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LINEAR PROCESS AND NONLINEAR SYSTEMS: A DILEMMA OF HYBRID SYSTEMS OF CONFLICT

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Solo Flight

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SOLO FLIGHT

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LINEAR PROCESS AND NONLINEAR SYSTEMS:
A DILEMMA OF HYBRID SYSTEMS OF CONFLICT

Planning and deciding upon a course of action today for leaders and planners of military operations has increasingly become a process-driven endeavour and the use of algorithms to enable these processes has become embedded with the decision-making cycle of western nation militaries and political systems. This in turn has resulted in a linear roadmap towards command and creates an uneasy connection between military strategy and operations. Countering Hybrid warfare and threats, such as the much-studied actions of Russia in annexing Crimea or their actions in Georgia have shown some of the risks to NATO processes[1] in addressing the complexity of these systems of warfare.

To support the decision cycles an input of data is applied to algorithms for answers to the predefined necessary questions to allow for the process to work. This data, in the form of information, is collected and applied linearly to IF/THEN concepts[2]. This process results in more questions that need more information that needs to be applied to get answers to those questions. Yet when the environment and system that these processes are being applied to becomes increasingly complex, such as hybrid warfare, hybrid threats, and asymmetric warfare, combined as a hybrid system, a linear process begins to show its weakness with managing the situation.

This paper will argue that western military algorithmic decision processes are linear in design

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[1] Edward N. Lorenz, 1963. "Deterministic Nonperiodic Flow." *Journal of the Atmospheric Sciences*, doi:10.1201/9780203734636-38 p. 190

[2] Andrew Smith, 2018. "Franken-algorithms: the deadly consequences of unpredictable code." The Guardian. Aug 30. Accessed 05 27, 2020. https://www.theguardian.com/technology/2018/aug/29/coding-algorithms-frankenalgos-program-danger.

and inadequately equipped to deal with nonlinear complex systems of warfare, such as Hybrid Systems, and fundamentally ill-equipped in generating effective strategies to counter Hybrid threats**.**

The paper is arranged in three sections first it will explore the natures of linear algorithmic processes, non-linear social systems in society and how the two have intersected in society and military processes and the effect of their ever-increasing complexity has on decision making. Second, a review of Chaos Theory will show that complex systems such as Hybrid Systems, made up of hybrid warfare, hybrid threats and asymmetric warfare are complex non-linear systems deeply interconnected but not necessarily coordinated. Finally exploring how combing the two, algorithmic decision cycles, and complex hybrid systems is a linear predictive process applied to a non-linear system and creates limitations to the planning and decision-making process.

STRAIGHT LINES A LINEAR PROCESS

$$X = Y$$

A Linear Equation

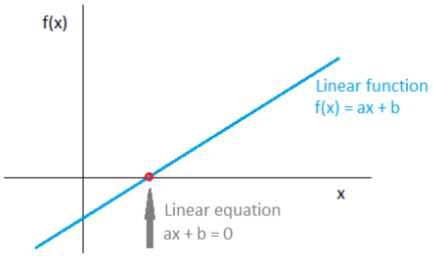

Figure 1. Linear Function

The above equation is the simplest form of a linear process, where the sum of the inputs (X) adds

up to the outputs (Y)[3]. Linearity allows for direct correlation of action to output. These results of linear equations are straight lines. The American mathematician George Dantizeg articulated the linear program well:

'*…the ability to state general goals and to lay out a path of detailed decisions to take to "best" achieve its goals when faced with practical situations…*'[4]

Dantizeg goes on to explain that the tools to do this are a way to formulate real-world problems into models that use algorithms as the technique for solving the models and computers & software as the engines to use the algorithms.

This use of mathematics to establish a set of rules to answer real-world problems has resulted in decision systems to incorporate linear processes. The Canadian form of Operational Planning Process (OPP), incorporates a flowchart, like an aspect that linearly applies tools to deal with strategic and operational planning considerations[5]. The process establishes a problem or set of problems to be addressed and then goes through a series of, what are essentially checklists, to establish factors, considerations to determine deductions all of which are applied towards developing a plan with the tools available to the military planners. The process is broken down into 5 stages of 1. Initiation, 2. Orientation, 3. Course of Action Development, 4. Plan Development and 5. Plan Review. These steps are all aspects of a linear process.

Stages 1 establish the conditions of what is the problem(s) which needs solving and establishes

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[3] Larry Hardesty. 2010. "Explained: Linear and nonlinear systems." MIT News Office. Feb 26. Accessed 06 2020, 04. http://news.mit.edu/2010/explained-linear-0226#:~:text=But%20the%20basic%20definition%20of,nonlinear%E2%80%9D%20takes%20in%20everything%20else.

[4] Dantzig, George B. 2002. " "Linear Programming."." *Operations Research* 50 (1): 42. https://search-proquest-com.cafvl.idm.oclc.org/docview/219190236?accountid=10524.

[5] Department of National Defence. 2008. *Canadian Forces Joint Publication 5.0.* Department of National Defence

the conditions for what the linear algorithms of the remaining stages are attempting to solve for. This process is widely established within the Canadian Armed Forces and engraved into the planner's mindset at many stages of the career. Like any good flowchart, the OPP has gateways built into its algorithms which allow it to appear dynamic and fluid to allow for the process to stop and restart back at an earlier stage in the process to allow for new inputs of data for analysis and incorporate into the planning process, as per the checklist of activities.

The relative simplicity of a linear model such as OPP does not preclude it from having simple engines and models to employ. These styles of processes, because they remain based in a linear process, can quickly become large burdensome entities to employ in complex systems. Ashby's Law of requisite variety states that if a system is to be able to deal with the diversity of an environment then the variety of responses to the environment must be at least equal to or greater then the nuances the environment has[6]. Data in data out is the issue here, where the sum of X = the sum of Y, the more information and dimensions at play requires more gathering and analyzing of that data.

[6] John Naughton. 2017. "2017: WHAT SCIENTIFIC TERM OR CONCEPT OUGHT TO BE MORE WIDELY KNOWN?" Edge.org. Accessed 05 31, 2020. https://www.edge.org/response-detail/27150.

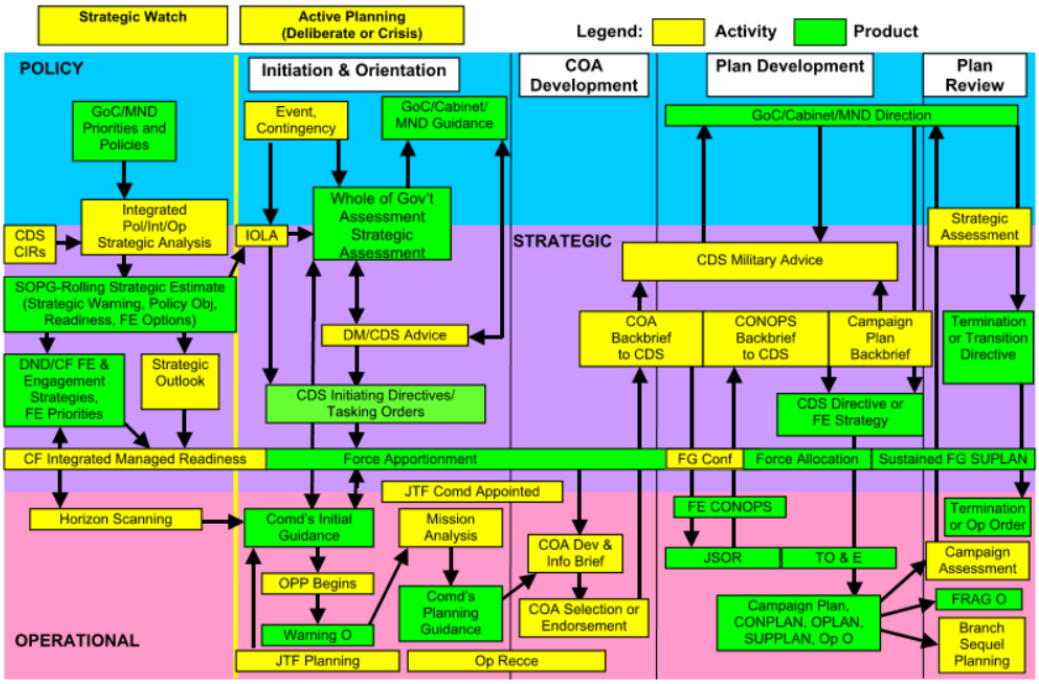

Figure 2 Example of decision cycles for OPP[7]

This results in larger and larger resources applied to work through the process and when the information does not come in linear fashion assumptions and approximations[8] are necessary to enter the equation to turn a complex system into something a linear process can compute against. These assumptions and approximations, in a social dynamic setting, are where the process becomes prone to bias and heuristic variations.

[7] Ibid. P. 29. Force employment planning process
[8] Dimitrios Kantemnidis. 2016. "Chaos theory and international relations." Naval Postgraduate School, MONTEREY. http://hdl.handle.net/10945/51731 P.4

NONLINEAR SYSTEMS, CURVES

$Y=X^2$

Nonlinear Function

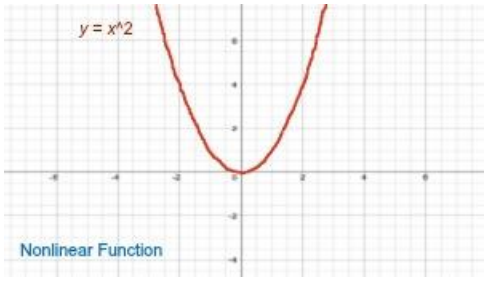

Figure 3 Nonlinear Functions

Where linear equations result in straight lines, nonlinear equations result in curves. Social and culture intersections with technology have in recent years dramatically increased the application of linear processes, such as computational algorithms, with interactions of nonlinear, complex, social fabric of society. At an individual level, social media platforms such as Facebook have been pioneering the social engineering of algorithms into a pattern of life recognition and manipulation. An example of this is the programs to predict and prevent suicide attempts by users[9] by mass data, they can analyze user online behaviours and develop algorithms that find correlations between behaviour sets X, and their commonality of having Y outcomes. Using these sets of correlations development of prediction models can assign risk factors, based on past user histories. If a user enters a risk zone these 'warning' signs are acted upon to attempt to get the user behaviour to move out the risk zone. This is an example of how the complexities

[9] Hayley Tsukayama. 2017. "Facebook is using AI and pattern recognition to try to prevent suicide." *Financial Post.* Nov 28. Accessed 06 05, 202. https://business.financialpost.com/technology/personal tech/facebook-is-using-ai-and-pattern-recognition-to-try-to-prevent-suicide.

of human behaviour and life have been parsed into quantifiable linear aspects to measure against, it does not address underlying causes or societal norms, individual circumstances and other environmental factors but rather becomes a numbers game of most likely actions based on an agnostic set of indicators selected by the code itself (see Fig 3).

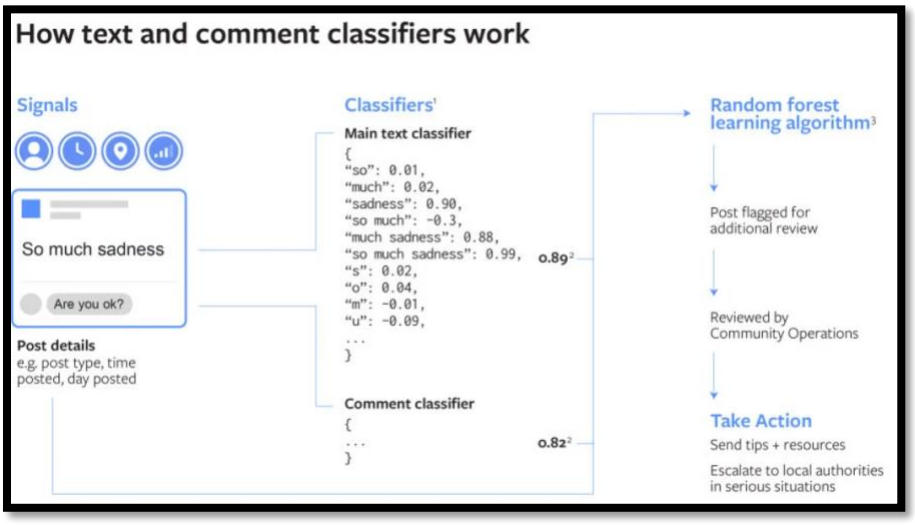

Figure 4Example of the Facebook algorithmic process in scanning and scoring user posts
Example of the Facebook algorithmic process in scanning and scoring user posts[10]

Other linear nonlinear intersections that have been occurring for decades is that of weather forecasting. The non-linear highly complex nature of atmospherics has been attempted to be understood and predicted using some of the most sophisticated and powerful computational powers on the planet[11] yet it remains difficult to have accurate medium- and long-term accuracy due to the seemingly endless variables to measure for a weather system. Complex systems can not simply be taken apart and put back together.

[10] Natasha Singer. 2018. "In Screening for Suicide Risk, Facebook Takes On Tricky Public Health Role." New York Times. Dec 31. Accessed 06 05, 2020.
[11] Daphne Leprince-Ringuet. 2020" his new supercomputer promises faster and more accurate weather forecasts." *ZDNet.* 14 01 2020. Accessed 06 05, 2020. https://www.zdnet.com/article/this-new-supercomputer-promises-faster-and-more-accurate-weather-forecasts/

The questions then are what is a Hybrid System? and why are they considered a complex nonlinear system? Hybrid threats, Hybrid warfare and Asymmetric operations combined to create what this paper calls a Hybrid System. These components have been actively studied in military circles especially in light of Russian operations in their annex of the Crimea in 2014 and China's increasing emphasis on the 3 non-wars[12]. The debate around Hybrid warfare is a type of new warfare or just another way of tactically applying new tools with traditional aims present in most conventional and nonconventional conflicts continues. Though what is more accepted is that the domains hybrid systems operate in coupled with the simultaneous nature of the conflicts have Hybrid Systems as a distinct set of strategies[13] that are derivable from them. It is the strategies of these systems that should be targeted for countering when defending against Hybrid Systems.

Hybrid systems are complex in two ways first being the various domains and areas of the state and non-state realms that they operate within. Monaghan details 23 different nonviolent threat instruments[14] some of which are cultural, domestic, criminal activity, economic, trade and legal to proxy and unconventional warfare. He also lists 16 different warfares[15] that can be employed in hybrid strategies including cyber warfare, network warfare, lawfare, terrorism, information warfare and conventional warfare.

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[12] Dean Cheng. 2012. "The Chinese People's Liberation Army and Special Operations." Special Warfare, Jul-Sep: 24-27. https://www.soc.mil/SWCS/SWmag/archive/SW2503/SW2503TheChinesePeoplesLiberationArmy.html.

[13] Alexander Lanoszka. 2016. "Russian Hybrid Warfare and Extended Deterrence in Eastern Europe." *International Affairs*, 92 ed. P.178. doi:doi:10.1111/1468-2346.12509.

[14], Sean Monaghan. 2019. "Hybrid Warfare and Hybrid Threats Are Different Things." *Prism*, 8 (2): P.89

[15] Ibid. P. 93

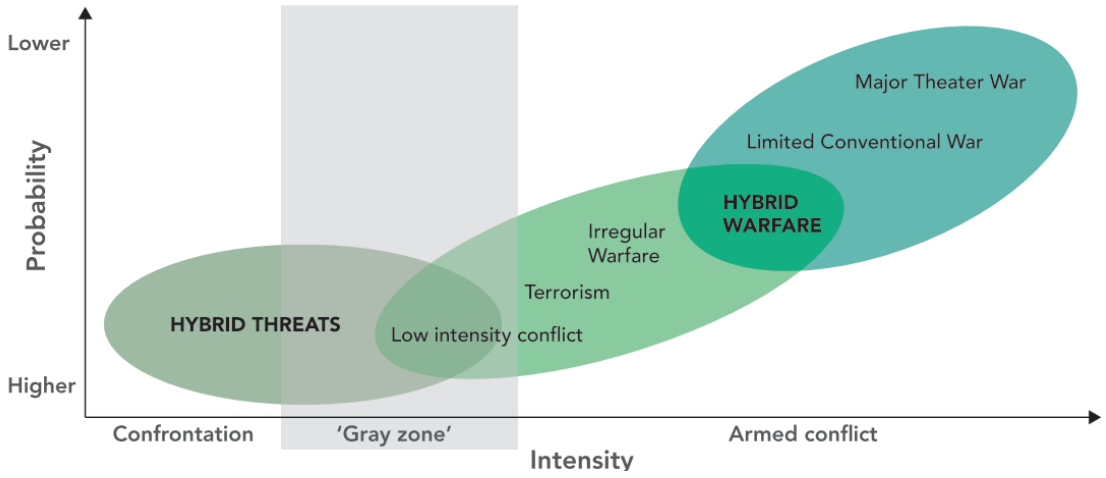

Figure 5CONTINUM of CONFLICT[16]

This continuum of hybrid systems (Figure 5) is broad to the point to be almost encompassing all aspects of societies and life. Hybrid Systems are premised on the concept of the recognition of the interconnected nature of the system and action in one dimension can have far-reaching effects along the whole continuum.

This interconnected nature has been a key component of the 'soft power' development of active hybrid operators such as Russia and China. Russian engagement of social media bots, computer programs that mimic human users in online media interactions, by arms-length intermediaries, such as the Internet Research Agency[17], to influence and confuse public sentiment in support of Russian strategy has been employed against the US, Estonia, Georgia and Ukraine as well as other EU political parties. The strategy helped obscure the physical actions and intent of the Russian ground forces movement into Crimea in 2014. As well these strategies of network-centric warfare employed directly towards the individual civilians of a state through non-state agencies (individuals and corporations) show the importance being placed on both

[16] Ibid P.87

[17] Frank G Hoffman. 2018. "Examining Complex Forms of Conflict: Gray Zone and Hybrid Challenges." PRISM: A Journal of the Center for Complex Operations, Nov: P. 33. https://search-proquest-com.cafvl.idm.oclc.org/docview/2156325964?accountid=10524.

individualizing and personalizing the actions against traditional non-combatants during a phase of operations that pre-date the start of conventional warfare[18]. All this is to say the complexity of the system is even more than just the individual tactics application itself.

The levels of engagements of Hybrid Systems alone make for complex environments and when you add in the second element component of its complexity, the simultaneous nature of the application, the results are exponential on the Hybrids Systems number of interconnected attributes. Hybrid Systems because of the various domains, actors and planes of operating allow for it to act simultaneously along with all intensity levels of the continuum of conflict[19] and at all four levels policy, strategy, operational and tactical planning.

As Clausewitz described all parts of the whole are interconnected[20] and when that interconnection is exploited in a synchronous timeless manner there will be an infinite number of consequences for each action occurring all at once, very much analogous with the astrophysical theory of entanglement.

CONTROLLING CHAOS

Chaos Theory (CT) shows a way in how complex systems are interrelated in a non-linear[21] fashion. CT is a mathematical theory that has primarily been derived for the study in physics and found its voice in the groundbreaking application in the study of long-range atmospheric

[18] Glenn J. Voelz. 2015. "The Individualization of American Warfare." *Parameters*, 1 ed.: P.103.
[19] (Alexander Lanoszka 2016) P. 177
[20] Clausewitz, Carl Von. "On War"https://www.clausewitz.com/readings/OnWar1873/BK1ch01.html.Bk 1 Ch 1
[21] (Kantemnidis 2016) P.4

predictions by Edward Lorenz[22]. In his paper Deterministic Nonperiodic Flow, Lorenz's, along with others[23], helped to show the concept of how systems are sensitive to their initial conditions and popularized the phrase of the Butterfly Effect[24] where a seemingly inconsequential change to a system can have profound long-range implications such as a butterfly flapping its wings in China can lead to a series of events resulting in a hurricane in Florida. Through the Butterfly Effect analogy, the seemingly random acts in a system can be shown to be interconnected so profoundly that it is mathematically quantifiable. The result is chaos is not randomness but rather order appearing random[25].

If a system is not random it does not necessarily mean it is predictable, at least not in a linear fashion. This is aptly true for international relations systems. In the concepts of linearity and nonlinearity the history of mathematics and physics had the linear approach of mathematics routed in the Newtonian principles and for years was the primary way to approach a problem set. The work of Einstein's Special and General relatively and that of Quantum Mechanics introduced a new way for non-linear math in explaining and defining systems. Newton's principles, primarily the conservation of mass, emphasized linear orientation to solutions in that linear systems can be deconstructed and reassembled, the sum of the parts makes the whole. Non-linear on the other hand cannot be solved or added back together[26]. Ashby's Law In highly complex systems there could be an infinite number of measurable and unmeasurable variables

[22] Edward N. Lorenz, 1963. "Deterministic Nonperiodic Flow." *Journal of the Atmospheric Sciences*, 130-141. doi:10.1201/9780203734636-38.
[23] (Kantemnidis 2016) p.5.
[24] JOSHUA KEATING. 2013. "Can chaos theory teach us anything about international relations?" *Foreign Policy*. May 23. Accessed Jun 2020, 4. https://foreignpolicy.com/2013/05/23/can-chaos-theory-teach-us-anything-about-international-relations/
[25] Ibid.
[26] (Kantemnidis 2016) p.4

that all affect the system. The scale of non-linearity makes it appear ambiguous when viewed through a linear systems lens and does not fit well into the linear process of reasoning. It makes it no less real though.

Hybrid warfare, hybrid threats and asymmetric warfare are holistically a system of conflict that is vastly complex in the number of dimensions and actions which can act all in a simultaneous manner that is should be considered a non-linear system like the weather. Using the tenant of CT is to accept or expect that all aspects of the system have some level of interconnectedness. The premise of Chinas Peoples Liberation Army (PLA) 3 non-war concepts of non-contact (Fei jierong; 非接融) warfare, non-linear (fei xianshi; 非线式) warfare and non-symmetric (Fei duicheng; 非对称) warfare[27] emphasize the strategic importance China places on an interconnected system that can be manipulated but adversaries will be unable to accurately predict or act towards the nuances. Countering Hybrid Systems requires a non-linear analysis and process as linear algorithms are unable to efficiently deal with the volume and instantaneous aspects of non-linear complex systems.

[27] (Cheng 2012) P.25

USING A STRAIGHT LINE TO FIND THE CURVES

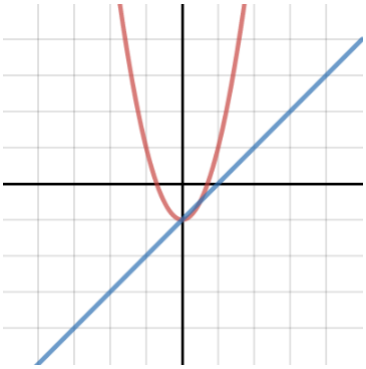

Figure 6 Linear Function (blue) Nonlinear Function (Red)

If the algorithmic process of problem-solving is linear, such as OPP, and you apply it to non-linear systems, Hybrid Systems, the quantity of data necessary to go through the series of a framework to determine an answer that can result in an action or strategy would be immense and time-consuming to gather and analyze, and even with capacity and time it still will not create a result. Inevitably concessions to the planning will have to occur to achieve some sort of result and this occurs through apply heuristics to the data, or lack of it, to make it fit. Heuristics would inevitably remove any cognitive coherence and be replaced with a risk of incorrectness.

Applying a linear process in a linear system allows for scientific reasoning to solutions, that is one that expects a whole answer for the data inputted to result in YES/NO. Non-linear systems, on the other hand, are highly complex and not easily, it at all, predictive[28] so when applying linear processes to a nonlinear system a level of approximation, or assumptions, must be factored in to make the system appear linear. This subversion of the conditions of the system begins to skew and remove the objectiveness of the process for obtaining a quantifiable result.

This approximation does not reduce the requirement for massive amounts of data to support the

[28] (Hardesty 2010)

analysis of a complex system with a linear process such as algorithms. When applied to complex international relations scenarios the assumptions can sometimes be unintentional, such as programming bias, that introduces cultural, social, gender and/or organizational biases of the programmers and planners. These fundamental viewpoint failures can create extreme cases of the butterfly effect when analyzing data inputs for military planners. Potentially the most difficult assumption creations are those of an organizational nature when working in Joint Interagency Military-Political (JIMP) frameworks.

Hybrid Systems have multiple actors, (state, nonstate, criminal, corporate and NGOs) enabling them to cross across multiple dimensions of social impact such as Financial, diplomatic, political and military organizations. Apply Ashby's Law again would dictate that this, in turn, would require an equally multi-organizational capability to counteract the engagement of the Hybrid system[29]. A truly sophisticated counter Hybrid strategy would be best suited through national policy development that saw a multi-agency congruency on conflict defence.

[29] (Monaghan 2019) p.90

CONCLUSION

The development of algorithms has been a simple question, answer and action style process that has grown out of basic rational reasoning intended to support decision-making cycles. The simplicity of algorithms is how it approaches solving a problem in a linear workflow manner. This remains even as they have grown, enhanced, and accelerated by the advent of modern computing and machine learnings integration. The linear aspect supports to decisions making when broken down back to their basics remain simple IF/THEN statements that are only as effective as the information given to them and also in how well the questions they answer have been stated. Simple heuristic, biases or even limitations foretelling what type of problem set an algorithm could be intended to answer can result in massive amounts of effort and resources expended to have the process possibly not address a problem correctly.

So, when a system becomes ever more complex, such as hybrid systems, the linear aspects are inadequate in addressing the nonlinear, complex system. Hybrid Systems have found it seems in exactly that which NATO and western nations considered their strength, the military processes such as OPP and strategic foresight to leverage their joint and coalition superiority. Unfortunately, that potential might have been unable to articulate or find coherence in creating results. Linear approaches to decisions in the establishment of strategies then become are either too slow to be developed and have inadvertently established too high a bar to get a YES response to act towards threats posed by sophisticated hybrid operations specially designed to operate under the threshold of conventional warfare. Western nations still see warfare is primarily conventional ways and remain in a competition of high jump between adversaries yet Hybrid Systems are the real threat as its strategies have turned the bar into a game of Limbo, if nations

are unable to adjust their processes with dealing with these threats, they will continue to employ the wrong tools to address the issues.

FIGURES

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