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Monitoring Commercial Operators' Movements in Terrestrial and Marine Protected Areas in Australia: A Review of Challenges for Emerging Technologies

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Introduction

Recent work by Wardell and Moore (2004) on visitor monitoring systems for national parks found that most Australian park agencies relied on traditional, unsophisticated yet robust sampling technology for capturing visitor data in the field. These technologies included mechanical (and occasionally digital) car counters, walking trail registration logbooks, localised surveys and visitor questionnaires, entrance fee records, and web-based surveys. Recently, some park agencies (e.g. CALM WA) started to introduce a limited number of GPS-based vehicle tracking systems for marine operators (Shark Bay NP).

The majority of these technologies provide only spatially or temporally limited information about visitor movements within protected areas. Without more detailed and long-term data, management planning decisions are based on managers' perceptions and influenced by external and financial and political pressures (Pitts and Smith 1993). Planning based on predominantly subjective observations can become problematic when trying to find the most efficient solution for striking a balance between conservation and visitor recreation.

The advent of inexpensive, mass-produced IT-based tracking and communication devices has opened a range of opportunities for developing solutions that would allow ongoing, automatic and remote collection of visitor movements in protected areas. In Australia, the initial focus for such technology is on commercial tour operators. Currently, the vast majority of commercial tour providers legally operating in National Parks and other relevant protected areas have to apply for a time-limited permit under relevant nature conservation statutes (Buckley et al. 2001). In some areas, they also have to collect and pay entrance fees (e.g. Kosciusko National Park, Snowy Mountains) or an environmental management charge (EMC, Great Barrier Reef) for their clients on a per capita and day basis. This provides mostly reliable information about the general commercial use of these areas, but very little data in terms of individual sites targeted by these operators. Some national or international icon sites or sites with special recreational infrastructure (e.g. diving pontoons) are firmly incorporated on itineraries of larger companies (e.g. Quicksilver, Aries (glow worm tours – Natural Bridge, CERRA)) and are visited daily, unless weather conditions impose such risks to call for a cancellation of the entire trip. In these cases, visitor fees would provide a good indication about some aspects of commercial usage of sites within protected areas.

Australia, however, has many protected areas that provide visitors with self-drive or smaller guided tours and, therefore, opportunities to select from a number of sites for their visits' itineraries. Fraser Island, the bareboat charter industry in the Whitsunday Islands and most national parks in the Australian Outback are typical examples. Many of these tours also encompass overnight stays (camping, anchoring) which tend to have greater localised impacts than short sight-seeing visits. Other types of operators without any site-specific itinerary include megafauna viewing charters, dive charters, and estuary and deep sea fishing tours.

Table 1: Vehicle tracking concepts and examples of existing technology.

Technological principle	Basic requirements	Examples	Objects
A) location restricted/dependent			
1.) sensing of signals emitted by object (movement/ optical)	a 'natural' signal emitted by the object of interest strong enough to allow detection against background signal / 'noise' (and natural variations in background signal)	track counters (digital, ground vibration), wireless sensor networks (WSN) with motion detection motes, vis-video surveillance, infrared image analyses, ...	Visitors on foot, vehicles (engine heat)
2.) detecting reflection of signals emitted from a base station (pinging)	detection of a reflection of a unique (strong) signal (often coupled with information from transponder)	military or commercial radar (commercial aircraft and vessel traffic surveillance systems, speed radar), sonar (U-boat or mine detection, fish finder, etc.)	Vehicles
3.) detection of specific transponder signal (tagging)	some type of unique ID tag (actively or passively transmitting object info) to be fixed to object of interest, and one or several local receivers (beacons or base stations) to detect presence / position of ID tag	RFID tags, swipe cards, toll bridge systems, mobile phone / PDA tracking, vehicle location systems, aircraft transponder	Visitors and vehicles supplied / fitted with tags
B) location unrestricted/independent			
GPS-based	access to GPS signal (satellites) and mechanisms for data storing and/or data transmission to central processing unit.	fleet (vehicle, trailer, container) management systems, fishing vessel tracking (QFS BNE), truck toll system for German highways	Visitors and vehicles supplied / fitted with GPS receivers and data logging and/or data transmission devices

The majority of these operators rely on vehicles which can be tracked by a range of technologies, including magnetically or electrically coupled RFID tags, E-tags (microwave transponders) and their relevant readers linked to a central database for cross referencing, mobile phone field strength readings, fleet management systems, recently developed GPS-based highway toll collect systems, and even military battlefield combat ID systems (BCIS). The successful application of any of these systems is determined by their costs, which include

- production and installation of the transponder and 'interrogator' devices (incl. development or adaptation, applicability),
- supply of power to various system elements,
- reliability of position information and spatial resolution under problematical field conditions (dense canopies, deep gorges, etc.),
- the object to be monitored,
- transmission of collected information to a data processing centre, and
- maintenance and 'half-life' of all equipment under field conditions in remote areas.

Methods

This paper tries to determine a range of robust, cost-effective and adaptable systems for monitoring commercial tour vehicles in protected areas in Australia based on the above criteria, a review of functional and technical (hardware, data capture and transfer, wireless communication) aspects of current object (vehicle) tracking technology, and spatial aspects of tour operations in Australia (e.g. the location of national parks in Australia in relation to major tourism nodes and mobile phone networks (coverage of existing and emerging systems: CDMA, GSM, 3G)). Additional feedback from consultations with a range of PAMs, operators and vehicle tracking system managers (e.g. the Vessel Monitoring System (VMS)), was used to further identify some of the challenging legal and data management aspects and constraints of such visitor monitoring systems.

Results

From a VMS point of view, commercial operations in PAs can be subdivided into guided tours and self drive tours using hired vehicles. Both commonly require a license issued by PAMs under relevant nature conservation legislation, which, in theory, enables managers to require implementation of a VMS. The range of vehicles used by commercial operators for providing access to PAs in Australia include cars, 4WDs, minibuses, campervans, buses and trucks and also any type of vessel (aircraft are not included as they are already closely monitored through air traffic control systems). In theory, there are three principal concepts of vehicle tracking technology (table 1).

Technologies listed under A1 – A3 were not considered further as candidates for widespread implementation: they were either expensive (A2), limited to short distances (A3, passive ID tags), heavily service-reliant (A3, energy supply and maintenance to tag readers), not capable of identifying individual (unique) objects (A1, track counters), or considered too intrusive (A1, video surveillance – object tracking).

In the Australian context, GPS-based vehicle tracking systems were regarded as the most promising solution for collecting more detailed information about visitor movements in terrestrial as well as marine PAs in Australia:

- most of its vegetated areas are eucalypt dominated, dry sclerophyll communities with open canopies and good GPS reception;
- all areas have mostly good GPS satellite coverage;
- most tourism hotspots in PAs are isolated (even data subject to a GPS error of 100m would still allow identification of the actual route(s) taken);
- independent of local sensor equipment, the same technology can be used for terrestrial as well as marine areas;
- well proven and developed technology (transport and logistics industry);
- ongoing reduction in costs for system hardware (on board units) and data transfer (via mobile phone network).

GPS-based VMS can be implemented using a variety of already existing hardware modules. These range from portable, handheld GPS-assisted PDAs to hardwired specialised onboard tracking units (Figure 1). All systems will require some post-event processing on one or several servers using special 'back-end' software for producing a range of relevant reports depending on the specific information needs of each end user. Whether these systems can provide real-time location and status information or only post-event data depends on cellular phone network coverage (data transfer via satellite, e.g. Inmarsat C, is generally cost prohibitive). Online real time vehicle tracking systems (VTS) are already in use for public transport providers (municipal bus company, Perth) and large mining and truck companies. A visual analysis of GIS overlay data (see maps in Appendix) of mobile phone coverage in Australia, however, suggests that the majority of VTS for PAs, if implemented, will only provide post-event data collection systems.

Another key element of most VTSs is their capability of accepting additional data input (usually relating to vehicle performance), which can be extended to record the number and type of visitors or clients carried on each trip, possibly even by tapping into the operators' business system via a Bluetooth connection. Another alternative would be post-hoc processing of data packages with trip details and a unique ID number at the backend VTS server and its data processing software. A simple GIS overlay analysis with areas or nodes attracting fees in individual parks can then be employed to automatically generate charges on a per visitor and per site basis. The backend system can be further extended to link with automatic pay systems so that payments for charges created by the VTS can be electronically transferred to the relevant conservation management agencies (similar to already existing road toll collect systems in Europe and Australia).

A further encouraging aspect for developing VTS-based visitor monitoring systems in Australia is the recent implementation of industry-wide stan-

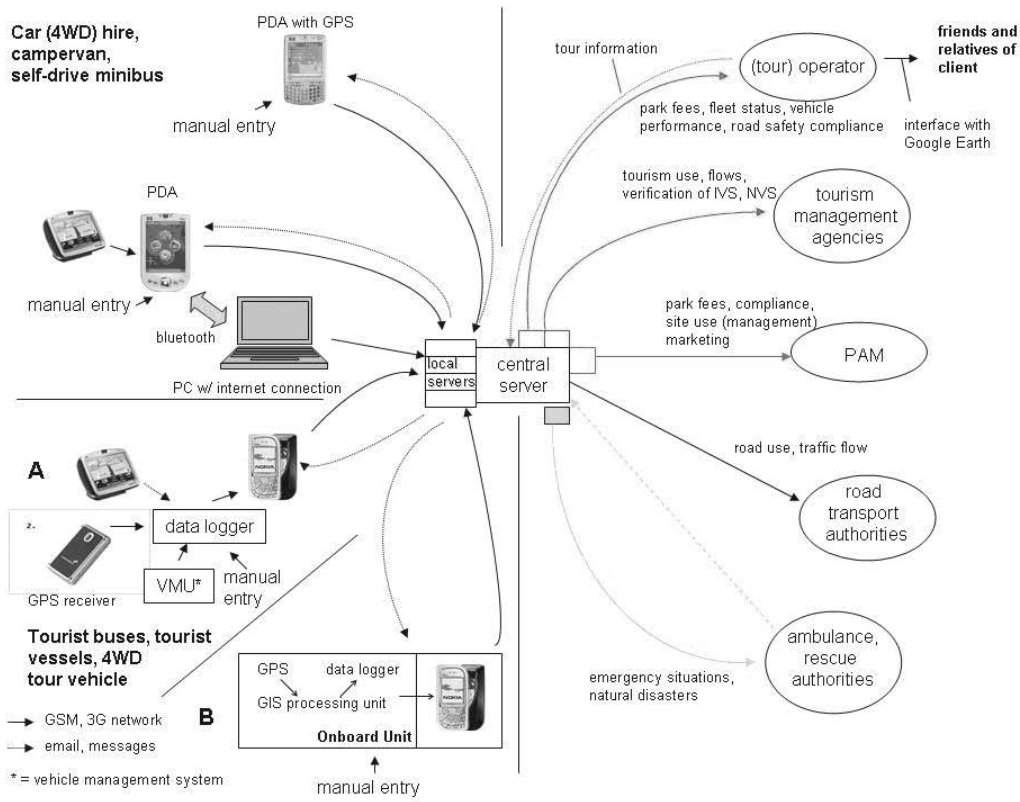

Figure 1: Hardware and server components for vehicle tracking systems.

dards for data collection, management and security by VTS providers under the Transport Certification Authority's (TCA) Intelligent Access Program (IAP) in 2005[1]. In other terms, most technical issues with VTSs are already largely solved or can be solved by using off-the-shelf hardware and software available for other applications, mostly in the transport sector.

There are, however, a number of constraints for implementing a VTS-based tour operator monitoring system in Australian PAs. These are linked in the first instance to data ownership, existing licence and entry fee structures (reflecting the variety of philosophies of PAMs about user pays systems), and the general mindset about the so-called 'big brother' syndrome of the system's key stakeholders: PAMs, operators, visitors and the general public.

The first and foremost issue relates to ownership of the positional data that would be generated by the VTSs. In the first instance, operators should be entitled to receive data about their own movements on a per trip or per week, month or year basis as part of the lease agreement with their VTS service provider. Where implementation of a VTS is prescribed as part of an operational condition of a license or permit required and issued by PAMs, the license provider should also be enabled to extract all data relating to its licencees free of charge, especially for compliance monitoring. In this case, operators would be required to agree to such data transfer as part of their licence conditions. The set of questions associated with data ownership becomes more complex when management agencies (e.g. road transport authorities or state tourism management and marketing agencies) interested in traffic and visitor flows wish to access VTS data:

- whether and to what extend can these data be released (and in what format) with or without permission of the operator,
- whether fees can be charged, and if, how should such payments be distributed between the VTS service provider and the PAM agency,
- who will be held responsible for insuring that such data are safely stored and not being released for wrongful purposes?

Based on feedback from current operations, these things have not been fully considered in the Australian VTS landscape.

1 National Transport Commission (Model Legislation – Intelligent Access Program) Regulations 2005 (Cth).

Another aspect of PA management in Australia complicates matters further: each State and Territory has passed its own jurisdiction for setting licence and entry fees under nature conservation legislation[2], or for road maintenance, use and management under transport legislation. This requires more work and, more importantly, much more consultation to develop and implement a national data capture and data filter (backend) system to reduce costs and improve efficiency. Without such a national system, other users of PAs (self-drive tourists using hire vehicles or private users) are less likely to adopt VTSs for automatic payment of park fees.

One of the key constraints for a VTS-based visitor monitoring system is the currently low or very low licence and park-entry fees. In Queensland, for example, use of National Parks by non-commercial visitors does not attract a fee at all. The EMC for visiting the Great Barrier Reef, on the other hand, has been set at AUD 4.50 per person per day for most operations. There are also no fee structures in the current systems that take into account the environmental sensitivity, managerial effort or operational expenses within individual parks. Costs for leasing a VTS (hardware, communication, and server support) are currently around AUD 100-150.- per vehicle and month. VTS not only provide visitor monitoring data and deliver fees, they also provide means for compliance monitoring (hardwired systems only). A full cost benefit analysis including all these aspects has yet to be undertaken in the Australian context.

One of the biggest hurdles for implementing any visitor monitoring system in Australia is the nationwide objection against any form of governmental control, monitoring and surveillance. Typical examples are common road safety enforcement technologies such as red light and speed cameras and even driver's licence demerit point systems in different states. These were either introduced much later than for example in Europe or, in regard to demerit points, are not fully cross-linked between States. A driver with a Queensland licence who was caught speeding in NSW will have to pay his/her fine, yet the accompanying deduction in demerit points will not necessarily be recorded in Queensland. Other examples include the slow uptake of remote sensing technologies for monitoring land clearing and other agricultural practices, despite Australia's nearly ideal environmental conditions (e.g. generally low cloud cover and flat, sparsely vegetated terrain).

Conclusions

Australia's vast and empty landscapes and, in most areas, its thin population base present an excellent case for introducing an efficient and effective GPS-assisted, VTS-based system for monitoring and surveying movements of visitors on commercial tours using PAs. Based on this first qualitative scoping study, the key impediments to introducing such sophisticated visitor monitoring technology are, in the first instance, legal aspects of data ownership, the complex nature of Australian nature conservation legislation, and ultimately and most importantly, the general resistance of key stakeholders to anything related to the 'big brother' concept of ongoing, remote surveillance.

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2 e.g. Environmental Protection (Biodiversity Conservation) Act 1999 (Cth), Nature Conservation Act 1992 (Qld), National Parks and Wildlife Act 1974 (NSW), National Parks and Wildlife Act 1972 (SA).