. 3. Visitors crowding inside the Potala Palace during golden week holidays.

Fig. 4. Visitors crowding in narrow stairway in the Potala Palace during Golden Week holidays.

Fig. 5. The traditional wooden structure of the Potala Palace must bear enormous loads as a result of the increase in visitors.

Fig. 6. Visitor congestion at entrance before implementation of reservation system (left) and orderly lines of visitors (right) after implementing the reservation and visitor management system.