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Concept Paper:

"Next Steps in the Fifth Generation Headquarters Concept"

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Topic 4: Cognitive and Socio-Technical Challenges

Abstract:

In 2016 a number of us proposed a Fifth Generation Headquarters Concept, by which Artificial Intelligence (AI) could be infused into military operational headquarters to enable it to achieve properties such as C2 Agility. In this paper, I advance the concept by identifying what types of AI fit into the different functions of headquarters. I take the cue from the relationship between the two current realisations of AI to human modes of decision-making: those based on statistical learning, and those on encoding logic or rules. These map to the 'two systems' model of human decision-making of Kahneman: system one, which represents intuitive thinking, and system two, describing human rationality. In turn, these two systems dominate, respectively, the modes of decision-making in the two 'hemispheres' of military headquarters: the J3 branch focused on current operations, and the J5 on longer term planning. Unlike J5, in J3 there is lack of time for elaborate rational business processes and thus staff adopt a mode of decision-making known as Recognition Priming. I suggest that a model by Mintzberg for combining intuition-dominant 'strategy formation' with more analytical 'strategic programming' can become the basis for formulating the business processes of a Fifth Generation Headquarters. I realise this in a concept I call 'Plan-as-an-App', by which J5 and J3 staff build, maintain and execute the Plan for an operation as an AI-based application using their particular skills; the app becomes the embodiment of the plan through the planning-execution-assessment lifecycle. I argue that this can support the property of C2 Agility in such a headquarters.

Next steps in the Fifth Generation Headquarters Concept

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Introduction. Well over one hundred years ago, in arguing for the institution of a *General Staff* for the British Army in light of developments on the European Continent, Spenser Wilkinson (1895) composed a work entitled *The Brain of an Army*. Certainly at times, a Headquarters – the locus of a staff – is referred to as the brain of a military force, with the Commander at its centre as the brain of the brain. Several years ago, several of us (Yue, Kalloniatis and Kohn 2016) proposed a 'Fifth Generation Headquarters' concept in order to crystallize thinking about the introduction of *human-engineered technological brains* – Artificial Intelligence (AI) – into such military organisations. There, we used the term 'brain' analogically as well, as with Wilkinson. This suggests that recent understanding of the cognitive mechanisms of the human brain may tell us far more about how such a headquarters should be constituted, and where the variety of forms of AI should be applied.

The Fifth Generation Headquarters Concept in Summary. The military and civilian spheres are presently replete with the 'Fifth Generation' image, as something transcending current capabilities in a range of spheres. Though taking its cue from so-called fifth generation air combat platforms – the Joint Strike Fighter, for example – it is now applied for 21st century concepts[1], to warfare itself, to C2, and – with colleagues (Yue, Kalloniatis and Kohn 2016) – to the construct of a Headquarters. Our original paper dealt swiftly with the first question that typically arises: what are the previous Headquarters' generations? We plotted the evolution of headquarters design from the Napoleonic period (First Generation), the Prussian-German General Staff (Second Generation), the technological enhancements of the Operations Rooms and CICs of WWI and WWII (Third Generation), and the J-staff system of NATO and the US DoD post-WWI reforms (Fourth Generation). Through this evolution we observed a number of developments: the refinement of structures and process for the human agents participating therein, the escalation of sizes of the headquarters and scale of operations they could oversee, the incorporation of scientific functions such as statistics and mapping in their tool-set, and finally the technologies that support them, leading to sophisticated Web1.0 based C4ISR systems supporting the human staff.

This is, what was termed in (Yue, Kalloniatis and Kohn 2016), the historical lens. Analogy was also used there to further explain a Fifth Generation Headquarters, that with the aforementioned Air Combat Platforms. The two key features there are the presence of Stealth, Networking and computer driven Agility. Thus (Yue, Kalloniatis and Kohn 2016) argued that a Fifth Generation operational Headquarters, while not necessarily physical stealthy, should have the capability to manage (not eliminate) its cyber presence – for the purposes of both defensive and offensive cyber operations. Networking is a given in the Age of NCW (Alberts, Gartska and Stein 1999). And Agility is precisely addressed in concepts such as C2 Agility (NATO STO 2014) – namely that the structures and processes of the Headquarters should be adaptable to be fit-for-purpose for the range of different operations modern military forces are required to conduct. The Fifth Generation Headquarters concept proposed the effects that should be sought – namely the integrated application of national power in whole-of-government, coalition and multinational activities. In (Yue, Kalloniatis and Kohn 2016) we discussed the principles upon which a Fifth Generation Headquarters should be founded, and there were two. One was the Principle of Requisite Variety (Ashby 1956), which underpins its ability to be a locus of Agile C2. Among other things this means ability to adjust the distribution of decision making. Associated with this, we proposed the Principle of Tailorable Distribution of Situation Awareness (Stanton et al 2006), taking as cue the concept that

[1] Note that however *in 1992* a conference in computer science was held, entitled the "International Conference on Fifth Generation Computer Systems"!

awareness (indeed cognition) is anyway distributed in socio-technical systems, as well as residing in the brain of the individual human operator.

A key point of that original paper was that one reason why the militaries of the US, Australia, the UK, Canada and the like are not yet full 'network centric' is because Revolutions in Military Affairs require both *Necessary and* Sufficient concurrencies of technological advances. The advance of the 'network' of the 1990s alone has been insufficient to overcome the natural inclinations of human decision-makers to hold on to power, to engage in tribalism, and to be too busy to pull information. We proposed that the coincidence now of both networks, artificial intelligence (AI) and data-analytics may constitute Necessary and Sufficient Conditions for the NCW revolution. This paper takes this possibility deeper.

Types of AI. I take as definition of AI that of Trappl (1986) "building machines that simulate human intelligent behaviour". There are numerous ways of classifying AI. One is a Four Type model (Hintze 2016): I AI as Reactive Machines, II AI using Limited Memory, III AI with a Theory of Mind, and IV AI as Self-Aware. This classification is unhelpful for research seeking to plan technologies into headquarters design over the next 10 years: both Deep Blue, which defeated Garry Kasparov at Chess in the 1990s, and AlphaGo of more recent times, are of the first type. Self-driving cars fit into a limited form of Type II. Little else exists of the latter two types – we are some way off a HAL-9000 or The Doctor of the USS Voyager.

Deep Blue and AlphaGo nevertheless serve to distinguish the two types of AI that are constructive for my purpose. The former is a primarily rules based system of if-then chains of logic able to consider the vast degree of branching of options of future strategies, or 'tree search look-ahead', by the opposite player in order to anticipate future moves. These are used in applications of often very deep specialised knowledge such as medicine, law, and geology, and sometimes are referred to as 'Expert Systems'. AlphaGo, by contrast, employs a feature known as Machine, or Statistical Learning, often through mechanisms such as Deep Neural Nets. But in short, it is an enhanced statistical method to detect patterns or correlations in as large as possible a dataset, where an algorithm is trained for this purpose on some initial set of data. Such systems are popularly seen in the present day in Recommender Systems built into web-based search/purchase systems – such as Amazon, Google and various news sites. To avoid confusion I will refer to 'Logic-Rules-based' and 'Statistical-Pattern-based' systems.

There are a few wrinkles in this basic decomposition. Lawrence (1991), in classifying AI, distinguishes Expert Systems from 'Natural Language Processing Systems'. The latter systems enable the user to interface with the machine as if through face-to-face interaction to interrogate its mechanisms for discovering knowledge. However, for us, Natural Language Approaches – undoubtedly very powerful – only represent *a means of interface* without pinning down the underlying analytical algorithm. For that reason the Logic-Statistical System distinction is more useful for approaching organisational constructs. The second wrinkle is that many of these systems today often come as a package, as Lawrence (1991) already notes. Indeed, the success of AlphaGo was predicated on such a fusion of the rules-based tree-searching system of Deep Blue, and statistical learning. This combination of tree-look-ahead and statistical learning offers superiority in a variety of game type tasks (Anthony, Tian and Barber 2017).

I suggest that an *initial* separation of these two approaches is appropriate particularly from the 'Trust' dimension in relation to human decision-makers. This is for two very particular reasons: statistical learning, by only observing patterns in the absence of logical reasoning, may give the wrong answer or the answer predicated in past behaviours without accounting for change. On the former, famously, in Google's research paper on the development of its chatbot (Vinyals and Le 2015), the bot when asked "what is ten minus two" replies "seventy-two" when it could correctly answer the sum of two and two. This was a consequence of the latter reason: "two plus two equals four" is a far more common pattern in text based searches than "ten minus two", so that statistical learning could uncover for the former the correct answer – for the wrong reason. This predication of statistical learning on past behaviours, without accounting for changes in circumstances, leads to the phenomenon of “information/opinion bubbles”, “rumour percolation” and “fake news”. Expressed another way (Reid 2018), faith in Statistical Systems make an assumption of *ergodicity*, known to *not* be a property of many complex systems. Naikar (2018) makes a similar point based on unpredictability in complex socio-technical systems. Clarke (2016), moreover, critiques the ‘strong claim’ of ‘Big Data’ that correlation being seen as enough induces a laziness to overlook the manifold efforts of many scientific approaches, of linguistics, sociology, taxonomy and psychological in understanding and categorising human behaviour – knowledge that can be encoded in Expert Systems. However, rules-based systems in turn may miss patterns and correlations that constitute tacit human experience – often difficult to translate into concrete forms by the software developers of particular Expert Systems.

Clearly, the correct approach is a dual use of Logic and Statistical Systems – but without confusion (reasons for which will be further adduced below). How can the two be put together?

Slow and Fast Thinking, and AI. Several years ago, a debate broke out between two leading schools in the study of human decision-making, those built around Daniel Kahneman, focused on scepticism of human intuition in decision-making; and those around Gary Klein, who enthrone that very intuition. This culminated in a joint work (Kahneman and Klein 2009) where the two leaders famously “failed to disagree”, carving out the regimes where each of their respective models apply. For Kahnemann, human intuition may be flawed because of the intrusion of one mode of decision making into the other, and impact of biases. Specifically, Kahneman has become famous for the two systems model of decision making (Kahneman 2011): System One, or Fast Thinking, is characterised by intuition based on collective patterns in previous experience; System Two, or Slow, is the deliberative, rational judgement underpinned by logic. The subtle role of biases such as priming (where a cue in the problem statement may lean one to a particular solution) and framing (where the contextualisation similarly biases thinking about the problem) in System One may ‘leak’ over into judgements that are properly the sphere of System Two – such as statistical or ranking judgements. Priming, however, is the key mechanism in the approach of Klein, better known as Recognition Primed, or Naturalistic, Decision Making (Klein 1998). Here, expert decision makers precisely use patterns in the context of their present decisions to enable them to leap ahead in an otherwise linear decision process. Such mechanisms are precisely what enable commanders to make decisions under time-pressure, high stakes and high uncertainty. Though Kahnemann and Klein found limited grounds to disagree, and indeed much common ground: both approaches recognise skill of experienced decision-makers and the presence of flawed decision-makers; both approaches recognise the necessity of interaction but also non-confusion between Systems One and Two; both systems agree that heuristics and intuition must be built on rich experience and a trajectory of trial, error and learning so that judgement becomes *expert* judgement or *skilled intuition*. In other words, intuition is not a property of human nature that has a magical aura. To quote the authors directly: “Two conditions must be satisfied for skilled intuition to develop: an environment of sufficiently high validity and adequate opportunity to practice the skill” (Kahneman and Klein 2009).

Our very description of these two models already suggests the mapping to AI, as set out earlier. Skilled intuition, or System One, is the realm of pattern matching or recognition priming – and is emulated in algorithms as Statistical Learning, or Recommender Systems. System Two is domain of logic and reason, deliberation, and is emulated by ‘pure’ Expert Systems. Part of this, the relationship to Kahneman, has already been suggested by Gurari (2017). But the role of Klein’s model, and the contextualisation in existing military staff structures to follow here, are new.

Back to Headquarters. This now points us to how AI may be *strategically* implemented in Military Headquarters. In a previous work, I have spoken of the two “hemispheres” (using Wilkinson’s analogy of the brain) of the NATO Common J-Staff System (Kalloniatis 2017).

While there are many J-numbers (J1=Personnel functions; J2=Intelligence, J3=Operations, J4=Logistics, J5=Planning, J6=Communications), in many instantiations the next level down in staff structures (at Directorate level, namely entities such as J23, J25, J43, J45, etc.) are oriented around the J5-J3 areas. J5 is the section focused on longer term Deliberate Planning; J3 is that associated with Monitoring the execution of plans and the adjustment of those plans in light of changes in the environment, often attempting to use a form of compressed Deliberate Planning. Thus J5 is the section where Operational Planning Processes (OPPs) (Guitouni, Wheaton and Wood 2006) are used. J3 staff struggle to use even abbreviated versions of such processes due to the time compression in situations in ongoing active operations. Studies reveal that implicitly commanders and staff are using Recognition Priming to make their decisions (Ross et al 2004). Despite several years of scholarly work on this model, we are not aware of its incorporation into any doctrinal military process, as all doctrine manuals we have access to (NATO, US, Australia, UK, and Canada) still give adaptations of an OPP for 'crises'; see for example (Joint Forces Staff College 2000; Allied Joint Publication-5 2013).

ICT projects that we are aware of that have sought to implement tools to support collaborative planning have, among other reasons[2], foundered because developers have sought to build them around doctrine rather than practice. It would compound this folly to attempt to lock AI in its means of serving military headquarters in the same way. The clue to success, I propose, is based on the mapping of the two different forms of AI we have discussed to the two different forms of decision-making between the J5 and the J3 'shops'. The former, the Planners, should be served by, *predominately but not exclusively*, Expert Systems encoding the logic and encoded knowledge around HR business rules, geography, logistics, history, communications systems and legislation – to name but a few. The latter, the Operators, should be served by, *predominately but not exclusively*, Statistical Systems that search for patterns in historical data about population and adversary behaviours, weather, ICT outages, and battle data – to name but a few. There remains nevertheless a role for Logic Systems in the Operators' space, for example around the *concept of an operation* and the rules of engagement, and a role for Statistical Systems for the Planners, for example in testing assumptions around a plan against patterns in the real world data.

This is the key concept of this paper, a subordinate to the overarching Fifth Generation Headquarters Concept, I term the *AI-assisted-Two-Systems-Headquarters Model*. The concept is summarised in Figure 1. *If the promises of AI are realised* (and we are allowed to be sceptical), all other functions beyond Planning and Operations – namely Personnel, Intelligence, Logistics, Communications Systems and Environmental Forecasting – will be subsumed in one or another form of technology with minimal human oversight.

The role of Planning – redux. In 2016 when the Fifth Generation Headquarters concept was presented to ICCRTS, a significant question was posed to us: what would the processes of such a Headquarters look like? At the time we had no answer. In light of the two systems concept above, I propose that the answer may be found in a 25 year old work of Organisational Theorist Henry Mintzberg (1994a). His seminal work *The Rise and Fall of Strategic Planning* firstly explodes the illusion that the elaborate strategic planning processes of a vast array of organisations – airlines, militaries, banks, and telecommunications firms – succeed in capturing the key step of *innovation or creativity* of a winning strategy through decomposition and linking of formal planning steps; always there is a box in the workflow labelled 'Magic

[2] Another reason is the lack of a defined organisational model to which the headquarters aspires. As Groth (1999) points out, different mixes of ICT facilitating coordination of work lead to quite different organisations. We have argued elsewhere (Kalloniatis, Kohn and Macleod 2011) that in projects we have observed at *least two conflicting organisational types* are being unintentionally built into the ICT infrastructure, the 'Joystick Organisation' (Power to the Centre) and the 'Interactive Adhocracy' (Power to the Edge) and without coordination between the two.

Happens Here'. This, Mintzberg proposes, is "closed to formalization" but is the role of "informal visionary and learning" activities. Mintzberg draws upon the Left-Right Brain decomposition (that the left hemisphere of the human brain is the seat of analytical thinking, and the right that of intuition), to propose a model of how left-brain *strategic programming* may interact with the more intuitive right-brain aspects of strategy-making. From this he derives an entire organisational process of varying functions, but where "planners logically take a position, not inside the strategy making process … so much as around it." (Mintzberg 1994b). Thus *plans* play a role as communication and control devices of the strategy; *planners* play a role in codifying, programming and elaborating the strategy, in discovering emergent strategy through analysis of trends in the organisation, and catalysing strategy by encouraging innovative thinking. Mintzberg's process model places all of these functions around the various black boxes where strategy making, as intuition, must figure. I slightly modify his representation in Figure 2 where I overlay the forms of AI that may support the human-centric activities.

The Left-Right brain model is evidently an anatomical expression of Kahneman's Two Systems (Kaufman and Singer 2012), thus the relevance of Mintzberg's proposal for the processes of an AI-assisted Headquarters is palpable. From this description the place for Logic Systems in strategic programming is clear. However, I also propose that AI may invade the "black boxes of strategy making" in the form of Statistical Systems. In this sense, I am also allowing for AI invasion into the human space of Command, using the Pigeau-McCann (2002) definitions, if not through impact on Will, then at least on Creativity.

Plan-as-an-App. Early feedback from the ideas presented in the paper thus far drew the criticism that the *analogy* between the J3/J5 and Statistical/Logic is an insufficient basis to argue for a particular concentration of AI as discussed thus far. After all, the J3 only use pattern detection for reactive decision making because of a lack of time; J5 use deliberate planning only because they have the luxury of time. Indeed, one proposal suggested that the analogy may be an argument why *complementary* AI systems are needed: J5 gaining the Statistical Systems and J3 the Logic Systems to complement their time-necessitated human thinking styles. But the pivotal suggestion came through rethinking the 'artefact' – the documented plan – produced by Planners, and the problems this generates in a Headquarters. Rather than AI *supporting* Planners in writing what will remain a 'dumb' document as the Plan, the *Plan itself may be an AI* – an App – that the Planners contribute the building of by inputting the logic *and intent* of the Plan, which is their key skill and responsibility. In turn, Operators who are immersed in the environment, may shape the input of its patterns into the App. At some point operational assessment is conducted and this too may be conducted interactively with the App where, by now, both the logic and the data of the operation reside. The Plan-as-an-App, in turn, will interact with the entire ecosystem of specialist technologies (logistics, personnel, weather, Coarse of Action and war-gaming, and HR/finance administrative tools) that support the work of the headquarters, many of which in turn are in current work around the world becoming built on one or another AI platform. The Plan-as-an-App may then be seen as corralling the inputs and outputs of the AI-ecosystem. It may, in turn, automate the generation of the documentation necessary for the interaction of the headquarters with its superior and subordinate units, the Instructions, Orders, and Briefs. As an AI, if the promises of Explainable-AI are realised, the Plan-as-an-App can be interrogated at any stage to enable understanding of the *Why* of the Operation, including assumptions and changes through the interrogation of the Plan's provenance. These interactions are depicted in Figure 3. A comparison of Figure 2 and Figure 3, shows that the Plan-as-an-App becomes the integrating point between left/right, or system 1/2, decision making models.

In this respect, the Plan-as-an-App becomes the *single product* across the headquarters, much like an automobile is the single product of a car manufacturer. Here different units in the organisation build (or source) the various parts - the body, wheels, engine – which are then integrated together into a single output. Such organisations are structured according to

Mintzberg's *Divisional Form* (Mintzberg 1979), which is a hybrid structure consisting of hierarchy (the management structure of the individual units responsible for components of the final output) and peer-to-peer interactions at the roots of the organisation, wherein the integration takes place. Elsewhere I have argued that military headquarters most resembles the Divisional Form, and that, in turn, this type of organisation by being hybrid, has the greatest potential for C2-Agility between purer organisational forms by virtue of their cohabitation in the one (Kalloniatis et al. 2010). The Plan-as-an-App through its ubiquity through the collective decision-making process enables the headquarters to achieve its Divisional form more coherently. Note that, though the input of Intent is indicated in Figure 3, it is not labelled 'Commander's Intent'. Through the interactivity enabled by the App, this allows for top-down and bottom-up processes to produce *Common Intent* (Pigeau and McCann 2002). Again, both hierarchical and peer-to-peer mechanisms are enabled, supporting the ability of the headquarters to achieve C2 Agility.

Other accoutrements. There is more that the Fifth Generation Headquarters needs, and that AI can provide, but around the hub of creating and enabling links. Rather than humans identifying with whom they should network, AI may guide it, for example by recognising patterns in the environment and recommending (thus by Recommender Systems). As in many existing Web2.0/3.0 technologies outside military enterprises, AI may play a role in drawing together feeds from various legacy components of ICT. A combination of Expert and Recommender systems may play a role in detecting changes in the environment, such as patterns of interaction by adversaries and tempo of their activities, to suggest or enforce changed business rules – and thus facilitate the adaptation of the C2, consistent with Agile C2. Finally, in a mechanism I have explored separately, AI may play a role not only in entities at the *nodes* of future C2 sociotechnical systems, but as *regulators of traffic* (by human and other artificial agents) *along the links*. I have shown that in certain models of C2 as a networked synchronisation process of agent OODA loops (Boyd 1987), with sufficient balanced connectivity the entire system may attain a level of *coherent* performance faster than that possible by the ensemble of human agents, and slower than that of the fastest AI (Kalloniatis 2016). Some types of AI thus may smooth out the disparities in decision speeds between human and machine. I call this process 'AI enabled *nudged* OODA-synchrony'.

Conclusion. I have advanced a previously proposed Fifth Generation Headquarters Concept by drawing upon the Two Systems of human decision-making to identify where different types of AI are most appropriately placed within military headquarters. The Plans area is the focus of deliberate logical analysis for future options and may be supported largely by Expert Systems; the Operators, with little time for formalised processes is the place for Recommender Systems detecting patterns in the environment. These two elements, Plans and Ops, form a minimal structure in a Fifth Generation Headquarters. Mintzberg's model for the relationship between left-brain planners and right-brain strategy-makers offers a template for how the processes of such a headquarters may be developed. Elaboration of this for specific military functions is the subject of future work, but the Plan-as-an-App concept illustrates how this may function within the core planning-execution-assessment lifecycle of a headquarters. Future work will also more thoroughly review AI developments to test whether this two-systems model is sufficient, determine the inhibitors in human adoption of new technologies in the organisational environment, and further elaborate on AI mechanisms that can support the movement between C2 types.

So much that I have proposed seeks to fit AI to human work modes – albeit a richer, contemporary model of human decision-making than often used in designing technology. Even when realised in real staff officers and real technological applications, is that enough? The answer is, of course, no. But in any setting, humans will react to their new environment and discover new ways to do business. If AI is implemented with the flexibility that it promises then the scope for ongoing *co-evolution* between human and machine systems will be enabled.

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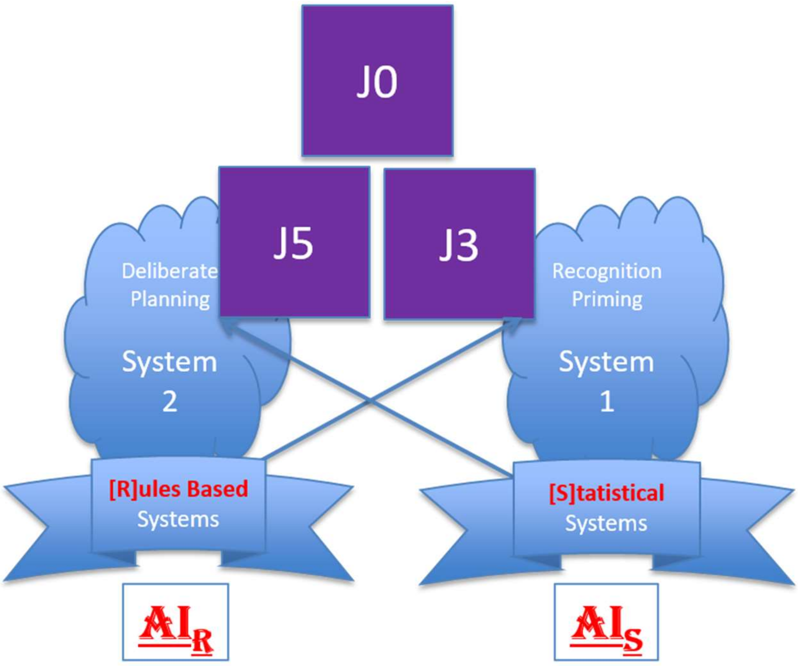

Figure 1 The AI-assisted Two Systems Headquarters Model, where the key staff J5 (Plans) and J3 (Operations) under the Commander (J0) are supported in their dominant decision-making systems by two different forms of AI, Rules/Logic based and Statistical/Pattern-recognition Systems.

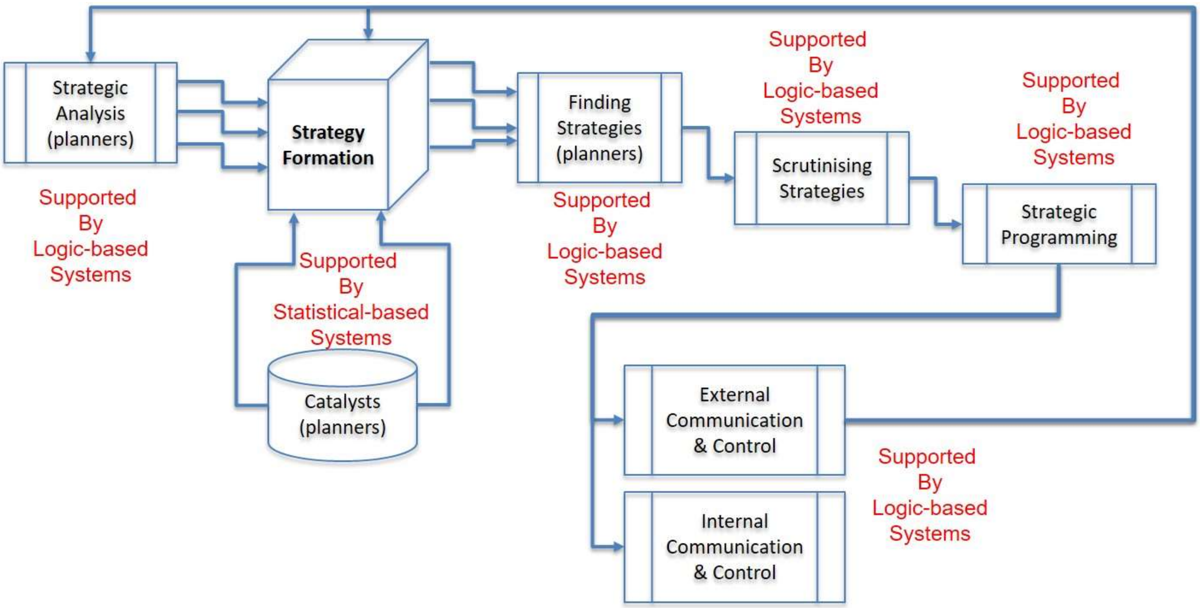

Figure 2 Adaptation of Mintzberg's Strategic Formation Process (Mintzberg 1994b) overlaid with types of AI that may support the process steps.

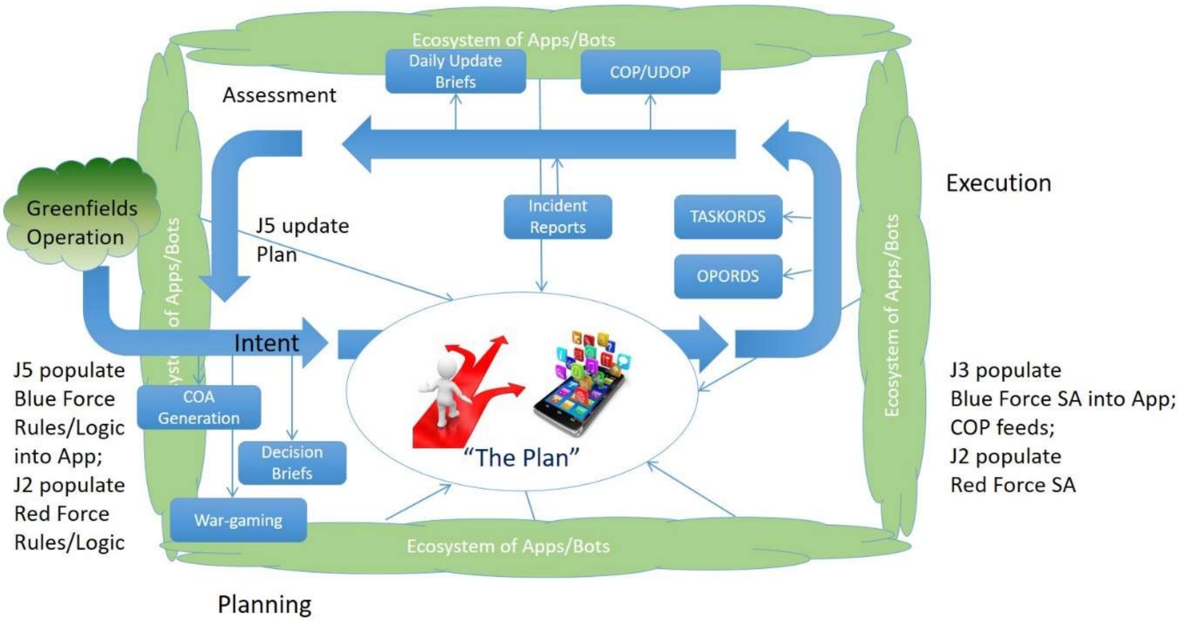

Figure 3 The Plan-as-an-App concept where headquarters staff collectively work to build and use the plan as a single AI-based application, that itself interacts across an eco-system of apps and bots which enable technical headquarters tasks, and automates the generation of many of the artefacts by which the headquarters interacts with superior and subordinate units.