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A systems analysis of the UK COVID 19 pandemic response: Part 2 - work as imagined vs work as done

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ARTICLE INFO

Keywords:
Systems thinking
COVID 19
Complex adaptive systems
FRAM

ABSTRACT

Modelling complex sociotechnical systems to try to understand how observed behaviours emerge from a network of interacting, interdependent and interrelated functions is a major challenge. Woods et al (Branlat, 2010), have pointed out that it is difficult to find a satisfactory current methodology. They suggested that perhaps the Functional Resonance Analysis Methodology developed by Hollnagel (Hollnagel, 2012) could be an appropriate approach to try. In Part 1 this approach was employed to build an overall model of the UK’s COVID 19 response management system, which was constructed as a framework against which, a series of more detailed analyses of specific health care responses could be examined. This meant being conscious of the bigger picture of simultaneous activities and the dynamic emergence of unexpected developments. At that stage, it was of necessity a model of “work as imagined” from careful official and speculative media sources.

Although, a full rigorous application will require a more authenticated, official (peer reviewed?), set of data, reports and evidence statements, which doubtless will be available eventually from the inevitable Public Inquiry, it seems a pity to delay gaining and applying any insights and adaptations from “work as (actually) done”, that have been observed to date. The recent select committee evidence from people at the heart of the system, (Committee, 2021), which may, or may not be corroborated later, nevertheless now provides a provisional database, which can be utilised to test whether the FRAM model can produce such insights from the actual performance of this highly complex system.

This paper has thus attempted a trial run and has found that it can produce a plausible set of insights, which can explain how the system behaved in practice. With such a serious challenge to Government systems worldwide, in all their advisory, operation and decision-making functions, such insights although provisional, could usefully be incorporated and formalised in the current systems rather than waiting for inquiry endorsed recommendations to be formally considered perhaps some years into the future.

The paper thus sets out a set of conclusions and recommendations, caveated by emphasising the lack of fully authenticated public domain data on which it is based. The main conclusion however is that the current system appears not to have included any of the functions which could have provided the adaptability and resilience required by fast moving emergencies, such as pandemics. The exception noted was the establishment of a parallel, independent vaccine development and delivery function and it is hoped that at least this lesson from the work as done could be recognised as providing the type of adaptability required and incorporated without delay.

1. Introduction

The current COVID 19 pandemic has posed serious challenges to the Governments and Institutions in the different countries. Emergencies and disasters on this scale have serious implications and consequences, for which few are prepared and even fewer are satisfied with their performance. In these times of increasing social interconnectivity and the sheer complexity of our hybrid sociotechnical systems, it is vital that we learn rapidly and adapt our responses in the light of experience.

Normally sufficient background and actual operational details are only made available in subsequent official inquiries held after significant delays and lasting years, before conclusions and recommendations are produced, which have usually had limited impact (Slater, 2019a,b). Nonetheless, Hopkins (Hopkins, 2006) recommends that the body of submissions and reports/evidence produced for them, makes a very useful database from which to analyse the underlying characteristics of the behaviours of the organisations involved.

To try and understand the sheer scale of the extent of the interactions...
between different bodies and agencies, a conceptual “model” of the system is needed to identify the required functions they deliver, and in particular their critical interdependencies. This includes identifying those that are ideally supposed to happen, while pinpointing what actually did happen. Woods (Branlat, 2010) has emphasised that we need appropriate modelling tools to track how they propagate (resonate), throughout the networks to produce the observed outcomes. He suggests that Hollnagel’s Functional Resonance Analysis Method, (Hollnagel, 2012) which has proved useful in analysing the example of the financial crash of 2008, (Sundstrom, 2017) would be worth applying.

This paper has thus set out to assess the viability and usefulness of this approach in examining the UK’s response to the COVID 19 Pandemic. In the absence of formal inquiry documents, the information available in the public domain has been relied on (Committee, 2021). This means that as the most detailed description of how the system operated, the evidence given to the Select Committee has been used in a trial run to see if the FRAM approach could usefully be applied in a more rigorous study when better data becomes available.

1.1. The basic FRAM model

Just prior to the COVID 19 emergency, a number of people, mainly from healthcare and academia, came together to form a community of interest, the Safety and Innovation Research and Education Network (Slater, 2019a,b). One of its main aims was to explore the use of a more systematic approach to understanding and learning from how teams of professionals work together successfully in high stress, high hazard applications. The group has embarked on a number of projects, some of which have been submitted for publication and some have had to be deferred as key contributors succumbed to the effects and the pressures of short and long Covid.

To date, a number of these projects are ongoing, including this analysis of the overall management of the pandemic, (Slater, 2021) the response of ICU teams (MacKinnon, 2021a,b) and addressing and improving the complications of the operations of an Emergency Department due to COVID (Andersen, 2021). This paper sets out to test and utilise the overall model, produced in the first of these.

The overview FRAM model (Slater, 2021) was put together to provide a perspective on how each detailed study fitted into and was impacted by all the other activities going on in parallel. Although its accuracy and validity were discussed with different parties, including people from the independent as opposed to the official Scientific Advisory Group on Emergencies (SAGE), as understandably people actually involved in the management of the pandemic, needed to keep focus on the emergency. So, in the absence of direct verification, the model produced in Part 1 was very much a “Work as Imagined” model, although many people on the outside had a similar understanding of the system as it was supposed to work.

With the recent select committee evidence from key people actually and intimately involved in the policy and management decisions, an insider perspective is now available. Of course, the subsequent Public Inquiry may eventually produce a definitive and possibly different view of how it worked in practice. But, for our academic purposes of testing the validity and usefulness of the approach and the model, the results of comparing the predictions of how the system was expected to perform against the now historical evidence of actual outcomes, illuminated by an insider perspective which may or may not be corroborated, is an opportunity well worth exploiting.

1.2. The proposed approach

The overall system which appeared to be in place is shown Fig. 1. This is a conventional set up, broadly in line with (and as capable as?) many major governmental set ups worldwide.

But what is clear, particularly with a long-lasting emergency, is that as well as the instantaneous variabilities in the interactions between functions, there can be permanent drifts in the effectiveness and status of the different functions that emerge over time. Indeed, most of these complex systems evolve and adapt in response to the experience gained in operating in unprecedented circumstances. This can result in a sequence of modified FRAM models not just instantiations of the basic model, but often with unexpected extra, or deleted superfluous functions and aspects.

As first pointed out (Slater, 2017) In these circumstances, the model is similar to a dynamic Bayesian Belief Network obeying the Markovian principle that the predicted behaviour in the next time slice is governed solely by the functions and aspect statuses of the preceding time slice. This is illustrated for Bayesian Belief Networks (Ale, 2012; Slater, 2017) and in a more recent paper on the evolution of response systems in emergencies (Patriarca, 2020).

There is ample evidence of the way the pandemic developed in the UK, from various media and Government publications and briefings. These documented events have characterised the UK experience and there are a number of key dates that have defined the response. It is proposed to use the FRAM model of the system “as imagined”, to look at each of these in turn as individual instantiations of the model to see how the different functions actually performed (as is) and what variations in their interactions resulted in the observed outcomes.

There are identifiable dates where the system seemed to behave differently; where different functions were introduced and there was a noticeable variability in how and how well constituent functions delivered. The table below identifies a number of these break points in mode and quality of performance and indicates, observations which suggest they could be instructive to analyse the change in the system which caused the observed performance to emerge. The analysis then deals with these in turn.

| DATE/TIME SLICE | OBSERVED CHANGES FUNCTIONAL VARIABILITIES |
|-----------------|-------------------------------------------|
| Jan 2020        | Original System already in place and operating (Or on standby?); and now aware of the Wuhan, China Flu outbreak. First COVID death occurs in UK on Jan 30th. WHO intelligence of Italian and Spanish difficulties is in the media. Actual infections in the UK, but Community testing abandoned, the system is working in the “contain” mode of the plan. | System mistakenly thinks its monitoring a possible Flu epidemic. Advice that all is under control |
| Feb 2020        | Rapidly deteriorating situation in Italy and elsewhere forces system to set out the plan formally and to try and implement it. A big, centralised expansion of the testing capabilities is promised. The actual roll out is still delayed. The system moves to “delay” mode to flatten the peak. Herd immunity is actively considered as a goal. | The planning function mistakenly assures the system that plans and preparations (Resources), are in place, adequate and tested. |
| First ¾ March 2020 | Despite Inertia (Group think?) in communicating significance of intelligence and the flawed analyses and advice from the Committees, the centre finally understands that the original plan contemplates 820,000 deaths from the pandemic. |

(continued on next page)
The implications of these variabilities are discussed for each instantiation in turn.

1.3. First instantiation – January 2020

Here the world finally learned that there was an outbreak of a SARS type virus infecting large numbers of people in Wuhan, China and now spreading to different parts of the world.

1.3.2. System response

In the UK, there was awareness (“it was in the news”). Two of the key functions contributed by SAGE (22/1) and COBRA (24/1) are activated, but “with uncertainty in the data”, the response system is not fully mobilised.

The first response from the centre (25/1) is to check if the required resources, to be delivered by the Preplanning and Preparedness background functions, are in place, and can deliver. In the Part 1 initial overall model, these functions are missing; so these, have now been added. At this point the system seems to have assumed that all is in order and the “system as imagined” can cope. It turned out that the planning was based on a conventional influenza epidemic – (output – wrong plan) and the preparedness function was “optimised” in the austerity budgets (might not happen), so was not in a position to supply the resources (notably in date PPE stocks) that would be required by the system. (Ale, 2020; Ale, 2021a; Ale, 2021b).

The reasons suggested for this lack of preparation imply that this was an unprecedented, unknown, “Black swan” event, or as some journalists opined, a 1 in a 100-year event. Neither of these is correct, SARS zoonoses incidents (SARS, MERS) are well documented and expected to occur much more frequently. (of the order of 1 in 10 per year in the preceding references). Countries such as South Korea had more appropriate planning and preparedness measures in place for such a pandemic. So, although we’ve added these functions, not only did they not deliver, but they actually misled decision makers in assuring them that they were on top of this, as a “Tier 1” risk on their risk register; and further had stress tested their product, (despite a critical report on a recent full-scale exercise – a dress rehearsal).
Insight – Planning and Risk analysis needs expertise that was clearly not prominent in the bodies tasked to deliver these functions. Appropriate Planning and Preparedness are required Resources, but perhaps should be Preconditions. In the event, the advisory committees were working to the wrong plan! The System was not in control.

1.4. Second instantiation – February 2020

1.5. Background

In the early part of the month, nothing much changed as it is alleged that “key people were skiing”. But the record shows that if any of the warning functions were active (there were by then, actual COVID cases and deaths in the UK), the outputs were not clear and did not alert or alarm the “key people”.

1.6. System response

As a result, none of the monitoring, track and trace and border control functions were active on any significant scale. Confident in their planning and preparation, and that there was nothing they needed to learn from other countries and the WHO, advisory and emergency functions assumed everything was under control.

It is reported that even if the internal functions were not working, there was an increasing pressure from sources outside Government (bypassing the system functions), to take notice and do something.

But the internal functions were not operating independently and imaginatively (Group think according to the select committee evidence.)

Insight – It is crucial that another function should be considered, as it is in many large organisations, a “Red Team” function to challenge received wisdom and try to foresee issues instead of waiting for hard evidence.

1.7. Third instantiation – early March 2019

1.7.1. Background

The mismatch between reality as observed in China and Italy and preconceptions, particularly the rapid spread of the virus, had started ringing alarm bells. The advisory functions (expert committees) and government scientific advisers (SAGE) at last were reacting to the real-world events and data from the experience in China Italy, and further afield, to update their epidemiological spreadsheet models. This resulted in an agreement that as it was too late to try and “contain” the spread by border controls, testing, tracing and quarantining (the successful South Korea strategy) their only option was to limit the size of the predicted “worst case” scenario (by delaying the peak with measures such as rigorous handwashing), so as not to overwhelm the Intensive Care facilities of the NHS. It was considered important that the population eventually attained sufficient “herd immunity” through surviving infections to limit the rate of transmission to manageable proportions. Some advisers apparently were suggesting “chicken pox parties” as a way of accelerating this necessary state. This flattening of the model infection level peaks was referred to as the “whack a mole” plan.

1.7.2. System response

At some point, the results of the model predictions of the size of the peak were published, in effect bypassing the system’s advisory functions to alert the central decision-making functions. As the knowledge that the “worst case could be of the order of half a million deaths before herd immunity is achieved” circulated in the media, the centre became more and more convinced that Plan A was going to be a disaster. This was eventually communicated directly to the decision makers by their own staff as the system’s functions had not been able to get across the full implications.

The centre then asked for a reset from planning and the advisory committees, but apparently there was no plan B, and it would take time to put a South Korean adaptation (lockdown, test, trace and isolate, close borders) in place. So, there was a delay to reset the system. But finally, the system decided that a massive testing program was needed and eventually a mandatory “lockdown” program was imposed to limit transmission.

At this point the full implications of shutting down the economy were realised, and another function was identified: “To protect the economy”, although exactly where this fitted is a matter of conjecture. It has been inserted here as directly interacting at the decision making (PM) level. This function also had to start from scratch to formulate funding for the lockdown consequences – something that also was not in Plan A.

The time delay in resetting the system and adding the further
functions required, resulted in the infections, hospitalisations and deaths escalating exponentially.

Insight – again it is apparent that any successful system must have these intelligent “front end” functions in planning, predicting, and probing to try to get ahead of the curve. The human mind works by using Bayesian risk estimating constantly challenging and updating its beliefs and assumptions. Predict, monitor and update/correct. Reinventing and completely resetting the system takes too much time.

1.8. Fourth instantiation – late March 2020

Since Plan B was non-existent, the planning functions had to scramble to provide promptly, the key functions needed to execute and operate it in a timely fashion. Key response functions – To manage the response – seemed to overlap, (DH), (PHE). There were other unclear roles. Functions such as, Monitoring, Test and Trace, border control, enforcement, all proved not sufficiently operable, or effective by default, or by design.

1.10. System response

The FRAM clearly shows the congestion of interactions that the management function was designed to cope with. Under the stress of rapidly rising hospital admissions, the preparedness function was discovered not to have provided the resources needed, PPE, ventilators, available ICU beds. The result was that this function could not operate as imagined. Consequently, this resulted in prioritisation and “war” footing instructions such as, “face masks were not very effective”, to conserve inadequate supplies. Freeing up ICU beds by discharging patients into care homes without testing clearly shows the pressure to accept collateral damage to survive. As the local health Authorities already had the expertise and resources to run monitoring, test and trace and isolate functions, it was surprising that it was expected to be more efficient and effective, to create it from scratch, in the middle of an emergency. Throughout the pandemic, the test and trace problem continued to be problematic, while the border function was perhaps never intended to be fully effective.

It seems that the central decision-making functions recognised this bottleneck choke point and created a separate function to initiate and manage a vaccine program. The success of this program has been crucial in ultimately allowing the system eventually to bring the pandemic under control. It seems that this was an imaginative move from the centre, independent of the normal chains of command, which kept it out of the congested overloaded “normal” channels.

The overloading clearly shows that little thought was given “a priori”, as to the probable effectiveness of having a single central body tasked with making it all happen. Any shortcomings should therefore rather first be ascribed to the system design, not necessarily to any shortcomings of the people involved.

Unfortunately, key decision makers themselves are taken ill with COVID. Not only does this disrupt and divert focus and priorities at a critical juncture, but one of the known side effects of COVID is “brain fog”, which probably did not add to the coherence and clarity of the decisions made at that time.

Insight – The day-to-day management and coordination function is clearly critical and required much more in terms of authority and competence, and in retrospect under the pressures of time and escalation, perhaps it was unrealistic to expect a single civil service department to have the ability to cope singlehandedly.

1.11. Fifth instantiation – April/May 2020

Despite the difficulties, the Plan B was implemented and succeeded in controlling the first surge in coronavirus infections, without actually exceeding the capacity of the system’s resources to cope, e.g., ICU beds in NHS hospitals. The compromises made, though, had knock on effects in care homes, where finally testing was taking place, but coordination problems with PPE, testing and tracing, and the delays in acting, are thought to have been responsible for an extra 20,000 unnecessary deaths. Nevertheless, the “Lockdown” (partial S Korean Plan B) worked.
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what had happened earlier. It is not clear that the front-end functions were anticipating scenarios and options for possible, potential scenarios coming up.

Insight – It is here that the lack of a set of formal learning, anticipating and challenging functions would have been invaluable.

1.12. Sixth instantiation – September 2020

1.12.1. Background

The numbers of cases now had been rising steadily again for the last two months, which was originally, mistakenly, attributed to the success of the testing program. It seems though that there was confidence that the system could cope and work as designed, as before. So now the advice from the front end was simple – lock down (Plan B) again.

1.12.2. System response

However, the feedback from the independent Vaccine Development function is increasingly positive and offers the prospect of a “silver bullet” with which to control the pandemic. So, this together with the fact that the extra economic pressure function is now very active, results in a radical Plan C which proposes a Project Operation “Moon-shot” to deliver 10 million tests a day and avoid a second national lock down. The attractiveness of these options delays the decision.

Insight – The centre seems to have discounted the advice from the advisory and planning functions and is placing more faith in its own internally generated initiatives. But again, the system does not seem to have any means of systematically and rigorously predicting the impact/results of new initiatives and proposals. Neither does there seem to be provision for challenging the assumed prognoses.

1.13. Seventh instantiation – October/November 2020

1.13.1. Background

The emergence of a new, more virulent strain, (the Kent variant), now causes a concerning surge in the cases monitored. But the UK system now includes a vital genomic tracking facility and is able to identify these more infectious variants.

1.13.2. System response

Now, the advice, then current, to go back to work is reversed and intermediate “local Covid alert levels” (partial lockdowns) are introduced.

Then in November five and a half weeks after the SAGE advice, tighter lockdown measures are re-imposed across the country. There is some confusion over the messages conveyed and the effectiveness of the different tiers varies. Devolved administrations, presumably feeding off the same basic monitoring data and advice, issue variations of the guidance, which again was confusing.

Insight – To be effective the system must get across clear consistent messages, but by now the abrupt U turns and delayed responses had caused confusion, and it is questionable whether devolution considerations helped the clarity of communication.

1.14. Eighth instantiation – December 2020

1.14.1. Background

At the beginning of December, the Vaccine development function delivers, and the UK licenses a vaccine against COVID 19. This probably strengthens the centre’s resistance to the scientific expert advice to tighten the Covid restrictions, particularly the idea of cancelling Xmas. Naturally, the economic advice is to the contrary. So, a 5-day window is proposed for multi household social mixing. The potential for consequent infection rises due to holiday travelling and crowded stations etc.

apparently is not appreciated.

1.14.2. System response

Eventually on Dec 19th the system reacts to the 70% increased transmissibility of the Kent variant and gradually starts to place areas under increased restrictions, with even more under the strictest conditions from Boxing Day.

Insight – The system is slow to react to the possibility of more infectious variants. Mutation is well known and expected, the virus structure and protein sequences and mutated structures are all recorded and reported, but how do these mutations increase the transmissibility and what other variations can be expected and what possible consequences should be anticipated. None of this forward thinking and planning seems to have been done (at least not publicly). The steady stream of lethal variants seems to take the system by surprise.

1.15. Ninth instantiation – early 2021

1.15.1. Background

The system is relying on the testing programs to monitor the extent and seriousness of the spread of infections, (the R number). Initially this was a broad national average calculated 2 weeks in arrears and proved inadequate for the proactive deployment of social distancing restrictions etc. Despite moving to more local calculations and more targeted interventions it takes time, and the second peak pushes the total death toll past 120,000.

1.15.2. System response

Fortunately, the successful Vaccine delivery function performs well and restores confidence. The lockdown measures are again eventually effective in reducing the infection spread sufficiently so that a return to normal in June is promised depending on the retrospective monitoring data.

The emergence of further variants (South African, Brazilian) means that the system is now taking the decision on timing to relaxation more seriously, and the system seems to be working. But this is not the system “as imagined” in January 2020.

Insight – Is the system still relying solely on lagging indicators? If so, why? There is also the indication from the vaccine developers that they could have had it in circulation earlier, perhaps, if the system had been better advised.

1.16. Tenth instantiation – summer 2021

1.16.1. Background

Yet another variant (the Indian) emerges and quickly becomes the dominant strain due to further enhanced transmissibility.

1.16.2. System response

Due to the success of the vaccine roll out in breaking the link between recorded infections and hospitalisations/fatalities, the system seems to be content to observe and try to contain the spread of this new variant locally. However, it is puzzlingly slow to try and interrupt its continued importation until the significance was obvious and threatened the promised restrictions release date. This is eventually postponed anyway, despite further predicted economic consequences. But at least it shows that the system has finally learned to be cautious and treat the advice seriously.

The emergence of yet another variant (Nepal) will probably be seriously, and the system seems to be working. But this is not the system “as imagined” in January 2020.

Insight – There is no sign that the system is expecting and is prepared for more variants? – Or perhaps as importantly any other developments that might cause complications. There seems still to be no function anticipating and addressing risks to be included formally in forward planning, economic or societal.
Fig. 1. Overall model (WAI).

Fig. 2. After Patriarca et al. (Patriarca, 2020).
2. Discussion

2.1. The usefulness of the FRAM approach

The conventional way of tracing out the web of authorities and responsibilities in a large organisation is to draw an “organisation chart” of linked, strictly hierarchical boxes. If a more formal analysis is needed, these could, possibly, be further developed as “fault trees” to attempt to determine which links “failed” in the chain of command and control. When the full range of linked activities necessary to describe the complex system of groups/committees/departments and contractors involved in the management of the COVID crisis is taken into account, however, it is difficult to see how conventional “organisation charts” could have revealed the critical interactions and interdependencies that are not readily apparent in these 2 dimensional, sequential, one on one representations.

Rasmussen (Rasmussen, 1997) and Hopkins (Hopkins, 2000) have employed a more generic mapping of the hierarchies and influences/responsibilities involved, which has proved very useful in understanding specific organisational failures (Accimap). Leveson (Leveson, 2011) has further developed a way of linking these hierarchies as nested “control loops”, (STAMP), a model which proved helpful in understanding the organisational failures responsible for the ineffective operation of national organisations, such as in the Columbia space shuttle disaster.

If, however, the focus of an analysis is to try to understand how a system is supposed to work successfully, identifying failures of individual functions and components gives only half the picture. When the focus is on improving the performance, rather than simple repairs to the existing system, this requires an understanding of more subtle effects and implications of component behaviours, particularly if the system as actually operated, is different in practice to what the formal organisation charts imply. Once locked into a pre-set mind-set, it is sometimes difficult to challenge the established group think of how its operation is imagined to be happening.

2.2. Overall general observations

The Overall FRAM model (Fig. 1) shows all these same groups/committees/bodies involved, as an interacting system of functions, rather than a 2-dimensional rigid predetermined grid of components. Thus, it does not need details of specific people, Bodies, or physical components responsible for fulfilling the task. It is also very much a provisional model put together to visualise the patterns of behaviour and the outcomes observed during the pandemic progression. From the big picture that emerges, it became apparent that a number of the functions did not operate exactly as envisaged and this variability in their outputs was clearly evident on the resulting effects on other downstream functions (see Fig. 2).

In particular, issues were apparent with the “front end” upstream group of functions which delivered preplanning, preparedness, intelligence and international updates for the decision making and advisory functions. Perhaps the most crucial variability was in the appropriate capability, but not the essential adaptive capability to handle the unexpected.

The FRAM model also shows the overloading of the central “management of operations” function and the difficulty of dealing with multiple conflicting demands such as ICU beds versus care home isolation.

Nevertheless, based on the account of how the system actually operated, given in the select committee hearings, (Committee, 2021), the model allows a provisional analysis of the factors involved in these problems which affected the performance as observed.

These are set out below.

2.3. The importance of planning

Although the old Prussian military adage cynically advises that “no plan survives first contact with the enemy!”, (von Moltke, 1891) working to the wrong plan would seem to be the worst of all worlds.

There was quite clearly a plan in place, fully exercised and recommendations made to make it Battle ready. But it seems as though that, in itself, was reassuring enough, as the planned response to a “Tier 1 Risk” (likely in the next ten years?) on their register, to allow it to be box ticked as sufficient and in place. Unfortunately, it was not sufficient to address the specific demands and to avoid short term expediency and austerity (and complacency?) pressures to degrade its importance and resource priority.

As this resulted in a false appreciation of the extent of preparedness required, it was assumed that critical components, such as stocks of PPE were adequate, in place and maintained.

But the military has observed that:

“Only a layman could suppose that the development of a campaign represents the strict application of a prior concept that has been worked out in every detail and followed through to the very end”

So, while plans are critical resources for action (Suchman, 1987) they are also fundamentally limited. The danger lies in sticking to plans when the conditions for their success are no longer met.

“Everything depends on penetrating the uncertainty of veiled situations to evaluate the facts, to clarify the unknown, to make decisions rapidly and then to carry them out with strength and constancy.”

In other words, how quickly and effectively can you adapt to the actual, not perceived situation.

In today’s terms, the UK management system had the planning capability, but not the essential adaptive capability to handle the unexpected and disruptive.

2.4. The management of adaptive capacity

Woods et al, (Branlat, 2010), from their studies of different high-risk domains (healthcare, mission control, military operations, urban firefighting), have proposed classifying adaptive failures in their management organisations into three categories:

(1) Decompensation – when a system exhausts its capacity to adapt as disturbances and challenges cascade.

(2) Working at cross-purposes – when sub-systems, or roles exhibit behaviours that are locally adaptive, but globally maladaptive.

(3) Getting stuck in outdated behaviours – when a system over-relies on past successes although conditions of operation change.

The UK Pandemic Response system clearly showed examples of all three categories. It has been observed that perhaps the predominant problem was in the third category, where it was alleged that a pervading influence of a “Group think”, was sensed and was reminiscent of the classic criticism of Generals always fighting the last war.

It is suggested that in a subsequent more complete analysis, such a set of basic patterns could help identify and propose ways in which a future...
UK emergency response organisation, as an example of a complex adaptive system, needs to behave in order to see and avoid, such problems.

2.5. The need for polycentric control

Traditional hierarchical systems have been shown to be inadequate in matching the complexity of the real world, and in providing the necessary adaptive capacity (Hollnagel, 2006; Ostrom, 1999; Shattuck, 2000).

“Within these multi-layered networked systems, it is necessary for particular roles, or centres, to adjust their behaviour by taking into account interdependencies with other roles, activities, and events (e.g., (Kulathumani, 2004))”. The FRAM model allows the tracking of these cross-scale interactions (vertical or horizontal). This is turn can allow management to avoid crossed wires in setting and delivering common goals.

In the UK example, much of the day-to-day management function of the response was centralised. This simplified the potential for control, but inevitably added inertia and discouragement of local initiatives. This meant that to deliver the Monitoring function, the centre attempted to build its systems from scratch, ignoring pre-existing and pre-planned Public Health Facilities at a local level. This not only wasted resources but added to the congestion of tasks that the central function had to deliver. This consequent lack of transparency and communication inevitably resulted in compromises which made sense seemingly only to the embattled centre.

It is hoped that more thought will be given in future as to how best to design a system, to implement the management of multiple and diverse tasks in multi-layered centres.

2.6. The decision-making functions

One of the observations that has been much commented on, has been the seemingly excessive delays in taking the key decisions, particularly when major changes in strategy were required.

There are several possible explanations that need to be worked through to get a clearer picture of what was responsible for the variability in the relevant interdependent functions involved.

For example

- Was the provision of advice (Policy and Technical) too little, too late or unclear, or inadequate?
- Was the central function overwhelmed with too much information, advice and pressure? (Polycentric arguments)
- Or was it impaired, temporarily; for example, key decision makers went down themselves with COVID, a known side effect of which, was a lingering “brain fog”.
- Or did the downstream functions just fail to respond?

All of these possibilities need and lend themselves to, deeper scrutiny of the intended and actual interactions involved, when a fuller disclosure of the details is available.

Finally, many people think that the key to decisive decision making is leadership and the “culture” they create or inspire in an organisation; and that improvements can most easily be brought about by installing leaders who have the appropriate vision (Westrum, 2004). But often there are less personal sources of culture which need to be understood and counteracted, if there is to be any hope of changing the organisational culture itself.

2.7. The “Resilience” of the system

In studying previous research on how effective organisations are when responding to emergencies, reference is often made to Perrow’s classic work on “Normal Accidents” (Perrow, 2000). He, prompted by the 3 Mile Island Nuclear Emergency, pointed out that the pressures on organisations working in challenging environments controlling hazards with potentially serious consequences, mean that accidents are to be expected (Normal). In response to this, the necessity of having Highly Reliable Organisations (HRO’s) and systems to cope with this pressure, required extensive and expensive, tightly coupled, interdependent, distributed, rigid management systems, probably only affordable by the military and critical infrastructure organisations, such as nuclear operations. But as Hopkins (Hopkins, 2006) has pointed out, one of the essential attributes of the management of these organisations was “chronic unease” – expect/be prepared for the unexpected. While useful for benchmarking the operation of complex systems, the HRO model is rarely applicable to democratic political administrations.

A more appropriate case study would be to understand the demonstrated effectiveness of healthcare professionals in meeting emergency challenges such as the Manchester Arena bombing. (MacKinnon, 2021). Here the key characteristic of front-line healthcare was adaptability, and the responding organisation was a classic complex adaptive system. This adaptive capability is often referred to now as “resilience”.

(Hollnagel, 2015), set out four essential capabilities that such systems must have in place, to be resilient. These are the functions that enable them: -
It is fundamental to effective resilience, that there is as much, (more?), emphasis on monitoring how the whole system is behaving, learning from its behaviours in real time and trying to anticipate how it’s going to behave in future, as in actually being able to respond to events as they occur.

The above FRAM model illustrates the set of functions needed to provide the system with its capability to adapt. Hence the UK pandemic management system, effectively lacking any of these key functions, was ponderous and slow (reluctant) to challenge and adapt – it was not very resilient: a lesson that could be immediately adopted and fitted into the present set up. But with an understandable emphasis on key decision makers in the system justifying, rather than openly embracing these lessons, this probably is difficult politically at this stage.

2.8. Estimating the extent of system resilience

Hollnagel (Hollnagel, 2015), has suggested a way of rating and ranking the resilient properties of a system. He maintains that “Resilience refers to something that the system does rather than to something that the system has; but it refers to something that is multifaceted rather than something that can be described by a single quality or dimension.). So instead of considering what resilient performance is, we should consider what enables resilient performance, what makes it possible – and conversely what would make it impossible, if it were missing”. These abilities can be inferred from asking a series of questions.

- **ABILITY TO RESPOND**
  - o What are the events for which the system has a prepared response?
  - o How was the specific type of response list decided? How is it ascertained that it is adequate? (Empirically, or based on analyses or models?)

- **ABILITY TO MONITOR**
  - o How have the indicators been defined? (By analysis, by tradition, by industry consensus, by the regulator, by international standards, etc.)
  - o How many of the indicators are of the ‘leading,’ type and how many are of the ‘lagging’? Do indicators refer to single or aggregated measurements?

- **ABILITY TO LEARN**

- **ABILITY TO ANTICIPATE**
  - o What kind of expertise is relied upon to look into the future? (In-house, outsourced?)
  - o How are the expectations about future events communicated or shared within the system?

In order for this concept to be useful as a tool, it is necessary that the answers to what enables the four functions and how effectively they are present can be rated. Such a rating can, for example, use the following Likert-type scale:

- **5 = Excellent** – the system meets and exceeds the criteria for the required ability.
- **4 = Satisfactory** – the system fully meets all reasonable criteria for the required ability.
- **3 = Acceptable** (just) – the system meets the nominal criteria for the required ability.
- **2 = Unacceptable** – the system does not meet the nominal criteria for the required ability.
- **1 = Deficient** – there is insufficient ability to provide the required ability.
- **0 = Missing** – there is no ability to provide the required ability.

If this approach is found useful, a much more detailed assessment of the operation of the ability of the system to Respond, Monitor, Learn and Anticipate will be made as answers to a carefully thought-out series of questions.

The purpose of this resilience ranking is then to provide a well-defined characterisation (or profile) of a system that can be used to manage the system and specifically to develop its potential for resilient performance. The intention is that this analysis is applied sequentially to successive time slices so that it becomes possible to see if there have been any changes and identify sources from the FRAM. The results are illustrated below.

A further application could attempt to look at how the overall
resilience of the system developed during the duration of the pandemic. Here a simple summing of the four attributes’ ratings has been employed. This notional total could be used to illustrate how the effectiveness of the different resilience functions varied over time; and how they responded to the demands on the system. The plot below shows this behaviour against a background of the COVID fatality rates over the same time period. This clearly shows a pattern of response that would be well worth probing with a validated data base. This does, however, indicate that 18 months later, the resilience effectiveness of the UK’s pandemic response system scored at (12/25, or approximately 50%), which with a score of 5/2 = 2.5, is still not acceptable.

3. Conclusions and recommendations

The main conclusion drawn from this work is that a trial application of the FRAM approach to modelling the UK’s Pandemic Response System to better understand what affected the effectiveness of its performance, looks to be promising in its potential. But it also appears very appropriate for a study which seeks to use this understanding to improve the system, not to find fault and assign blame for any problems that emerged.

A recent book (Kernick, 2021), illustrates this approach in addressing issues in the UK’s system for managing fire risk in buildings, after Grenfell. She sums it up by questioning the intention of examining the operation of such systems. Is it for tinkering at the edges, or calling for its wholesale replacement? She argues it should be neither but should aim for constructive systemic change. The following table illustrates the concepts (after Kernick). The study concludes that a FRAM approach could facilitate this.

| Question | Change         | Kernick       | Slater       |
|----------|----------------|---------------|--------------|
| What’s wrong with the system? | What is the system perfectly designed for? | How is it supposed to work? |
| Intent   | Solving a piecemeal issue | Shifting the conditions holding the status quo in place | Making the system work |
| Assumption | Complex, emergent world | Complex Adaptive Systems |

The major advantage of applying the FRAM modelling approach is that, as this paper illustrates, it is, by definition, a systemic approach. It describes and spotlights the behaviour of the system’s functions, not the people involved. So, it is both more objective and nonthreatening in its identification and resolving of issues. Variations in performance happen in response to changing conditions and demands, and the analysis seeks only to understand why, not to apportion blame and shame.

Such systemic overview analyses are then made possible by applying a FRAM approach, as, as this paper illustrates, we can see patterns as they emerge, rather than having to wait until the whole process is finally complete. There is much interest and demand for learning the lessons promptly and this approach offers opportunities for continuous improvement rather than perceived criticism.

After the Grenfell Fire, such lessons were obvious in days (Slater, 2017) – but it is now some four years later, and the Inquiry is still running. Interim Official Reports have been excellent, but inevitably only address piecemeal change (e.g., Cladding (Hackitt, 2018)).

But there seems to be a reluctance to learn from other incidents, or other countries. The experience of the Taiwanese and South Korean Authorities in handling the MERS and SARS pandemics seems to have been ignored. There seems to be a predilection in the system for not learning and anticipating.
3.1. The observed lack of resilience

Hollnagel, has suggested a practical technique, with which to assess how effective, are a system’s functions to deliver interactively, the adaptive monitoring, learning, and anticipating needed to inform and condition its responses. Overall, on this rating, this trial application finds that the scores of the resilient capabilities of the current UK pandemic response system, (as imagined), are poor, but what is more interesting is to trace how the system scores vary at the different time slices. The analysis shows some, but disappointingly little improvement. This is more support for encouraging undertaking promptly, the type of independent assessment suggested here, to make the lessons and feedback from such analyses available, without waiting for the findings of more ponderous, less focussed Public Inquiries.

3.1.1. Responding

On this basis we can see that preplanning and pre-planned responses can only be valid and immutable when the events are unfolding according to the script. And as we have seen, this rarely happens in the real world. Hence initially there was effectively no response. However, much of the subsequent recurring difficulty in responding effectively and in time, could have been due to the lack of adequate monitoring, learning and anticipative capability. It will be interesting to trace this through in the full analysis.

3.1.2. Monitoring

Initially the plan did not envisage that an extensive national monitoring capability would be critical to understanding exactly how the pandemic was developing. This understanding was to be based on epidemiological modelling, calibrated with field observations. These then always seemed to be some 2 weeks in arrears – lagging indicators. Thus, real time monitoring data were not available, and hence the effects of corrections, or adjustments, would not be apparent promptly – and the test and trace program was being reinvented, developed and implemented from scratch. Why in this immediately interconnected society more use was not made of the internet is something which will doubtless be examined in detail. But there was not a sufficiently effective monitoring function available – certainly at the start.

3.1.3. Learning

It was not just the quality and effectiveness of science and advice that inhibited learning, but the reluctance to challenge received advice in the light of emerging experiences. Misconceptions such as “Bevavioural fatigue”, effectiveness of face masks, asymptomatic transmission, were apparently not corrected promptly, despite evidence available to the contrary. Lessons learned from the delay in the first lockdown were evidently not learned, as there is evidence that the same mistakes were made for both the second and third waves. This in turn is clear evidence that the system as a whole, did not learn.

3.1.4. Anticipating

At every stage, the response of the system has been too little until too late, resulting in one of the highest tolls of excess deaths in the world. Paradoxically, the development, in parallel, of the vaccine development and production facilities, is the exception that shows what could have been done. Nowhere else, in this whole episode is there any recorded instance of the original system anticipating any of the crisis points. Luckily, the decision to introduce a new centrally controlled vaccine development and delivery function, stands as a shining example of anticipation, enabling successful adaptation. It is all the more striking as seemingly the sole example, which for the system must have appeared as a stroke of luck. Otherwise, this UK capacity for rapid vaccine development could have been anticipated (foreseen and relayed through advisory functions?) and driven forward earlier and more urgently if it had been part of the planned response. (It is possible that a vaccine could have been delivered within 6 months rather than a year, as the research that developed it in universities and pharmaceutical companies started in early January).

Finally, one might legitimately ask whether it is necessary to employ such a rigorous, structured approach and in particular, FRAM modelling, to discerning and understanding the responses observed. There have been a number of media reports endorsing many of the conclusions here. But the value of understanding the outcomes on a systemic basis is that it allows a more fundamental appreciation of the wider context than just individual decisions and actions, appropriate, or otherwise. It enables an analysis to be constructive not critical, systemic not piecemeal and hence likely to be more valuable and sustainable than tinkering round the edges.

3.2. Preliminary findings and recommendations

Planning Risk registers are not just checklist tick boxes, they are Action Agendas

1. Planning and Risk analysis needs expertise that was clearly not prominent in the bodies tasked to deliver these functions. Intelligent Planning and Preparedness should be mandatory Preconditions, not nice to have Resources. So, the effect was that the system was attempting to implement an inappropriate response.

2. The system lacked Resilience in its reaction and response to and in the management of disruptive events. In today’s increasingly complex world it is apparent that any successful system must have pro-active “front end” functions capable of imagining, predicting, and probing to try to get ahead of the curve. The human mind works by using Bayesian like risk estimating, to predict, monitor, update and correct, constantly challenging and updating its beliefs and assumptions. Reinventing and completely resetting the system retrospectively simply takes too much time.

3. Another aspect of anticipation is ensuring the Intelligence available on threats is at least up to date. This is one of the UK’s strengths which in an adversarial context it would be expected to take the initiative (Enigma?), not concede it. As well as the commendable Vaccine initiative, perhaps more attention should be given to understanding and pre-empting the enemy’s (Coronavirus) likely future behaviour and potential developments/threats, to augment the lagging monitoring intelligence. Surely the mutations were predictable and yet still seem to be surprising the system.

4. Many organisations, in highly competitive and critical situations, bidding wars and take overs, etc., employ a “red teaming” approach with a designated internal team tasked to find weaknesses and issues that can impair the effort or be exploited on an adversarial basis, by the competition. It is perhaps an extreme form of anticipation but has a proven track record of successful application and could have helped avoid some of the miscalculations here.

5. How the response was managed on a day-to-day basis, needs urgent examination. There is a model in how the vaccine was developed, but this was clearly a satellite operation outside the main channels. There were multiple centres and organisations involved which needed mobilisation and direction on an unprecedented scale. That demanded more emphasis on delivery than kudos. The day-to-day management and coordination function is clearly critical and required much more in terms of authority and competence, and in retrospect under the time and escalation pressures encountered, it was unrealistic to expect a single department to have the ability to have been effective.

6. One of the puzzling aspects to observers from the outside, is the way “the Science” was apparently rigorously followed. Generally, scientific views are peer reviewed and have to be transparent in their evident basis. Some of the “followed science” seemed neither transparent, nor justified. For example, pronouncements on the effectiveness of face masks and the predictions of “behavioural” responses, which eventually had to be withdrawn. There are several
guides as to principles and how ideally scientific advice should be given, which are worth revisiting. (Slater, 2000) Possibly the problem lay in the composition of the advisory committees. Ideally, they should be independent, not Officials (CMO etc.,) and perhaps drawn from a wider cross section than just epidemiologists, vital though they are. But again, the system does not seem to have any means of systematically and rigorously predicting the impact/results of new initiatives and proposals. Neither does there seem to be provision for challenging the assumed prognoses. It seems that it was more convenient to have “followed the science”, so that science was “to blame” for all the inconveniences of the lockdowns. (House of Commons Science and Technology Committee, Seventh Report of Session 2005 – 6).

7. Never admit mistakes, never apologise may seem good advice for political leaders, but in building trust to manage through a highly unpredictable and unprecedented crisis there are drawbacks. In having to change the science (above) and to explain delays, it helps to conceal the difficulties and issues. There may well be good reasons, but lack of candour degrades trust and feeds the conspiracy and fake news speculations. Churchill emphasised potential downsides (Blood, sweat, toil and tears), and achieved a remarkable response and appreciation for the choices that had to be made.

8. Belatedly, (the COVAX initiative), Governments have acknowledged that they were dealing with a global pandemic. One of the disappointing features has been the isolationist attitudes of Governments. Not only was there not enough proactive sharing of intelligence, but international squabbling and the scramble for PPE and Vaccine supplies, fed populist tendencies in many countries. Interestingly, and perhaps appropriately, the more populist governments delivered some of the worst, not best outcomes. Global alliances and the virus fighting equivalent of Interpol are perhaps among things to be seriously considered for the next pandemic.

9. Finally, although its contribution has been treated as strictly outside the scope of this analysis, the performance of the WHO has also been puzzling. It is apparent that it has real political constraints as demonstrated in its inability to trace/advert the origin of the virus, a vital piece of information with profound implications for what is coming next. Perhaps, if this approach has shown promise, a FRAM analysis of the WHO system of pandemic response would seem to be a good next step.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The Author is particularly grateful to Professor Ben Ale for helpful and useful comments and a less insular perspective.

References

Ale, B.J.M., 2012. Using Dynamic Bayesian Networks to implement Feedback in a Management Risk Model for the Oil Industry. PSAM 11. Helsinki: ESREL.