A Introduction

A.1 Project aims and deliverables

In 2004 Silvertip Design demonstrated the feasibility of building road/rail vehicles (Figure 1) that can transfer between modes while moving (summary E.12.1). We now plan to develop the dualmode concept, and build and demonstrate a full sized prototype.

Figure 1 - BladeRunner: dualmode concept – 1/8 scale working model

This BladeRunner (BR) development project is based on standard tractor unit chassis components to which three modules are added: Plug–in frame module; Body lift mechanism and the Mid–Lift axle mechanism. Each of these modules (E.12.2) has a range of options to suit different applications. The body is demountable and can be a simple load platform for freight or a passenger compartment with a large low floor area offering easy access for all. The twin bogie configuration permits the road vehicle to act like a tram and run along an existing tramway or railway line. A trolley version could be guided to draw power from a rail or wire and so make the most efficient use of alternative power sources.

A.2 The reasons for the work

In the next few decades one of the greatest challenges for vehicle manufacturers, fuel suppliers and Governments will be to reduce carbon dioxide (CO_2) emissions from road transport.

The key transport outcomes sought by the UK Government by 2010 are:
• 12%-20% reduction in CO_2
• 6% reduction in road congestion
• 40% reduction in people killed and seriously injured on the roads

Transport currently gets 90 percent of its energy requirement from oil and given that new oil discovery worldwide peaked around 1960 and has been running well below consumption since 1980 a production peak is about due. This point at which the rate of World oil production starts to fall year on year is termed 'Peak Oil'. Somehow by 2025 demand for oil is also expected to increase by 50 percent. There is now a serious prospect of very high fuel prices, which may turn out to be a more important challenge for society than meeting our Kyoto obligations.

In reality, reducing Green House Gas emissions, making progress towards sustainable transport, and preparing for an era of energy constraints all amount to the same thing: drastically reducing fossil fuel use. However, many transport initiatives towards these goals remain isolated experiments. The new technologies and the associated new forms of transport do not seem to address the challenge of sustainable development. In short, they do not create a basis for high mobility and low emissions. Nor do they consume low levels of energy or space. It is therefore an objective of this project to provide the means to both increase the capacity of the transport network – to promote recycling – while at the same time reducing the amount of fuel it consumes, the space it uses and the emissions it produces.

From the outset we are aware of the difficulty of the project in hand. Although "sustainable mobility" is a long-term goal we appreciate the importance of a niche development process. The dualmode concept we are to develop is modular, uses predominantly proven technology and isolated niches can be readily scaled up to create larger systems and resilient networks.

A.3 The project cost and length

The project will last 3 years and cost £1.5m; 70 % of which is internal. The important milestones are specification (◊6mths); design and build (◊14mths); circuit testing (◊22mths); demonstrations (◊24mths).

A.4 The project location

As much of the work as possible, including some of the assembly tasks will be carried out at new premises. The body for the vehicle will be both designed and fabricated at Don–Bur's factory in Stoke–on–Trent. Initial testing on the rail tracks will be carried out on the privately owned line in Wensleydale. The road tests will be carried out at one of a selection of test circuits around Europe. TRL, Mira or LTC are the obvious UK choices.

A.5 Why do you need the grant and what would happen without it?

The BladeRunner is a new vehicle configuration and as such is not yet fully defined in the European legislation. The existing market for road rail vehicles relies on legal concessions.

Government policy may also be a barrier. Even though the European governments are committed to environmental protection and other social goals, they are not putting out a clear message that there is a need for specific new technologies. Manufacturers therefore remain uncertain about the market developments and are reluctant to invest in 'risky' alternatives.

B The technical work plan

B.1 Tasks and associated technical risks

The path a vehicle takes across the ground is a function of the steered angle of the wheels and the relative slip on all of the tyres. Each slip component is in turn a function of the forces acting on the wheel and the condition of the road/tyre interface at any instant. For a rail wheel, its path is defined in terms of longitudinal and lateral creep rather than slip, but is similarly a resultant of the external forces on a stiff, but compliant, system.

BladeRunner uses twin bogies to support a long rigid body section. This configuration allows a yaw moment to be applied directly to each bogie to alter its direction of travel slightly. This supplementary steering system can be as equally effective on road tyres as it is on rail wheels and will be used to guide or trim the vehicle as it changes mode between road and rail.

Uncertainties lie in the dynamic behaviour of the vehicle, in particular the interaction between road/rail steering forces. Also the effect of the tyre composition, infrastructure variations such as gauge width, and pavement texture on the performance of each mode particularly during changeover.

In order to align the vehicle with the rail tracks a number of automatic guidance systems are already available. Vision servo devices like that used on the Civis are already proven and may become available for use on BladeRunner. Inductive sensors, monitoring the rail line or a line of embedded magnets, can also be used to help control the bogies until the rail wheels are engaged. Sourcing and incorporating these features into the BladeRunner vehicle as driver assistance features will be a challenge.

In road mode the turntables rotate freely so that the vehicle acts like the SCM semi–trailer *(E.1)* but with the added benefit that it will be impossible to jack–knife the unit. In rail mode the turntables can be locked so that the vehicle behaves like a two-axle railway carriage, reliable and safe. A control system needs to be developed which can improve the performance of the rail configuration on tight curves and at high speeds but which will also revert to 'safe mode' when necessary.

Reconfiguring the standard tractor chassis components to produce the rear bogie, designing standard modules to suit both bogies and interfacing with the on–board electronics will require close co-operation with one or other of the chassis manufacturers. To produce a generic solution that then suits a number of different chassis types and makes, is a further challenge.

Presentation is important and with many of the potential markets relying on public acceptance and legislation change the finished vehicle must both work well and look convincing.

B.2 Proposed methodology

Although a dualmode vehicle of this type does not yet exist – other than as a model – we do know how rail carriages behave on rails and also how the turntable–bogie design of our earlier project (SCM semi–trailer) performs on road tyres. Existing road/rail vehicles transfer from one mode to the other slowly and sometimes with the help of kerbs to guide the vehicle onto the rail tracks. For many applications this level of performance would be sufficient, including some of the early market niches. It is however, an aim of this project to investigate ways to achieve automated lateral guidance to assist with the 'landing' of the vehicle and endeavour to implement them at higher speeds. The characteristics of the novel steering system and the mode of operation should allow us to overcome earlier *(AHS E.6)* constraints.

The key to the success of the project is the small team of innovative and highly skilled engineers, each of whom has an understanding of the technology developments appropriate to the project and an enthusiasm to work together. The BladeRunner project is a systems approach to transport and will provide the equipment, the time and the space to specify, design and build light and inexpensive dualmode vehicles well suited to a new and growing range of commercial applications.

As for legislation changes, a national regulatory review in Australia found that "Linked–articulated steerable axle group systems should be earmarked as a priority Performance Based Standards (PBS) application and considered for a case study." Also in relation to overall length of tractor–semitrailer combinations, "the introduction of 15m long triaxle semi–trailer incorporating a steerable axle would allow a net benefits package in excess of $20M per year to be addressed." These recorded benefits turntable bogie steering systems offer should help stimulate comparable legislation changes in the European Union. We will continue to contribute to these debates by sponsoring research and giving presentations during the course of the project.

B.3 Work plan

See (Work Plan : Gantt Chart & Project Costs) E.12.8

a) Investigate possibilities of early hybrid demonstration opportunities. (WP 1.1)

b) Initiate research projects in to Strategic Niche Management (SNM), Traffic Control System and Bogie Dynamics, in relation to the road/rail concept and implementation. (WP 5,6,7)

c) Initiate University projects looking at conceptual designs of urban, inter-urban and regional transport and the associated townscapes and environments that could be created. (WP 8.1)

d) Design and build full sized prototype road/rail bogies based on type approved tractor unit chassis components. Structurally test the coupling mechanisms. (WP 2)

e) Design and develop the control modules and link them into the on-board systems where appropriate. (WP 3)

f) Design and build a demountable body and a load platform for the vehicle. (WP 4)

g) Test and evaluate the configuration in different application scenarios. (WP 9)

h) Create a platform for testing and demonstrating additional features. (WP 10)

B.4 Project costs

See (Work Plan : Gantt Chart & Project Costs) E.12.8

B.5 Projected cash flow

Negotiations with our suppliers and our sponsors are not yet complete.

B.6 Project team

See (Professional reviews) E.11

Carl Henderson BEng (Hons), MSOE, MIRTE, MSc	Lead Engineer
Bernard Snowball	Design Engineer
John Leake BSc	Hardware/Software Designer
Ing. George Canderle	Robotics/Control Engineer
Gary Squire BA (Hons)	Project Leader
Chee Kwong Siew LLB (Hons), BA, MA	Vehicle Designer
Mark Townend	Signal Renewals Requirements Engineer

Manufacturing & testing resources

Fontaine International Europe Ltd.	Enterprise Way, Lowton. WA3 2AG
Don Bur (Bodies & Trailers) Ltd.	Longton, Stoke–on–Trent. ST3 5BW

Consultants/advisors:

Prof. Roger Kemp FREng (Technical and Safety Director)	Alstom Transport UK.
Paul Thompson *see (ZF - Letter) E.12.9*	ZF Great Britain Ltd. NG7 2SX
Volvo/Renault, Scania/Hino, Merc	Chassis manufacturers/dealers
Ben Lane (Co–auther):	Experimenting with Sustainable Transport Innovations–Workbook ISBN 9036512751
John Busby Limited. (Author):	"UK survival in 21st Century". http://www.after-oil.co.uk
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Jerry Alderson (Executive)	Cast.Iron (Cambridge & St Ives Railway)
Scott Handley (CEO)	Wensleydale Railway PLC. DL7 8EE

C Marketability

C.1 The market: trends and opportunities

The global market for new trucks and buses that could utilise the BladeRunner configuration is a little over 200,000 units per year *(Global Truck & Bus Sales E.12.7)*. The market we intend to enter first is the high value branchline services for passengers and an extended range of railway maintenance vehicles. With the demonstration of the benefits of the configuration along both the road and rail corridors we hope to be able to push for the general acceptance of the system for use across Europe. There are also a number of protected niches we can try to exploit until the regulation issue is addressed.

'Peak Oil'

"The BladeRunner hybrid vehicle offers an interim and potentially final solution to coming transport and distribution problems." *John Busby – statement (E.1)*

HilTech – Winter Olympics 2010

"BladeRunner is unique in that it provides for a high volume road / rail intermodal option which will be a rail tunnel at much less cost than would otherwise be the case and is environmentally acceptable but providing low cost, fast and simple road-rail transfer-ability. An excellent example of solving traffic volume, environmental and public aspirations." *John Holden – statement (E.3)*

International Trade – Container freight.

In recent years, the global container trade has been growing at an annual rate of about 9 percent. By 2010, it is expected that 90 percent of all liner freight will be shipped in containers. Thus every major port is expected to double, or even triple its processed containers by 2020. The move to larger ships on the main routes increases the need for additional transhipment facilities and competition is stiff within Europe for this work. The split of rail and road traffic feeding the main UK container terminals is estimated to be approximately 25 percent rail and 75 percent road, but varies by port. Due to the capacity limitations of the rail network much of this future expansion will inevitably draw on the flexibility of the road bound trucks. Automated guided vehicles (AGV) are seen as a way to improve the handling capacity of the port. The Delta Terminal at the Port of Rotterdam has been operating such vehicles within the terminal for a number of years. Experiments are also ongoing at other ports around the world including Thamesport in London. Within the terminal, the travel distances are short and the traffic is relatively high, therefore trucks are operated at low speed.

More recently a lot of work has been done in the area of truck automation, automated highway systems and intelligent transportation systems. By apply these technologies to BladeRunner vehicles, dockside AGVs could transfer directly onto the rail lines and then move rapidly to inland terminals, regional distribution hubs or ultimately take to the roads to make the final delivery. In so doing they help solve the 'last mile' problem, an issue for railways around the world.

Figure 2 - "Automated Cargo Transportation system between Inland POrt and Terminals"

Single track systems – Very large networks in populous India and China

"BladeRunner dualmode vehicles + Tag Convoy inter-vehicle signalling and communications technology combine to provide a solution for adding useful capacity to rural railway lines." *Mark Townend – statement (E.9)*

Cast.Iron – Cambridge And St.Ives Railway Organisation

"BladeRunner vehicles, acting like buses, operating on the St.Ives line would offer a very high benefit-cost ratio." *Jerry Alderson – statement (E.4)*

C.2 Competitive edge (or its 'unique selling points')

See (Technology Road Map : Fuel Saving Potential - MIT) E.12.4

See (BladeRunner : Specification and Comparative analysis) E.12.5

See (BRT & LRT alternatives) E.12.6

- **Volume:** At 18 metres long the BladeRunner vehicle has the same load carrying capacity as the articulated buses, now popular for BRT systems, in a configuration that offers manoeuvrability enhancements such as crab parking, ease of reversing and clear visibility all around the vehicle.
- **Comfort:** The pitch freedom of the separate bogies and the drastically reduced overhang improves the comfort for passengers and reduces the likelihood of damage to freight.
- **Control:** In the BladeRunner concept each of the AHS (Automated Highway System) performance goals (see E.6) is addressed directly resulting in a series of simpler and more robust control strategies. A large headway is first provided to facilitate look-ahead control strategies while the vehicles are in road mode. When above embedded tracks additional rail sensors provide an accurate location mechanism that is used to finely trim the yaw steering system in a look–down feedback control. Finally the rail wheels are lowered to provide the ultimate in accurate, noise free and robust measurement of lateral position. Rail guidance improves the control of the vehicles such that they can be safely grouped into very short headway convoys where look–ahead control becomes impractical.
- **Stability:** In the road configuration BladeRunner's bogies can act independently to resist roll and yaw instabilities or can act together through the body to change the vehicle's 'posture' and so resist roll without needing to deviate from the desired path.
- **Noise:** The rail wheel configuration used by BladeRunner eliminates all sources of wheel noise other than that of the light rolling associated with running smooth rail wheels on a relatively smooth steel rails.
- **Loading gauge:** Blade Runner offers a way to increase the capacity of the railway corridors, eliminate the signalling costs and bottles necks, and reduce the maintenance costs and delays.

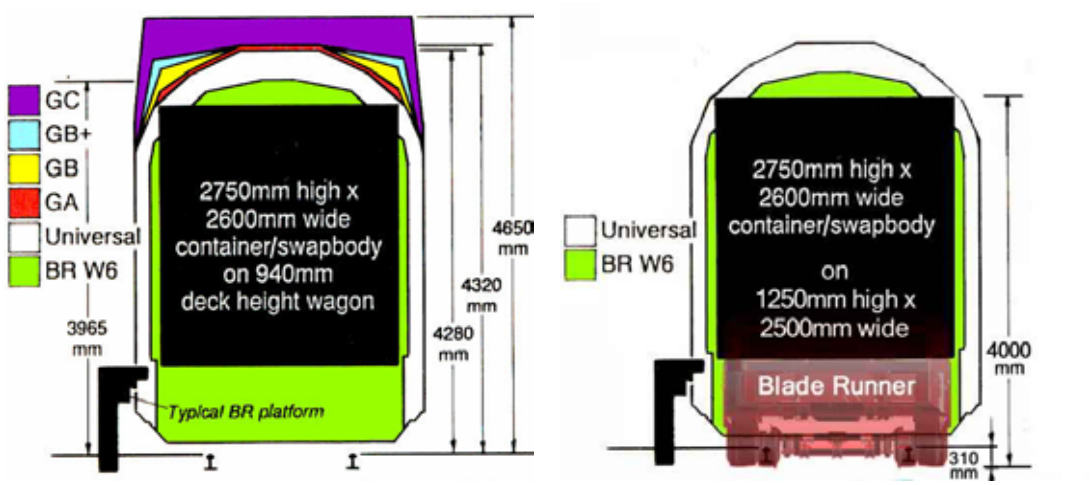

Figure 3 - Loading gauge

This diagram shows how British Rail's obtruding platforms would present a problem in adopting the standard Continental width (line running through platform edge). Increasing the structure gauge to give extra height, for the GB+ loading gauge needed for unaccompanied piggyback or the GC gauge required for tractor-and-trailer piggyback, would be very expensive. The black box shows the SB1 loading gauge RfD has adopted for Channel Tunnel containers and swap-bodies. 'Universal' gauge is the West European standard for vehicles.

C.3 Intellectual property rights (IPR)

Title: Improved Steered Vehicle – patent no. GB2364678

D Business Development

D.1 Background history of your business

See (Professional reviews) E.11

Carl Henderson BEng (Hons), MSOE, MIRTE, MSc Lead Engineer

D.2 Previous or current public support

See (Feasibility Project : Summary) E.12.1

D.3 Wider business development

We have a number of options.

1) Lease the technology to the vehicle manufacturers
2) Supply the vehicle manufacturers with components to convert their own chassis
3) Convert standard vehicle chassis into dualmode bogies and send them on to the body builders
4) Start to assemble our own range of vehicles

The development project will be based on 3) although it may later grow into any or all of the above, depending upon the opportunities that arise over time.

D.4 Effect of the project on business growth

At the outset to the project we will form a limited company. Silvertip Design will grow from one employee to potentially six. New premises will be found which fulfil the needs of the project and allow the business to develop.