

S Stock Value Engineering: The Benefits of Co-operation

**Railway Division Rolling Stock
Lecture- Geoff Bolton and Malcolm
Dobell**

16 January 2012

Improving the world through engineering

www.imeche.org

Value Engineering S Stock fleet

Geoff Bolton, S Stock Project Engineer

Malcolm Dobell, Head of Train Systems

London Underground

2

20 January 2012

Agenda

- S Stock
- Origins of this Value Engineering process
- Value Engineering
- Benefits
- The ones that got away
- Opportunities for the future
- Conclusions

20 January 2012

3



S Stock

- 191 trains
 - 58, 8-car
 - 133, 7-car
- All axles motored
- Open through gangway
- Three sets of double doors/side
- CSDE/SDO
- OPOCCTV, platform cameras, cab monitor
- Three phase ac VVVF inverter drive
- 1395 cars
- ~2800 bogies
- ~4800 shoes
- ~5600 motors
- ~16800 door leaves



20 January 2012

4

Origins of Value Engineering

- S stock ordered 2003 by Metronet as part of PPP
- Extensive risk transfer down supply chain
- Contract novated to LU, 2008
- Opportunity to work together on saving money identified in 2009
- By then, almost too late; trains already in production.
- However.....

20 January 2012

5



Origins of Value Engineering

- 8 car trains in production
- 7 car production 2 years away
- Numerous opportunities to save money
 - Simpler or different manufacturing techniques
 - Improved design
 - Simplified LU requirement
- Joint agreement to pursue savings

20 January 2012

6



Value Management/Engineering

7

20 January 2012



What is Value Management/Engineering

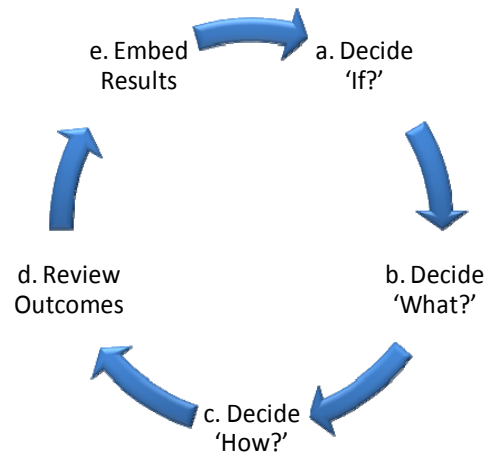
Value management/engineering is a systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.

20 January 2012

8



The Value Management process lifecycle

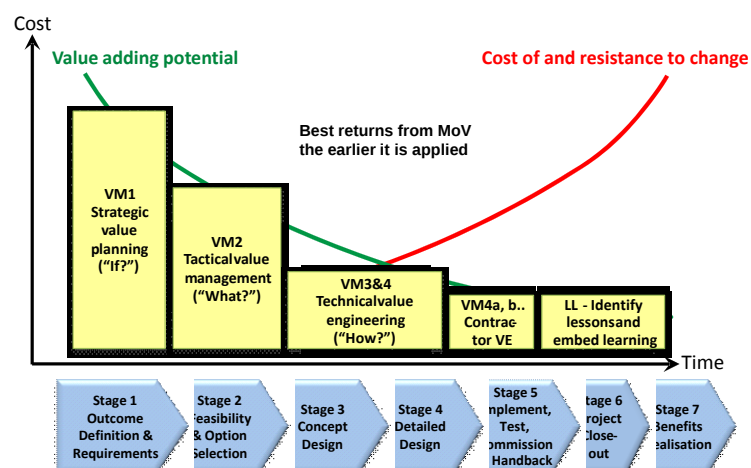


20 January 2012

9



VM applies throughout lifecycle



20 January 2012

10



Original charter 2009

1. Apply to S7 only (S8 already under way, S7 is still a huge order - 931 cars)
2. No delay to S7 unless jointly agreed.
3. LU and BT to share after BT's up-front costs
4. Reducing cost, not stripping out value.
5. Interchangeability of Line Replaceable Units to be maintained (at least within sub-fleets).
6. Trains must retain their operational flexibility.
7. Reliability and whole life cost to be improved

“Even if we only achieve objective 7 the work will have been worthwhile”

20 January 2012

11



Process

- Ideas generation
- Idea development
- Discussions with suppliers
- Proposal with benefits/savings
- Approval
- Implementation

20 January 2012

12



Case Studies

13

20 January 2012



Summary of changes taken forward

System

- Parking Brake provision (S7)
- Reduction in battery capacity and deletion of cell block voltage monitoring (S7)

Electrical installation

- Electrical installation (S7)
- Remove bodyside to roof connectors
- Remove spare wires in cab back wall
- Cab back wall earth reduction
- Remove cable tray EMC barriers (underframe drop-out box, saloon and cab back wall)
- DM car underframe cable tray rationalisation
- OPO connector simplification
- Self-adhesive labels

Mechanical

- Underseat boxes simplified design (S7)
- Shorten Door Guides (S7)
- Mount levelling valve directly on underframe
- Cast bolster brackets instead of machined
- Non-structural T bolts
- Arc barrier wing outer flange removal

Livery

- Cab valance colour (all black)
- Unpainted de-icing tank
- Unpainted auxiliary control equipment box
- Doors interior paint gloss level tolerance
- Unpainted door kick plate (stainless steel)

20 January 2012

14



Battery size

- Battery emergency duty is 2 hours, allowing for temperature and ageing effects
- S8 battery loads based on supplier commitments at design stage
- At test, loads found to be significantly lower
- S7 has approx 88% loading of S8
- Battery capacity reduced from 220Ah to 150Ah
- Opportunity taken to rationalise cell layout
- Major mechanical redesign rejected due to technical risk
- Risk of S7 battery fitted to S8 train designed out

20 January 2012

15



Electrical installation

- Major redesign of wiring and electrical equipment layout (no change to schematics)
 - CIS controller moved from ceiling to seatbay
 - Relay box moved from interend to ceiling
 - 4 relays moved from cab back wall to relay box
 - Seatbay liner removed
 - Connection boxes rationalised and standardised
 - Unnecessary connectors eliminated
- Significant benefits beyond cost savings
 - Reliability – reduced wiring /component count
 - Maintainability – better access to maintainable items
 - Production – fewer harnesses to install

20 January 2012

16



Electrical installation - benefits

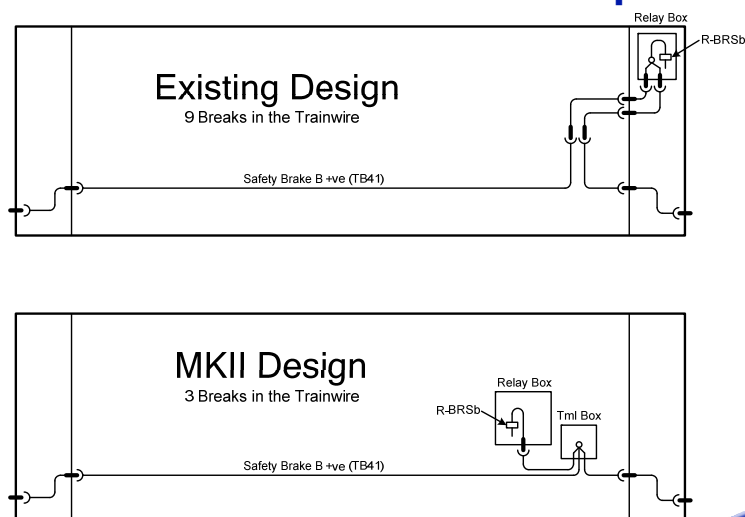
- 6 connection boxes per car instead of 12
- 2 different designs of connection box instead of 6
- 'Off the shelf' connection boxes
- 6 terminal rail assembly designs instead of 60
- 178 terminals per car instead of over 300
- 15 mating connectors removed per car
- 30% fewer control & safety wires per car
- Improved circuit segregation

20 January 2012

17



Electrical installation – example

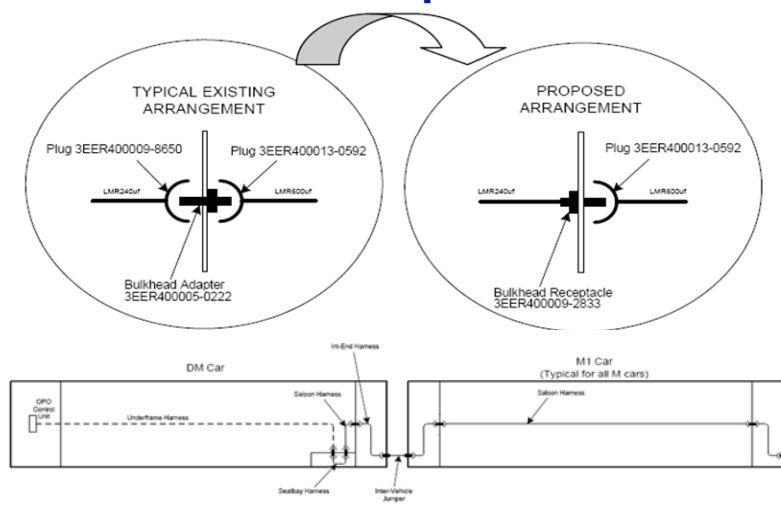


20 January 2012

18



OPO connector simplification



20 January 2012

19



Shorten door guides

- Door leaves retained in bottom track
- Load cases with doors open are trivial compared to load cases with doors closed
- Shorter door guides maintain required integrity
- Endurance test of shorter door guides



20 January 2012

20



Cab valance

- Single colour rather than two
- Saving £32,000
- And it looks better!



20 January 2012

21



The ones that got away

Concept (S7)

- Trailer car
- Bogie / suspension concept

System (S7)

- External side displays (alternate cars)
- Single Train Data Recorder
- LED lighting
- M door wash / wipe

Electrical installation

- Remove negative separation contactor
- VAML conduit instead of PLU
- Traction motor connector
- Door leaf pushbuttons

Mechanical

- Remove 'internal' drain for gutters
- Use of swaged pipe ends instead of olives
- Reduced tip-up seat provision (S7)
- Tapping bar material
- Revised inter-car coupler
- Simplified coupler alignment mechanism
- Simplified grabrails
- Cab back wall vents

Livery

- Unpainted roof
- Unpainted body end

20 January 2012

22



Traction package

- Remove one traction package per 7-car set
- Run at maximum rated power (higher current per package than for 8-car set)
- However the following activities were required
 - Weight balance and vertical and longitudinal centres of gravity
 - Bogie suspension re-assessment due to reduced weight could mean
 - Different primary/secondary springs
 - Different anti-roll bar stiffness
 - Possible re-distribution of underframe equipment to improve weight balance
- Finally concluded too much technical/time risk and limited saving, given orders already placed

20 January 2012

23



Bogie/suspension

- Currently flexible H-frame bogie with air suspension
- Proposed more conventional bogie with rubber hemisphere suspension
- Cheaper and lighter
- But.....too much technical risk



20 January 2012

24

Results

- **24 ideas incorporated into production line**
 - 5 solely on S7
- **Over £4m saved despite the late start**
 - 50:50 share between LU and BT
- **Demonstrable reliability and through life savings**

20 January 2012

25



Opportunities for the Future

- **What have we learned?**
 - If VE had been built into the design and development process, how much more might we have saved?
 - 5% to 10% of the nominal cost?
- **What will we do in future**
 - More dialogue with potential suppliers pre-contract, constructively to challenge requirements
 - VE built in to the requirement for future contracts
 - Next procurement likely to be of similar size to S stock

20 January 2012

26



Conclusions

- We have learned a lot about how our requirements have been implemented
- Not everything will be got “right first time”
- Continuous development ought to be a way of life
- We will apply this technique from the beginning in future.



20 January 2012

27



Acknowledgments

- **Bombardier Transportation** for their work in the VE programme and providing input to this presentation
- **London Underground** for permission to present.

20 January 2012

28





Railway Division Centre Events

North East Centre-

Keynote Address (Lecture)- 8 February 2012, National Railway Museum

Scottish Centre-

Hitachi- IEP & other Developments (Lecture)- 16 February 2012, Edinburgh (TBC)

South West Centre-

The Future of Railway Engineering (Young Member Presentations)- 23 January 2012, Western House

Midlands Centre-

Midlands Engineering Dinner 2012 (Annual Dinner)- 09 March 2012, The ICC

North West Railway Centre-

Rail Lubrication (Lecture)- 14 February 2012, Manchester Metropolitan University

South East Centre-

First UK Rail 'Driver Advisory System' (Lecture)- 23 January 2012, I.Mech.E. HQ