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Development and Operation of a Technological Museum at Sovereign Hill, Ballarat

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SUMMARY Experiences in planning and operating the Mining Museum and associated displays at Sovereign Hill are related. Live-steam operations in particular require careful planning to ensure that exhibits survive for the benefit of future generations.

1 INTRODUCTION

Aspects of our engineering heritage are preserved and displayed at Sovereign Hill, Ballarat, with particular emphasis on gold-mining technology. The Mining Museum is a complete reconstruction on an original mining site, and has developed in parallel with the Goldmining Township and the Red Hill Gully Diggings at Sovereign Hill. The Gold Museum, a more formal museum in a modern building, is sited nearby.

Sovereign Hill is operated by the Ballarat Historical Park Association, a non-profit community-based organisation registered under the Victorian Companies Act. The philosophy and guidelines for development are laid down by an Honorary Board elected by the members, and are implemented through a professional staff. Membership of the Association is open to all.

Since the park opened to the public in 1970 it has been an outstanding success, and in 1983-84 it was visited by over 430,000 people. In that year an average 300 school children visited the complex on every school day throughout the year, on organised school excursions. Well over 5 million visitors have passed through since 1970, so it is reasonable to say that many Australians have formed their opinions of 19th Century living conditions and technology as a result of what is depicted at Sovereign Hill.

In addition to its importance in preserving and displaying our heritage, Sovereign Hill is of commercial significance to the Ballarat area. With a full-time staff of over 150, and an annual expenditure of $4.2 million (1983-84), the complex is a major local industry. The flow-on benefits to local businesses are estimated at $10-15 million per annum.

2 THE MINING MUSEUM

The Mining Museum at Sovereign Hill consists of the surface installations and underground workings associated with a Ballarat quartz mine of the period 1880-1916. A quartz mine was a mine which worked quartz reefs containing gold. Hard-rock mining methods were used and the quartz ore was crushed in a stamp mill, or battery, to liberate fine particles of gold for amalgamation with mercury.

The Mining Museum is divided into surface and underground areas, of which the surface buildings and structures can be examined at the visitor's leisure. The underground area is accessible only as a guided tour, which takes about 45 minutes to complete.

The weatherboard buildings on the surface include the boiler house, changehouse, engine house, mine blacksmith's shop, and battery house. The engine house contains the winding engine, air compressor and pumping engine, and the battery . house contains the changehouse and the mine office complete the scene. Mining museum staff also have responsbility for engineering plant in other businesses in the Township area. A total of 7 steam engines are fully restored and operational, with much ancillary plant.

3 MUSEUM PHILOSOPHY

Sovereign Hill is a "living history" museum or theme park which portrays life on the Ballarat Goldfields. It has standards of conservation, research and interpretation which are similar to those of the more formal, government-funded museums. The Mining Museum area was the first to be given attention when Sovereign Hill was developed in the late 1960's. At the time, the Board saw mining as the central theme for the complex, and were aware of two Ballarat traditions; the big quartz mines which survived into the second decade of this century, and the small-scale alluvial mining of 1850's. There were still many vigorous people in Ballarat who remembered the big mines, and even more who had been involved in the small-scale mining revival of the 1930's. It seemed natural at the time to develop these two areas as displays for the coming generations.

Today, nearly 20 years after these decisions were made, it is more difficult to reconcile the Diggings area of 1851-54 to the adjacent township of

1854-61, and to the quartz mine of a much later era. Much research and planning by a professional staff has led to definitions of the time period represented in each area, and of the materials which should be used to present each area to the visiting public.

For many reasons the several areas had to develop as they did. The diggings was the original Ballarat, world-famous after 1851 for the richness of its surface gold. The Red Hill Gully Diggings is of that period, with no hint of the subsequent larger-scale developments, or the oil-engines and Ford Model T's of the 1930's revival. The township is late 1850's, with one or two facades and businesses of 1861, the year the railway came and completed the transformation of Ballarat from a mining camp into an industrial city. No large-scale mining exhibits show the technology of the 1860's and 1870's because the equipment of that era has not survived, or is not available. The complete quartz-mining plant of 1880-1916 was collected some years ago when most items were commonly available and even stocked by mining equipment suppliers. It would be nearly impossible to build the Mining Museum again in the 1980's.

Given that three distinct periods are being represented at Sovereign Hill, no reduction in standards of historical accuracy is permitted when a display is planned for one of the areas. In recognizing the interpretive problems and in trying to minimise its impact, we do much better than most outdoor museums and theme parks where there is usually no attempt to define the era being depicted, or to separate objects and displays from different periods. At Sovereign Hill a picket fence separates the mine area from the township, and a coach road runs between the township and diggings.

4 DISPLAY RESEARCH AND DESIGN

Professionally qualified staff are employed in the curatorial and research departments. However engineering research, by its specialised nature, is heavily dependant on voluntary assistance. The elected Board of Sovereign Hill includes four professional engineers who give their time for this purpose in varying degrees.

As an example of the research process, consider the "Buninyong Company" display now being developed. As a result of a change of philosophy is the underground museum, a large chamber which had been excavated some years ago for a formal museum-style display became available for redevelopment. Constraints on the new display were that it had to depict an activity which took place underground in Ballarat and district some time before the 1916 cut-off date for the museum. It obviously could not duplicate any of the existing displays.

The literature was searched, particularly old Geological Survey reports and recent historical publications. Mention was found of an underground rope-haulage and pumping chamber at the Buninyong Company's alluvial mine in 1864. Curatorial staff found a lithograph in the museum archives which showed the chamber and machinery in sufficient detail for an engineering sketch to be prepared. Preliminary costs and an artists impression of the display were considered by the Mining Committee, and a recommendation made to the Board that the project be supported and funding sought. This process involved:

a) A decision that alternatives uses of the chamber were less attractive.

b) A decision that additional time could be provided within the guided tour of the mining museum for the equipment to be demonstrated.

c) A decision that alluvial (Deep Lead) mining should be depicted in the underground mining museum, which had previously been restricted exclusively to quartz mining.

The detailed planning, including engineering drawings, will proceed with a combination of voluntary work and paid consultancy.

5 PROJECT COST ESTIMATION

The old adage "reckon it out then double it" has some place in historical reconstruction, especially when major components have to be procured or fabricated. Restoration of an existing machine such as a steam engine can be costed out carefully after inspecting the state of wear of components and determining which parts are missing. This cannot be done without a partial dismantling which includes, for this example, removal of cylinder heads and bearing brasses. Normal casting and engineering costs will apply for new components. The cost of pattern making can be important for complex one off parts; it is cheaper to track down duplicate originals held by collectors or other museums and borrow the parts if possible as patterns.

Non essential work (from a functional point of view) can be surprisingly expensive. This includes such things as painting and lining (pin-striping), brass-bound wood lagging of cylinders, dummy flanges on steam pipes, and false brickwork on concrete foundations.

Economies can be achieved by skilled application of old methods. Hardwood bearings were commonly used in outback locations last century, and in Red Gum and Grey Box such bearings have given excellent service at Sovereign Hill as low cost substitutes for expensive castings. For success, such bearings must be well-lubricated.

Measures such as the machining in place of large-diameter bearing journals, and hand-fitting of badly worn "brasses," can save outside costs but may increase the internal labour component. Where staff are involved in museum operations and capital works, the temptation is strong to hide some restoration costs as "operations", particularly when an over-run on an estimate is developing. While this doesn't add to an organisations overall costs, it does distort the accounting records and makes the estimation of the next project difficult, probably leading to another under-estimate.

As an example of the estimation of a major re-creation project, consider the estimates for the "Beam Pump" project made in 1982, which are listed below. (The stages referred to are the actual sequence of construction).

ITEM	ESTIMATE 1982 DOLLARS	ACTUAL 1984 DOLLARS
Engine and crankshaft foundations	3000	
Purchase of steam engine	2000	
Pit excavation and retaining walls	5000	
Timber for beam and rods	2500	
Assembly	5000	
Underground drains and plumbing	1000	
Contingencies	4000	

Stage 1 subtotal	22500	54000
Restoration of steam engine	6000	
Steam plumbing	1000	
Restoration of gears and bearings	1000	
Manufacture castings	5000	
Contingencies	4000	

Stage 2 subtotal	17000	15000
Building alterations	2000	
Shafting and crank	1000	
Construct flume	3000	
Rising main in shaft	2000	
Construct plunger pump	5000	
Contingencies	2500	

Stage 3 subtotal	15500	17000
Grand Total	55000	86000

A statement was included in the proposal outlining the difficulty of estimating such a project. Almost every component might be obtainable as a donation, or at scrap price, or might be very expensive to reproduce as a casting or a fabrication. The Beam Pump project proceeded following receipt of a grant from the Buckland Foundation to cover stage 1 construction cost estimates.

At the time the estimate was made, no components for the project were on hand. It was suspected that "Bob" components in particular, might be obtainable, but that a suitable engine would be found readily. In the event, most of the required bob castings were obtained as a donation shortly after the project was announced. The steam engine was purchased from a dealer following national advertising (including a letter in "Engineers Australia") and the writing of dozens of letters over more than a year. A spur gear was obtained at scrap price from a wrecked mining shovel, but a matching pinion gear was sought for many months and purchased at the "spare part" price.

Obtaining the bob castings was a windfall, but created a new problem. The castings were for a bob nearly double the size of the one which had been estimated, and the cost of excavating and lining the bob-pit in bluestone masonry was well in excess of budget. A decision was made to proceed, accepting the inevitable overrun in this area. The main beam of the bob is a 10 m length of 300 x 450 mm oregon, which was not obtainable in imported timber. The problem was solved by finding an oregon pine tree in Victoria of a size permitting the piece to be cut from it. Considerable care was then required in curing and treating the piece after it arrived on site freshly cut.

Seven-inch plumber blocks proved almost impossible to obtain, despite a search of Victorian scrapyards. They were eventually found in a Queensland sugar mill. Sovereign Hill is fortunate in having many friends throughout Australia, and without their help many projects could not be attempted.

To contrast these successes, consider a lapsed project of some years ago. The proposal was to build a 10 m diameter waterwheel and have it drive a small quartz-crushing battery. Essential to the project was a cast waterwheel hub and the cast ring gear which bolts to the periphery of the wheel. These had been located at an abandoned mine site and application was made through the relevant government department for their removal. This was refused, and instead the equipment went to a "tourist attraction" where it lies in pieces today. Such problems cannot be foreseen at the budgeting stage.

6 OPERATING COSTS

Operating costs must be considered for each new project. These include the cost of power which may be firewood for the boiler, the cost of staffing the exhibit, usually with a qualified engine-driver, and the cost of maintenance. For many machines the maintenance costs includes a major replacement in 10 or 15 years, such as replacing the mortar boxes in a stamp mill. Such costs must be acknowledged by the management before the project is approved. Where operations are externally funded or subsidised, provision for major replacement should be built in to accounts. For operation of the Sovereign Hill battery, for example, the following costs are assumed:

Labour	$135.00
Firewood	$ 25.00
Chemicals	$ 1.50
Water	$ 0.70
Grease & Oil	$ 1.70
Electricity	$ 0.50
Stone	$ 25.00
Tailings removal	$ 3.00
Repair fund	$ 5.50

TOTAL	$197.90

This cost applies to some 2-3 tonnes of stone crushed daily, although a greater throughput is possible with a modest increase in cost. It is evident that any custom milling of ore for prospectors must be charged at a realistic level. The decision to part-subsidise the client's costs because of the publicity value or the extended hours of demonstration to visitors, can then be an informed one made by management.

7 FINANCE

Sovereign Hill has been self-funding since its inception. Nevertheless, the rate of new development has been helped from time to time by Government grants and private donations for specific projects. The members of the board, the members of the various committees and the Friends of Sovereign Hill all give their services voluntarily. All profits from operations are directed back into capital development.

There is strong evidence that museums cannot achieve commercial success while maintaining an adequate standard of historical accuracy and conservation. Other privately-run ventures which aspire to be like Sovereign Hill have stopped developing soon after opening in order to preserve a cash flow, and often suffer from lack of even basic maintenance of exhibits. That Sovereign Hill has gained credibility as a museum has been possible because of a high standard of business management and marketing expertise. An examination of past accounts shows that there has been no surplus of funds generated which would have provided a satisfactory return on investment for a commercial operator. Considering that this is the most successful outdoor museum in Australia, the message is clear: no private operator or Government body should contemplate developing a technological museum on any basis other than non-profit. Any surplus of income over expenditure must be earmarked for development, conservation and research.

8 CONSERVATION OF EXHIBITS

Once given responsibility for an object, a museum has the following options:

i) Store it for future research in a safe place.

ii) Store, while researching and publishing.

iii) Mount a static display.

iv) Include it in an activated display.

While in storage, a steam engine should have all packings removed to prevent the accelerated pitting of shafts which occurs beneath the packings. Engines and other machines should be turned over and lubricated on a weekly basis.

In the case of steam-driven machines, activated displays may be achieved by using concealed electric drives, or by operating the engine on compressed air or steam. Each approach has its advantages and disadvantages.

To use an electric drive, the engine must be stripped and the piston and valve assembly removed. These can be stored for future research or restoration. If the budget permits, it is best to make up new piston rods and eccentric rods so that the originals can be protected from the heavy wear which will occur. Well-lubricated gland packings are required and proper, regular lubrication of packings is almost impossible to achieve.

An example of a situation where an electric drive was required is provided by the Furniture Factory at Sovereign Hill. The building was designed as a leased business, and the Mining Museum team had to design the building's internal layout with steam engine and drives to lathes. An early decision was made to place the steam engine within the building. Some evidence was available for engines being situated within working areas in Ballarat, possible because of the cool to mild climate. A suitable engine would be of the 1850's as this building is the only steam-powered plant within the township area, defined as 1851-61, and is not part of the Mining Museum. The engine should also be relatively small and be attractive.

A suitable engine was located by advertisement in Eastern Victoria, at a private museum which was being sold up. The engine was in poor condition, and was in fact situated by the roadside as a signpost for the museum. It was decided to operate the factory by concealed electric drive because:

a) the furniture factory was located at some distance (150 m) from the boiler house.

b) no engine driver would be available in the leased business.

c) the installed boiler was approaching the limit of its steaming capacity.

The restoration and installation of the engine cost $5000 in 1979. A 50 mm drive shaft ran the length of the building, and two lathes were driven through fast and loose pulleys to lay shafts, with 4-step pulleys for varying speed range.

Compressed air is often used to drive steam engines for display, but there is a high risk of damage due to poor lubrication of rubbing surfaces. Particularly at risk are the cylinder bore and valve faces. If compressed-air must be used, a proper airline lubricator must be installed as close as possible to the valve chest, and a good compressed-air lubricating oil used. Even then, the air velocity through the engine is usually too low, and the oil mist drops out in the bottom of the cylinder. Tests at Sovereign Hill, involving stripping an engine for examination after running on air, showed that a steam line lubricator is quite unsuitable in this application.

Displays of machinery can be in the formal museum setting like "glass-case" exhibits, or they can be in a simulated working environment. Display in the original location is the most desirable destiny for an old machine, but in most cases it is impossible because the industry continues to operate on the site, or the site is being redeveloped. There will always be a need for "living history" museums to house significant machines.

Mechanical wear is an inevitable result of operating machines. 19th Century equipment is usually of massive construction and designed for a very long wear life, so that the problem is not as serious as it might be for modern machines. Also, the original design usually included provision for taking up considerable play in bearings, gears and linkages due to wear. This provision was necessary due to the uncertain quality of lubricants, and the possibility of unskilled operators having charge of equipment.

The result today is that with modern lubricants and careful operators, while running under light loads for only a few hours per day, a machine may have a life expectancy of many centuries. Designs often incorporated replaceable wear surfaces which can be renewed without comprising the historical integrity of the exhibit.

Low-speed steam engines are best at 50-60 r.p.m. This speed is sufficient for most operations and avoids the high stresses and high wear rates which might cause premature component failure. Some difficulty may result with governors designed for a higher speed. This can be solved by changing the belt pulley size on a flyball governor or installing softer springs in the more advanced types. Large engines which are lightly loaded present a special hazard in the event of a runaway due to the loss of a governor belt. Flywheel speeds increase rapidly in such an event and self-destruction could be reached in a few seconds. A orifice plate fitted in the steam delivery line will limit the open-throttle speed of the engine. The engine should also be loaded wherever possible with some realistic task. This not only reduces acceleration in a runaway but gives better sealing on a D-valve. Engines seen in some museums and steam rallies develop a valve rattle because there is inadequate pressure in the steam chest to hold the valve face firmly against its seat.

9 RESTORATION TECHNIQUES

Some of the techniques used at Sovereign Hill may be of interest to other museums, so a brief discussion is warranted. Most cast parts can be welded with modern methods, so repairs are possible. Replicas of castings can be made by fabricating from mild steel plate with plenty of filler-welding and grinding. Casting features can be added with auto body filler, prior to painting.

Shot-blasting and bead-blasting are useful timesavers for cleaning smaller components. Hardfacing and metal-spraying can be used to build up worn surfaces, such as air compressor poppet-valves.

Foundations must be designed with regard to static and dynamic loadings and the quality of footing material. Old engineering books give safety factors which apply to static loads to cope with dynamics at the low speeds involved. Foundations are simplest in reinforced concrete, with PVC drainpipe provided as bolt tubes. A bolt may be set in the vertical PVC pipe with a large washer behind the bolt-head. Bend in the bolt gives the required freedom of movement at the top of the pipe. Alternatively, bolt ends may be boxed to the outside of the foundation so that nuts and washers may be fitted to the bottom of the bolt after the foundation is completed. The use of epoxy resin has proved satisfactory for fixing large-diameter bolts into holes which were drilled into reinforced concrete with a rockdrill.

Lubricating oil was filtered and reused until recent times. At low temperatures this may be quite acceptable but filtered oil at Sovereign Hill is not used in any original equipment, because its quality cannot be verified.

10 REGULATIONS AND PUBLIC SAFETY

Sovereign Hill deals with many Government departments in its planning and day-to-day operations. Local Government planning approval is required for any new development, with Labour and Industry approval for industrial activities and amusement structures. The Mining Museum operates under the Mines Act and Regulations, with some input from Department of Labour and Industry.

A Mining Committee meets monthly to plan and monitor developments in the mining area, and reports to the Board of Sovereign Hill. For at least a decade the District Inspector of Mines has been a member of the committee, which also includes several Professional Engineers from the local community. A Health and Safety Committee, of Safety and Medical professionals and operations staff, meets independently.

A prime concern of both committees is safety; avoiding accidents to visitors and staff. This must be achieved around machinery without seriously reducing visibility, or compromising the historical presentation. As much of the exhibit as possible must be visible to the public, and viewing should be from as many angles as possible.

The public must be kept clear, at greater than arms reach, from all moving or hot parts.
Barriers and spacing must be designed to prevent deliberate attempts at self-injury. As an example, the authors installed an unlagged steam pipe some 3.5 m above ground, well out of reach of non-athletes, and then had to deal with a visitor with burnt hands who had taken a running leap to swing on the pipe. Needless to say, the pipe was lagged the following day. An older generation was familiar with open belt drives and their hazards; today's visitors are almost universally ignorant of the perils which surround them in a 19th Century plant. Steam exhausts must be well out of reach, as people insist on plunging hands into the escaping steam to test its temperature. Sovereign Hill has had success with

barriers made of timber, and avoided the need to use modern materials like weld-mesh or perspex. This contributes to the atmosphere achieved throughout the museum.

Visibility must be given attention - it is no good restoring and operating equipment which is poorly illuminated or obscured. Illumination is best and most economically achieved at Sovereign Hill through the use of skylights and clerestory windows. The period depicted is largely before the advent of electricity.

Public viewing platforms work best when elevated above the working floor of the plant. As little as 500 mm elevation can make it possible to see over adjacent machines and across the room. When large numbers of visitors are handled, accesses and viewing areas must be connected on the one-way "sausage machine" principle. Viewing areas should be wide enough, say 2 m, for two rows of spectators at a railing to be passed by through traffic behind them.

The most difficult decisions arise when a regulating body requires a macine to be modified to suit modern regulations. Sometimes there is no alternative. The Cornish flue boiler at Sovereign Hill is fitted with an electric low-water alarm and a locked safety valve. Permission was granted for the old lever-arm safety valve to be retained in parallel with the modern one, and the alarm is hidden in the lagging. A modern water-treatment unit is concealed behind panelling in the boiler house. At the time of each annual inspection, cast pressure vessels such as valve bodies are crack-tested. The riveted boiler seams are x-rayed periodically.

Less success has been achieved with the main winding engine, which was imported from Scotland in 1904. The engine has been restored to its original condition and safe operation has been demonstrated. However, modern regulations require a "dead-man" facility so that the brakes are applied in the event of any mechanical failure or loss of power. To incoporate such a facility would require a significant change in the mechanism of the engine, compromising its integrity as a museum object. As there is no intention of using the winding engine to hoist people up the shaft, it is hoped that this impasse can be resolved with minor changes to the mode of operation.

11 INTERPRETATION

People want to stop and talk to operators. In an ideal world, every visitor could have an extended chat or a personalised guided tour. When the area is noisy or when the demanding work is being undertaken, no contact is possible. A compromise should be sought somewhere between the extremes. For example, every public area employee's productivity must be assumed to be less than it would be in a private area, due to the need for communicating with the public (often called "interpreting the exhibit"). A gregarious employee will do less than half the work normally possible, while a reserved nature leads to high productivity. The museum is there ultimately to please the public, so the problem must be accepted, and a certain level of interpretation chosen and costed into the operation. The enforcement of this level is the responsibility of supervisors who need some measure of an empoyees' productivity to decide whether the level is being achieved. Possible measures include manufacturing output, restoration rate, machine availability (breakdown rate) and visitor satisfaction as measured by comments or surveys. The concept of "living history" is at odds with the use of interpretive signs, which intrude into the field of views and exude a "museum presence." In operating areas the staff may be too few or too far away to assist the visitor's understanding of activities. In some areas the noise is too great to permit conversation. Freely available brochures tend to be discarded after reading, and create a litter problem.

The solution to these problems has not been determined. Some outdoor museums offer a "guided tour" soundtrack on a cassette recorder which can be hired. Some offer a "theme lounge" adjacent to each operational area, where visitors may explore the subjects in greater detail after viewing the activities. At Sovereign Hill, the great number of the visitors (up to 7000 per day) make some proposals impractical. The engineering areas are the ones of greatest concern. Most people can comprehend the purpose and function of 19th Century shops, homes, horse-drawn vehicles and social activities. They cannot be expected to comprehend two-stage intercooled air compressor, a tandem-compound steam engine or a reciprocating bob pump with Cornish pitwork.

It is the author's opinion that a working compromise can be achieved by the simple labelling of exhibits, and the availability of high quality publications describing the historical development and function of each engineering component or process. Publications must be well illustrated and must be sold near where the exhibits operate, perhaps in a "theme lounge" environment. Such publications would make a useful contribution to the awareness of our engineering heritage. The problem of interpretation is still under consideration at Sovereign Hill and is by no means resolved.

12 STAFFING

Staff operating boilers and steam engines must be qualified to do so, and must be particularly aware of the public risk. To operate on a seven day basis requires a minimum of three engine drivers if holidays and sick leave are to be covered. When simultaneous working of more than one display area is required, this number rises. It also rises if operating staff are also the skilled staff who are depended upon for restoration and construction of new exhibits.

At Sovereign Hill, three engine driver/boiler attendants are currently employed on a rotating roster. One of these was trained on the job and a second has improved his qualifications there. A fourth is in training and soon to sit his exams. This number of staff is proving inadequate as new displays are developed and as projects require construction expertise. The result is that annual leave entitlements build up while the staff cannot be freed to take their leave. This is a result of the enthusiasm of the staff rather than the intention of managment. The necessary skills are in short supply and considerable on-the-job training is required, so that this situation is not easily remedied.

Development and maintenance of the underground museum also calls for special skills, and a minimum of two experienced miners are employed for the purpose. These men must be versatile, and willing to assist with surface construction and restoration while underground activity is suspended.

13 CONCLUSION

The Sovereign Hill operation is an example of a successful technological museum. The authors consider that its success is due to a high standard of research and presentation, made possible by a sound level of funding generated by careful commercial management. Such conditions can only be met in Australia by a non-profit organisation with considerable voluntary assistance, and with professional staff in management. Careful cost control and engineering supervision are prerequisites to success.

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