Spatially Smart Wine

Spatially Smart Wine was a project initiated by an enthusiastic group of Sydney Young Surveyors, with the support of the Institute of Surveyors New South Wales and the School of Surveying and Spatial Information Systems and the University of New South Wales. We present here the first part of the paper

Precision viticulture (PV) is styled from the zonal management paradigm of precision agriculture, where large homogeneous fields are divided into smaller units based on yield or other field characteristics which may be differentially managed (Lamb et al., 2002, Bramley, 2009, Bramley and Robert, 2003) *(Note that McBratney et al. (2005) suggest the definition of precision agriculture is continually evolving as we develop further technologies and greater awareness of agricultural processes)*. PV acknowledges the numerous spatial variations that affect grape quality and yield, including soil characteristics, pests and diseases and topography (Hall et al., 2003, Arnó et al., 2009), providing land managers with the tools to quantify and manage this variability (Proffitt, 2006). Land managers can thus 'selectively' treat areas, for example by the variable application of mulch, water, fertiliser, sprays etc.

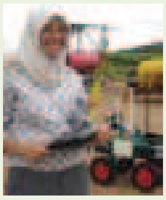
The general process of PV is cyclical across observation, evaluation and interpretation - which informs a targeted management plan followed by ongoing observation and evaluation (Bramley et al., 2005). The benefits of PV are increased knowledge of vineyard processes, allowing for targeted improvements to yield, wine quality, reduced disease incidence and increased resilience across the vineyard (Johnson et al., 2003). Data capture undertaken as part of PV can inform mechanised operations for greater efficiency in irrigation, spraying, mulching and pruning, and selective harvesting. Decision support systems are further supported and may aid land managers when in the field (Johnson et al., 2003). PV mitigates against the growing problems of climate change (Battaglini et al., 2009, Shanmuganthan et al., 2008), food security (Gebbers and Adamchuk, 2010) and supports the growing awareness of the consumer and market demands (Delmas and Grant, 2008, Rowbottom et al., 2008, Chaoui and Sørensen, 2008).

Research into the use of autonomous machinery in vineyards is still young and presents opportunities for further development (Grift et al., 2008, Longo et al., 2010). The use of wireless sensor networks is a recent addition to PV, but not yet routinely implemented (see examples in Shi et al., 2008, Matese et al., 2009, López Riquelme et al., 2009, Morais et al., 2008). A significant limitation of current applications and research is the lack of an appropriate, multi-functional decision support system (McBratney et al., 2005, Arnó et al., 2009).

This research focuses on the contribution of surveying and spatial technologies to PV, with a focus on sensor applications for tele-operated and autonomous machinery. This paper reports the preliminary findings of a scoping fieldtrip, with an outline of technologies tested for their utility and suitability to the client's needs.

The 'Spatially Smart Wine Project'

'Spatially Smart Wine' is a joint initiative of the International Federation of Surveyors (FIG) Young



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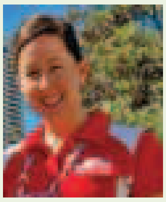

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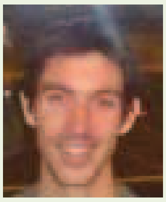

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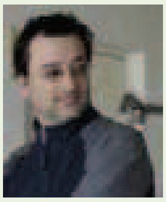

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Surveyors Network, the New South Wales Institution of Surveyors Young Surveyors Group (Australia) and the University of New South Wales Schools of Surveying and Mechatronic Engineering. The project was initiated to improve the networks and skills of young surveyors in the Sydney region, and to generally improve community understanding of surveying (see Figure 1). Additional benefits are increasing surveyors' knowledge of PV!

General details of how the project was run are reported in Fairlie and McAlister (2011). Fieldwork was undertaken at Jarrett's wines, a small to medium (300 hectare) vineyard 30km south west of Orange, NSW, Australia – approximately 300km west of Sydney. Established just over 15 years ago, the management of the vineyard now incorporates organic and biodynamic farming principles. The vineyard manager sees PV as a critical element of sustainable vineyard management.

Biodynamic viticulture rejects the use of synthetic chemical fertilisers and pesticides. Both organic and biodynamic farming practices embrace the use of natural products, but the underlying philosophy of biodynamics is the use of soil and plant 'preparations' to stimulate the soil and enhance plant health and product quality (Reeve et al., 2005). The adoption of organic and/or biodynamic farming practices is likely to increase with greater awareness of climate change and sustainability requirements (Turinek et al., 2009). The general thesis of these farming processes is sustainable agriculture, with no long term environmental damage. There remain a number of research gaps in organic and biodynamic farming practices – for example, critics cite a lack of scientific understanding and rigour within the biodynamic field (Kirchmann, 1994) . PV technology has a role to assist, for example in research on soil nutrient variability, mapping and management, weed control, and achieving dual outcomes of economic and environmental sustainability. Research is advancing with regards to robotic weeders, online systems to manage soil nutrients and crops, but commercial adoption and availability of products is limited (see Dedousis et al., 2010 for an overview of the field). The general goal of the fieldwork was the testing of survey and spatial technologies for PV, particularly taking into account client needs and fitness-for-purpose.

Figure 1: The authors at Jarrett's Vineyard

Table 1: Surveying technologies and their applications to PV. Compiled from (Keightley and Bawden, 2010, Bramley, 2009, Bramley and Robert, 2003, Lamb et al., 2002, Grote et al., 2003, Bramley et al., 2005)		
Sensor/ Technology	**Application**	**Benefits**
Aerial LiDAR and Terrestrial laser scanning	Measurement of tree/vine trunk diameter Height of vegetation and topography Leaf area density and index 3D reconstruction of vegetation/objects	Carbon measurement: wood volume of perennial crops indicative of carbon storage (Keightley and Bawden, 2010) Foliage density and height for variable spray applications (Gil, 2007, Rosell et al., 2009, Rosell Polo et al., 2009)
Satellite/aerial multi- and hyper-spectral imagery	Selective harvesting Yield estimation Digital Terrain Model Soil information Crop vigour indices (such as Normalised Difference Vegetation Index (NDVI), Leaf area index (LAI))	Topography provides indication of water/soil variation (Bramley, 2009, Bramley and Robert, 2003, Lamb et al., 2002) Healthy, vigorous grapevines typically have higher reflectivities (Arnó et al., 2009). Leaf density has been shown to be linked to grape yield and quality (Lamb et al., 2002). NDVI measurements can identify downy mildew (Mazzetto et al., 2010) LAI is related to fruit ripening rate, so can be used to parameterise plant growth models and for decision support systems (Johnson, 2003). LAI can also inform spraying (Siegfried et al., 2007)
Ground Penetrating Radar (GPR)	Soil water content	Soil water content informs planting and vineyard management (Grote et al., 2003)
Tele-operated and autonomous machinery applications	Mulching, irrigation, spraying, harvesting etc.	Relieves staff workload and allows for supported decision making, such as real-time measurement and resultant variability in applications (see for example, Bramley et al., 2005)
GPS	Accurate location of position GPS data can be incorporated into maps, giving new interpretative power to generate more meaningful maps	The accessibility and low cost of GPS means that grape-growers can accurately locate themselves within their vineyard when sampling for vine growth, development and productivity (Lamb et al., 2002)
GPS- and GIS-enabled Toughbook	Data collection of location of vines posts, quality of vines, defects (destroyed vines etc), rabbit holes etc	Cost-effective and convenient for basic mapping and data collection, replacing the traditional pen and paper-based method (Koostra et al., 2003)
Note the focus of this table is on technologies traditionally associated with the geospatial and surveying professions. It does not represent an exhaustive list of sensor technologies used in precision viticulture.		

Outline of this paper

In the following sections we will provide an overview of surveying technologies applicable to PV, an initial high level qualitative analysis of technologies tested, and finally an overview of the outputs and accuracies achieved in uniting the Unmanned Ground Vehicle with surveying technologies.

Application of surveying technologies to precision viticulture

PV requires much finer sampling than precision agriculture (Bramley and Janik, 2005), hence the greater need for surveying and spatial professionals to engage with this industry. Viticulture is particularly suited to spatial and surveying technologies, due to the 'fixed' nature of plantings and the perennial nature of crops (Arnó et al., 2009) and spatial analysis is critical to managing vineyard productivity and minimising risk in small scale vineyards.

Vineyard establishment in Australia will typically involve soil sampling (including type mapping, salinity measurements and moisture distribution), topographic mapping and surveyor set-out of plantings, with grape varieties located according to appropriate soil type, nutrient and moisture levels. Topographic variation is a critical driver of vineyard yield variation (see Bramley 2006, Bramley and Williams 2007), particularly in the Australian case where yield is closely linked to water supply and generally varies with topography (Bramley 2003b).

Once established there are a number of ongoing roles for spatial data and analysis. Vineyard leaf area is a key determinant of grape characteristics and wine quality and is a predictor of fruit ripening rate and instances of infestation and disease. Vineyard leaf area measurements can inform pruning procedures, shoot thinning, leaf removal and irrigation (Johnson et al., 2003). International monitoring of emissions for climate change mitigation and adaptation is further creating a role for spatial technology in the vineyard. Transient biomass (changes in biomass from year to year) provides an indication of the most productive areas of the vineyard, and monitoring of biomass may be a future requirement of climate change policy. Measurement of transient biomass year by year (i.e. following pruning) is common, but difficult and expensive – remote imaging options present much more efficient forms of measurement (Keightley and Bawden, 2010). Uniquely, Mazzetto (2010) present a ground-based mobile remote sensing lab to allow more frequent and targeted vineyard spatial analysis.

Table 1 provides an overview of sensor technologies for PV and their applications and benefits.

The paper was presented at FIG Working Week 2011, Marrakech, Morocco, 18-22 May 2011

...to be continued


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Land governance

This paper discusses the World Bank support for sustainable land reform, focusing on the East Asia Region, with particular emphases on initiatives in land governance, land development investment, tenure security, NSDI, e-government, land tax, spatial planning, disaster response and mitigation. Readers may recall that we have published the first and second part of the paper in October 2011 and November 2011 issue. We present here the concluding part of the paper

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The importance of good land governance to strengthen women's land rights, facilitate land-related investment, transfer land to better uses, use it as collateral, and allow effective decentralization through collection of property taxes has long been recognized. The challenges posed by recent global developments, especially urbanization, increased and more volatile food prices, and climate change have raised the profile of land and the need for countries to have appropriate land policies. However, efforts to improve country-level land governance are often frustrated by technical complexities, institutional fragmentation, vested interests, and lack of a shared vision on how to move towards good land governance and measure progress in concrete settings. Recent initiatives have recognized the important challenges this raises and the need for partners to act in a collaborative and coordinated fashion to address them. Increased awareness of the successful implementation of innovative approaches to good land governance can help to not only improve land governance itself, but can also contribute to the overall well-being of the poorest and the achievement of the MDGs.

Good governance is increasingly recognized as critical to effective development and sustainability. Specifically for the land sector governance, a fully functioning land and property system is composed of four building blocks: (a) a system of rules that defines the bundle of rights and obligations between people and assets reflecting the multiplicity and diversity of property systems around the world; (b) a system of governance; (c) a functioning market for the registration, exchange of assets; and (d) an instrument of social policy. Each of these components can be dysfunctional, operating against the poor.

Even in terms of standard indicators such as corruption, land has long been known to be one of the sectors most affected by bad governance, something that is not difficult to understand in light of the fact that land is not only a major asset but also that its values are likely to rise rapidly in many contexts of urbanization and economic development. The most authoritative survey of global corruption finds that, after the police and the court, land services are the most corrupt sector, ahead of other permits, education, health, tax authorities, or public utilities (Transparency International 2009). This survey found the levels of bribery across public sectors as follows: (a) land services, 15%; (b) police, 24%); (c) judiciary, 16%; (d) registry and permit services, 13%; (e) education, 9%; (f) health, 9%; (g) taxation, 7%; and (h) utilities, 7%.

Although individual amounts may be small, such petty corruption can add up to be large sums; in India the total amount of bribes paid annually by users of land administration services are estimated at $700 million (Transparency International India 2005), equivalent to three quarters of India's total public spending on science, technology, and environment.

The effects of weak land governance will be particularly harmful for the poor in developing countries for whom land is a primary means to generate a livelihood, a key vehicle to invest, accumulate wealth, and transfer it between generations, and key part of their identity. All over the world, land and real estate are a main component of household wealth. Because land comprises such a large share of the asset portfolio of the poor, giving secure property rights to land they already use can increase the wealth of poor people who are not able to afford the (official and unofficial) fees needed to deal with the formal system. It also implies that improved land governance has great potential to benefit the poor directly and indirectly.

Land governance assessment framework

The World Bank, in collaboration with other partners, has developed the Land Governance Assessment Framework (LGAF), a tool designed to help countries assess their policies and practices regarding land governance, setting a benchmark for comparison and monitoring of progress. It comprises a set of eighty detailed Land Governance Indicators which are ranked on a scale of pre-coded statements, from the degree of good governance to best practice. The LGAF addresses the need for guidance to diagnose and benchmark land governance, helping countries prioritize reforms, and monitor progress over time. It focuses on five broad thematic areas that have been identified as major areas for policy intervention in the land sector, viz. The legal framework, land-use planning, public land management, the availability of land-related information, and dispute resolution mechanisms. Table 2 presents a summarized version of LGAF's five thematic governance areas, comprising twenty-one index groups and eighty specific indicators (World Bank, 2010).

Initially piloting of the LGAF has been undertaken across a range of countries in different regions during 2008-09. In East Asia, Indonesia was the pilot country. If applied in a way that draws on existing expertise and broad participation

Table 2: LGAF Dimensions ordered by Thematic Areas
THEMATIC AREA 1. LEGAL AND INSTITUTIONAL FRAMEWORK
LGI-1. Recognition of a continuum of rights: The law recognizes a range of rights held by individuals as well as groups (including secondary rights as well as rights held by minorities and women).
LGI-2. Enforcement of rights: The rights recognized by law are enforced (including secondary rights as well as rights by minorities and women).
LGI-3. Mechanisms for recognition of rights: The formal definition and assignment of rights, and process of recording of rights accords with actual practice or, where it does not, provides affordable avenues for establishing such consistency in a non-discriminatory manner.
LGI-4. Restrictions on rights: Land rights are not conditional on adherence to unrealistic standards.
LGI-5. Clarity of mandates and practice: Institutional mandates concerning the regulation and management of the land sector are clearly defined, duplication of responsibilities is avoided and information is shared as needed.
LGI-6. Equity and non-discrimination in the decision-making process: Policies are formulated through a legitimate decision-making process that draws on inputs from all concerned. The legal framework is non-discriminatory and institutions to enforce property rights are equally accessible to all.
THEMATIC AREA 2. LAND USE PLANNING, MANAGEMENT, AND TAXATION
LGI-7. Transparency of land use restrictions: Changes in land use and management regulations are made in a transparent fashion and provide significant benefits for society in general rather than just for specific groups.
LGI-8. Efficiency in the land use planning process: Land use plans and regulations are justified, effectively implemented, do not drive large parts of the population into informality, and are able to cope with population growth.
LGI-9. Speed and predictability of enforcement of restricted land uses: Development permits are granted promptly and predictably.
LGI-10. Transparency of valuations: Valuations for tax purposes are based on clear principles, applied uniformly, updated regularly, and publicly accessible.
LGI-11. Collection efficiency: Resources from land and property taxes are collected and the yield from land taxes exceeds the cost of collection
THEMATIC AREA 3. MANAGEMENT OF PUBLIC LAND
LGI-12. Identification of public land and clear management: Public land ownership is justified, inventoried, under clear management responsibilities, and relevant information is publicly accessible.
LGI-13. Justification and time-efficiency of expropriation processes: The state expropriates land only for overall public interest and this is done efficiently.
LGI-14. Transparency and fairness of expropriation procedures: Expropriation procedures are clear and transparent and compensation in kind or at market values is paid fairly and expeditiously.
LGI-15. Transparent process and economic benefit: Transfer of public land to private use follows a clear, transparent, and competitive process and payments are collected and audited.
THEMATIC AREA 4. PUBLIC PROVISION OF LAND INFORMATION
LGI-16. Completeness: The land registry provides information on different private tenure categories in a way that is geographically complete and searchable by parcel as well as by right holder and can be obtained expeditiously by all interested parties.
LGI-17. Reliability: Registry information is updated, sufficient to make meaningful inferences on ownership.
LGI-18. Cost-effectiveness and sustainability: Land administration services are provided in a cost-effective manner.
LGI-19. Transparency: Fees are determined and collected in a transparent manner.
THEMATIC AREA 5. DISPUTE RESOLUTION AND CONFLICT MANAGEMENT
LGI-20. Assignment of responsibility: Responsibility for conflict management at different levels is clearly assigned, in line with actual practice, relevant bodies are competent in applicable legal matters, and decisions can be appealed against.
LGI-21. Low level of pending conflict: The share of land affected by pending conflicts is low and decreasing.

by relevant stakeholders (including governments) from the beginning, the LGAF can not only help to broaden the range of issues to be covered in such analysis but also the relevance of the resulting analysis and the credibility of resulting recommendations for policy or further study. In all of the countries studied, the LGAF was useful as a diagnostic tool to identify gaps in policy and the way in which institutions function or responsibilities between institutions are assigned. A second use of, to monitor discrete (rule-based) indicators for policy reform, follows immediately and can provide an excellent opportunity for a broad-based coalition of actors (including NGOs, the private sector, and academics) to monitor to what extent recommendations are followed through. Finally, and possibly most importantly, the LGAF points towards a number of quantitative indicators which, together with the initial diagnostic, are essential to continually monitor land governance. The fact that each of these indicators is related to one or more core areas of the land administration system suggests that collection and publication of these indicators on a regular basis, and to accommodate wide variations of these indicators over space in a way that can be easily disaggregated, should be a routine in any land administration system.

Sustainability of land administration systems

For the investment in a land administration project to be considered successful, it should be expected that the developments by the end of donor engagement are sustainable. Sustainability has many elements including: (a) capacity; (b) budget; (c) good governance, transparency and accountability; (d) security of land records from loss, destruction and fraud; (e) reliable and consistent delivery of services which are accessible, government commitment and public confidence; to name but a few.

There should be sufficient capacity in the public sector and hopefully also private sector. Land administration agencies should have sufficient recurrent budget to maintain their operations and have access to additional investment budgets to undertake the necessary developments and improvements to maintain their efficiency and effectiveness. Whilst in many developed countries there are examples of land administration agencies which are self-funded, from land registration and other fees they collect, it should never be forgotten that it has taken a very long time to achieve such a status, and much longer than the duration of on one or more phases of land administration project implementation.

The Thailand land titling program is one example of a successful program that has long been sustained after the donor support had finished in 2002. The Thai Department of Lands (DoL) has continued to implement the program, under government funding. A technical review undertaken by the World Bank in August 2009, noted that the land registration in Thailand now generates around ten times its operating costs per annum through fees collected for land transactions and enquiries, although DoL remains an on-budget agency and all revenue is returned to the Treasury. In Thailand, the majority of all land transfers are generally completed in less than three hours.

Concluding remarks

Land-related issues will continue to be high priority areas of engagement by the World Bank as evidenced by the continuing concerns of food security, climate change, disaster mitigation and response, poverty alleviation, growing urbanization, carbon, conflict, human rights and so. That land is now more clearly seen as a cross-sectoral issue, may see an increasing trend of dealing with land issues under a broader project or program agenda. ICT, and specifically geospatial information technologies, will increasingly be on the critical path of the support provided by the World Bank. The importance of the cadastre, in its broadest sense, and its governance, remains paramount in almost all development interventions. It therefore follows that investment in land administration systems should explicitly see the development of the NSDI and spatial enablement of the government as part of overall reform, which facilitates an expanded agenda that includes land governance, social development, sustainable management of natural resources and the environment, disaster prevention, climate change, carbon monitoring and so forth. However, such investments need to be calibrated for the specific country requirements, including capacity and sustainability.

For land-related professionals, especially surveyors and spatial information scientists, it is essential that their engagement in land administration, and governance reform, is based on the prudent and balanced application of new technologies and appropriate levels of spatial accuracies. Over-engineered data bases, requiring unnecessary data fields and unnecessary high levels of spatial accuracy, are costly to develop and maintain. These professionals must also recognize the broader social, cultural, political, economic and financial factors that shape the cadastres and NSDIs. The focus of thinking and investment should be on good governance and completeness, reliability, fitness-for-use and cost-effectiveness of land-related data rather than spatial accuracy. The International Federation of Surveyors (FIG) has a very prominent role to play at both global and regional levels in shaping the thinking of land professionals to ensure sound investment in modern technologies.

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