Aspîre - Analyse. Optimise. Deliver.

Support Engineering & Imperative Intangibles..!

Feedback & the Intelligent Customer

There are two categories of Support Engineering activity, the tangible and the intangible…

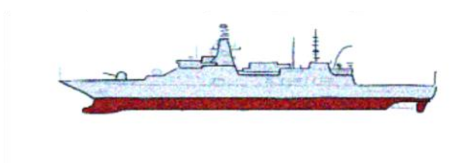
Tangible activities lead directly to the production or the procurement of a support resource, their absence would be instantly apparent – something, spares maybe, would be absent.

Intangible activities are analyses whose absence would not be immediately apparent, spares optimisation for example.

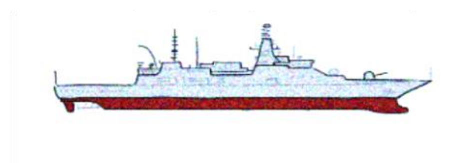
But who cares about this distinction…and what has this got to do with feedback and the intelligent customer?

A Tale of Two Platforms

…a game of spot the difference…



Platform 1



Platform 2

Consider the two platforms above, ships in this illustration, but the argument applies to any platform.

In terms of their support arrangements the platforms appear to be very similar. Both platforms have:

- Suites of spares
- Technical publications
- Tools and test equipment
- Trained manpower
- Supporting facilities – stores, workshops etc, on board and ashore
- Packaging and handling equipment
- Contracted support from industry.

But these two platforms are far from being equal.

Platform 1's support is the result of a heavily tailored, low cost, support engineering programme; a support programme comprised in the main of 'tangible' support activities.

Platform 2's support is the result of a systems engineering based support engineering programme, a support programme comprised of 'tangible' and 'intangible' support activities.

Platform 2 is infinitely superior to Platform 1. Why should this be the case? Let us consider these 'tangible' and 'intangible' activities and their effects, let's compare the hypothetical support programmes of our two hypothetical platforms…

REQUIREMENTS GENERATION

Platform 1

The technical requirements for Platform 1 were derived from those developed for an earlier, similar system, there are availability, reliability and maintainability targets set at the platform level. The strategy was to develop an 'output' based contract, the focus was on the final deliverables, the support resources; for example electronic technical publications, training materials, spares, maintenance plans etc.

There were some 'process' requirements defined in the statement of work [SOW], for example the programme called for tailored; reliability and maintainability [R&M], training needs analysis [TNA], reliability centred maintenance and Logistic Support Analysis [LSA] programmes.

Platform 2

The technical requirements for Platform 2 were derived via a systems engineering based programme. The 'problem space' and then the 'solution space' were defined for the platform and the associated support solution.

Whilst this may sound rather esoteric, it means that the end user had the opportunity to define what they required from the support solution. For example, the nature of future conflicts and the role of Platform 2 in such was defined; any proposed support solution would have to function effectively during such conflicts.

Innovative approaches could be considered, in a structured manner. During the earliest phases of Platform 2's life cycle a series of assessments were conducted, a range of alternative support technologies were evaluated, including; additive manufacturing, augmented reality, automation, alternative forms of electronic publications, the Internet of Things, sensor RFID's, NFCs, virtual sensors, data science, mobile devices, social media technologies, etc, etc. Some of these concepts were rejected, others were assessed as being potentially beneficial and included in the 'solution space'.

Use was made of historic data garnered from extant fleets, this enabled robust baselines to be established for both the platform design and for the support system. This information included quantitative data, for reliability and maintainability etc, and qualitative data, for example "Lessons Identified" (both positive and negative).

The baselines facilitated the modelling and hence the analysis of the data, the models in their turn facilitated the assessment of innovative technologies and alternative support strategies, and hence informed the development of SMART (specific, measurable, achievable, relevant, time-bound) technical and process (SOW) requirements.

Specific requirements included:

- ❑ Durability and robustness, important to a system that would be operating 'up threat'.
- ❑ The concept of 'designing' an optimal support solution was central to the requirements.
- ❑ A mandatory systems engineering approach to support engineering.
- ❑ All support decisions to be justified, an audit trail of the decision process to be provided in the form of a support case which would be developed on a rolling basis throughout the design and development process.
- ❑ A standardisation programme, to be applied to the platform design and to the associated support system, with aim of achieving coherence with other platforms, existing and planned.

SYSTEM DESIGN

Platform 1

The equipment to be fitted onboard Platform 1 was selected by the prime contractor from their established and trusted supply chain, in the main original equipment manufacturers [OEMs]. They made extensive use of off the shelf equipment and systems. The programme relies on OEM manuals, and on the OEM for the recommended maintenance regime, spares holdings, and the tools and test equipment held on board etc.

Platform 1 has been designed so as to be survivable in the event of a strike by an anti-ship missile or warship artillery rounds. Battle damage control systems, resources, and training have been established accordingly. The effects of enemy action on individual systems was not taken into account however, Platform 1 relies on redundant systems and backup modes of operation to provide resilience, to enable it to reach a safe location where repairs can be conducted.

The support strategy for Platform 1 is founded on that for extant platforms, it is assumed that the platform will have ready access to the port facilities of friendly nations; to date this has never been an issue.

Some analyses were conducted, the majority by the OEMs. TNAs, RCM and some LSA for example, was carried out on key systems, albeit in a disparate manner having been conducted in isolation from each other.

There are several hundred OEMs supporting the programme so collecting and collating the associated data was a major task, but an Logistic Support Analysis Record [LSAR] was created and handed over to the customer.

An FMECA was conducted and recorded in the LSAR, this informed the RCM analysis, also recorded in the LSAR. The corrective and preventive tasking identified via these processes was loaded into Platform 1's maintenance management system [MMS]. Conflicts between this data and that contained in the OEM maintenance manuals were resolved by a team of support engineers post the delivery of the contracted support outputs by the prime contractor. The OEM manuals taking precedence over the FMECA/RCM analysis results.

Recognising that the client no longer has the skills to conduct complex maintenance tasks the support strategy is to repair by replacement of major components on board and to utilise contractor support. Contractors being flown out to meet the platforms, as required, in suitable friendly ports.

The electronic publications provided on board and the training programme reflect this philosophy. The publications are in the form of PDF documents that can be read on any device with suitable PDF reader, other forms of electronic publications being deemed to be high risk, unnecessary and too expensive.

Basic technical training is provided by the client, but much of the equipment training is provided on an as required basis by the OEMs.

This approach has significantly reduced the volume of tools and test equipment carried on board, on board spares holdings are also reduced, albeit at the expense of increased holdings ashore. Training time has been reduced but at the expense of increased OEM training and increased travel and sustenance costs.

Platform 2

New technologies (in the 'solution space') were evaluated and some were adopted, adapted and fielded. Platform 2's makes use of IoT and mobile technologies and these interface with the electronic technical publications and the onboard MMS. This has resulted in a marginal increase in the effectiveness of the on-board maintenance activities, and a significant increase in the quality and the quantity of the technical feedback data.

Platform 2 makes extensive use of off the shelf equipment and systems, analytical techniques were employed to ensure that the best balance was achieved between initial cost, through life cost (TLC) and operational effectiveness when selecting options. A model based systems engineering [MBSE] approach was deployed to facilitate the design process, this enabled TLC and system operational performance to be monitored more-or-less continuously throughout the development programme. This facilitated a range of investment appraisal techniques, including; trade-offs, sensitivity analysis and breakeven analysis.

"***Simple solutions seldom are. It requires a very unusual mind to undertake the analysis of the obvious*.**"

Alfred North Whitehead – Mathematician

The Prime contractor undertook the majority of the analyses in house, limiting, as far as was practicable, the input of the OEMs to the supply of data and information. An on line, facility was established to facilitate this process.

The nature of future conflicts was taken into account when designing the platform and the associated support. spares optimisation, level of repair analysis [LoRA], training needs analysis [TNA] and maintenance task analysis [MTA], amongst others, were all applied and all took cognisance of the planning assumptions.

"***Decisions are made in peace that create unacceptable costs in war*.**"

David Beaumont – 'Logistics in War' blog

A damage modes and effects analysis [DMEA], taking into account the effects of enemy action, was performed along with an FMECA, as integral elements of a support engineering programme that focussed on durability and robustness in addition to reliability, maintainability and testability.

Platform 2 has onboard a range of stock materials, steel, aluminium etc, and the automated machine tools (milling machines, pillar drills, lathes etc) with which to work them. Similarly, metal powders and polymers and a selection of machines provide a limited additive manufacturing capability. In both instances the data and the skills required to operate such 'digital' machines are made available via support contracts and the training programme. These onboard capabilities greatly enhance the crew's ability to carry out battle damage repairs as well as 'normal' corrective and preventive maintenance.

The arising rate for both corrective and preventive maintenance is lower than the norm for a ship of this class and complexity. The preventive maintenance burden has been further reduced because the need to conduct preventive maintenance, in particular condition based maintenance, was considered during the design process.

The outfit of spares held on board Platform 2 is optimised for specific operations. For combat operations the scaling will sustain the platform during an extended period of austere conditions, when resupply may be difficult or impossible.

The platform design facilitates the ability of the crew to conduct repairs at sea, this is in addition to the provision of redundant systems and reversionary modes of operation. The crew are cross trained, to mitigate the impact of crew attrition.

"***Everything is very simple in war, but the simplest thing is difficult. These difficulties accumulate and produce a friction…***"

Carl von Clausewitz

"***The real magic is in making the intangible***

The maintenance plan for Platform 2 takes account of conflict conditions. It was developed (and is maintained) via the application of a robust reliability-centred maintenance programme. The RCM programme took account of alternative

***idea, the creative impulse, manifest and live in our reality*"**

Mark Ryan - Actor

operating environments (e.g. warm, shallow water, cold blue water operations) and the wide range of innovative, affordable, technologies that are now commercially available for monitoring the condition of engineered assets.

Platform 2 carries a range of monitoring equipment, ranging from simple RFID scanners, thermal imaging cameras, vibration sensors and endoscopes etc, designed to connect to mobile devices, through to more sophisticated technologies e.g. those designed to detect systemic, latent, defects in electrical and electronic circuits.

All of which has contributed to a notable increase in system availability and a considerable reduction in no fault found [NFF] rates.

An integrated training and technical documentation programme, utilising a consolidated set of analyses, incorporating elements of TNA, MTA and LoRA, has delivered an integrated electronic training and technical documentation system. This system runs in freely available internet browsers.

Industry support is available alongside and whilst as sea, bandwidth and operational constraints allowing. A maintainer on board can seek support from their peer network, or from industry, via a mobile device, utilising basic augmented reality, as well as more conventional means, such as fault data, voice, video, photographs and the written word.

IN SERVICE

Platform 1

Platform 1 is seen as a capable, but expensive asset. Being difficult to support; deploying the platform has become a strategic decision.

Platform 1 is expensive to operate, in part, because manpower costs are very high, and due to the high costs of industry support. There is a backlog of maintenance building up due to the extended onboard maintenance times coupled with a shortage of spares. Maintenance actions beyond the capabilities of the crew are prevalent due to the lack of training on some complex systems and the absence of the requisite tools, test equipment or technical publications. Delays are therefore experienced, and high costs incurred, as representatives of the OEMs are flown out to meet the ship, in the nearest friendly port, in order to carry out repairs.

There is a backlog of line replaceable units [LRUs] on board which are awaiting return to a variety of OEM facilities. The NFF rate for such items is running at circa 67% resulting in higher than expected support costs.

Morale amongst the engineering trades is poor. Their workload is high but job satisfaction is low and retention is becoming a serious issue. Recruitment and training costs are escalating.

Platform 2

Should Platform 2 have to operate ‘up threat’ the front line command are very confident that they will be able to sustain this critical capability even when operating under austere and challenging conditions.

Maintenance technicians are able to carry out the majority of maintenance tasks, on board, efficiently, with limited recourse to external industry support. i.e. they can now do more with less.

The end users developed a high level of confidence in the support solution as a result of the highly integrated support programme and the visibility provided by the evolving 'Support Case'.

Cumulative marginal gains, achieved over a wide range of equipment selection, design and support options, have had a dramatic impact on both the TLC and the operational effectiveness of Platform 2; it is an effective and affordable platform.

IN SUMMARY

Platform 2 is superior because a wide range of 'intangible' analyses were applied, analyses specifically designed to ensure that the platform would satisfy the operational need, that it would be sustainable in wartime, and that the optimum, the most cost effective, solution, was developed and fielded.

Platform 1 relied on long established "custom and practice", on doing the 'obvious' to deliver support. It relied heavily on activities conducted, and the data provided, by the OEMs in the supply chain. The belief being that such inputs can be collated into a support solution. Such un-integrated programmes incur significant costs when the time comes to manage this incoherent data, to deal with the inevitable inconsistencies etc.

Platform 2 however relied on a rigorous, highly integrated, systems engineering programme in order to achieve the outcomes described above. Such programmes also eliminate nugatory effort and ensure that the remaining effort is expended efficiently. Rework is greatly reduced, whilst the quality of the output increases; such a programme delivers a lot more for a lot less effort.

The result is that the cost of the support engineering programme for Platform 1 could cost more than that for Platform 2.

The approach adopted for Platform 2 also delivers a robust audit trail, providing visibility to both the developer and the end user, and thus it builds confidence in the programme and in its outcomes.

"***I never guess. It is a capital mistake to theorise before one has data.***

Insensibly one begins to twist facts to suit theories, instead of theories to suit facts."

Sir Arthur Conan Doyle

Platform 2's support engineering programme did rely on garnering performance data from extant systems in their present operating environments in order to understand the strengths and the weakness of present technologies and modes of employment.

This allowed the developers to capitalise on their strengths and to address the weaknesses; it also provided data, and effective support engineering is dependent on the availability of historical data.

Developing new defence systems is not, as it may first appear, a process of step change, it is an evolutionary process, we evolve new systems and new approaches based on our experience in the past.

Effective feedback is therefore essential to effective support engineering.

It is disturbing, but there are a lot more examples of "Platform 1s" available than "Platform 2s" and yet the

solution lies easily within our grasp. There is no downside to this, so the present situation is something of an enigma; particularly so given that this situation is widely recognised. The author has discussed this issue with many individuals; in military HQ's, in procurement agencies and in industry, in companies both very large and very small, in the UK and abroad, and there is a general consensus with the scenario presented above.

So why does this situation exist? The answer is complex. In part, it is because the key analyses <u>are</u> intangible, the effects of their absence only manifest themselves over time, when a platform is in-service, when the TLC soars and the availability is poor. The effect of their absence is much less evident during development.

It is therefore relatively easy for such apparently esoteric activities to be overlooked or for them to be cut in order to save money. Intangible analyses may be absent from a programme simply because the stakeholders are not aware that they exist or that they are an integral element of support engineering. Some stakeholders are aware of such activities but they are excluded, because they don't understand them.

And this is where the intelligent customer makes their bow. Intelligence is derived from an understanding of what has gone before, an understanding of what is possible today (<u>everything</u> described above is eminently possible today) and from an understanding of what is possible in the near future – and it is inconceivable that we couldn't improve significantly on the Platform 2 scenario outlined above in the very near future.

Aspire: Aspire Consulting Ltd are a private and independent company who have provided expert Supportability Engineering services for over 20 years. Our Support Engineering services, our training and our software have been deployed across the Defence and commercial sectors to optimise the operational performance and through life cost of complex systems.

Author: Peter Stuttard is the Chief Executive of Aspire, a Support Engineering specialist of over 40 years' experience. An ex REME aviation engineer, he has worked at senior level on a wide range of national and international programmes, from armoured fighting vehicles, submarines and combat aircraft, to tug-boats and communications systems.