OPERATION CANTHI: ON MERGING EARLY WARNING, EARLY RESPONSE, SYSTEM ANALYSIS, AND DEEP LEARNING

DOI: https://doi.org/10.37458/nstf.27.1.2
Original scientific paper
Received: October 20, 2025
Accepted: March 10, 2026

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Abstract: At the future-ops section of the Land Information Maneuver Center (LIMC) of the Dutch MoD, an experiment had taken place to integrate qualitative analysis by humans and deep learning. In this experiment, qualitative analysis executed by humans focused more on establishing causal

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relationships. The deep learning focused more on establishing correlations.

In order to integrate qualitative analysis and deep learning a gap had to be bridged. The Causal Loop Diagram (CLD) served as a bridge between the two. To make this work, so-called plug-ins were introduced in the CLD. These plug-ins represented either deeper layers and/or calculations. It prevented the CLD from become unreadable complex. With the plug-ins, the CLD became de facto a three-dimensional diagram. Early Warning and Early Response analysis were also integrated within the CLD by a plug-in.

This calibrated version of the CLD facilitated the cross-fertilization between qualitative analysis and deep learning. Now, human analysis can form the starting point for the selection of data and indicators to be used for deep learning. Thus the number of variables used in the deep learning effort could be reduced. Also, deep learning uncovered causal relationships that went unnoticed until then. It led to regrouping of drivers within the CLD.

By integrating deep learning, the future-ops section had the possibility to calculate backwards. For example, it could be calculated which measures and interventions at what point in time would be most effective. By that, it was possible to reach a maximum effect in pushing back a threat while keeping the impact for society as low as possible.

In short, by calibrating the CLD, LIMC was able to merge early warning, early response, system analysis, and deep learning into a single, but layered, system analysis. It was an attempt at Augmented Intelligence – in which the cognitive process is improved and enhanced by the combination of human-machine design and

assessment. Its program had never been carried out fully, as its activities were halted in November 2020.

Keywords: intelligence analysis, early warning, early response, system analysis, deep learning.

Information Maneuver and methodological innovations

This article is on a project by the Dutch MoD in which an effort was made to merge early warning, early response, system analysis, big data, and deep learning into one big layered methodology. It was a project of the now defunct experimental Land Information Maneuver Centre (LIMC).

First, a short introduction on information maneuver and the LIMC will be given. Information Maneuver refers to the use of offensive information-activities, defensive information-activities, and information exploitation activities. The data and information obtained is meant to enhance the situational awareness (SA), and eventually to result in situational understanding (SU) needed for decision making. In this concept, information maneuver is one of the pillars of addressing modern day conflicts (Van Dalen/Dekkers, 2019).

In March 2020, LIMC had been activated. Its mission was to create foresight and action perspective during the Covid-19 crises for both military and governmental decisionmakers, the then National Operational Team Corona (Landelijk Operationeel Team Corona, LOTC). The LOTC was the intermediary between the national and local governments (Mijlpalen, 2020).

During its existence, from March to November 2020, the LIMC established two lines of operations – a current ops and a future ops. The current ops focused on near-current insight related to Covid (e.g. wise distribution of scarce medical resources). The future ops were focused on predicting the course and spread of the virus and its impact on society and relied solely on statistical and anonymized data.

An article in the NRC – published in 15 November 2020 – led to (political) questions on the legal bases of LIMC's activities. This led to a halt of the activities of the LIMC on November 27, 2020 (Onderzoekscommissie LIMC, 43). LIMC and the military chain of command were under the assumption that the legal bases was sufficient, however there were misinterpretations of the legal basis with regards to the strict interpretation of national privacy laws within the Ministry of Defense. After 3 years, 4 investigations and an independent official investigation, it was also concluded that the current policy and judicial frameworks hamper the possibilities of collecting, storing and processing data for decision making short of formal deployment. Besides, the Brouwer Committee praised the LIMC personnel that they, after a quick start, had collected useful information on the precise healthcare situation for civil authorities, in the midst of a hectic time in which this overview was widely lacking (6.2). It concluded that the personnel had been generally alert concerning the processing of personal data, based on the available knowledge of the privacy laws (6.2, 164) – and that in all interviews held with LIMC personnel there had been a clear basic attitude that no data should be processed of civilians on Dutch territory (RQ 5.4.6; Onderzoekscommissie, 2022).

Because of the sudden cancellation, no substantive lessons or insights have been drawn for future work, hence this article. Complex systemic and data-rich environments will inevitably and increasingly be part of future conflicts. It was, among others, advised to start both policy and legal reforms to make this possible in the future (Onderzoekscommissie, 2022). As one of the outcomes of the investigation, the legal constraints will be repaired when the new "Defence Readiness Act" is in place.

Future ops

Activities of the future ops only partly touched on the public domain. It had two main activities. Firstly, it focused on methodological innovations – like the integration of early warning, early response, system analysis, big data, and deep learning. The future ops not only aimed to improve the research methodology, but also to merge analytic techniques and make them interact as much as possible (LIMC introductie, 2020). The overall approach was to merge qualitative and quantitative methods. It also aimed to develop hypotheses, not just from theory or qualitative analyses, but from data as well (tbv communicatie, 2020). It was mainly a theoretical exercise. The ultimate goal of the future ops was to aim for Augmented Intelligence (tbv communicatie, 2020). For more on Augmented Intelligence, see De Valk, 2022.

Secondly, as part of this aim for augmented intelligence, the future ops also experimented with deep learning. It did an early warning experiment with deep learning – by using anonymized data (Onderzoekscommissie LIMC, 25, 29) as wind, temperature, rain, air, on mobility, and

wastewater treatment (presence of covid). For this experiment the research design was changed from a process directed analysis into a data driven analysis and intervention (Mijlpalen, 2020). This deep learning experiment resulted in an actual early warning for the second wave of Covid-19 – based on deep learning. It turned out to be an earlier and more precise forecasting of the second wave of Covid-19 than by any of the other organizations in the Netherlands – including the RIVM (RIVM = Rijksinstituut voor Volksgezondheid en Milieu; in English: National Institute for Public Health and the Environment), see 'Quantitative warning'.

The focus of this article will be on the theoretical experiment of the future ops – merging early warning, early response, system analysis, big data, and deep learning. It is on merging qualitative and quantitative approaches. This part of the future ops was internally nicknamed Operation CANTHI, for two reasons. Firstly, the inner and outer canthi – where the upper and lower eyelids meet – refer to anything that can meet the eye. Secondly, it is the abbreviation of Cannot-Afford-Not-To-Have-It.

The four-tiers of the future ops

To understand the complex, and ever more data-intensive environment, the MoD will become more dependent on the construction of robust empiric modelling. These are representations of real complex systems. On the long run, it can result in automated model detection systems (LIMC, Data-Driven Model Discovery, 2020). It implies a strive for methodological innovations – and the integration of qualitative and quantitative approaches. The future ops developed a

four-tier program to realize this ambition. But only part of this program was carried out, due to the abrupt ending of LIMC (Vier Tiers Groep, 2020).

Tier 1 was on issues like disclosing data, making dashboards and reflecting on data lacking. This tier had been completed.

In Tier 2, The goals here were to develop insight and foresight into the Covid-19 crisis and to provide concrete avenues for action (see: 'Plug-in: Perspectives for Action'). After these steps, an assessment should have been made on the gap between this approach so far and Augmented Intelligence. The end-result should have been a step-by-step plan on how to reach a full-fledged Augmented Intelligence process. These last two steps – an assessment of this gap and closing this gap – have not been carried out. This tier did produce a successful attempt at integrating national critical infrastructure into the system analyses. The result of this integration will be discussed further in this paper when dealing with the financial-economic sub-loop, for example (see: 'Plug-in: Cluster Function').

In Tier 3, the goal was to achieve a fully integrated model of analysis using input from humans and deep learning. The aim was to reach an optimalization by gauging quantitative analysis and parameters for qualitative indicators. This could then be used as an accelerator for the development of a high-quality deep learning model.

This model should be achieved by going through the following phases. The first phase is aimed at the development of so-called B-theories. The level-B theory is a problem oriented special theory, and its explanation

of a phenomenon is limited to a certain narrowly in scope defined category of cases, based on data (De Valk/Goldbach, 2020). By a selection of specific countries, these data should be rebuilt into B-theories. This step has been carried out partly for the countries of Taiwan, South-Korea and Germany (see: 'Plug-in: Requisite Variety').

During the second phase this should be transformed into a statistical model. The third phase converts this into a neural model. The final phase should lead to Augmented Intelligence. Only the first phase of Tier 3 had been realized partly.

The ultimate goal of Tier 3 was to go beyond just current intelligence, situational awareness, and situational understanding. The goal was to come to a full-fledged methodology for Information Maneuver through Augmented Intelligence. In Augmented Intelligence, both correlations from artificial intelligence and causal relationships from analysis by humans should fully interact, and are fully integrated. Normally, a model is built from theory, in Augmented Intelligence it is built from data – and then a finetuning should take place between data and model. The aim of such a model is to be able to formulate more precise perspectives for action per driver or variable, including its mutual coherence. Critical Indicators are then established to assess the threat (based on NATO's NIWS-method), and variables will be developed not to miss a threat ('to refute that there is no threat'). In the first approach, the emphasis is on identifying critical indicators of that specific threat. As a consequence, the main emphasis is on reducing the Type-1 errors of the indicators. In the second approach, the emphasis is on refuting the 'no-threat' assumptions

– based on the composing variables of such a threat. As a consequence of that second approach, the main emphasis is on reducing the Type-2 errors concerning those assumptions (for more on these two types of warning, see: De Valk, 2023). The aim of this double approach is to enhance both the analytic accuracy and the analytic confidence.

In Tier 4 – which was not carried out – the idea was to develop generic models for, for example, CBRN related circumstances, and transform it into a more general model for core task 3 of the MoD (providing assistance during disasters and crises). Regarding core tasks 1 and 2 of the MoD (respectively: defending national territory and that of our allies, and; enforcing the national and international rule of law) further research is needed to build similar generic models. The aim for Augmented Intelligence was also meant to enhance the systematic and human resilience, in order to cope with future hybrid threats (Inleiding, 2020). Concerning Augmented Intelligence, it should be looked at also for dealing with issues like hidden and dirty data (Marx, 1984). Tier 4 necessitates a multi-year planning (Vier Tiers Groep, 2020), and is meant to ultimately develop automated model detection systems (LIMC, Data-Driven Model Discovery, 2020).

Innovations and the Causal Loop Diagram

In the first two tiers of this four-tier project, there was a focus on innovating and calibrating the Causal Loop Diagram (CLD). A CLD is a technique for doing a system analysis, and a method for visualizing the system studied. The visualization helps to understand causes and effects. In this case it is meant to capture the

dynamics and complex environment of society. It tries to understand the dynamic nature of these interacting elements by viewing phenomena in the environment as a whole – a holistic view (Flood, 1999; Holland, 1995; Meadows, 2009). Due to these dynamic interactions, systems exhibit properties that cannot be explained by their individual parts, because the individual parts together exhibit properties that they do not possess when studied in isolation of each other (Vennix, 1996). This approach is opposite to the more traditional reductionist way of explaining phenomena. Reductionism assumes that phenomena can be explained by reducing them to their individual parts. Systems thinking, however, provides a helicopter view over these interlocking structures. It helps organizations to change from a reactive attitude in which events happen, to organizations that have a proactive attitude anticipating on what might happen (Van Rijn, 2016).

The CLD will be used to explain how the different elements – as early warning, early response, and deep learning – can be merged into one bigger methodology. These innovations were made by a multidisciplinary team in which a virologist, behavioral scientists, modelers, methodologists, and data science specialists worked together (Inleiding, 2020). New functions were developed for designing a CLD – which made an integration of Early Warning/Early Response and deep learning possible.

Firstly, Early Warning/Early Response were integrated as part of a CLD. This innovation was not meant for the Covid-19 crisis alone, but was also meant to be able to deal with future hybrid conflicts. By integrating early warning and early response in a CLD, time can be gained

and more efficient and effective responses become possible (Inleiding, 2020). For an example, see 'Plug-in: Early Warning', and 'Plug-in: Early Response'.

Secondly the ability to integrate the correlations of big data and deep learning requires new CLD-functions. The complexity of some nodes – the basic building blocks of the CLD – was so great, and sometimes big data driven, that it wouldn't have worked visually to write it out fully in the main CLD. For this issue so-called plug-ins were developed. These plug-ins serve the next functions:

1. As a node in the CLD can be based on complex and layered underlying methodology, this would complicate the CLD too much. Therefore, it would be more convenient to indicate this in the CLD with a single symbol – a plug-in. Behind a plug-in, there can be deeper layers and calculations, by which the CLD is in fact a three-dimensional diagram.

2. Quantitative cluster-functions in general can be represented by such a plug-in. It serves to bridge the gap between cause-and effect relationships and correlations (e.g. 'Plug-in: Cluster Function'). It lets big data and deep learning interact with a CLD. It lets the causal relationships of the CLD merge and interact with the correlations of deep learning. It facilitates to combine qualitative analysis by humans with quantitative deep learning by machines. Elements of these interactions will be explained later when dealing with the plug-ins.

3. It is a visual aid for users who don't have a data science background. Thus, it eases and enhances the interactions between the traditional qualitative analysts and the data science specialist (LIMC, Data-Driven Model Discovery, 2020).

4. A plug-in can indicate the room to maneuver or the area to influence. It visualizes the effects of the own perspectives of acting – which is characteristic for Information Maneuver (e.g. 'Plug-in: Perspectives for Acting').

This way, the CLD will be calibrated to the needs and characteristics of Information Maneuver. It will enhance the granularity, or depth of field, of an analysis. It will also identify the tipping points where an issue goes through a paradigm shift from one system of causes and effects to another. This last issue will be elaborated in the part on 'Plug-in: requisite variety'.

Types of plug-ins

In order to calibrate the CLD to the requirements of executing Information Maneuver, a new function has been introduced – the plug-in. Each type of plug-in has its own symbol. A plug-in may give insight into the possibilities to influence the system, or the possibility to insert a cluster function. A cluster function means that under this plug-in there is a complex relationship of interdependent elements that are inserted as a whole in the CLD.

Different forms of Early Warning are possible. Basically, there are two main approaches, a qualitative approach – based on indicators or assumptions – and a quantitative approach. Which approach is preferred depends on the issue at hand. A qualitative approach is often used for intelligence and security issues on a threat by humans. The quantitative approach is often used for safety and security issues on risks by natural disasters or machine failure.

Table 1: Types of plug-ins (LIMC – IM, 2020)

Plug-in	Description	Symbol	Own influencing	Cluster function
Early Warning	It indicates at an early stage of escalation or hostile action which (positive) effects early warning will have to mitigate.		+	-/+
Early Response	It indicates at an early stage of escalation or hostile action which (positive) effects early response will mitigate.		+	-/+
Behavioral Dynamics Model (BDM)	It indicates the effects of behavioral influencing. Underneath this plug-in there is a layered model of the BDM composed of concept, factor, subfactor, behavior, and group.		+	+
Conditions	Conditions to be met before a factor can be materialized, e.g. a change in law before a certain act can be carried out.		+	-
Perspectives for Acting	It indicates the effects of measures (not being BDM).		+	-
Cluster Function	It represents a complex of aspects of which a certain factor is composed of, e.g. healthcare.		-	+
Requisite Variety	Indicator for a change in the system, by which the CLD will follow a different structure.		-	-

Plug-in: Early Warning

Plug-in	Description	Symbol	Own influencing	Cluster function
Early Warning	It indicates at an early stage of escalation or hostile action which (positive) effects early warning will have to mitigate.		+	-/+

Qualitative warning – threats. If a threat is posed by another country or grouping, the qualitative Early Warning is often preceded by an analysis of the opponent's intentions, capabilities and activities. Depending on where things are heading, a qualitative Early Warning can be developed for the near or mid-term. Often, a system analysis (CLD) and Early Warning are two separate analytical processes. For Information Maneuver, it is necessary to integrate the Early Warning into the system analysis (CLD) in order to assess its effects. From a methodological point of view, there are four types of qualitative Early Warning (De Valk, 2023):

1. To assess there is a threat. A common method is to develop Warning Scenarios and to monitor these with Critical Indicators (as NATO's NIWS).

2. To asses there is no threat. It can be ruled out that there is a threat, e.g. to protect the King.

3. To refute there is a threat. In practice this is carried out at, for example, airports with Predictive Profiling and Security Questioning.

4. To refute there is no threat. The variables of the threat are determined, and for each variable assumptions are formulated in such a way as if there is no threat. Subsequently it is tried to refute these assumptions.

All four types could be integrated into a CLD with the help of the plug-in. But the more pragmatic and tactical (in civilian terms: operational) these types of warning are (type 2 and 3), the less likely it is that there will also be a system analysis like a CLD in place.

Quantitative warning – risks. If the risk is caused by a natural disaster or machine failure, like the second wave of Covid-19, it is likely quantitative Early Warning is preferred. The designated institute in the Netherlands to make a second wave assessment is the earlier mentioned RIVM. For its national assessment the RIVM used a quantitative approach of statistical analysis based on the intake of new patients. The LIMC experimented with a different quantitative approach – deep learning. It took a while before this process was established as the future-ops did not want to be dependent on external algorithms. But on the 31st of July 2020, LIMC gave a warning with an 88% likelihood, this warning was released on August 4th as 'Spotrep Tweede Golf COVID-19 in Nederland' (Onderzoekscommissie LIMC, 17-18, 125). This was substantially earlier than the RIVM could warn, because of the difference in methods used (Berekenen R_o).

This difference in approach also led to other assessments with a higher accuracy than the RIVM could produce – including local assessments, in contrast the RIVM could only make assessments on a national level. LIMC could assess the Intensive Care capability needed a week ahead (Mijlpalen, 2020) per wastewater treatment with an accuracy of about 3-4 beds. LIMC could also predict the number of new patients admitted to hospital on a daily basis. It could do so by applying deep learning to the local reproduction number R_o. Compared to the RIVM, LIMC was able to (Berekenen R_o):

- assess more precisely and earlier if implemented measures were effective;
- identify and visualize local hotspots;

- develop perspective for acting that were aimed at regions, and not just the national level.

These precise assessments by LIMC turned out to be an invaluable help for the logistics of the hospitals. It helped to improve the IC-planning during the Covid-19 crisis – and it saved lives. All the data used for this deep learning early warning were anonymized data.

Before the 2020 summer warning, the future ops had already concluded in April 2020 that the initial RIVM data were not correct. It was the first in the Netherlands to analyze the difference between the number of registered Covid-19 deaths and the mortality surplus. The future ops concluded that there were so-called 'silent deaths', and reported this early during the outbreak when this was not an issue yet (Onderzoekscommissie LIMC, 135. De Stille Zorgdoden, April 2020).

Deep learning and LIMC. To be able to make an Early Warning for the second wave of Covid-19, LIMC first had started to make a geographical overlay to assess the near real time capacity/overload of an IC. This effort already helped to coordinate the movement of IC-patients from one area to another. With permission of the civilian authorities, LIMC used data of the foundation Nationale Intensive Care Evaluatie (NICE) and the website zorgcapaciteit.nl. It was followed up in July 2020 by a project to predict, with deep learning, the second wave of Covid-19. For this, the future ops used data as wind, temperature, rain, air, anonymized data on mobility, and wastewater treatment (presence of covid) (Onderzoekscommissie, 124-125. Mijlpalen, 2020). In this experiment, the research design changed from a

process directed analysis into a data driven analysis and intervention (Mijlpalen, 2020).

In Figure 1, an overview of the deep learning research process is presented. It was designed for and applied to develop a predictive early warning model. It is composed of two parts– one for training and one for prediction. The training-part is meant to learn and to develop. The predicting-part is the environment of the production (Experimenten, 2020).

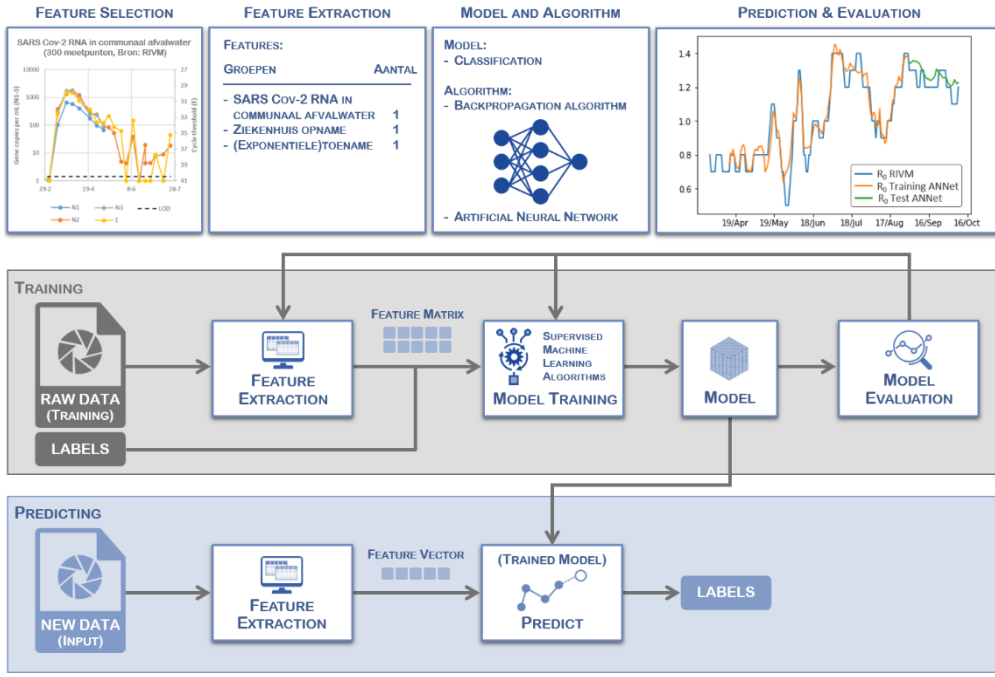

Figure 1. Deep learning research process

During the deep learning research process, the focus was on establishing the R_o. The reproduction number R_o is roughly the number of new cases of the disease, caused by one single infected individual. The R_o was established with the help of the SIR epidemic model (Van den Driessche, 2017).

Deep learning can also be part of a broader project to develop Augmented Intelligence, by which analysis by humans is merged with analysis by machines. Computers can process huge amounts of data and find correlations which is beyond the capacity of human analysts. Human analysis, however, can give meaning to data and correlations generated by a computer. Neural networks not only offer the capability to extrapolate into the future, but also to calculate back into the past. This quality of neural networks makes it possible to calculate back into the past from a preferred end-state to determine which measures and interventions at what point in time are most effective and needed. This optimalisation can reduce the (social-economic) impact of an issue – while at the same time the desired end-state of a crisis will be reached (Toelichting, 2020).

Early Warning and CLD – an example. A plug-in with an assigned symbol was built to represent Early Warning within the CLD. The reasons were:

- It makes it possible to integrate Early Warning in a CLD – instead of being a separate analytical processes;
- By using a single symbol for the early warning, it keeps the CLD readable;
- By having a symbol in place, it facilitates the selection of the type of Early Warning that is most applicable for the issue at hand – being either a qualitative or quantitative one;
- It opens up the possibility for introducing big data, correlations and deep learning, and to integrate these in a cause and effect system analysis (CLD).

Behind a single Early Warning symbol, there can be a complex configuration of techniques and calculations, but the influence on the CLD is represented as a single node.

By predicting the second wave of Covid-19, it was shown that it is possible to merge big data and correlations in a cause-and-effect system analysis like the CLD. In short, the future-ops had managed to calibrate the CLD in such a way that it meets the requirements for Information Maneuver. In the next segments of the CLD, just the Early Warning and Early Response are represented (Briefing vs05, 2020). In Figure 2, it is shown how Early Warning and Early Warning are integrated in the CLD. For a more complete CLD, see the next heading.

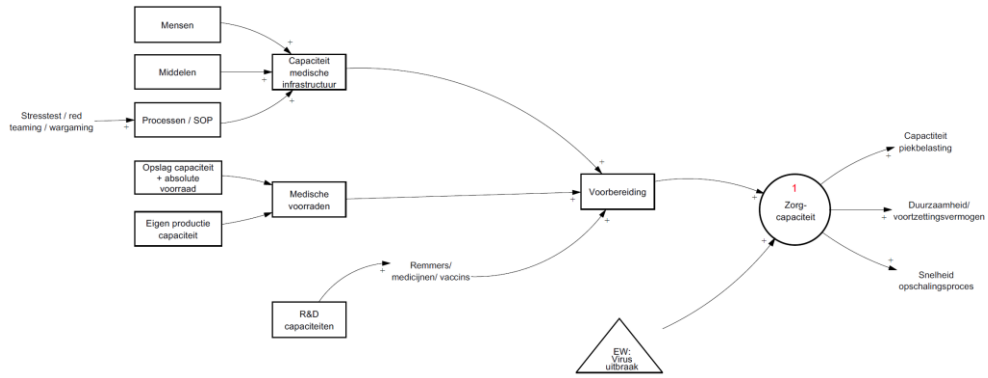

Figure 2. Early Warning and Early Response

Plug-in: Early Response

Plug-in	Description	Symbol	Own influencing	Cluster function
Early Response	It indicates at an early stage of escalation or hostile action which (positive) effects early response will mitigate.		+	-/+

Early Warning facilitates the Early Response. They are a natural combination to mitigate threats. In the case of Covid-19, with an Early Response in place, preparatory measures could be taken to cope with the virus.

Like Early Warning, Early Response can manifest itself in many ways. If simple, and composed of a few factors, these factors can be written out in the CLD. If it is more complex, a plug-in will be the best solution – for the same reasons as mentioned in the previous section on Early Warning.

As an example, in Figure 3 a simple Early Response is written out in the CLD, without using the plug-in function. It is meant to show how the Early Response can be integrated within the CLD. Its composing nodes are presented. These nodes are represented in orange, although the elements in purple on the top-left also have elements of being conditional to be preparatory (see: plug-in Perspectives for Acting). The CLD that is presented is limited to both the Netherlands and the direct cause-and-effects relationships to mitigate Covid-19. All the nodes in orange can be replaced by the single plug-in of Early Response to make the CLD more readable.

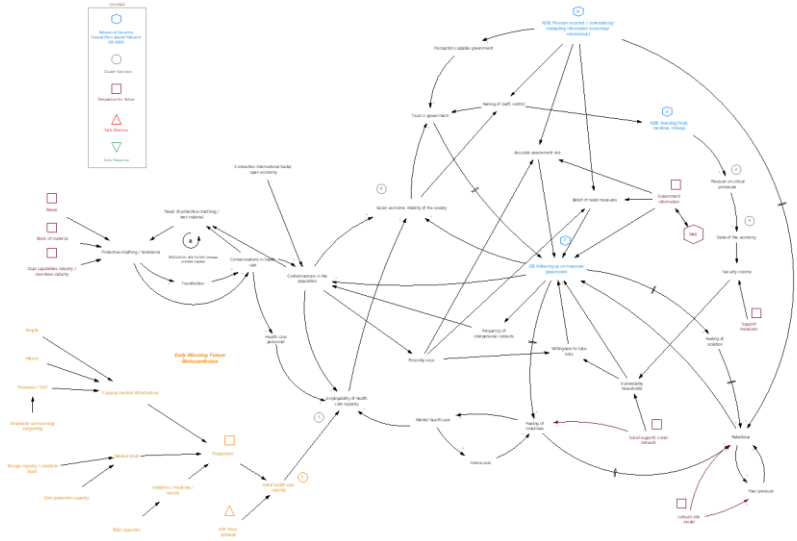

Figure 3. Early Response (nodes in orange)

Early Response: Taiwan and South-Korea. Concerning Covid-19, some countries like Taiwan and South Korea were better prepared than the Netherlands.

In the early weeks of Covid-19, Taiwan, which neighbors China, and had 600 direct flights per week to China – only had 45 confirmed cases while other neighboring countries had hundreds or thousands. The reason for this relatively low number was its Early Response (Kuo, 2020):

1. It enforced a strict border control and quarantine measures;

2. It used big data analytics and technology to establish the quarantine system;

3. It ensured mask supply and resource allocation;

4. It reassured and educated the public, while fighting misinformation.

The South Korean case is a bit a different. It started by losing control but regained it without using a lockdown. Instead, it relied the publics own responsibility, establishing quarantine facilities, improved testing, contact tracing and monitoring, and upscaling its facilities (Fisher, 2020). It was supplemented with mobile phone tracking, CCTV, and a system to track and map the movements of citizens who had tested positive. Anyone who entered South Korea was requested to upload an app onto their phone and to update it daily. The testing kit South Korea used was developed and produced domestically, which meant the country was not dependent on imported test kits (Levkowitz, 2020. See also Brouwer, 2020; Walensky 2020).

The examples above present a global overview of the Taiwanese and South Korean Early Response. In actuality the responses composed of dozens of measures, allocated in many different fields of health care, society, and technology. In order to prevent the CLD becoming too complex to read, it can be represented by one single symbol of Early Response – a plug-in.

The Netherlands was not only taken by surprise but also unprepared, contrary to, for example, Taiwan. A well thought out and well executed Early Warning/Early Response can change the whole dynamics of a crisis. This can also affect the cause-and-effect relationships – or even the structure – of a CLD. When the Covid-19 crisis started, these two countries were in a different paradigm of dealing with the crisis. In the section regarding the ‘Plug-in: Requisite Variety’, this will be worked out further.

Plug-in: Behavioral Dynamics Methodology (BDM)

Plug-in	Description	Symbol	Own influencing	Cluster function
Behavioral Dynamics Model (BDM)	It indicates the effects of behavioral influencing. Underneath this plug-in there is a layered model of the BDM composed of concept, factor, subfactor, behavior, and group.		+	+

For this part on Behavioral Dynamics Methodology (BDM), it is important to understand that at LIMC also theoretical experiments were carried out. Meaning, experiments that were not meant to be part of the concept of dealing with the Covid crisis, and that were never meant to be implemented. BDM was such an experiment, and was aimed at to investigate at a theoretical level what the added value of such a method could be (C-LIMC. Compare: Onderzoeks-commissie LIMC 41).

What is BDM? BDM doesn't focused on what people do, but under which circumstances people are willing to change their behavior. BDM is a science based approach for the implementation of effective and measurable strategies of influencing and strategic communication. The idea is that this approach will lead to effective and measurable strategies of intervention. It is applicable to all scenarios and behavioral aspects in which shaping and controlling behavior, perceptions and attitudes are crucial for getting a desired outcome. This encompasses conflicts, open diplomacy, to reduce violence, stability and social marketing. It is built on three categories of parameters – descriptive, prognostic, and transformative ones. These parameters have been subject of both empiric and theoretical research, and have been established as been critical factors in influencing and

convincing groupings. Contrary to the main military structured analytical techniques, this approach focusses on formulating problems and potential solutions from a behavioral perspective, and is analyzed from a so-called emic-perspective (Van den Berg, 2018). In such an emic approach, the reasoning is expressed in terms of the conceptual schemes and categories that are regarded as meaningful and appropriate by the members of the target group. It is the behavior described as if it is seen from the perspective of cultural insiders.

A theoretical exercise. For a time, BDM was trained within the MoD in a kind of vacuum. As a concept, it had its own beginning and end, hardly embedded within the Dutch Defense Doctrine (NDD). By integrating it within the CLD, it got a place within the tactical-operational domain. And it became possible to make BDM measurable within a CLD system analysis (LIMC – IM, 2020).

For a BDM, a Problem Space Map has to be made. It has to be worked out for its four composing elements – Factor, Subfactor, Behavior, and Group. Subsequently, elements of this Problem Space Map can then be integrated in the CLD. This is done with a symbol, representing either the Behavioral Dynamics Desired Behavior (DB), or the Behavioral Dynamics Non-Desired Behavior (NDB). This DB or NDB may end up in different places within a CLD – depending on the specific type of Desired/Non-Desired Behavior (DB/NDB) at hand. As a theoretical experiment, three essential behaviors were identified (Toelichting, 2020):

- a plug-in on the hoarding of food, medicine and money – a Non-Desired Behavior (NDB);

- a plug-in on the provision of incorrect, contradictory and misleading information, either consciously and unconsciously – a Non-Desired Behavior (NDB);

- a plug-in on following up on governmental measures – a Desired Behavior (DB).

These three NDB/DB are put in the CLD in blue as respectively number 2, 6, and 7 (see CLD 'Early Response').

BDM: Epilogue. In the media, it had been suggested that BDM may have been implemented at LIMC. The potential application of BDM at LIMC led to questions in the Dutch Lower House, among others for its association with Cambridge Analytica. In August 2020, the minister of defense answered to the Lower House that BDM has not been purchased through Cambridge Analytica, but through SCL-Defence. And that this already had taken place in 2017, before the public outcry on Cambridge Analytica in 2018 because of its data-mining, data-analysis and micro-targeting at elections. The minister stressed the need of BDM, and put that with this methodology the MoD will be more effective (MoD, 2020). BDM had gained the interest of the MoD was caused by, among others, a pilot in Mali against Improvised Explosive Devices (IED). After a targeted communication with the local population – this population started to report more on IED-locations (MoD, 2020).

For the MoD, information operations /warfare are an integral part of modern conflicts. For people to stop fighting or supporting terrorist, one way is first to understand why they are doing so, rather than solely use

force, as a way to reduce bloodshed. BDM is a conceptual means to address the inextricable tangle of why people come to their beliefs and consequent (in)actions. However, there is no training ground but war, and only war provides the legal and ethical consent for doing so. This implies that the MoD – according to the Dutch legal order – is not allowed to use BDM at will in peacetime. The methodology of BDM however might have had clues to predict the spread of COVID-19 in the Netherlands. Or, as the MoD has formulated it, the ethics of BDM is not in the methodology, but by those who use it (MoD, 2020). This means that the proportionality and subsidiarity will always be leading in the considerations to use such an instrument – as will be International Humanitarian Law (IHL).

Concerning suggestions that BDM may have been implemented at LIMC, the following can be noticed:

- Influencing in any shape or form had not been intended, ordered, needed or practiced.
- BDM had never been implemented as a method, it had never been tasked by anyone, and it was also not a task for LIMC.
- It was a theoretical experiment to assess if elements of this model would generate foresight during crisis.
- During internal discussions, the commander of LIMC was skeptical if BDM would work at all during the stress of a crisis – and he found the BDM quite academic (letter Commander LIMC to the author).

Plug-in: Conditions

Plug-in	Description	Symbol	Own influencing	Cluster function
Conditions	Conditions to be met before a factor can be materialized, e.g. a change in law before a certain act can be carried out.		+	-

Sometimes a condition has to be met, in order a node could "work". A conditional element that precedes the next mode, before that next node could work or be activated. In the experiment itself, it has not been used in the CLD.

Plug-in: Perspectives for Action

Plug-in	Description	Symbol	Own influencing	Cluster function
Perspectives for Acting	It indicates the effects of measures (not being BDM).		+	-

In the Netherlands, the agencies take a position of supplying the commander with 'perspectives for action' (in Dutch: 'handelingsperspectief'). This is a position in between the so-called traditionalist and activist approaches. The traditionalists advocate to respond to specific requests for data and analysis rather than initiating direct interaction with consumers. The activists advocate a closer working relationship between producers and consumers through the development of a two-way flow of information and feedback (SII, 1980; Hulnick, 1986). The Dutch agencies take an in between position, by trying to show the elbow room of the consumer – the perspectives for action – without giving

policy advices. Of course, a more general meaning can be attributed to this symbol, as showing the options of intervention and to influence.

Its manifestation in a CLD can take different forms – e.g. multiple Perspective for Action influence one node, one Perspective for Action influences multiple nodes, or one Perspective for Action influences one node. Of each, an example will be given with the help of the CLD in Figure 4.

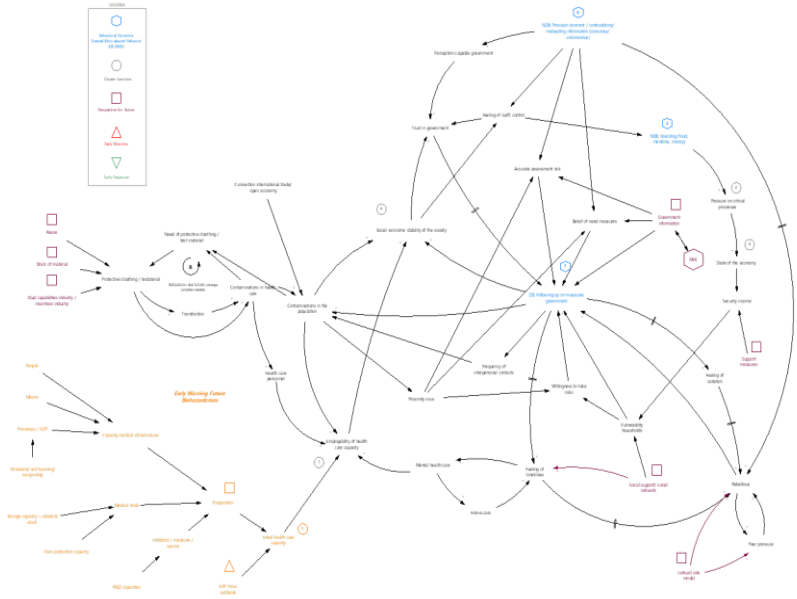

Figure 4. Perspectives for action (nodes in purple)

Multiple Perspectives for Action can influence one node. In the center-left of the CLD, this is the case for the node ‘protective clothing’. To improve the position of protective clothing, the government can promote to reuse clothing, to enlarge the stock, and to facilitate a dual capabilities industry.

A case in which one Perspective for Action influences multiple nodes is given at the bottom-right. The nodes 'rebellious' and 'peer pressure' may be influenced by a '(virtual) role model' advocating the governmental position. Finally, one Perspective for Action influences one node. In the center-rights there is the node 'income uncertainty' that can be influenced by 'support measures'. In actual practice, this showed to have been effective.

Until now, only the direct link has been described from the cause 'Perspective for Action' to its direct effect on a next node. But a causal loop diagram tries to capture the complex dynamic nature of these interacting elements by viewing phenomena in the environment as a whole (Flood, 1999; Holland, 1995; Meadows, 2009). It means the Perspectives for Action must be seen in this larger context, in which the Perspectives for Action will exhibit properties that will be further reaching than just the directly neighboring node (Vaandrager et al., 2023).

The advantages of this representation by a plug-in are twofold. Firstly, it visualizes clearly to the consumer what the effects are of the own acting, and how that will influence the whole issue or system. Secondly, calculations can be put into it the own acting, and the effect can be calculated for the system as a whole.

Plug-in: Cluster Function

Plug-in	**Description**	**Symbol**	**Own influencing**	**Cluster function**
Cluster Function	It represents a complex of aspects of which a certain factor is composed of, e.g. healthcare.		-	+

The Cluster Function plug-in represents a complex of aspects and factors of which a certain node is composed of. Two examples will be worked out. Firstly, on healthcare, and secondly on financial-economic issues.

Healthcare. The healthcare node stands for a complex of factors of a different nature. If all those factors would have been represented in the CLD separately, the CLD would become unreadable. Therefore, a cluster function has been developed, under which a variety of factors are assembled under the umbrella of one overarching node.

In the case of the Dutch Covid-19 crisis in 2020, the healthcare node got its place in the center of the CLD as the 'employability of the healthcare capacity'. In turn, this employability was influenced by feedback loops within the CLD. The feedback loops that influenced this employability were (Toelichting, 2020):

- Pressure on the healthcare system by al lack of protective clothing;
- Pressure on the healthcare system by an underestimation of Covid-19;
- Pressure on the healthcare system by – in the long term – fear for social-economic instability;
- Pressure on the healthcare system by – in the long term – the state of mental healthcare;
- Relieving the pressure on the healthcare system by following up on governmental measures.

Especially the capacity of the Intensive Care (IC) was a bottleneck in the Netherlands. Patients even had to be replaced to Germany, where they had more IC-beds per

capita. At the start, the Dutch had 1150 IC-beds and could finally upscale it to 1600 during the peak of the crisis. As this lack of IC-capacity had been a serious problem, you would expect a raise in the number of IC-capacity after the crisis to be prepared for an eventual next crisis. In February 2025, five years after Covid-19 outbreak had started in the Netherlands, the capacity of IC-beds have sunk to 850 instead. This due to both governmental cutbacks, and a new way of paying for the health care costs by the health insurers (NOS, 2025). You can use the LIMC methodology to predict the number of the IC-capacity needed. It can also be calculated what the knock-over effects are of the reduced IC-capacity of February 2025.

Financial-economic. Financial-economic issues can have an impact on a pandemia. But a pandemia can also be the tipping point for a financial-economic crisis. In any system analysis on a pandemia like Covid-19, financial-economic issues will have to be part of the analysis. In the case of LIMC, it had been worked out in a separate loop (Figure 5), which had been developed by an expert that helped LIMC on his own account (TOC,2020):

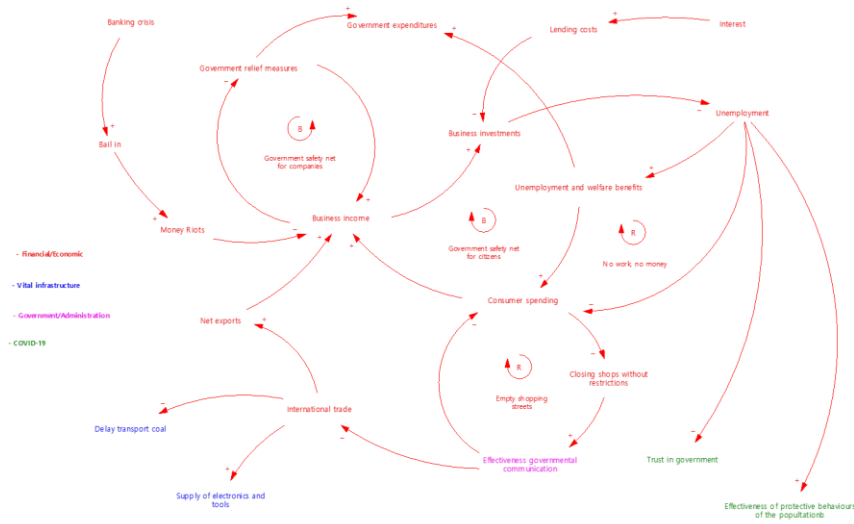

Figure 5. Financial-economic sub-loop (in red)

In the financial-economic sub-loop of Figure 5, it is shown how it connects with other sub-loops and factors, as the critical infra-structure, governance & policy, and the healthcare/Covid-19. If you zoom in on the loop, international aspects are included – as a banking crisis that is included in the top-left of the loop.

But the scenarios of the aforementioned LOTC were limited to the Dutch economy only. And thus a possible international banking crisis had not been included. The reason was that the (axes of the) LOTC scenarios had not been based on an underlying thorough methodology. It rather was composed by seniority, meaning that those who decided which scenarios were chosen did so by their rank and not by their methodological expertise. LIMC, with its schooled analysts, helped to improve these scenarios. LIMC solved it by developing an LOTC+ scenario – leading to two sets of indicators to be monitored.

One on just the Dutch economy, and an extra set of financial-economic aspects, based on a thorough methodology and system analysis – including a possible international banking crisis that would be damaging for the Dutch financial-economic situation. In the Dutch case the domestic financial-economic situation was solid, with large buffers to deal with the crisis (= trend, not a scenario). The risk on a financial-economic crisis was therefore to be expected from the outside (= scenario, not a trend), e.g. an international banking crisis. This is the node 'banking crisis' in the top-left of the sub-loop. The aim was to provide Early Warning for Perspectives of Action in case of serious instability concerning the financial and gold sector (Scenario, 2020).

It resulted in two main shifts in the type of financial-economic indicators to be monitored. Firstly, it was now also on international related indicators. And secondly, the functioning of the banking system got a central role in the set of indicators. In the next overview, the most important indicators are presented (Aanvullende, 2020):

Trust between banks	*Trust in the economy*
• LIBOR OIS Spread (max. 24 hours loan system between banks) • TED Spread • $ Velocity • EURIBOR • Intensification of SWAP lines (15 countries with the $)	• Capital flight (gold rate, silver rate) • US consumer confidence (St Louis FED) • TARGET2 balance • Dutch national debt (above 90%) • Dutch inflation (CPI) ('runaway inflation') • Dutch CBS: unemployment, consumer confidence • Dutch savings versus expenses • To shut down the stock exchange US/NL (3x in a week)

What is important to realize in this context is the experimental character of LIMC, is the impact of the crisis – and thus the quest for high quality analytical

indicators for actionable intelligence. And if possible, not just for a couple of days ahead, but weeks or month.

Of all the indicators mentioned, the LIBOR OIS Spread – the maximum 24 hours loan system between banks – is by far the most critical and telling indicator. Luckily, it did not reach alarming values. But if it would have, LIMC could have warned its superiors. In the case of a money issuance stop at the ATM's, a restart was to be expected to last about seven days. That is longer than citizens can stay without food. Such a banking crisis may lead to riots and looting and in case of such an unrest, an appeal could be made on the MoD to help to protect properties, as banks, jewelers and food warehouses.

It also points at another issue, not limited to the Covid-19 crisis. It is worth for the intelligence community to have real time live feeds of indicators that are telling and critical for a major crisis. And the LIBOR OIS Spread would be one of those indicators. Especially, because its values, and their tipping points, are known, precise, and telling. Monitoring such indicators with real time life feeds would be a small, but significant, step in moving from a process directed analyses into data driven analyses and interventions.

Plug-in: Requisite Variety

Plug-in	Description	Symbol	Own influencing	Cluster function
Requisite Variety	Indicator for a change in the system, by which the CLD will follow a different structure.		-	-

In the 1950s, the British cybernetician W. Ross Ashby became interested in the way in which complex systems

operating in changing environments succeed in maintaining critical variables within tightly-defined limits. Ashby came up with the concept of variety as a measurement of the number of possible states of a system. For a system to be stable, the number of states that its control mechanism is capable of attaining its variety must be greater than or equal to the number of states in the system being controlled. It is used, for example, as the basis of a viable system in organizational design. If a system is to be able to deal successfully with the diversity of challenges that its environment produces, then it needs to have a repertoire of responses which is (at least) as nuanced as the problems thrown up by the environment. So a viable system is one that can handle the variability of its environment (Naughton, 2017).

The healthcare system – in its environment – can be seen as such a system. An important selective mechanism for the survival of systems is the measure of which these are able to deal with the flow of environmental variability. The clue to survival is to develop mechanisms that are able to deal with environmental disturbances that could cause a shift beyond the tolerable limits of the essential variables leading to the systems demise (Vaandrager, 2023).

In active (feedforward and/or feedback) regulation, each disturbance –like the Covid-19 crisis – will have to be compensated by an appropriate counteraction. This means that if you wish to completely block the effect of the Covid-19 crisis, the healthcare system must be able to produce at least as many counteractions as there are disturbances. Therefore, the variety of healthcare system must be at least as great as the variety of the Covid-19

crisis. This principle has important implications for practical situations: since the variety of perturbations a system can potentially be confronted with is unlimited, we should always try maximize its internal variety (or diversity), so as to be optimally prepared for any foreseeable or unforeseeable contingency (Heylighen, 2001). We can build a case-theory (as on the outbreak of Covid-19) because it specifies the boundary conditions of a stressed control system – in our case the healthcare system (Flueckiger, 1995).

Perturbations with high variety, like the Covid-19 crisis, affect the healthcare system's internal state, which should be kept as close as possible to the goal state (in the Dutch practice, this is determined by the government and health insurers), and therefore exhibit a low variety. The boundary conditions of the healthcare system will be dependent on a lot of factors. These factors can be visualized in a CLD. It is obvious that the healthcare system – as a system – can absorb more perturbations (e.g. a more severe pandemia) with an Early Warning and Early Response in place, than without one. This to such an extent that it even will change the change the structure of the CLD. To visualize this, a couple of examples are presented.

Requisite Variety explained by differences of the structures of CLD's. One of the aims of the future ops was to build models to be prepared for future crises. The goal was to reach a maximum effect in pushing back an outbreak while keeping the social-economic impact as low as possible (Toelichting, 2020). In the beginning of the Covid-19 crisis, two factors – two core uncertainties – showed to be decisive in dealing with the outbreak:

- Factor/driver 1: the extent to which the healthcare system had been surprised;
- Factor/driver 2: the extent to which society had been prepared to deal with an outbreak.

The first driver can be linked to an well-functioning Early Warning system, the second driver can be linked to a well-functioning Early Response system. Countries were warned and prepared for the outbreak to a different extent. This had consequences of how their system – society and healthcare – could deal with the crisis. Those differences had their effects on the structure of their CLD – the structure of the system analysis of their crisis. To illustrate this, examples of the CLD of three countries are presented for their state of affairs during early 2020:

1. Taiwan: 'nipping it in the bud',
2. South Korea: 'pushing back the outbreak',
3. Germany: 'controlled epidemic'.

All three will be worked out in a system analysis, a CLD, with some explanatory text (LIMC, Data-Driven Model Discovery, 2020).

Taiwan: 'nipping it in the bud'. Taiwan successfully prevented the outbreak of Covid-19 (Kuo, 2020; Wang et al, 2020):

- Strict border control from 31 December 2019 onwards; travelers of high risk areas were put in quarantine and tracked and traced by their mobile phones;
- The use of big data and technology to build a quarantine system – focusing on the integration of

contaminated cases, customs data-bases, and national healthcare data-bases;

- Stocking protective clothing and to forbid the export of it;
- To reassure and to inform the population – and to combat disinformation;
- Robustness of the system – including transparency and accountability.

In this CLD (Figure 6), contrary to the others, also attention has been paid to Early Warning, Early Response and Perspectives for Actions.

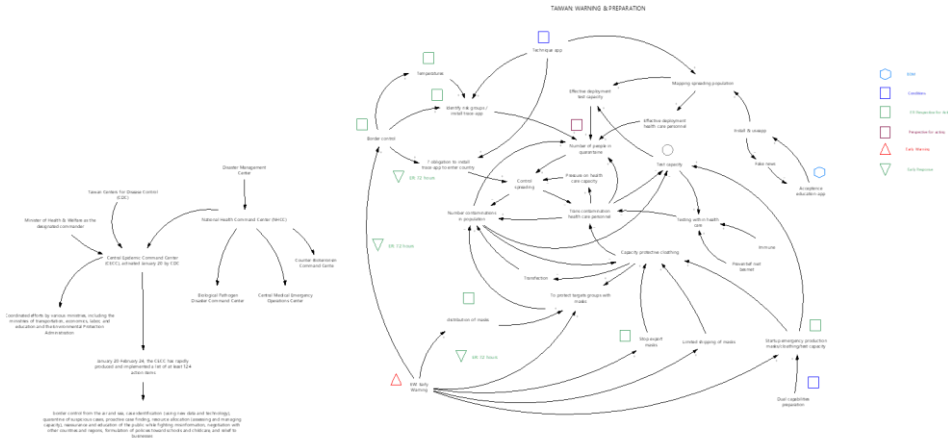

Figure 6. Taiwan

South Korea: 'pushing back the outbreak'. South Korea managed to control the outbreak with other means than a lock-down (Fisher & Sang Hun, 2020):

- To respond before there is an actual crisis – to identify sources of infection, including to incorporate the delaying effect of the incubation time;

- To test as many people as possible, including at drive-throughs, with the help of in-house developed and produced tests;

- To map the virus, supplemented with contact-tracing (already applied during MERS);

- To monitor metadata of telephones, payment transactions, to inform those people who had been in contact with a contaminated person, thermic camera's at large buildings, to ease the privacy laws in favor of safety; travelers had to install an app at the boarder;

- To emphasize the own responsibility of the population as a narrative;

- A modern healthcare guaranteeing the Covid-19 related costs, to treat mild cases in special centers so the hospitals stayed operational.

If worked out in a CLD, it would look like as follows (Figure 7):

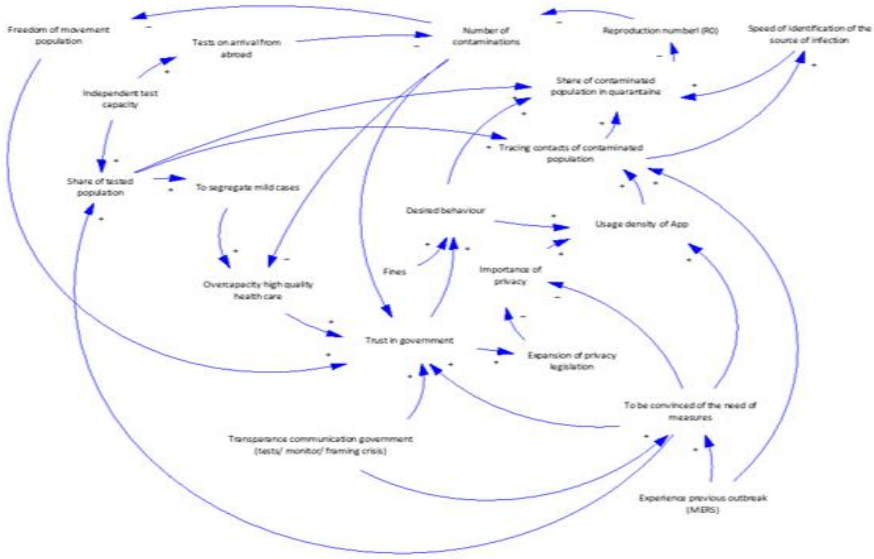

Figure 7. South Korea

Germany: 'controlled epidemic'. German had been warned by the outbreak in Italy – and had more time to be prepared and more data to assess the virus (Deutsche Bank, 2020):

• Its high-quality healthcare system is seen as a central pilar of a welfare state – enough IC-beds, qualified personnel and test capacity, high insurance rate (98,2%) of the population, and therefore it had inside knowledge on complicating factors;

- The federal structure had furthered a tailormade approach and quick response;
- Political consensus and a quick and generous deployment of fiscal means (economy);

- The population trusts the institutions and is willing to think in the long term;
- Bundeskanzler Merkel implemented a strong, technocratic, and cautious leadership.

If worked out in a CLD, it would look like as follows (Figure 8):

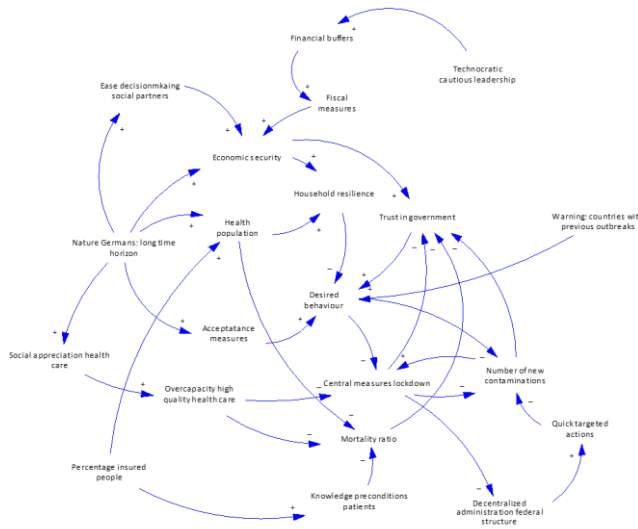

Figure 8. Germany

Compared to these three countries, the Netherlands was in early 2020 in a less advantageous position in terms of Early Warning, Early Response, and IC-capacity. At 28 January 2020, the RIVM put on twitter that Covid-19 doesn't look to be too contagious – versus the strict border control of Taiwan starting at 31 December 2019. And during the Rutte administration, the IC-capacity had been reduced from 1900 to 1200/1150. Germany had 29/30 beds per 100.000 inhabitants, the Netherlands only 7 (Saab, 2020) – and in 2025 this has sunk to as low as 5.

Varieties in Early Warning and Early Response will alter the structure of the CLD – and thus the Requisite Variety of the system. The Requisite Variety can serve as an indicator for a change by which the CLD will follow a different structure. More escalating situations may be possible than the three examples presented. Looking at the scale of crisis possible, the next options could be worked out (LIMC, Data-Driven Model Discovery, 2020):

1. Taiwan: 'nipping it in the bud',

2. South Korea: 'pushing back the outbreak',

3. Germany: 'controlled epidemic',

4. Healthcare temporarily overloaded (Italy 'no control'),

5. Healthcare long-term overloaded,

6. Healthcare has collapsed,

7. Healthcare and critical infrastructure has collapsed.

The higher the number of the ranking, the more factors within the CLD a lower ranking have not or less well functioned. At every higher number in the ranking, the CLD tends to become more complex. And it is not only the structure of the CLD that will change every step. Also, the overall structure of the crisis and how to deal with it, will change in nature (next heading).

The amount of disorder during crisis management. A crisis, and how to react on a crisis, can be arranged by categories of disorder (Figure 9). The most disadvantageous category is chaotic and one acts to see what happens and then acts to react – an act, sense,

response approach. In early 2020, the Dutch situation bore elements of the Chaotic and Complex category. The suggested modelling effort of future ops was meant to move towards the 'good practices' of the Complicated category – in which you sense, analyze, and respond. In this category, a more precise, adequate, and effective acting is possible (Toelichting, 2020):

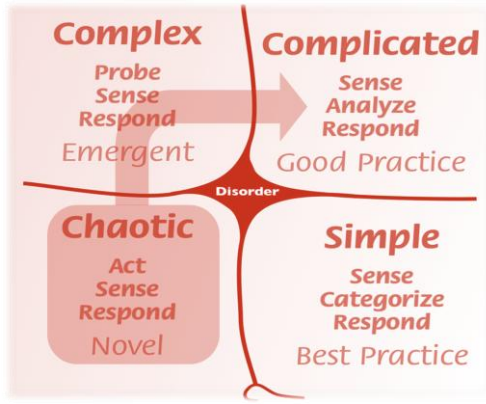

Figure 9. Amount of disorder during crisis management

Early Warning and Early Response will enhance the resilience of a system. With the refined LIMC-approach, we have an instrument to asses better the requisite variety of the healthcare system. If it would be developed further, it also could also lead to an automated model detection system. This will enhance the granularity of the analysis. This helps to identify tipping points, in which the system will change from one to another structure. It will help authorities, by functioning in a less chaotic a complex category of disorder during its crisis management.

Concerning the Covid-19 crisis, the LIMC-methodology made it possible to warn earlier and more accurately than

the RIVM-methodology. LIMC was also able to forecast more precisely the need of IC-capacity on the near term and the development of the virus. And, contrary to the RIVM-methodology, with the LIMC-methodology is should be possible to – from an end-situation – calculate backwards which measures and interventions at what point in time are most effective and needed. Thus serving the aim of reaching a maximum effect in pushing back the outbreak while keeping the social-economic impact as low as possible.

Conclusions

In March 2020, the Land Information Maneuver Center (LIMC) was founded. To understand the complex, and ever more data-intensive environment, the future ops section of the LIMC was aimed at the construction of robust empiric modelling. In the long run, these could form the input for automated model detection systems. It was an experimental strive for Augmented Intelligence. For this, LIMC had developed a four tier program that had been carried out only partly – due to the sudden halt of its activities in November 2020.

One element of the experiment that could only be carried out partly was bridging the gap between qualitative and quantitative analytic techniques, with a focus on calibrating the Causal Loop Diagram (CLD) to fit the requirements for Information Maneuver. In calibrating the CLD, LIMC tried to merge early warning, early response, system analysis, and deep learning into one, layered, methodology. Although designed for Information Maneuver it can be applied to all integrated forms of strategic warning and crisis management. The main take-aways of this LIMC-experiment are:

- The introduction of plug-ins as nodes of the CLD made it possible to experiment with the integration of early warning and early response in a system analysis as CLD – instead of being separate processes. The idea was to save precious time, and being able to calculate the effect of these nodes to avert a threat.
- By having a symbol in place, it facilitates the selection of the type of Early Warning that is most applicable for the issue at hand – being either a qualitative or quantitative form of Early Warning.
- It provides clear insights into, and the effects of, the own possible courses of action.
- It opens up the possibility to include correlations – of big data and deep learning – and to merge these into a cause-and-effect analysis of the CLD. As well as the possibility to retract if the calculations turn out to be incorrect,
- The possibility offered by deep learning to calculate backwards from a future end state. This makes it possible to determine which measures and interventions at what point in time are most effective and needed. Thus reaching a maximum effect in pushing back a threat while keeping the impact for society as low as possible.
- It is a visual aid for those who are not familiar with big data and deep learning to obtain insights in its workings and being able to place it within the overall picture.
- It can be indicated when the limits of a certain system are reached – the requisite variety. The LIMC-approach enhances the granularity of this analysis – thus also identifying tipping points in

which the system will change from one state to another state.

- It keeps the CLD readable. The plug-ins are a help to integrate all the above mentioned elements while at the same time keeping the causal loop diagram accessible and readable.

In short, it calibrates the technique of CLD in such a way that it now meets the requirements of Information Maneuver, including strategic warning and crisis management.

There seems to be a kind of 'natural' division in using qualitative and quantitative techniques:

- Analysis by humans will focus more on qualitative analysis, causal relationships, and drivers based analysis.
- Deep learning will focus more on quantitative analysis; correlations, and big data.

The experiment demonstrates possibilities for cross-fertilization – partly made possible by the introduction of the plug-ins:

- A cross-fertilization from human analysis to deep learning, for example, concerns the selection of data for the deep learning. If some data show up in crucial (highly connected) nodes of the CLD, these can be more telling than others. This helps to reduce the number of variables to be used in the deep learning in an underpinned way.
- A cross-fertilization from deep learning to human analysis is that deep learning correlations can be leads for causal relationships that went unnoticed until then. It could lead to a regrouping of drivers within the CLD.

- in the LIMC-approach, automated elements can be included easily. For example, monitoring indicators like the LIBOR OIS spread with life feeds. This is a – small, but significant – step in moving from a process directed analysis towards data driven analysis and intervention.

Threat analysis and system analysis are now almost completely the domain of human analysts. It is prone to a lot of biases that are absent in machine assessment. Augmented intelligence – the combination of human-machine design and assessment – will eventually lead to a synergetic effect. In intelligence augmentation, the cognitive process will be improved and enhanced. But the human will ultimately remain in the lead.

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