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1. Synopsis

1.1. Defence is not a strategic afterthought. It is a fundamental responsibility of the government. Over recent years, many significant strategic capabilities have been severely reduced. Ostensibly, this is because of a reducing or changing strategic threat but the realities have been budgetary.

1.2. We are at a point where we need to regenerate them, which involves capitalising them realistically, or lose them forever.

1.3. A particular area of decline has been development of heavy armoured vehicles. Regeneration/recapitalisation would give the country credible armoured capabilities — something which, despite the developments in other areas of military technology, there remains a strong need for. It would also be a significant potential revenue generator for the UK.

2. About the authors

2.1. David Lister is a military historian and consultant on British armour to several large international companies. Over more than a decade of archival research, he has written several books on the subject of British Armoured Fighting Vehicle (AFV) and associated weapon development which span more than a century. His most recent book covers British MBT and AFV development, along with the weapons for these vehicles, during the period after WWII until the modern era.

2.2. Jason Barnes is a technology and strategy writer with close on 30 years of experience of writing on topics which include the military, maritime, advanced materials development and manufacture, automotive and connectivity.

2.3. The authors' reason for submitting this evidence is to offer some insight into how we have arrived at our current crisis, what worked previously, what is now missing and the very real dangers of the ground we tread. More positively, it highlights the opportunities going forward, both strategically and economically.

3. Background

3.1. Since at least the 1930s, British tank, AFV and large-calibre gun research has had one basic tenet: when a system or weapon enters service, work immediately begins on its replacement.

3.2. This work was historically carried out by the British Army's in-house design teams, working in association with industry. For armoured vehicles, the primary centre of knowledge and excellence was the Military Vehicles and Engineering Establishment (MVEE).

3.3. Although the MVEE may have had different names throughout the years, such as the Department for Tank Design (DTD), and Fighting Vehicle Research and Development Establishment (FVRDE), its remit remained unchanged: to develop armoured vehicles for the British Army. This was a continuous task which kept the staff fully employed and up to date on the latest trends. It created a massive amount of experience which led to some of the best AFVs in the world.

3.4. In the area of tank guns, a similar organisation called the Royal Armament Research and Development Establishment (RARDE) continuously developed Britain's weaponry. This resulted in Britain establishing an early lead in tank guns, which we maintained until the turn of the century. Examples include the excellent L7 105mm, which was universally adopted by Western armies in the 1960s and 70s as the tank main armament of choice, and the follow-on L11, which remained for quite some years the most powerful tank gun fielded by any Western-aligned military. The loss of the primacy in overall gun performance, including the crucial key area of MBT main gun armour penetration, has coincided, in part, with the diminishment of interest in developing tanks that has plagued us for the last 20 years and more.

4. Design fundamentals and context

4.1. A challenge in MBT and AFV design is how to realistically scope their desired capabilities.

4.2. The design of an MBT in particular but other AFVs to varying degrees is based on the ‘armour triangle’ of mobility, protection and firepower. In recent years, these have been joined by other criteria, including Stealth and electronic capabilities such as battlefield connectivity. The aim is to balance these features in such a way as to give a qualitative edge over potential adversaries’ weapon systems, however the fear appears to be that once such capabilities have been decided, they will almost immediately be rendered obsolete by the pace of technological change — that, or the emergence of something new(er) must immediately be incorporated or the ‘new’ solution will no longer be good enough.

4.3. In reality, this is not the case.

4.4. If we constantly look to address a moving target in terms of what is the cutting edge, then we will never be able to develop and field something. Arguably, this is what happened with the Future Rapid Effects System (FRES) — we chased the stars, while failing to accept that our feet were still on the ground. We should recognise that pace of change in all spheres of technology is not the same as in the Information and Communication Technology (ICT) sector. Especially in periods of (relative) peace, MBT/AFV designs and capabilities can remain current for years, not mere weeks and months. However, that is not to say that progression is not necessary and should not be pursued.

4.5. Design needs certain flags to be placed in the sand which remain unmoved. An example is that the new F-35 is currently entering service with a targeting system which is less advanced than that on the in-service F-16 and other aircraft. This is because design cut-off dates have to be set. The issue is addressed by having a planned upgrade path — “get it into service with a meaningful new capability, and then get on immediately with addressing what needs to be changed/tidied up”.

4.6. This is not a design ‘failure’. It is in line with something that was once commonly accepted: that system design is largely iterative, and that key upgrades/capabilities can follow on at specified dates.

4.7. Back in the heavy armour sphere, there are clear, logical technological progressions from (in the British context) the Comet and Centurion tanks of late WWII, to Chieftain, and to Challengers 1 and 2. There are clear progressions of many of the earlier vehicles once they were in service. Centurion upgrades ran to a total of 13 Marks, with variants of a vehicle which entered service in the 1940s still giving credible service with some armies in specialist roles today. Chieftain underwent similar numbers of changes/upgrades in order to remain current to the end of its service.

4.8. These upgrades covered all aspects of those vehicles — powertrains, guns and ammunition, sighting and other systems, armour and so on. They stand in stark contrast with the upgrades to date to, for example, Challenger 2, which has remained largely unchanged at its core since service entry over 20 years ago; changes to Challenger 2 since 1998 have been largely limited to the addition of new armour packages. Electronics systems additions have been external to the vehicle's fire control, surveillance and battlefield networking systems and have been intended to counter the IED threat in Iraq. Other fundamentals, such as the powertrain, have remained untouched.

4.9. Longevity of a Main Battle Tank (MBT) design stretches into decades. The basic design of the US's M1 Abrams dates back to the 1970s, as does that of Germany's Leopard 2. As such, they are older than Challenger 2 and more contemporaneous with Challenger 1. However, both have been kept up to date with constant programmes of iterative improvements. In many respects, their capabilities eclipse those of the 'more modern' Challenger 2. Hence the need for progress.

4.10. Arguing that to start design of a vehicle now is to court immediate obsolescence is simply not credible and it is a concern that needs to be robustly dismissed.

4.11. Generally, post-war projects have taken 10 to 15 years to reach service from the start of work.Examples of UK development times are:

- FV214 Conqueror Heavy Tank: 10 years
- FV4201 Chieftain MBT: 17 years
- MBT-80: approximately 15 years (planned)
- FV4034 Challenger 2 MBT: 12 years

4.12. Even a relatively simple vehicle, such as the FV432 armoured personnel carrier, which is effectively a steel box on tracks, can trace its lineage back to the late 1940s, which would give a project development time of around 15 years.

4.13. As noted above, part of the development project team's scope is deciding exactly what is desirable in an AFV, what is feasible with current technology, and what is likely to be possible with near-future technology.

4.14. In the case of an MBT, this assessment phase will inevitably look at lighter tanks, with big guns. The aims will be to reduce overall vehicle weight and the logistics burden, improve mobility and strategic reach, and deliver a large punch in a small package. It is an approach which has been tried innumerable times, by many countries, and it has always either failed horribly or morphed back into the bigger conventional machines which we are familiar with. Again, FRES promised to deliver such a solution and failed. The attempt was defeated by the unbending laws of physics.

4.15. Until such time as there are truly disruptive technologies in the field of MBT/AFV design — and note that there are none on the horizon at present — this will not change.

4.16. The path to a new MBT is not always straightforward, and often it is as important to prove what does not work as what does. Too often, the media will seize upon research which does not lead to a successful solution as a "failure" and a "waste of taxpayers' money". In engineering development terms, however, failure is often as valid an outcome as success — especially where the fielding of a poorly researched and flawed concept potentially compromises performance, safety and soldiers' well-being.

4.17. For example, if we look at the development that preceded the Chieftain MBT, work started with discussions about the weapon system just as its predecessor, the Conqueror Heavy Tank, was close to entering service.

4.18. The Chieftain design team was attempting to build a well-protected vehicle, which necessitated a low profile. This led to several limitations, one of which was the physical size, and in particular the length, of the complete ammunition round for the main gun. To address this, the first designs of the next-generation tank (called the Medium Tank No2, or MT-2) used liquid propellant guns.

4.19. Initially, this novel concept seemed promising but after several years of research and development the inherent problems of the system became apparent. This resulted in the use of a more conventional loading system for the gun, but with the propellant in consumable bags rather than traditional brass shell cases.

4.20. Because of all this, a design that we would today recognise as having the shape of the Chieftain did not appear until the early 1960s, despite work having started at least a decade earlier. Even then, the FVRDE was involved in fixing minor mistakes between the prototypes and the production version. The Chieftain eventually entered service in 1966 and as noted above was kept current and in the front line with a long series of upgrades.

5. AFVs for the 1980s

5.1. Half a century ago, almost to the day, the British Army was in the same situation as it currently finds itself.

5.2. Our Infantry Fighting Vehicle (IFV) project was well behind those of our allies and our potential foes, and floundering badly. The 'box on tracks' FV432 compared unfavourably with the Soviet BMP-1 and the German Marder 1, both of which were turreted designs with some self-defence/fighting capabilities. We fitted gun-equipped turrets to some FV 432s to provide a rudimentary IFV but this was largely to explore the concept and how it would be used in the field, not to provide a credible long-term IFV solution. Our MBTs were about 15 years from the end of their planned service lives and other AFV systems were also due to be replaced.

5.3. To address these significant challenges, the FVRDE conducted a series of studies called 'AFV's for the 1980s'. The premise was to try and design a light MBT and use one universal chassis for all AFVs in the British Army. This universal solution was to be based on the IFV chassis that would eventually become the FV510 Warrior. However, it quickly became clear that the chassis was unsuitable for use as an MBT, as within the weight limitations being considered the necessary levels of armour protection could not be achieved. The 'AFVs for the 1980s' project continued for non-MBT roles, and, inevitably, a conventional design was pursued for the next-generation MBT. This was to be the MBT-80.

5.4. The MBT-80 was to use a brand-new gun with a range of options. Development had been started as soon as the L11 120mm gun had entered service. Advances in ballistics allowed for a 110mm gun to provide performance that was at least as good as the 120mm, but in a smaller package. The MBT-80 was also to employ newly developed composite armour to provide protection. It would have incorporated those armour arrays into its basic design, unlike previous designs where the composite armour was applique in nature.

5.5. The MBT-80 never arrived in service, despite nearly completing development. This was due to political considerations, which famously led to the purchase of Challenger 1.

5.6. Challenger 1 was essentially a Chieftain with next-generation Chobham armour. It gave the British Army a still-relevant gun — the L11 — with a significant upgrade in protection but little else. In NATO tank gunnery competitions, such as the much-respected Canadian Army Trophy, it performed less well than the contemporaneous early versions of the M1 and Leopard 2. Challenger 1's gun sighting and other systems needed to be brought forward a generation and this opened the way to the Challenger 2.

5.7. Challenger 2 still benefited from significant design input from the British Army establishments detailed above. At the point it entered service, it was fully the equal and better of any MBT in the world, satisfying the three traditional elements of mobility, protection and firepower.

5.8. However, after Challenger 2 entered service the difficulties began, which plague us today.

6. The Brewing Storm

6.1. Since the late 1990s, the basic principle of starting work on the next generation of AFV immediately upon the service entry of its predecessor has been abandoned. This has led directly to the current impending disaster. Now, at a time when many of our current AFVs are entering the final phases of their service lives, we should be arranging for their replacements to be manufactured. This work should already be under way, in fact. We appear, from public sources, not to have even started any design effort.

6.2. Despite warnings of the problems that this would cause, the British Army's direct in-house experience of AFV development has been allowed to wither away. The various organisations listed above no longer exist, and their knowledge has largely disappeared or been dissipated within non-specialist successor organisations such the Defence Science and Technology Laboratory (DSTL) and QinetiQ.

6.3. The ability to manufacture AFVs and ancillaries such as guns and barrels has been severely reduced. The Royal Ordnance Factories no longer exist, and both Alvis and Vickers, two of our long-standing AFV manufacturers, were subsumed into BAE Systems.

6.4. BAE Systems, meanwhile, now positions itself as an international rather than a British defence manufacturer. Since the purchase of United Defense Industries in 2005, it continues to furnish the US military with a large proportion of its AFV fleet and is currently fielding new designs. In Europe, however, it recently sold its Land Systems division to Germany's Rheinmetall.

6.5. A massive trove of experience has thus been lost.

6.6. Politics have had a direct influence on all of this. The unending calls to find savings have meant that the dedicated research departments, which were expensive, became liable for the axe — not least because there was an erroneous (and, in reality, largely budget-driven) assumption that the 'Age of Heavy Warfare' was over.

6.7. Time and again, claims about the obsolescence of tanks have been proven to be wrong.

6.8. The collapse of the Soviet Union in 1989 was heralded, in particular by those with a politically driven eye on monetary savings, as the end of heavy armoured warfare. Little more than a year later, British Army and other Coalition heavy armoured units were in action in the Middle East against Saddam's Republican Guard. They were back there again in 2003, having in the meantime seen service in NATO peacekeeping operations in Central Europe and, notably in 1999, found themselves involved in a tense stand-off against Russian armoured units at Pristina International Airport.

6.9. Russian heavy armoured units have since been in action in Georgia in 2008 and Ukraine in 2014, and are currently seen as a potential threat in the Baltic States.

6.10. Can we really claim to have seen the end of heavy armoured warfare? We seem to be the only country suggesting so.

6.11. Comparisons have been made between the British Army and the United States Marine Corps (USMC), which is about to lose its heavy armour capabilities. However, such comparisons are ridiculous; the roles with which the USMC is going to be tasked and the terrain over which it will likely fight precludes the use of heavy armour. The US is also engaging in research into new types of extremely long-range artillery. These will offset the removal of the M1 Abrams from the USMC's order of battle.

6.12. By contrast, the UK has no such comparable artillery research in place and the likely settings in which the British Army is likely to find itself having to operate are far more diverse than those of the USMC. In many, if not nearly all cases, they will find themselves facing opponents with a heavy armour capability. Attempting to engage without credible capabilities or counter-capabilities will result in the British Army sustaining very heavy casualties. It will likely result in defeat.

6.13. It should be noted that the British Army is not the first army in a Western-aligned nation to consider getting rid of the MBT. However, those which divested themselves have subsequently had to reacquire an MBT capability. Both Canada and the Netherlands, for instance, now operate the Leopard 2 having previously decided that they had no MBT requirement.

6.14. The lack of interest in heavy armour by the British Army is also reflected, if not caused, by recent senior officer appointments within the British Army. Since 2000, none of the Chiefs of the General Staff have come from an armoured background (five have been Infantry, one each have come from Engineers, Artillery and Intelligence). This has clear implications for the understanding and acceptance of heavy armour's capabilities and roles.

6.15. A problem is that any challenge to this is seen, and dismissed, as 'cap badge infighting'. We need to get past this and reach a point where we have a well-equipped and balanced British Army which is capable of engaging with and defeating peer threats. At the moment, we cannot do that. We are deficient in many areas, both in terms of capabilities and, crucially, numbers.

6.16. We continue to gap capabilities or take capability 'holidays' even when there is no clear follow-on solution. An example was the wasting-out of service of the FV102 Striker, a missile-armed vehicle based on the excellent CVR(T) platform. The Striker vanished from British Army service in 2005. This left Challenger 2 as the Army's only realistic long-range vehicle-mounted anti-tank asset. The role that the Striker fulfilled was of a long-range anti-tank weapon that provided 'overwatch'. It could provide mobile protection for British Army units moving forward, and break up the enemy's armour formations before they had the ability to engage. There is still very much a need for this capability but a replacement, based on the new Ajax platform, was cancelled to save money.

6.17. The current aims in terms of the British Army's heavy armour capability can hardly be described as ambitious. The concentration is on capability sustainment or managing obsolescence out to end of life of designs which are already decades old.

6.18. Where are our modern replacements?

6.19. Challenger 2 is showing its age and the cupboard is bare. The AS90 Self-Propelled Gun (SPG) fleet is in a chronic state of disrepair having 'enjoyed' minimal maintenance and no essential upgrades — replacing the 39-calibre barrel on the gun with a 52-calibre barrel which would have extended its range was not done to save money. The Warrior IFV upgrades have been troublesome and are finally looking like they are progressing but the basic vehicle entered service in the 1980s. For comparison the US Army is now actively looking for a replacement for its M2/3 Bradley, which is newer than the Warrior.

6.20. We have no new designs in the pipeline, or, apparently, the capacity to make the designs we need. As noted above, the current research departments such as DSTL and QinetiQ do not appear to have a focus on heavy armour. A search of their websites and projects shows no mention of any AFV development.

7. A New Hope

7.1. There does, however, appear to be an opportunity in this disaster.

7.2. Historically, one can think back to the US Army in the late 1930s and early 1940s. It had a mere handful of armoured vehicles and no real means of fighting a modern war. But it was able to take all of the lessons learned from the first two years of WWII and produce some truly outstanding armour designs in very little time.

7.3. In the UK, although our wider manufacturing base has shrunk, we continue to be world-leading in many areas.

7.4. We have specialists in large fabrications, such as would be needed to build AFV chassis and turrets of all descriptions. We continue to have significant advantages in the materials sciences, and so the potential to develop new natures of armour — an area in which we currently remain highly competitive.

7.5. We are the home to world-leading developers of powertrain and motive technologies — electric drive, for instance, is making significant strides in the hands of the UK's Advanced Propulsion Centre and others such as the UK Battery Industrialisation Centre. This has the potential to revolutionise car design and can affect AFV layouts in the same way. It could readily lead to common platform designs that address multiple roles and needs.

7.6. We have a significant design lead in automotive component development, such as suspension and other systems. Our automotive Tier 1 and 2 sector is as good as can be found anywhere in the world and can be repurposed to provide many of the components needed by heavy armour. This may be useful as demand for cars falls off, helping to preserve jobs and expertise in key geographic regions while addressing a national and even an international need.

7.7. We have an opportunity to regenerate much of what we have lost by taking advantage of flexible modern manufacturing developments such as Industry 4.0.

7.8. What we lack is an organisation, or a department, which can pull all of these disparate elements together.

7.9. Our own MBT, IFV and SPG fleets will all need replacing in the very near future. Upgrades to Challenger 2, if approved, will likely give us another 15 years from that platform. In other parts of the AFV fleet, such as the AS90, the need is more pressing.

7.10. Other militaries are at a similar juncture and there are notable trends which push towards heavier vehicles. For example, more armies are looking seriously at providing infantry and other human assets with the same levels of battlefield protection as provided to MBT crews. The Israelis' development of the Namer IFV provides an example. The driver of this trend is recognition of the true lethality of the modern battlefield.

7.11. Current manufacturing and automotive/propulsive developments can enable us to make a heavy armour platform the basic elements of which can also be used to produce lighter designs.

7.12. This is not a new concept, the Germans were pursuing exactly this as long ago as the closing stages of WWII. The UK achieved a very successful platform design with the CVR(T), design of which was started by Alvis in the 1960s.

7.13. The difference is only one of scale/vehicle size but 'starting heavy and going light' has the advantage of ensuring system longevity; weight is a constant factor in MBT/AFV design. It is accepted that current solutions are approaching the limits in terms of strategic and tactical mobility, and the trend since WWII has always been to add armour, systems and so weight to a basic design. Few if any military vehicles leave service lighter than when they entered it.

7.14. We can learn from the mistakes of FRES. We can take a considered look at near-term and longer-term technologies in terms of their suitability and applicability. We can leapfrog current projects and return to offering something which is truly world-class.

7.15. We are at a watershed. We can leave the field of AFV design and put behind us forever a significant strategic capability. Or, we can take a conscious strategic decision to regenerate. It is noticeable that countries with sufficient political will have done this. South Korea for instance has moved from a nascent and comparatively mediocre capability only some years ago to a position where it now offers some highly credible heavy armour solutions.

7.16. Regeneration will do two things: first and foremost, from a military perspective, it will give us the capabilities we need to field an army which continues to be credible in terms of its ability to defeat the enemy and avoid the needless deaths of our own service-people. Secondly, it would give us an invigorated industry sector with significant value-add and potential revenue-generating possibilities — something that was for years a justification for continued defence R&D spending and production in some highly niche areas.

7.17. All of this would tie in nicely with the current stated government policy to pump-prime the economy and overcome the recession caused by global pandemic.

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