Final (v5)

ProRail ERTMS Implementation Strategy Due Diligence

Final Report

London
27 July 2007

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Summary

Booz Allen Hamilton has performed a due diligence on ProRail's ERTMS implementation strategy and supports all principal conclusions

- As part of this due diligence, Booz Allen has:
  - conducted a series of interviews with key staff from ProRail, NS, Ministry Verkeer & Waterstaat, reviewed a selection of reports and performed independent analysis based on international experience with ERTMS
- We support all the principal conclusions within the ProRail ERTMS strategy but believe the associated business case does not include all costs and benefits
  - New Rolling stock fitment costs have been estimated at a higher level than expected
  - The savings in basic signalling costs when implementing ERTMS Level 2 may have been significantly underestimated
  - Performance Benefits have been conservatively estimated
  - GSM-R upgrade costs have not been included
- Furthermore, Booz Allen concludes that
  - Most other costs are in line with expectations
  - Operationally, dual fit of rolling stock is feasible and appropriate
  - A discounted business case is needed to support a 35/40 years rollout
  - Significant procurement efficiencies may be achieved for ETCS rollout through economies of scale and optimal balance of risk between ProRail and its suppliers

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To introduce ERTMS in the Netherlands, ProRail have developed an ERTMS Implementation Strategy for the Netherlands

- ERTMS is a common interoperable European specification managed by the European Railway Agency and supported by products from 6 major signalling manufacturers.
  - ERTMS is mandatory for new lines and larger reinvestment in signalling and train control on the operationally integrated European Railway Network.
  - ERTMS is installed on more than 6.000 km of lines today, including Italy (Roma to Napoli, Turin to Novara), Spain (Madrid to Lleida) and Switzerland (Mattstetten to Rothrist)
- ERTMS applications are expected to grow significantly in 2008 and beyond. Countries are required to submit ERTMS implementation plans later this year.
  - The Netherlands is part of a group of countries with significant planned ETCS applications which are expected to be in commercial operation in the near future
- ProRail, with the support of NS and Railion, have developed an ERTMS Implementation Strategy for the Netherlands. In support of this development, ProRail has sought an independent review of their ERTMS Implementation Strategy to provide independent challenge to the robustness of the strategy.
  - ProRail assigned Booz Allen to perform this independent review

ProRail's ERTMS implementation strategy: 'Implement ERTMS nationwide by dual-fitting all rolling-stock to allow the most cost-effective natural infrastructure replacement with ERTMS Level 2'

- ***Principal Conclusion No. 1***: Aim for implementation of ERTMS Level 3, but for the time being focus on ERTMS Level 2
- ***Principal Conclusion No. 2***: The most efficient method of introducing ERTMS would be migration via 'dual' systems in the rolling stock. With this method, the overall costs would be minimised and the benefits would be reaped more quickly
- ***Principal Conclusion No. 3***: By introducing ERTMS along infrastructure corridors and coupling it with the replacement of existing protection systems, inefficient investment would be avoided
- ***Principal Conclusion No. 4***: Because of the opportunities which exist, but also because of the risks and uncertainties, it is necessary for preparations for nationwide implementation begin right now
- ***Principal Conclusion No. 5***: Action will be needed to improve the business case for ERTMS for nationwide implementation

Each of the Principal Conclusions are supported by a range of key assumptions…

Principal Conclusion	Key assumptions
Principal Conclusion No. 1: Aim for implementation of ERTMS Level 3, but for the time being focus on ERTMS Level 2	▸ Move from complex, expensive trackside equipment, to cheaper more flexible equipment in the cab ▸ Reduce infrastructure complexity and hence reduce failures, maintenance costs and longer term replacement costs ▸ Level 1 is not suitable due lack of added value and its limitations on capacity ▸ Main benefit from Level 3 comes from removing track side train detection & better use of capacity ▸ Migration is much easier from L2 to L3 than from L1 to L3 ▸ L2 also provides benefits for infra managers and train operators ▸ Combining ERTMS implementation with asset replacement makes a certain proportion of asset replacement costs un-necessary ▸ Rolling stock costs are the same for L1 and L2
Principal Conclusion No. 2: The most efficient method of introducing ERTMS would be migration via 'dual' systems in the rolling stock. With this method, the overall costs would be minimised and the benefits would be reaped more quickly	▸ The optimum solution would be to convert all the rolling stock belonging to the rail companies over just a few years (big bang). ▸ Combining ERTMS implementation with asset replacement makes a certain proportion of asset replacement costs un-necessary ▸ The "Dual systems in the ROLLING STOCK" costs include NS, freight and regional rail ▸ In the "Dual systems in the INFRASTRUCTURE" scenario, the cost of rolling stock conversion is also significantly higher ▸ Extra investment in protection (so-called interlockings) would be required to make dual systems in the INFRASTRUCTURE possible

Each of the Principal Conclusions are supported by a range of key assumptions…

Principal Conclusion	Key assumptions
Principal Conclusion No. 3: By introducing ERTMS along infrastructure corridors and coupling it with the replacement of existing protection systems, inefficient investment would be avoided	▸ The infrastructure corridor approach would enable complex interfaces to be rationalised, and would provide users with a single type of system in any one infrastructure corridor ▸ Implementing ERTMS just at the time when the useful life of the present systems is over would save on investment in replacements and would cause less disruption to clients ▸ The further implementation of ERTMS would not be worth while until 2012 at the earliest ▸ If ERTMS implementation not linked to replacement, extra costs will be incurred for engineering, implementation, removal of existing systems and adaptation of existing interlockings
Principal Conclusion No. 4: Because of the opportunities which exist, but also because of the risks and uncertainties, it is necessary for preparations for nationwide implementation to begin right now	▸ In the short term, implementation of ERTMS is necessary and worthwhile for a number of infrastructure corridors ▸ A decision to implement ERTMS nationwide would not be expedient in the short term, due to uncertainties which (might) have a serious impact on costs ▸ In the coming period (2007-2008), focus on further planning of cost-effective ways of achieving the migration ▸ Undertake these next steps in the rail sector in a coordinated manner, considering and involving all the organisations concerned ▸ Postponing these preparations is not an option; they will have to be carried out in any case, and waiting longer just means the risks may be even greater ▸ In this way, the rail sector will be basing its policy right from the outset on the costs and benefits

Each of the Principal Conclusions are supported by a range of key assumptions…

Principal Conclusion	Key assumptions
Principal Conclusion No. 5: Action will be needed to improve the business case for ERTMS for nationwide implementation	▸ Translate the operational and technological lessons learned from the experience of ERTMS on the HSL, Betuweroute and Amsterdam-Utrecht lines ▸ Decide on a sector-wide Implementation Team with targets for reduction of costs (e.g., -30%) and maximisation of benefits ▸ Expressly involve (outside) parties with relevant knowledge ▸ Test out the conversion of working tracks to Level 2 on a scale yet to be determined ▸ Monitor, and promote if necessary, the development of ERTMS Level 3. Prepare for migration to ERTMS Level 3 by first implementing ERTMS Level 2

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Booz Allen's due diligence approach involved the challenge of key assumptions through focussed interviews and literature review…

- Booz Allen performed the independent review in the form of a due diligence exercise, with the goal to provide independent challenge to the robustness of the strategy
- This included an assessment of the approach, challenge of assumptions and professional judgment relating to the deliverability of the strategy, focusing on four specific areas:
  - Technology: Assessment of the various options relating to L1, L2 (with/without line side signals) and ATP replacement
  - Implementation: Assessment of the overall roll-out plan in relation to asset condition, ATP replacement needs, migration approach (dual fit infrastructure, dual fit rolling stock, STM requirements)
  - Cost/Benefits: Comparison of the costs and related assumptions using cost profiles prepared by Booz Allen for other assignments and knowledge of the signalling industry, and high level assessment of the benefits of ERTMS, including benefits from reduced line side signals, whole life cost benefits, capacity benefits, bi-directional operation, performance
  - Deliverability: Assessment of consolidated risks and show stoppers, potential procurement options and the competitiveness of the market

Booz Allen commentary

Conclusion 1 (Aim for ERTMS Level 3, but focus on Level 2 now) is a sound conclusion, recognising that Level 3 is at an early stage of development

	Key assumptions	Booz Allen comment
PC1	▸ Move from complex, expensive trackside equipment, to cheaper more flexible equipment in the cab	▸ Agree that ERTMS Level 2 will lead to simpler, cheaper and more reliable line-side equipment compared to a like for like replacement option
	▸ Reduce infrastructure complexity and hence reduce failures, maintenance costs and longer term replacement costs	▸ Agree that ERTMS Level 2 will lead to simpler, cheaper and more reliable line-side equipment compared to a like for like replacement option
	▸ Level 1 is not suitable due lack of added value and its limitations on capacity	▸ Agreed - Level 1 has significant incremental costs as must be fitted as well as ATB (unless Rolling Stock is dual fitted).. At best, Level 1 with infill will achieve a similar capacity to the existing conventional Class B system (ATB)
	▸ Main benefit from Level 3 comes from removing track side train detection & better use of capacity	▸ Level 3 is at an early stage of development and the principal benefit is derived from minimal line-side infrastructure. Capacity benefits (over L2) are possible, especially if the L2 infrastructure is not optimised
	▸ Migration is much easier from L2 to L3 than from L1 to L3	▸ Agreed – involves decommissioning of track circuits (infra) and train integrity assurance (trains)
	▸ L2 also provides benefits for infra managers and train operators	▸ Agreed
	▸ Combining ERTMS implementation with asset replacement makes a certain proportion of asset replacement costs unnecessary	▸ Agreed assuming reduced lineside signals. This cost saving has not been fully reflected in the estimated costs
	▸ Rolling stock costs are the same for L1 and L2	▸ Agreed

Conclusion 2 (Dual fitting rolling stock is the most efficient method to minimise costs and achieve early benefits) is a sound conclusion although the cost benefit analysis has some flaws and inconsistencies

	Key assumptions	Booz Allen comment
PC2	▸ The optimum solution would be to convert all the rolling stock belonging to the rail companies over just a few years (big bang).	▸ With full commitment of stakeholders it will be possible to convert the fleets within three/four years, with the added benefit of certain economies of scale
	▸ Combining ERTMS implementation with asset replacement makes a certain proportion of asset replacement costs un-necessary	▸ For infrastructure, a "natural" implementation (consistent with the Mistral Programme) avoids some signal replacement costs if not dual fitted. If only 50% of signals are retained, we would expect to see, (from experience of other member states estimates) a net reduction in overall infrastructure costs.
	▸ The "Dual systems in the ROLLING STOCK" costs include NS, freight and regional rail	▸ Noted. Foreign trains correctly excluded since they should be funded from own member state
	▸ In the "Dual systems in the INFRASTRUCTURE" scenario, the cost of rolling stock conversion is also significantly higher	▸ In this scenario, no retrofitment of trains is needed therefore costs will be significantly lower
	▸ Extra investment in protection (so-called interlockings) would be required to make dual systems in the INFRASTRUCTURE possible	▸ Agreed. Dual fit infrastructure (L2) is more costly than L2 only infrastructure due, primarily, to costs associated with the necessary lineside signals

Booz Allen commentary

Conclusion 3 (a "natural implementation" of ERTMS along infrastructure corridors avoids wasted investment) is also sound although the interim migration tactics need careful planning and management

	Key assumptions	Booz Allen comment
PC3	▸ The infrastructure corridor approach would enable complex interfaces to be rationalised, and would provide users with a single type of system in any one infrastructure corridor	▸ Agreed – this approach will avoid "islands" of ERTMS and minimise "mode changes" for train drivers. It also reduces the infrastructure costs associated with mode change interfaces.
	▸ Implementing ERTMS just at the time when the useful life of the present systems is over would save on investment in replacements and would cause less disruption to clients	▸ Agreed – especially if L2 only (no dual fitted infra) were made possible by a fully fitted rolling stock fleet
	▸ The further implementation of ERTMS would not be worth while until 2012 at the earliest	▸ Certainly, our experience in other countries (UK and DK) is that mainline roll outs will not take place in ERTMS Level 2 until around this date. These are reflection not only of the current status of their national plans but an assessment of the maturity and reliability of the technology. NL has relatively more experience with ETCS type systems than both DK and UK, which will be invaluable in amongst other things, developing robust cost estimates ▸ However, some early dual fit infra schemes, before 2012 may have a positive, long term business case
	▸ If ERTMS implementation not linked to replacement, extra costs will be incurred for engineering, implementation, removal of existing systems and adaptation of existing interlockings	▸ Agreed – this would be a sub-optimal approach

Booz Allen commentary

Conclusion 4 (Nationwide implementation preparations should begin immediately) is a sound conclusion that ensures coordinated planning and achieves early benefits

	Key assumptions	Booz Allen comment
PC4	▸ In the short term, implementation of ERTMS is necessary and worthwhile for a number of infrastructure corridors	▸ Agreed, this in line with the current strategy for those corridors and supports EU directives on interoperability
	▸ A decision to implement ERTMS nationwide would not be expedient in the short term, due to uncertainties which (might) have a serious impact on costs	▸ Agree, costs and economies of scale are uncertain so it would be sensible to plan carefully for a coordinated, cost-effective ERTMS roll-out
	▸ In the coming period (2007-2008), focus on further planning of cost-effective ways of achieving the migration	▸ Agreed as above
	▸ Undertake these next steps in the rail sector in a coordinated manner, considering and involving all the organisations concerned	▸ It is necessary for all parties to agree on the strategy and to correctly fund and incentivise those parties to support it
	▸ Postponing these preparations is not an option; they will have to be carried out in any case, and waiting longer just means the risks may be even greater	▸ Agreed
	▸ In this way, the rail sector will be basing its policy right from the outset on the costs and benefits	▸ Agree, but it is evident that the policy requires agreement with the Ministry. This agreement is fundamental in nature and could have a big impact on the costs/ benefits to be analysed

Booz Allen commentary

Conclusion 5 (Action will be needed to improve the business case for ERTMS for nationwide implementation) is a common theme among Member States and is likely to be achieved, with time and experience

	Key assumptions	Booz Allen comment
PC5	▸ Translate the operational and technological lessons learned from the experience of ERTMS on the HSL, Betuweroute and Amsterdam-Utrecht lines	▸ Agree, identify impact of lessons learns on unit costs
	▸ Decide on a sector-wide Implementation Team with targets for reduction of costs (e.g., -30%) and maximisation of benefits	▸ Agreed, this target is common, and in line with other Member States' aspirations for efficiencies
	▸ Expressly involve (outside) parties with relevant knowledge	▸ Agreed, lessons learned from other projects will always be helpful
	▸ Test out the conversion of working tracks to Level 2 on a scale yet to be determined	▸ Test tracks and pilot projects are a way to gain confidence and highlight possible efficiencies
	▸ Monitor, and promote if necessary, the development of ERTMS Level 3. Prepare for migration to ERTMS Level 3 by first implementing ERTMS Level 2	▸ Migrating from L2-L3 is less costly than from L1-L3. However, the implementation of L2 should not be justified solely on the basis of later reduced costs of migrating to L3

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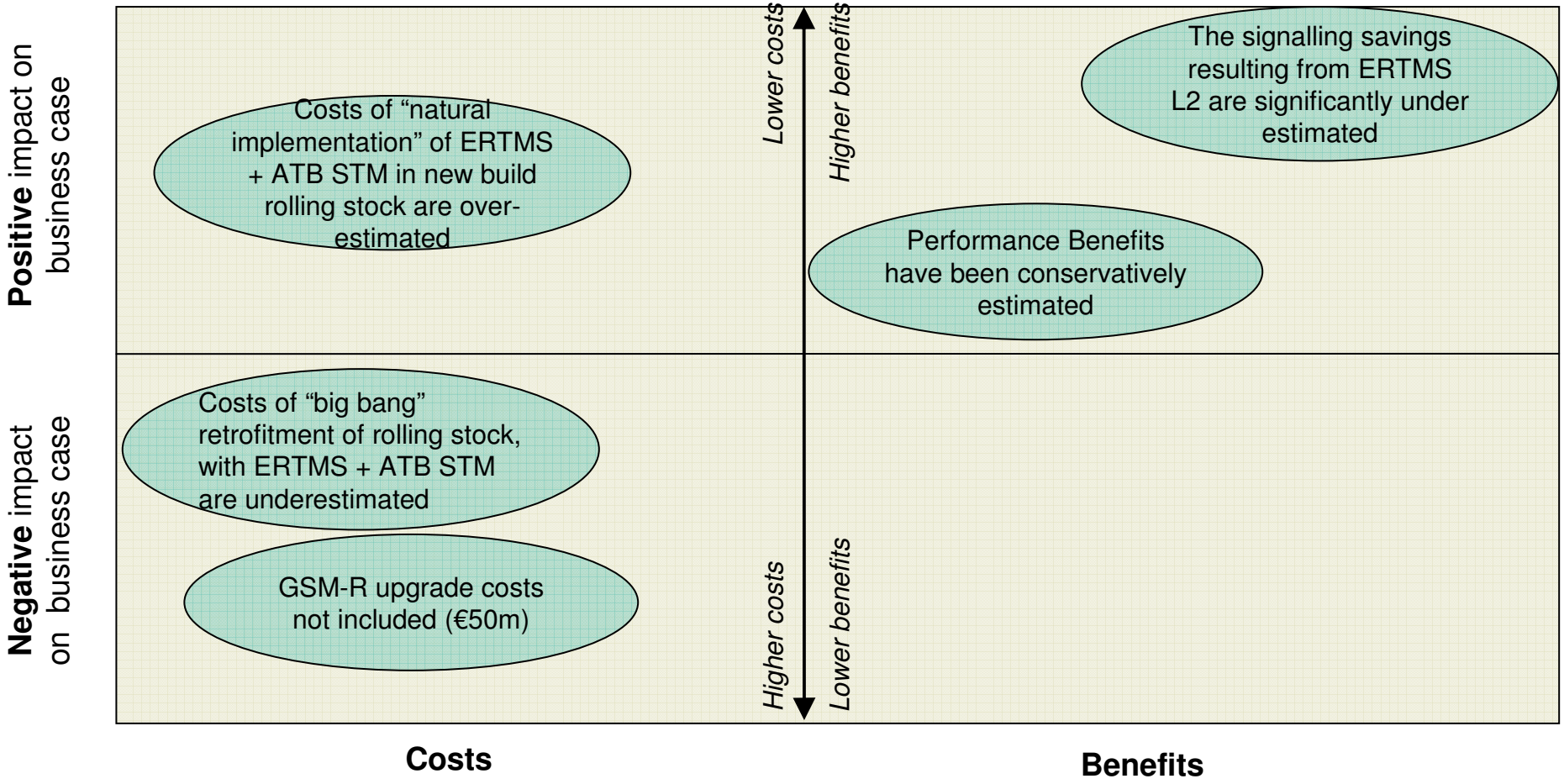
We agree with all the principal conclusions within the ProRail ERTMS strategy but believe the associated business case does not include all costs and benefits

- Costs of “natural implementation” of ERTMS + ATB STM in new build rolling stock are over-estimated, whereas costs of “big bang” retro-fitment of rolling stock, with ERTMS + ATB STM are underestimated
  - Overall, “big bang” is more costly from a rolling-stock viewpoint
- The signalling savings resulting from ERTMS L2 may be significantly underestimated
  - Overall, “big bang” allows ERTMS level2 with reduced signals – this is less costly from an infrastructure viewpoint
- GSM-R upgrade costs (necessary for system availability) have not been included
  - This could add an estimated €50m of infrastructure costs
- Performance Benefits have been conservatively estimated
  - Full consideration of benefits will strengthen the case to support the strategy

The Booz Allen conclusions each have differing impacts on the business case but does not change the overall conclusion



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ERTMS specific capital cost estimates are based on engineering judgement and information from actual ERTMS projects

- ProRail has estimated asset quantities for its Level 1 and Level 2 costs estimates on the basis of asset densities for the Betuweroute project and Amsterdam-Utrecht projects
- Unit rates have also been derived from out-turn rates achieved for the Amsterdam-Utrecht and Betuweroute projects
- ProRail has assumed that 50% of signals will be retained for the Level 2 option but has not quantified the impact of this reduction on overall signalling renewal costs
- Incremental maintenance costs for both Level 1 and Level 2 are assessed as very low at approximately 1% of capital costs per annum

ERTMS costs are generally in line with our expectations for a network wide estimate; however we believe L1 costs to be low and L2 costs to be high

- Top down comparison on a rate per track km shows costs for ERTMS Level 1 to be 70-80% of costs for comparator projects in Belgium and Denmark
- A similar top-down analysis for ERTMS Level 2 shows ProRail's Level 2 estimate to be higher than comparators
  - Not clear how historic Betuweroute cost data has been normalised to be an appropriate benchmark for the whole of the network
  - RBC density compares to comparators whilst balise density is significantly greater than comparators
  - Maintenance savings & reduction in failures from fewer assets for L2 has not been addressed
- It is unclear how the ProRail estimate has been adjusted to take account of '*average*' Netherlands conditions covering both heavily trafficked inter-city routes and lightly used rural lines
- It is also not clear how the ProRail estimate addresses the impact of potential efficiencies of scale if ERTMS is rolled out on a corridor basis

High level comparison of Level 2 infra costs with other projects shows the ProRail costs to be a prudent estimate although we believe opportunities exist to reduce these costs significantly

- Reported ERTMS Level 2 costs for recent projects and network estimates vary considerably from less than €50k to over €200k per route km
- The wide range of historic costs may be explained by several factors including
  - Projects not including the same scope (i.e. some may include a significant amount of conventional signalling works);
  - The early stage of implementation of the Level 2 technology; and
  - The limited scope of several route based projects carrying all 'generic' development costs
- However, an average cost per route km for ERTMS Level 2 infrastructure of €130k may be derived which corresponds closely to a recent benchmarking study which gave an average cost of €140k
- Therefore, ProRail's ERTMS strategy cost of €190k per route km (€600m/ 3250km) seem to be conservatively high
  - Indeed ProRail staff acknowledge this could be reduced to €150k through inclusion of 'efficiencies'

A high level validation process indicates a dual system on the rolling stock to be significantly cheaper than dual system on the infrastructure…

- The two options of dual system on the rolling stock or dual system on the infrastructure consist of different balances of new and retrofit cab fitments and ERTMS Level 2 trackside equipment with or without reduced conventional signalling
- Dual systems on the infrastructure comprises 100% new cab fitment (ERTMS + STM) (no retro-fitment) but also requires significant amounts of conventional signalling renewals to cover routes where rolling stock not yet fitted with ERTMS
- Dual systems in the rolling stock requires a significant amount of retro-fitting of rolling stock but also leads to much lower conventional signalling renewal costs than for the dual system in the infrastructure option
- We estimate undiscounted costs for dual system in the infrastructure to be more than €500m greater than for dual system in the rolling stock
  - The discounting effect could be significant and should be analysed

…the key issue being the amount of conventional signalling savings achieved through a reduction in lineside signals

Rolling stock costs for the 'big bang' Dual System in Rolling Stock option are greater than those from the "natural rollout" approach for the Dual System in Infrastructure option

- The ProRail strategy assesses cab fitment costs for big bang to be €280m compared to €740m for a natural rollout fitment approach
- However, the €740m for the natural fitment approach includes a provision of €280m for additional rolling stock within the transition phase, which would not be required through use of an ATB STM (Specific Transmission Module)
- ProRail's adjusted rolling stock cost for Dual system in infra would therefore be €460m + STM costs
- We assess retrofit costs to be significantly higher than new build fitment at an average of €250k/ cab compared to €150k for new build
  - These unit costs include the efficiency benefits of large batches. STM costs assessed at €50k per unit.
- Based upon an assumption of 90% retrofit for 'big bang' fitment this gives a non-discounted rolling stock cost of €336m compared to €224m for natural roll-out
  - The discounted cost differential between the two options would be greater due to the Dual Fitment in Rolling Stock costs being incurred much earlier

ProRail have made an assessment of the cost drivers and risks with regard to the infrastructure systems

- ProRail acknowledges that the six Unisig suppliers (Alcatel, Alstom, Ansaldo, Bombardier, Invensys and Siemens) and the infrastructure managers in Europe are crucial in development of ERTMS systems. Demand by these infrastructure managers will determine the extent to which the suppliers are willing to invest
- ProRail expects that interoperable specifications will open the market to new suppliers of components only (Hitachi is mentioned as a supplier of balises only), leading to lower costs
- ProRail sees opportunities for cost saving in future through more efficient data preparation
- The stated strategy of migrating to Level 3, if implemented too early, will mean that ProRail could face the risk that heavy development risk costs will to be borne by ProRail / Netherlands whilst other Member States opt for a slower migration to this technology

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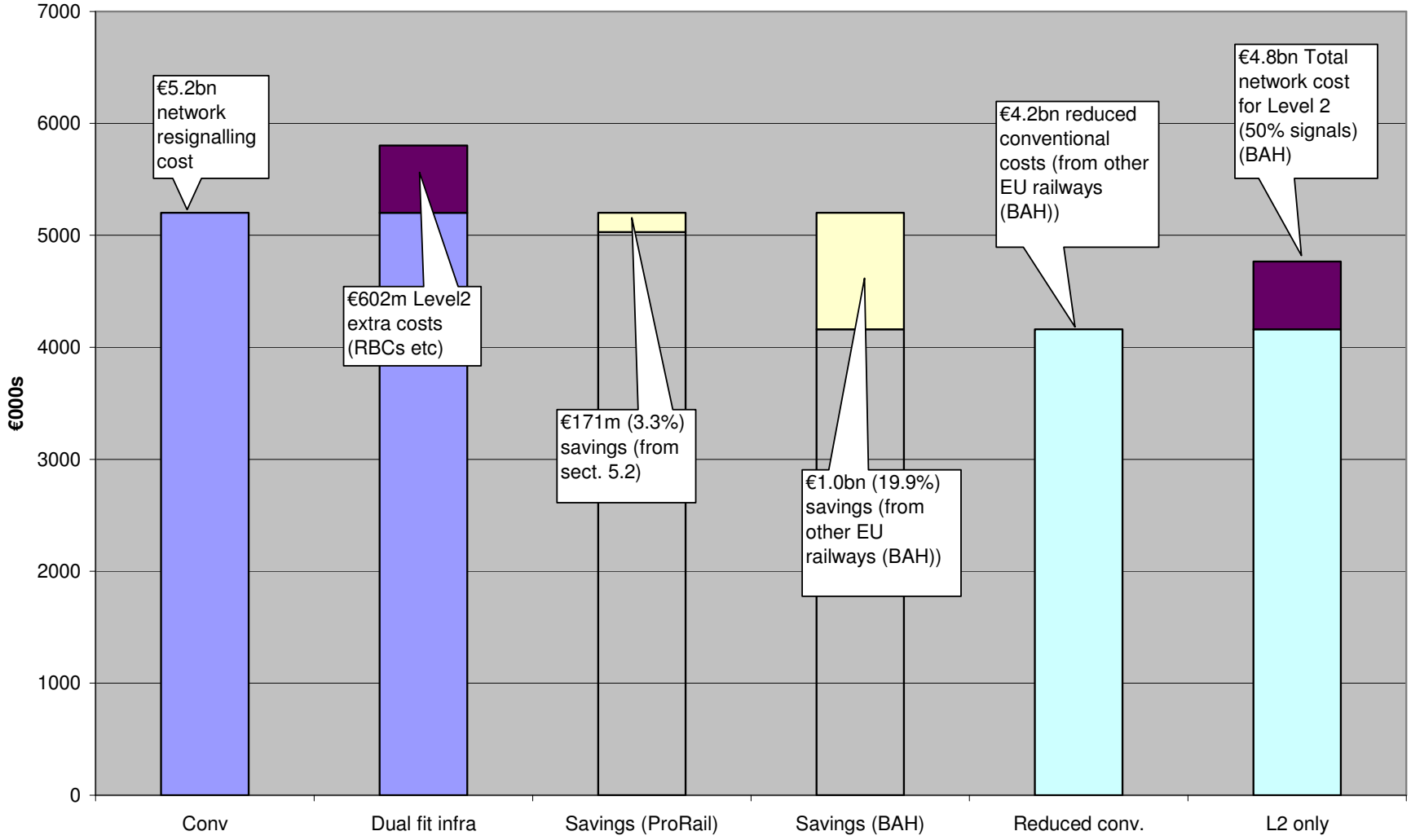
The savings in basic signalling costs when implementing ERTMS Level 2 may have been significantly underestimated

- A Level 2 railway with 50% of signals removed justifies significant savings in basic signalling costs
- The estimating technique used is to analyse each element in the capital cost breakdown for resignalling projects
- Using experienced signalling engineers from infrastructure owners, the percentage of materials and effort no longer needed by a reduced signal count
  - Materials items considered: Impedance bonds, ATP, Interlockings, Relays, Cables, Signals, Train detection, Points, control systems, Level Crossings, Power supplies, Cable containment, Equipment cabinets
  - Resources considered: Outline design, tendering, detailed design, data preparation, Installation, Testing, Commissioning, Project Management
- The costs of each element, reduced where appropriate, are then summed to determine the overall reduction in basic signalling costs arising from the reduced signal design
- This method of estimation indicates that the ProRail estimate of ~3% savings is much too low

Estimated savings in basic signalling costs from removing 50% of signals are thought to be about 20% of total costs, not 3%



The long term overall Infrastructure costs of ERTMS Level 2 (with reduced lineside signals) are lower than conventional signalling costs

- Early schemes will appear costly due to inexperience and continuing specification development
- There will be a “learning curve” cost in initial 5 or 6 upgrade schemes
- For the long term strategy, the “steady state” costs should be used and assume:
  - Experienced staff, data preparation tools, well understood methods of working, mature specifications
- The conclusion that resignalling with ERTMS level 2, with reduced lineside signals, will result in overall infrastructure cost savings is consistent with the assumptions of other EU Member States’ infrastructure owners (UK, Denmark, Sweden)
- Similarly, overall infrastructure maintenance costs are reduced through a reduction in lineside equipment

Key issues underpinning the investment cost estimate comprise unit costs for retro-fitting rolling stock and cost savings from ERTMS Level 2 (with reduced signals) relative to ERTMS Level 2 (dual-fit)

ProRail strategy assumption	Booz Allen comment
▸ Rolling stock fitment costs assessed as significantly higher for Dual System in Infra (€740m)* than for Dual System in Rolling Stock (€280m).	▸ Higher retrofit unit costs relative to new build costs make rolling stock costs for Dual System in Rolling Stock more expensive (€336m) than Dual System in Infra (€224m).
▸ ProRail sees significant efficiencies of scale through 'big bang' fitment of rolling stock whilst Dual System in the Infra also requires additional rolling stock relative to the Dual System in the Rolling Stock scenario	▸ Retrofit unit costs at €250k/ cab relative to new build costs of €150k/ cab offset efficiencies from big bang fitment of rolling stock. Booz Allen see no requirement for additional rolling stock to support the "Dual fit Infrastructure" option if ATB STM is fitted
▸ Incremental infrastructure costs for Dual System in the Rolling Stock (ERTMS L2 (reduced signals)) are greater than incremental infrastructure costs for Dual System in the Infra (ERTMS L1 or L2 (dual fit)).	▸ Booz Allen assess the incremental infrastructure costs for Dual system in rolling stock (i.e. ERTMS L2 (reduced signals)) to be significantly lower than for Dual system in infra (i.e. ERTMS L2 plus all existing signals and ATB)
▸ ProRail assess incremental ERTMS L2 (reduced signals) costs as €600m with savings of €170m from infrastructure not required if ERTMS (i.e. 50% reduction in signals)	▸ Significant cost savings in basic signalling costs are achievable with ERTMS L2 through a 50% reduction in signals and associated items; these savings have been estimated to be in the order of €435m when extrapolated across the whole network
▸ Overall ProRail assess investment costs for Dual system in Infra to be €1135m compared to €880m for Dual System in rolling stock	▸ Booz Allen agree that the Dual System in Rolling Stock is a cheaper option but believe a non-discounted cost differential between the options to be in excess of €500m. A discounted differential could be significant and should be analysed

*** All values are undiscounted and indicative (+/- 40%)**

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ProRail strategy allows no costs for GSM-R upgrade, but this has major capacity and reliability implications

- The existing GSM-R network is designed to meet the EIRENE specification for Level 2 operation and so is capable of supporting Level 2 operations – however…
- The network availability has been specified for GSM-R voice operation but not for Level 2 data operation
  - Redundancy of infrastructure is not provided leading to long (up to 4 hour) repair times – unacceptable for signalling purposes
  - Costs need to be included to provide hardware redundancy (e.g. BTSs, BSCs, MSCs, UPSs) to bring system availability up to a level needed to support L2 signalling
- The network capacity has been specified for GSM-R voice operation but not for Level 2 operation
  - L2 operation requires an available circuit switched channel for each train – capacity upgrade works will be required to support L2 operation, especially in busy station areas
  - Later ERTMS specifications may resolve this issue by providing support for packet switched operations
- Additional upgrade costs estimated at €50m (ProRail)

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Performance Benefits are referenced in the strategy but have been very conservatively estimated in the business case

- Reduced journey times are made possible through higher speeds
  - Maximum speed (160kph) can be increased where infrastructure and rolling stock allows
  - Coarse speed limit bands (imposed by ATB design) can be safely replaced by higher speed limits
- Shorter headway may allow capacity of existing lines to be increased
  - A two minute technical headway is believed possible – compared to three minutes with existing technology, which dependent on other bottlenecks may improve capacity
  - Some costly infrastructure upgrades (e.g. four tracking Utrecht – Betuweroute; Amsterdam – Almere) may be avoided or reduced in scope but have not been analysed in this review
- Improvement in public perception and image of safety is an additional, if intangible, benefit (ATB has poor reputation)
- Delay reduction through reduced trackside equipment failures is a significant benefit
  - Needs a true value of delay to be calculated (e.g. “weighted delay minutes” concept)

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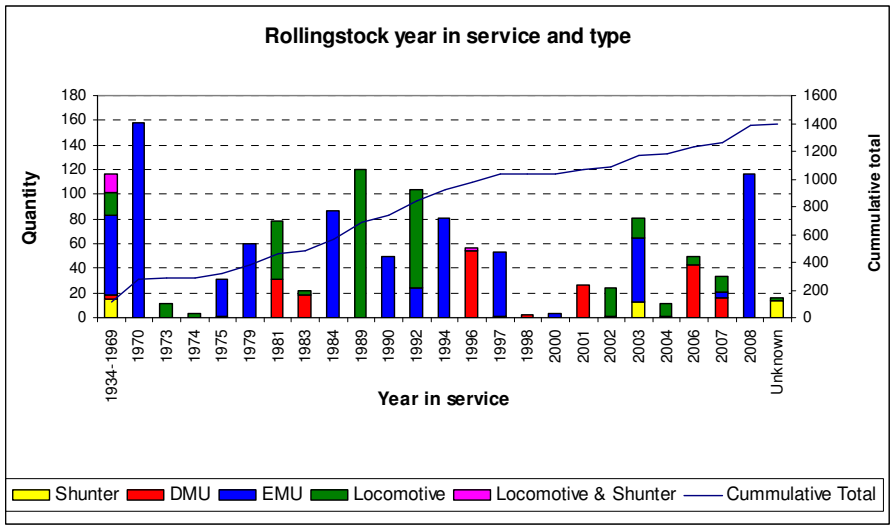
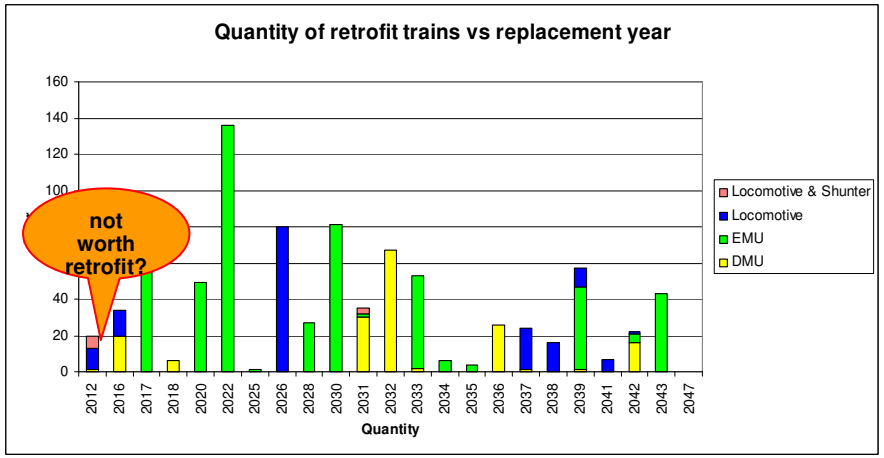
The Implementation strategy is supportable from an operational perspective but the migration plan (to 2012/13) needs to be developed, planned and costed as part of the overall strategy

- Overall track fitment
  - By 2009 three routes are to be fitted with ERTMS: Betuweroute, HSL Zuid and Amsterdam to Utrecht (dual signal)
  - Incrementing in this way from a freight only, to a High speed and then a mixed traffic railway will test ERTMS and add progressively increasing experience and complexity under different operating environments before further national roll out
  - By 2013 further ERTMS extensions will be either new lines (Hanze) or linking existing fitted route i.e. the Betuweroute feeder lines with the Amsterdam to Utrecht corridor
  - By 2020 ERTMS is rolled out over a significant part of the existing network
- Commentary
  - The Mistral programme has a range of natural end of lifetime dates for 25% of interlockings over the next 10 years but given that the majority of early ERTMS track km are on new tracks (apart from Amsterdam to Utrecht, only later moving to existing tracks), there is a broad and logical fit to natural replacement dates and ERTMS to tolerances of +/- 5 years
  - The roll out of track fitment by corridor is logical from an operational perspective – as it is applied through the three early schemes to increasingly complex routes with a diverse range of operating conditions prior to national roll out (new High speed, Freight Only and Mixed traffic railway), therefore building experience and performance out from the fitted lines
  - Usefully, the train interface will be assisted by the existing commitment to fit ERTMS to a third of the Railion fleet gaining huge operational experience before full commitment to ERTMS operation and STM fitment to many trains
  - Quieter, rural lines are being left until later, where there is less business benefit from a move to ERTMS shows prioritisation
- Issues
  - The roll out plan implies that operational performance and lessons learnt will be satisfactory applied prior to ERTMS roll out on mixed traffic railways such as Amsterdam to Utrecht (or can be contained by reliance on existing signals) and that the STM based train unit will address the most critical operational issues associated with migration to ERTMS

Operationally, findings indicate that the dual train fit strategy is appropriate, but a national rolling stock plan is a priority





- BAH analysis reconciles against Pro-rail data for domestic fleets, at around 1400 units
- But market uncertainty on fleet size post 2008 (few new orders), raises some uncertainty on viability of large older train retrofit and ultimate fleet size
- Until such time as a national fitment plan is developed and agreed with all operators, costs will not be a stable figure
- Time allowed for overall fitment appears realistic on an international comparison but so far Railion's 6 week fit appears excessive (for series fitment)
- Therefore, surveys work needed for main train types to re-confirm adequate fitment allowance
- Dual fit and corridor replacement is least intrusive operationally and based on STM route is a logical intermediate step for ease of train fitment and operations

Interviews with the largest of the involved parties (NS and Railion) reveal a number of issues that need to be resolved

- Railion are committed to fitting around a third of its fleet with ERTMS, which should provide significant trainborne equipment reliability proving. These are trains that operate on the Betuweroute – retrofitment is subsidised
- However, Railion have a number of issues with the Strategy from a perspective of future funding (of their remaining fleet), consultation and timing that must be addressed
- NS appear to be relatively relaxed about the changes required to the Rule Book and for staff training for ERTMS, though clearly a successful implementation on Amsterdam to Utrecht will be key (the plans for which have not been part of this scope)
- There are gaps in the Strategy that need to be resolved:
  - A clear rolling stock fitment plan to be agreed with all operators, especially for retrofit/train replacement in order to stabilise fitment costs (there are many old trains which may be uneconomic to fit with ERTMS) is needed
  - A risk management plan to address the implications of the roll out strategy, in particular the approach to migration was not identified and needs to be well in place before Amsterdam to Utrecht goes live with ERTMS
  - A clearer articulation of the benefits of the preferred strategy and greater justification for the rejection of other options is lacking in the strategy, which would strengthen the strategy
  - Closer co-ordination and collaboration of the views of operators other than NS (e.g. Raillion) needs to take place. Further rail franchising should be co-ordinated with the plan to avoid later re-negotiation with franchise operators
  - Development of training and operational planning assumptions (and review of costs) needs to take place to fix the full cost of migration to ERTMS
  - The extent to which Reliability and performance analysis will play a part in lessons learnt in the early ERTMS schemes was unclear and needs to be developed as the planning and specification of the national roll out progresses
  - The interface plans and level of agreement with visiting international operators is unclear

Significant procurement efficiencies may be achieved for ERTMS rollout through competition, economies of scale and optimal balance of risk between ProRail and its suppliers

- Historic costs for ERTMS reflect an early implementation of this technology with these costs inclusive of various items which would not be necessary for each route of a network roll-out
  - Such costs include items such as safety assurance, rule book and other operational issues
- A route or region based competitive procurement of ERTMS will also offer efficiencies of scale for those elements of ERTMS costs that relate to non material items such as
  - Design, data preparation, installation, testing, commissioning and project management
- ERTMS Level 2 offers opportunities for scope optimisation through reduction in signals and other line-side equipment and potentially fewer interlockings, although achieving optimisation will require roll-out of ERTMS in association with conventional signalling replacement
- It is essential that ProRail works with its suppliers to achieve an optimum balance of risk within the procurement process with suppliers only carrying those risks over which they have control
- ProRail needs to engage with its suppliers over the next few years to quantify and agree the size of these benefits and hence improve the robustness of the cost line in their business case
- Significant efficiencies are expected from a route based signalling replacement strategy for the line-side equipment. We believe the opportunities for procurement efficiencies would be the greatest in the Dual system in Rolling Stock approach, as this may be more likely to be implemented through a route based approach (will deliver earlier benefits as all the trains would have been already fitted)

Contents

Interviews have been carried out with a range of stakeholders including ProRail and NS staff

Nr.	Name	Function	Company	Fields of knowledge
1	Henri van Houten	System manager ERTMS en NPM	ProRail Infra management Signalling department	Specifications ERTMS, Benchmark Europe, Suppliers
2	Chiel Spaans	GSM-R specialist	ProRail	GSM-R
3	Alexander van Andel	Strategy Development Manager	ProRail	Implementation strategy ERTMS
4	Maarten van der Werff	Manager System Migrations and Development	ProRail Infra management Signalling department	System performance, System migration, renewal strategy signaling systems, supplier strategy
5	Hugo van de Berg	Programme manager Network development	ProRail Capacity Management, Network development	Characteristics Dutch railnetwork, infra utilization and-performance, capacity-projects, (societal) benefits
6	Lion Wildenburg	Consultant	Lloyds Register Rail	Coordination of infra-related costs of ERTMS
7	Jos Holtzer	Mgr Rolling Stock & Infrastructure	NS	Rolling Stock, current
8	Tjeu Smeets	Strategic advisor	NS	General NS
9	Bert van Son	Project manager Rolling Stock	Railion	Rolling stock freight operators
10	Hans-Willem Vroon		Railion	Rolling stock freight operators
11	Pieter Kraaijeveld	Director Strategy Development	ProRail	General ProRail
12	Otto van Rooij	Project manager	Ministry V&W	

Due to time constraints only key supporting documents have been reviewed in depth

Nr.	Title	Author	Company	Date
1	Recent developments in Dutch signalling, One small country, four Mega-projects	Maarten vd Werff	ProRail	March 2007
2	Signalling in the Netherlands	Maarten vd Werff	ProRail	May 2007
3	Kostenschattingen implementatie ERTMS in Nederland	Lion Wildenburg	ProRail	September 2006
4	Outline strategische keuzes voor implementatie ERTMS in Nederland	Alexander van Andel	ProRail	April 2006
5	Implementation strategy ERTMS the Netherlands		ProRail	September 2006
6	ERTMS/ETCS projects Multi Annual Ten Programme 2007-2013	Otto van Rooij	Ministry V&W	August 2006
7	Implementatiestrategie ERTMS voor Nederland		ProRail	May 2007