Making the commercial case for the 5AT. (Presentation by Alan Fozard to the First World Steam & Tourist Train Congress, Brienz, Switzerland on Monday, 6th October, 2003).

Slide 1 –Title Page

Good afternoon. Many of you will be familiar with David Wardale's book "the Red Devil and other tales from the age of steam" in which he describes his experiences as a steam locomotive design engineer in South Africa, the USA and China. In the book he also tells of his close collaboration with the late great Argentinian steam locomotive engineer Livio Dante Porta and of his application of Chapelon and Porta technology to various locomotives. Most notable was the rebuilding of a SAR Class 25NC 4-8-4 into the famous Red Devil.

Slide 1A - The Red Devil

This proved to be a very successful rebuild which produced large gains in power and very worthwhile savings on water and fuel consumption compared to the unrebuilt locomotive.

Slide 1B – The 5AT – Modern Steam for modern rail

At the very end of his book David outlined the improvements which could have been made to the classic Stephensonian steam locomotive had steam continued in everyday use on the main line. By way of an example he suggested that a very much improved BR Class 5 Mixed Traffic 4-6-0 locomotive could have been developed using this "second generation" steam locomotive technology. Since he wrote the book he has continued to refine this idea and as some of you will know he has set out his proposals for an advanced technology class 5 locomotive for hauling premium, charter and tourist trains on the main line. This has now evolved into the 5AT project.

Any proposal of this nature has to be commercially viable to be successful. So around two and half years ago David and I started work on putting together a business plan for the 5AT. The plan has gone through a number of drafts and iterations and the first definitive issue has recently been completed. So what I am now going to describe stems from the work involved in compiling this plan.

I am going to structure this presentation by asking, and hopefully answering, four questions -

Slide 2: What, Why, How and When?

What is the 5AT?

Why develop the 5AT?

How can a commercial case be made for the 5AT?

When can we expect to see the 5AT in operation?

Slide 3: What is the 5AT?

As I have already mentioned the 5AT is a proposed "second generation" steam locomotive for hauling premium, charter and tourist trains on the main line.

It is being designed according to the methodology developed by Porta and will incorporate the latest proven advances in steam locomotive technology. We envisage that the 5AT will be the first totally new "second generation" main line steam locomotive since all previous modern main line locomotives incorporating the technology have been rebuilds of earlier designs.

The 5AT design will be evolved from the BR Railways Class 5MT mixed traffic locomotive first built in 1951. The 5MT is a simple 2 cylinder 4-6-0 which itself was a development of the LMS Class 5MT design of 1934 . Altogether over 1000 of these versatile locomotives were produced between 1934 and 1956 and were found all over the UK rail network until the very end of steam. A number are still used on heritage lines and a few are authorised for main line running.

The 5AT - incidentally the AT stands for advanced technology - will have the same dimensions and axle loading as the 5MT and indeed it looks fairly similar to the older design. However it is very important to realise that what David is proposing is not simply an update of the 5MT it is a totally new design.

A key factor is that the 5AT will have the range and performance to keep up with modern traffic flows on the main line.

Slide 4: 5MT and 5AT compared

This shows comparative general arrangement drawings of the 5MT and the 5AT with the 5MT at the top and the 5AT below. As you can see both locomotives have the same dimensions but the 5AT has the larger tender to cater for the much greater water and fuel supplies it carries.

Slide 5: The 5AT (Robin Barnes' illustration)

And here we have a superb illustration of the 5AT by Robin Barnes. This one is a particular favourite of mine as it shows the locomotive in a striking blue and silver colour scheme. I like to think that this 5AT is awaiting its next turn of duty on a regularly hauled Premium "limited" train.

Slide 6: 5AT Design Features:

The 5AT is being designed for a maximum speed of 200 km/h (125 mph) and continuous operating speeds of up to 180 km/h (113mph) which should enable it to keep up with normal modern fast traffic on the main line excepting, of course, Eurostar and TGV!.

It will produce a maximum of approximately 2550 hp at the drawbar (at 130 km/h – 81mph) on level track.

The locomotive's overall thermal efficiency at the drawbar should be around 14% at 130 k/h (81 mph) - in other words it will be approximately twice that of late first generation steam locomotives and about twice that of the BR 5MT on which it is based.

It will be light oil fired and be able to operate on diesel fuel (which of course is widely available at train servicing facilities on the rail network). A coal fired version of the locomotive could be produced.

Very important is its range which, under normal average operating conditions, is expected to be about 610 km (380 ml) before needing water supplies and 920km (575ml) for fuel. (If this were insufficient it would be possible to increase range by about 50% by developing a tender with three axle bogies).

A major attribute will be its high reliability which David Wardale is intending to be at least as good as modern diesel locomotives.

Another extremely important aspect of the design – especially for the locomotive operator - will be low maintenance and operating costs.

And for a steam locomotive it will have good adhesion.

Slide 7: York 1962

This is a lucky photograph that I took in the Summer of 1962 at the York loco yard when steam was still in everyday use on the main line. It shows the famous Flying Scotsman and Class 5MT 4-6-0 73096. Happily both locomotives are still with us today and regularly haul charter trains.

The important thing to note is that although the 5AT will have the same dimensions and axle loading as the 5MT you see here its improved technology will allow it to significantly outperform the larger Flying Scotsman.

Another point that for a given axle load the adhesive weight will be the same for both types of locomotive. This combination of adhesive weight and power should provide the 5AT with good acceleration – a very important factor on modern rail networks where there is a high traffic density.

Slide 8: Power:Weight Ratios.

This is an interesting graph which compares the power weight characteristics of the 5AT with those of modern diesel and electric traction. The y axis shows the power weigh ratios in horse power per ton of train weight and the x axis indicates the class type and train formation with different numbers of coaches. Power weigh ratios for the 5AT are shown in red and those for other classes in blue.

On the far right of the graph is shown the recently introduced Voyager Diesel Multiple units which have a very high power/weight ratio of 15 hp per ton and consequently very rapid acceleration, A four coach train hauled by a 5AT would have a power weight ratio of 13 horsepower per ton. However, it must be said, the Voyager will have better adhesion than the 5AT because its power is distributed over many more axles.

A more appropriate comparison is with the current workhorses of the UK rail network the diesel Turbostar multiple units of Class 165 and 170 which were introduced in the 1990s and have a power weight ratio of 9 horsepower per ton. A Class 5AT locomotive hauling 8 coaches would have a similar power weight ratio of 8.8 horsepower per ton.

For comparison purposes an example of a late design of first generation steam locomotive – the British Rail "Britannia" Class 7MT 4-6-2 designed in 1951 – is included on the far left. This has a power weight ratio of 4.9 hp per ton when hauling 10 coaches. Compare this with the 5AT with an equivalent load of ten coaches and under the same conditions which has a power weight ratio of 7.6 hp per ton. In other words the 5AT will be some 55% more powerful than the larger Britannia Pacific.

Slide 9 Why develop the 5AT?

In the UK increasing traffic densities, faster traffic speeds and tighter safety regulations are all making the pathing and running of steam hauled trains on the main line ever more difficult. Some people are predicting that, in the longer term, heritage steam locomotives will be barred from significant parts of the rail network and might even be banned altogether from the main line at some future date. So a primary reason is to ensure that steam has a long term future on the main line for present and future generations to enjoy.

A second reason must be to make a realistic commercial return for its operators. This is essential because the 5AT won't be built unless it has the potential to do so. Like any other form of new motive power on the railways the 5AT will have to make profits for its operators otherwise it loses its whole raison d'etre.

Another reason for building the 5AT is to demonstrate the main line possibilities of the modern steam locomotive. Although Chapelon, Porta, David Wardale, Roger Waller and Phil Girdlestone have all rebuilt existing designs, no completely new **main line** "second generation" steam locomotive has ever been built to demonstrate the full possibilities of this modern steam technology. The 5AT may have the same format as the old 5MT but it will be a totally new, optimized, "second generation" steam locomotive and therefore be well placed to demonstrate the true potential of this modern steam technology.

A final reason is to ensure that main line steam locomotive development continues into the foreseeable future. Engineers with direct experience of "second generation" steam locomotive technology are regrettably, very few in number. The knowledge of these engineers now needs to be passed on to a younger generation. Indeed one can argue that unless the development of a new main line second generation steam locomotive is carried out within the next few years, the experience of these engineers is likely to be lost and main line steam locomotive development would be in danger of coming to an end altogether.

Slide 10: How can one make a commercial case for the 5AT?

So how does one make a commercial case for a new generation steam locomotive? The obvious first stage is to attempt to quantify how much the locomotive would cost to design and build. In rounded figures our latest estimate for developing and building the initial 5AT locomotive is £3.5 million at current price levels. At present exchange rates this equates to about €5.0 million or US$5.7 million.

Slide 11: Composition

Our estimated figure of £3.5 million includes:

- Design engineering and drawings
- Project Administration & Supervision
- Building costs (we expect that the assembly and building of the locomotive would be subcontracted under the close supervision of the project design team)
- The necessary Liaison with rail & regulatory bodies
- Testing and Acceptance
- External costs of vehicle approval

Slide 12: Subsequent 5AT locomotives

Once the initial Class 5AT locomotive has been developed we anticipate that the building costs of subsequent locomotives could be reduced to about £1.5 million at present day values which is similar to the cost of modern main line diesel locomotives. The development and prototyping costs for the first locomotive – which we call the "Development Overhead" - are therefore estimated at around £2.0 million.

Slide 13: How can one make the commercial case – stage 2.

The second stage in making the commercial case for the 5AT was to develop a spreadsheet business model to see if the 5AT could be commercially justified. The model can be used to test various assumptions and ascertain potential returns under various operating conditions.

Slide 14: 5AT Business Model

Our business model is designed to estimate the potential returns over the anticipated life of the locomotive (approx 30 years). Modern diesel locomotives in the UK usually have an expected life of about 30 years and there is no reason to believe that the life of a modern steam locomotive would be significantly different. Indeed as you know the steam locomotives which still haul steam charter trains on the main line are all well over 30 years old.

The model attempts to estimates potential profitability in two ways :

Firstly potential profits with the locomotive operated on a hired out basis to train and charter operators.

Secondly it attempts to estimate the the likely overall "ball park" annual profits to a train operator of running various types of 5AT hauled train

Slide 15: Assumptions as variables

To illustrate the possibilities provided by the business model I am showing here a set of assumptions the values of which can be varied to see what effect they have on projected profitability and cash flow. The actual values shown are for illustration only.

This part of the model assumes that the initial 5AT locomotive is funded by loans and is subsequently operated on a hired-out basis. It estimates the profitability and cash flows over the projected life of the locomotive. We can alter the value of the various parameters you see here such as interest rates, the average annual number of revenue generating trains, the journey length, hire charge etc. and determine what the likely effect on profitability and cash flow will be.

Slide 16: Conclusions from Model

It quickly became evident from our estimates that the 5AT needs to be much more intensively operated than "heritage" steam locomotives if it is to be commercially justified.

It was also apparent that the commercial returns to the operator of the first 5AT would be much improved if the Development Overhead – the costs of the design engineering and the additional costs incurred in building the initial locomotive - could be financed separately.

Slide 17: Effect of defraying development overhead by sponsorship

To show what a significant difference the separate funding of the Development Overhead could have on the lifetime profitability of the locomotive I am going to show two graphs which highlight the situation under a typical set of assumptions.

The left hand graph shows the overall surplus or loss under these assumptions over the lifetime of the locomotive where the development overhead is fully written off in the costs of the prototype locomotive. The right hand side graph shows the same situation but with the development financed separately. In both graphs the y axis represents the surplus at current year value and the x axis is the timescale in years. In the left hand graph the overall surplus after 30 years is approximately £ 7 million. The equivalent figure where the development is separately financed is over £17 million; in other words there is a difference of over £10 million between the two. The difference is due to the increased interest and depreciation costs.

In both cases the assumptions made are that finance for the locomotive would be raised through loans at an average annual interest rate of 5% above inflation, that the locomotive would underake an average of 156 trips a year – that is three trips a week – and that the average trip length is 320 km – 200 miles.

Slide 18: 5AT hauled trains

As I mentioned earlier we have also attempted to compute "ball park" profits for various types of 5AT hauled trains. These are:

1. A premium luxury dining train, - similar in concept to those successfully operated in the UK by VSOE.
2. A mixed 1st Class Dining/Standard Class Train – which is probably the classic train formation run on steam-hauled charters
3 An all-standard class train.

Slide 19: Robin Barnes' illustration of a Premium Train

And here we have another of Robin Barnes' superb illustrations this one showing a 5AT hauled Premium train of matching Mk III rolling stock. And a striking sight it will be. Any resemblance between this train and the old Coronation Scot is not entirely co-incidental!

Slide 20 : Ball Park profitability estimates for 5AT hauled trains.

Assuming the initial 5AT locomotive operates to a regular itinerary of trips or a regular scheduled service, that it hauls an average of 3 trains a week throughout the year with an average journey length of 320 km (100 miles) and 60% passenger loading, and that the train and locomotive are leased or purchased by the train operator under a normal commercial leasing arrangements, the indications are that all three types of train could make attractive profits. This is especially the case if the development overhead is fully financed by sponsorship or some other means.

Slide 21: Profitability estimate graph of premium train

By way of an example this graph illustrates the "ball park" annual pre-tax profitability of the premium train under a given set of assumptions with the development overhead being financed through sponsorship or other means. The ball park profitability is shown on the y axis and the % passenger loading on the x axis. The different lines represent profitability at different fare levels. Obviously at low passenger loadings horrendous losses occur. Equally with the higher projected fares and high passenger loadings quite spectacular profits can be made. Likely profits would probably be somewhere between the two extremes. However the graph does illustrate the obvious - that any 5AT train operator must make every effort to get high passenger loadings at optimum fare levels. To achieve that will require attractive trains and imaginative itineraries.

Slide 22 When can we expect to see the 5AT in operation?

And now we come to the when - when can we expect to see the 5AT in operation?
The estimates we have made in the Business Plan suggest that the first 5AT locomotive could be designed built, tested and accepted in 7 ½ years from the start of the detail design stage. This of course assumes that appropriate finance is provided at appropriate times throughout the project.

Where are we now? The current situation is that David Wardale is about half way through the Fundamental Design calculations which he is undertaking according to Porta's design methodology. He expects to complete them next year. These calculations – which are fully funded - establish the technical feasibility of the locomotive and set the parameters for the detail design stage. Once complete - and assuming finance is in place - the detail design stage could commence. The next stage however will be to produce a draft safety case for the locomotive. Realistically then we are looking at timescale in the next decade - 2012 or later - for the initial 5AT to be accepted for use on the main line.

However all the work we have done so far indicates that the 5AT can be both technically and commercially successful.

Slide 23 Major keys to commercial success

We see the major keys to success as being:

- Gaining appropriate finance to design & build loco.
- Recruitment of a motivated and skilled project team
- Good Quality and Project Management
- Project completion within timescale & budget
- Regular operation
- Performance as per specification
- Very high reliability
- Optimum passenger numbers
- Appropriate fare structures.
- Customer satisfaction (both the train operator and passengers on 5AT hauled trains).

Slide 24: Prospective users of the 5AT

We consider that the 5AT should be of interest to various types of operator.

- Train Operating Companies
- Major Leisure Travel Companies (who might be interested in the concept of a 5AT hauled dedicated cruise train)
- Charter Train Operators
- Possibly other types of organization (such as the longer steam heritage railways)

Slide 25: A final question

This is a photograph of a replica of what is considered to be the very first full size steam railway locomotive. The original was built between the years 1802 and 1803 by the Coalbrookdale Company at Ironbridge, Shropshire, England under the direction of William Reynolds and in collaboration with Richard Trevithick. So it can be considered as a precursor to the famous Pennydarren locomotive of 1804.

So my question is this: "Are we willing to allow main line steam locomotive development to end exactly 200 years after the first steam locomotive was built?"

The 5AT group are of one mind in saying a very loud **NO** to this question!…. and we hope that you will see it in your hearts to support us in this very exciting project.