Tracking the right path: safety performance indicators as boundary objects in air ambulance services

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Abstract
Indicators are used by most organizations to track their safety performance. Research attention has been drawn to what makes for a good indicator (specific, proactive, etc.) and the sometimes perverse and unexpected consequences of their introduction. While previous research has demonstrated some of the complexity, uncertainties and debates that surround safety indicators in the scientific community, to date, little attention has been paid to how a safety indicator can act as a boundary object that bridges different social worlds despite being the social groups' diverse conceptualisation. We examine how a safety performance indicator is interpreted and negotiated by different social groups in the context of public procurement of critical services, specifically fixed-wing ambulance services. The different uses that the procurer and service providers have for performance data are investigated, to analyse how a safety performance indicator can act as a boundary object, and with what consequences. Moving beyond the functionality of indicators to explore the meanings ascribed by different actors, allows for greater understanding of how indicators function in and between social groups and organizations, and how safety is more fundamentally conceived and enacted. In some cases, safety has become a proxy for other risks (reputation and financial). Focusing on the symbolic equivocality of outcome indicators and even more tightly defined safety performance indicators ultimately allows a richer understanding of the priorities of each actor within a supply chain and indicates that the imposition of oversimplified indicators may disrupt important work in ways that could be detrimental to safety performance.

Keywords: boundary objects, safety indicators, critical services, system performance

1. INTRODUCTION

Safety performance indicators are a topic of debate in the safety literature and in practice. The managerial purpose of safety indicators is to understand system performance with regards to safety and so make changes to improve, before any major system failures are experienced. This reliance is further strengthened by neoliberal ways of thinking and associated growing pressures for standardization and management (Kongsvik et al., 2018). Safety indicators are, like other performance indicators, aimed at reflecting performance in relation to the goals and objectives of a system.

Defining and using 'good' indicators has therefore become a preoccupation in both theory and practice, and is particularly important when it comes to the management of critical systems and services: those that fulfil some of the most basic needs of a population, such as energy and healthcare. Ensuring continuous critical service performance is at the core of the societal safety concept (Olsen et al., 2007). Critical services that contribute to such needs are increasingly delivered through procurement and contracting processes, to the extent that public procurement today represents almost one third of total government expenditure (OECD, 2022). The organizational fragmentation and complexity that this can produce further amplifies the need to develop robust and reliable safety performance indicators, including indicators that can reflect inter-organizational performance.

While there are clear advantages to increasing use of indicators they must be used carefully. The development and use of an indicator represents a process of abstraction and reification, in which intangible organizational and social factors and processes are translated into symbolic objects that can be measured, communicated and governed. However, complex and/or ambiguous indicators may make it difficult for different actors to develop a common understanding of safety. In addition to safety, other values such as production and efficiency often become connected to the same indicators. Consequently, despite their potential value, poorly conceptualized indicators can act as "decoys", directing attention away from critical information and organizational processes. Similar to social studies of indicators in other domains (Turnhout, 2009), what appears is a paradox making it clear that effective development and use of safety performance indicators are not self-evident processes: Safety performance indicators are necessary for the evaluation of safety management, but at the same time they are controversial and contested. Studying the meaning of a safety performance indicator beyond its eponymous function is therefore important to gain a greater understanding of conditions for indicator effectiveness and usability. This includes studying the multiple meanings that may be assigned to an indicator, how and by whom those meanings are constructed, and the associated implications for action. As practitioners are increasingly expected to understand the impacts and measure the benefits of public procurements (OECD, 2022) and other contracted services, this negotiation of meaning around shared safety indicators is of particular importance in the interorganizational networks that commonly deliver critical services.

In this context, where multiple organizations or groups interact, indicators can be conceived as boundary objects (Star and Griesemer, 1989), facilitating communication about the reliability and safety of system performance, and inviting collective examination of risks in ways that may not otherwise take place (Macrae, 2014). Conceptualising artefacts—such as safety performance indicators—as boundary objects that have meaning in more than one social world provides a useful way to consider how the tensions between different actors and viewpoints of safety may be negotiated or resolved. Further, boundary objects can have a political dimension: they may be used to impose meaning, rather than fostering collaborative negotiation (McGivern et al., 2018).

We investigate these issues using a case study of the Norwegian air ambulance service. In these services, operational helicopter and fixed-wing services are publicly procured by a national health trust. Air ambulance services are used in Norway for both planned and emergency patient transports, and so a necessary precondition for service provision is that the operator provides continually available crewed aircraft at bases around the country. Procurers, operating companies and pilots all have a role in system safety and yet we find that a key measure of system safety – availability – means different things to the different social groups. Availability serves as a boundary object that is negotiated and interpretated within the different groups involved in the provision of this critical service. How indicators are shaped by their social and relational context, and the social and organisational work that surrounds and is informed by them, emerges as a critical question in both understanding how safety indicators 'work', and also how they might be better constructed and developed in future

2. THEORETICAL FRAMING

We start by reviewing the current status of the literature on safety indicators, particularly debates about both the meaning and effectiveness of indicators. This leads us to selection of boundary object theory as our main analytical perspective, given its usefulness in cases where multiple actors assign varying meanings to a common object or concept, in this case a performance indicator.

2.1. Safety Performance Indicators

Measuring safety performance is a hot topic in the safety literature with recent contributions on what makes for a good safety indicator in fields as diverse as aquaculture (Holmen et al., 2021),

patient safety (Labella et al., 2022), merchant shipping (Gil et al., 2022), road transport (Ibrahim et al., 2022), building construction (Liang and Liu, 2022), and the process industries (Selvik et al., 2021). It seems that those with interests in all complex socio technical systems are still struggling with how best to detect flaws in order to predict systemic failures and prevent them.

All safety indicators are proxy measures for the desired outcome i.e., no deaths or injuries. Any indicator that does not measure that directly has built into it a model of why accidents happen and how they can be prevented (Reiman and Pietikäinen, 2012). With some exceptions (Leveson, 2015; Sultana et al., 2019) the theoretical origins of given sets of indicators are often obscure. Reiman and Pietikäinen (2012) note that safety performance indicators have various purposes in organizations where the typical indicators measure outcomes of activities or events that have happened (so called lagging indicators), while others provide information in support of anticipating and developing organizational performance (so called leading indicators). While lagging indicators have been used to define safety priorities or make conclusions about levels of safety, most systemic and dynamic approaches to safety performance claim that they are, on their own, of little help in understanding how the system is actually doing. For guaranteeing safety, lagging indicators must be complemented by leading indicators of system conditions and processes that drive safety forward (Hopkins, 2009; Reiman and Pietikäinen, 2012). Some researchers have gone so far as to propose that a set of indicators could be developed that would provide instantaneous feedback on the state of safety in a given system, a so-called safety barometer (Knegtering and Pasman, 2013), but difficulties in including organizational qualities into safety indicators have also been acknowledged (Kongsvik et al., 2010; Reiman and Pietikäinen, 2012). Despite significant research interest in safety indicators, including a special issue of Safety Science on this topic in 2009, several researchers have suggested a significant gap between parameters that are being measured as an indicator of system performance and the actual performance (Körvers and Sonnemans, 2008; Lindhout et al., 2020). Further, Swuste et al. (2019) predicted that the topic of safety indicators will remain in the spotlight for some time to come given their finding that ‘indicators do not logically relate to current safety theories and models’ (pg 85).

Criticism of the confusion surrounding indicators extends across sectors. Construction sector research has highlighted the extent to which companies tend to focus on factors that are easily measurable (Oswald et al., 2018) and easily quantifiable (Oswald, 2020), rather those that give a good indication of likely future safety performance—the selection of which would rely on a sophisticated model of what drives safety outcomes. Within research on patient safety, safety indicators and quality indicators more generally have been criticized for focusing on easily measurable factors at the expense of more important but less tangible factors (Groene and Sunol, 2014). For instance, research on safety indicators in prehospital care shows that safety monitoring systems have gradually evolved rather than being designed with clear purposes, leading to ‘safety blind spots’ (O'Connor et al., 2021).

Kongsvik et al. (2018) also highlighted two key limitations of indicators, noting that they are based on limited (and often biased) data about the system, and that there is always uncertainty associated with how well an indicator represents the actual underlying state of the system that the indicator is supposed to represent. It is particularly important that indicators can never fully capture or perfectly represent the underlying state of safety and so their use can lead to perverse consequences. In particular, there may be a tendency for individuals to ‘manage the measure’ rather than managing the original desired outcome for which the measure is simply a proxy.

Much of the research described above on what represents good indicators of safety performance is predominantly managerial and/or in technical nature and draws on a deductive mode of analysis. While this coupling between management’s desire to measure and safety science making safety measurable has been helpful in many ways, the continuing debates demonstrate that alternative

perspectives are needed that move beyond epistemological questions regarding what makes a good indicator. Safety science more broadly also draws on more inductive, empirical and constructivist theoretical perspectives about what constitutes and explains safety. Such approaches have been particularly valuable in contexts where there may be discussions or controversies over safety and lead us to ask questions about the ontology of indicators. A desire to investigate the nature of indicators in a social setting leads us to the selection of boundary object theory to investigate the use of 'availability' as a key outcome performance indicator in the Norwegian air ambulance service.

2.2. Boundary Objects

In one sense, a performance indicator is simply a number that may be assumed to measure a stable and widely agreed aspect of safety or system performance. But this simple view fails to consider the role that a conceptual and symbolic object such as a performance indicator has in social interactions, as well as the profound impact that non-human actors can have on human actors (Star and Griesemer, 1989; Suchman, 1987). In the case of the Norwegian air ambulance service, some of the most relevant actors are the procurer organization (which contracts the service), the operator organizations (which deliver the service) and the pilots (the professional group responsible for operating the aircraft). These people inhabit different 'social worlds' – groups that make meaning together and act on the basis of those meanings (Star and Griesemer, 1989). To study the role of the outcome indicator acting at the interface between social worlds to ensure public safety, we draw on the concept of boundary objects, as originally developed by Star and Griesemer (1989) as an extension to actor network theory. Boundary objects can be either abstract or concrete things that have shared meanings across multiple communities and enable collaboration from different social worlds (Anderson et al., 2018).

The notion of boundary objects has been used in a range of qualitative and ethnographic research particularly in the field of organization studies, in the sociology of science and technology and in knowledge management (see Trompette and Vinck (2009) for a detailed review) and increasingly in health and safety-related studies (Macrae, 2014). The theory has proven to be a useful way to consider how tensions between different actors and viewpoints are negotiated and resolved. As Star and Griesemer explored in their much-cited study of scientific work in a natural history museum, boundary objects provide a way of working such that, 'consensus is not necessary for cooperation nor for successful conduct of work' (1989, pg 388). Boundary objects support coordination and cooperation between social worlds by satisfying the informational needs of each group because the boundary object is at the same time 'weakly structured in common use, and become strongly structured in individual use' (Star and Griesemer, 1989, pg 393). Boundary objects are therefore '…entities that enhance the capacity of an idea, theory or practice to translate across culturally defined boundaries' (Fox, 2011, pg 71). Many studies have found that the concept explains what is observed when different communities of practice interact (Wenger, 1998).

In health studies, a wide range of artifacts have been conceptualised as boundary objects including quality models (Wiig et al., 2014), care pathways (Allen, 2009) and patients themselves (Bishop and Waring, 2019). In contrast, boundary object theory has not been widely used within the safety field, despite the interest in organizational safety in recent decades. A few safety scholars have used boundary object theory to investigate how different professional groups interact and the implications for safety outcomes. Macrae (2014) studied how experienced flight safety investigators interpret and acted in response to reports of flight safety incidents, examining how "incidents are transformed into risks, which then function as boundary objects, facilitating communication about the safety of organizational practice that otherwise may not take place" (Macrae, 2014, p 207). The process of constructing a particular risk as a boundary object allowed safety investigators to create objects of collective enquiry, around which specialists from various operational areas are connected and work together to examine organizational practices and improve safety. More recently, studies

using boundary object theory in the safety domain have focused on the extent to which different social groups working in complex systems negotiate an outcome which balances system safety and other potential goals (Hayes et al., 2022; Tillement and Hayes, 2019). In these cases, artefacts produced at work have a strong symbolic meaning that varies between professional groups and allows work to proceed, even in the face of multiple, and sometimes conflicting, goals.

This means, importantly, that a boundary object is 'something people … act toward and with. Its materiality derives from action, not from a sense of prefabricated stuff or "thing"-ness' (Star, 2010, pg 603). In our case, the availability of standby resources in the air ambulance service fits this description. It is monitorable and quantifiable, but at the same time it implies different things to different social groups. As such, it is a classic boundary object, 'a set of work arrangements that are at once material and processual' (Star, 2010, pg 604), not simply a static material object but rather 'the stuff of action' (2010, pg 603). As Fox describes, 'the concept of a boundary object is attractive. It offers the promise of communication across barriers, to facilitate the growth of knowledge or the success of a policy or other innovation. An effective boundary object might even succeed in bringing harmony to a dissensus, or peace to a conflicted situation' (2011, pg 80).

Alternatively, as some of the studies in the safety domain have shown, boundary objects are a way of managing conflict without necessarily finding a resolution. Instead, they may be 'to some extent imposed on particular groups and sometimes these are contested' (Oswick and Robertson, 2009, pg 188). As Oswick and Robertson point out, boundary objects are 'not inherently apolitical' (2009, pg 187). This has relevance in understanding the way in which indicators are used to try to manage system safety performance across multiple system boundaries. Therefore, what makes effective safety performance indicators needs to be given further consideration. In the perspective of boundary object theory, instead of attributing the effectiveness of indicators to objective scientific or policy criteria, the effectiveness of safety performance indicators becomes dependent on its usefulness and a social matter (Turnhout, 2009).

3. THE FIXED-WING AMBULANCE CASE AND 'AVAILABILITY' AS AN INDICATOR

The Norwegian air ambulance service, consisting of both fixed-wing (airplane) and rotor-wing (helicopter) services, is an important part of the emergency medical service chain on occasions requiring patient transport over long distances or from inaccessible areas. A national health trust owned by the four regional health trusts (subject to the Ministry of Health and Care Services) is responsible overall for the operational part of the services. This responsibility includes the procurement and contract management of air transport services at thirteen rotor-wing bases and nine fixed-wing bases on contracts ranging from six to eleven years in duration. Also, they oversee a flight coordination central, located at the University hospital of Northern Norway (UNN), which coordinates all fixed-wing operations. Personnel required to operate the air ambulance service (pilots, maintenance staff and, for rotor-wing services, rescuers) are provided by the contracted operators. The local health trusts affiliated with each base provide medical staff, usually meaning that a nurse forms part of the fixed-wing crew and a medical doctor is part of the rotor-wing crew.

While the air ambulance service includes both fixed-wing and rotor-wing services, the first is the focus of this paper. We take as our case for study the transition in air ambulance fixed-wing services from one private provider to another and the impact that this transition had on preparedness in the period June 2017 to approximately July 2020 (one year after contract start). We focus particularly on exploring how 'availability' served as a boundary object during the transition of responsibility for service provision when a new contract was awarded to an incoming operator who had not operated in Norway previously. The transition phase between the awarding of the contract (in June 2017) and the start of the new contract period (July 2019), involved conflicts between the outgoing operator on the one side and the procurer and incoming operator on the other. Also, the negotiations between the incoming operator and the pilots of the outgoing operator (represented by

their trade union) stalled. It was not until Parliament intervened, that negotiations were successfully concluded, and pilots were employed by the new operator. In summary, the transition phase, as well as the contract implementation phase (approximately the first year of the contract period) involved periods of reduced service output, extensive media focus and political involvement in the procurement process (self identifying reference removed). The consequences for the patients were not registered or systematically examined by the air ambulance service in retrospect (Norwegian Board of Health Supervision, 2021).

A core expected outcome and requirement for the air ambulance is preparedness. In essence, preparedness involves having crewed aircraft or helicopters available at all bases 24/7, thereby being ready for both planned and acute patient transport. Within the service, this is often referred to as 'availability'. When referred to as the state of having standby resources (and not specifically as an indicator), 'availability' is used interchangeably with 'preparedness'. Given that the helicopters and aircraft must be crewed to be defined as available, the concept reflects organizational performance and not a static presence of resources. As the following analysis shows, availability is not a neutral concept but has multiple, and sometimes contested, meanings across the different actors involved in the procurement process.

4. METHOD

This study adopts a case study methodology (Yin, 2018), using data triangulation, involving a combination of semi-structured interviews and document studies. Data was collected as part of an ongoing research project on societal safety issues related to publicly procured critical services.

An overview of the interviews of the four key groups that are analysed as part of this article is shown in Table 1. The interviews were carried out between August 2020 and June 2021 by one or two interviewers, with one of the co-authors involved in all interviews. Interviews with procurer representatives were mainly done at their headquarters in Bodø, while other interviews, due to the Covid-19 pandemic, were digital. Three of the interviews with the procurer representatives, being the first interviews to be conducted, had the aim of gaining broad knowledge of the air ambulance service including how procurements were carried out and contracts were monitored. These interviews included between two and four interviewees. Some of the procurer representatives were present at more than one group interview.

The remaining interviews were chronologically structured; the interview questions centred around the research participants' experiences with and perceptions of the different procurement phases. To capture the interview participants' experiences and descriptions, the introductory question for each phase was "Can you describe the period from xx to xx?" This was followed by questions regarding their actions in this phase, the challenges they encountered and their assessment of the procurement process at this stage.

Questions were deliberately open-ended, to minimize the possibility that the interviewers influenced the research participants' answers. If the research participants' statements appeared unclear, we validated our understanding by rephrasing the statements and asking the participants whether our understanding was correct. Central statements given by the first interview participants of each group were rephrased as questions to the remaining participants from the same group, to check whether the statements were representative for the group as a whole. References to concrete facts regarding the procurement process (e.g., dates, availability figures) were crosschecked with information found in documents.

Table 1. Overview of research interviews.

	Group interviews	Individual interviews	Interview participants

Procurer	4		8
Outgoing operator		3	3
Incoming operator		4	4
Pilots		6	6
Total	4	13	21

Interviews with the pilots' trade union, representatives from the rotor-wing operator, rotor-wing personnel (pilots and rescuers) and medical staff have also provided relevant background information. The documents reviewed are publicly available and include policy documents, board meeting documents, correspondence, and newspaper articles. The different actors' perceptions of preparedness and availability were not part of the initial interview guides but emerged as a relevant theme in the early data analysis phase. At first, in our reading of board meeting documents, availability figures seemed to be 'neutral'. However, in interviews, each organization's representatives described issues related to availability, but from different starting points. Moreover, their descriptions of availability levels during the various procurement phases contradicted each other, making the apparently neutral figures part of their conflicting views regarding the procurement process. This triggered our interest in availability as a theme. To further clarify our understanding of availability as an indicator, the last group interview with procurer representatives was focused on availability. The interview questions centred around how availability was monitored and procurer experiences with this, whether availability as an indicator reflects the operators' contributions to the service and the state of the operational service as a whole, and other factors that are important for air ambulance service outcomes.

Interviews were transcribed using NVivo. In the coding and analysis process, we followed a systematic text condensation approach (Malterud, 2012). Given our interest in availability as a boundary object, we identified interview quotes concerning 'availability' and 'preparedness' and coded these text sections. The further analysis led to a condensation of the codes centred around three themes: what 'availability' implied for the research participant groups, how availability was perceived in the transition phase and contract implementation phase, and how the reduced availability could be explained according to them.

As described above, 'availability' emerged from the data being collected regarding system safety as the research progressed. Deciding on performance indicators as an object of study before the interview process would have led to more detailed questions regarding the research participants' assessment of availability as an indicator. However, our approach has allowed us to situate 'availability' in a social and relational context which is considerably wider than its immediate use as an indicator and contract measure. Discovering the boundary object enabled us to analyse how research participants make use of it when describing their work processes and interactions with others. With procurer interviewees we were able to combine these two approaches by including an additional interview focusing on availability, but the time frames of the project did not allow a second round of interviews with representatives from all the organizations.

Analysing our empirical material, we see that availability was shaped and applied in a wide network of social groups and that it was formed due to their interaction over time. Some of these groups (media, politicians) were beyond the more limited social network that the project aimed to study. Extending the study to these groups that were not anticipated when the project was conceived may have provided additional insights. Based on our experiences, we recommend the design of future studies to allow for additional social groups that emerge from initial data collection to be included. Research designs that allow for the dynamic nature of social interactions regarding indicators and follow their interaction processes over time (e.g., using two rounds of interviews) are also to be encouraged.

5. RESULTS

In the transition and contract implementation phases, several social groups were affected by the reductions in preparedness that occurred as part of the contract transition. This analysis focuses on the four most relevant actors which were directly involved in maintaining availability, namely the procurer organization, the outgoing and the incoming operators and the pilots.

5.1 The procurer organization

5.1.1 Defining and managing availability

The procurer organization is responsible overall for the operation of the air ambulance service, including the procurement and contract management of operational services. To the procurer organization, 'availability' reflects two matters. On the one hand, it is the 'actual availability', meaning standby resources which are at the disposal of the emergency services and which the procurer organization is responsible for coordinating from a flight coordination central. By using availability in this way, anything affecting availability plays an equal role, whether it is unsafe weather conditions, lack of aircraft (due to planned maintenance or unforeseen technical problems), the crew situation (lack of available crew) or other circumstances that have the potential to impede patient transport by air. On the other hand, availability as a reactive measure of contractor performance is also seen to be essential and so used for contract management with the fixed-wing operating company. Here, it is the conditions within the control of the operator (such as planned maintenance and lack of on-duty crew) that are taken into account.

In the previous fixed-wing contract, the requirement for most of the bases was that for each quarter of a year, manned aircraft had to be available at least 95 percent of the time (taking only conditions within the control of the operator into consideration). According to procurer organization representatives, a downside to this was the operator could adopt a strategy of managing the measure in order to minimise costs. For instance, if the operator had 100 percent availability for two months at one base, it would be possible for them to move resources to a base with lower average availability to avoid payment cut-offs there, or to take pilots out of service for training purposes. While this was within the boundaries of the contract, significant reductions in actual availability at some bases could have negative implications for the patients, making availability a patient safety issue.

Requirements regarding the availability of rotor-wing resources have been more detailed, and also more successful in terms of achieving a high preparedness. Therefore, in the current fixed-wing contract, the procurer organization defined requirements which are similar to those used in past and current rotor-wing contracts. In these contracts, resources can be out of service for a limited number of hours each month due to either planned maintenance or lack of crew. In the case of unforeseen technical problems, alternative resources must be provided within 12 hours. According to operator organization interviewees, the current requirements effectively drive desired behaviours and have increased overall fixed-wing availability. Nevertheless, deciding whether the lack of resources is within the responsibility of the operator can sometimes be difficult. This was the case in the high conflict transfer period between the fixed-wing operators in 2019 (self identifying reference removed), moving attention away from maximising the availability of the service to patients towards allocation of blame for any shortfall. Also, payment penalties incurred must be balanced against the total financial situation of the operator. As one procurer representative described,

> *A cut-off for lack of preparedness is about 200-220 000 kroner per 24 hours per event. Of course, if there are many of those it's quite expensive for the airline. And then the dilemma for us is if they say that "if you curtail us [i.e., reduce payment] now, we are not going to make it [i.e., go bankrupt]." In that way we lose our scope of action.*

This person is concerned that imposing a significant financial penalty on the operator that is designed to improve their performance could result in loss of the service entirely if the operator fails financially. This was seen to adversely impact system performance.

5.1.2 Availability as a performance indicator

In addition to using availability to manage their contractor, availability is treated by the procurer as a visible overall indicator of the quality of the service they provide. This measure is used internally and in communication with those higher in the supply chain to demonstrate outcome. Internally, daily availability overviews are presented on a screen in the coffee break area at the headquarters so that real time availability data is always on show to staff and visitors. It is also reflected in how the procurer reports to the owners (i.e., the four regional health trusts). Along with economic overviews, other more detailed safety indicators and flying time production, availability figures are reported at all regular board meetings. Here, the overviews of availability are accompanied with brief descriptions of availability reductions. An example of this from a board meeting in 2018 is:

> *Availability for fixed-wing ambulances has so far this year been 92.7%. In the period August-September availability has been 95.7%. Out of service situations are mainly due to sickness and lack of crew. [There has been] a significant improvement in availability the last months compared to April/May this year. Out of service situations due to [pilots reporting] "unfit" [for flight] are reduced and back at prior levels. Only 3 hours in August and September.*

Overall, procurer representatives experience that the owners define the frames for the air ambulance service but leave the running of the services to them. The preparedness situation exemplifies an exception to this. As the quote above shows, detailed operational information is reported to the owners even though this is outside the direct control of the procurer. According to one interviewee, "In my experience, what the owners are concerned about is when there is a failure in the agreed delivery. In other words, unexpected events or concerns about the preparedness […]. That's when I experience that we get the most involvement from the owners." In this way, availability has become a proxy for the effective performance of the procurer and/or operator and yet, procurer organization interviewees emphasize the complexity of the air ambulance service and that the service to end users is dependent on the combined contributions of multiple organizations. Coordination issues, for example between air ambulance units and road ambulances, have been highlighted both in an internal report aiming to improve the efficiency of the service (Luftambulansetjenesten HF, 2017) and in an external investigation of the fixed-wing ambulance services (Norwegian Board of Health Supervision, 2021). They also highlighted that the system is flexible in the sense that fixed-wing resources can be acquired from a neighbour base if the closest resource is unavailable.

5.1.3 Procurer experience of availability in the transition phase

During the transition between fixed-wing operators in 2019, a considerable number of pilots lacked the mandatory training to operate the new aircraft models that were to be used. Seeing in advance that this would have a substantial effect on availability, the incoming operator provided extra resources (crewed aircraft) from its umbrella organization and the procurer acquired extra resources from private companies and the Armed Forces to make up the shortfall. The situation was closely followed by the owners and the Ministry of Health and Care Services. In the words of one of the interviewees, "anything that smells like it might reduce preparedness on a national level makes the alarm bells [in the Ministry] sound".

By this time, availability as a performance measure was being communicated to the public by the media. The Ministry of Health and Care Services instructed the procurer to publish online daily updates regarding availability at each of the fixed-wing bases. These overviews showed the number of hours that the different resources were available and were published until May 2020. According to the procurer, availability becoming the public point of reference created problems for them in relation to how the operator's performance was perceived by others. In the new contract, the procurer had attempted to move away from a fixed percentage by using a more fine-grained method

for assessing availability, but the media and other external stakeholders made calculations of what the availability percentage should be when the new contract requirements were met. One example referred to in the media was that requirements in the new contract equalled an availability of 98.4 percent. In October 2019, the procurer published a press release to make clear that this was not the case. As described by one of the procurer representatives, "in a way we have been pushed into using percentages in the new contract. And that is because in media and politically it became the big point of reference".

On the positive side, public awareness of the preparedness situation has affected the monitoring of the air ambulance service. As explained by one procurer interviewee,

> *The air ambulance service has never been as monitored as it is now. I make daily statistics for this, and this is partly because we were overwhelmed with telephone calls from the media from the autumn of 2019 onwards. We are on it and consider each case of unavailability. Is it the operator's responsibility or outside it? Ask critical questions all the way. That didn't happen as much in the last contract. The air ambulance service operated out of reach of common people, if I can use that expression.*

Despite the ambiguity over exactly what constitutes availability and who is responsible for any temporary lapses in performance, this interviewee notes that media interest has improved their monitoring of the operator's performance.

5.2 The outgoing operator

5.2.1 Availability perceptions

When the outgoing operator lost the fixed-wing contract to a competitor, it marked the end of a more than 30-year presence at some of the bases. Outgoing operator interviewees have described how contributing towards patient transport is professionally meaningful. Maintaining availability above the accepted level is one aspect of this. Not least, this is apparent when they describe the effort that was made towards the end of the contract period. As expressed by one interviewee,

> *[When the contract period was over] I was simply overjoyed by the fact that we had delivered and we were very proud that we had delivered the availability we did. Once we had filled the gap of the pilots that left, towards the autumn of 2018, we delivered to the letter until the last second. And that was absolutely not to be taken for granted.*

As well as being a source of professional pride, availability was also a contractual matter for the outgoing operator. Not least, this was apparent in their response to the fact that the pilots were needed both to operate the current ambulance service and to train for the coming service in the spring of 2019. One of their suggestions was to reduce availability for a period, but this was rejected by the procurer organization. Recapturing the dialogue with the procurer organization, an operator interviewee phrased it this way:

> *'The availability requirement in our contract… if you are willing to adjust this we can take the employees out of service and sign them up for courses run by the new operator. […] But in that case, we can't be punished for this.' The [procurer organization] sharply turned this down: 'No, you have to deliver the service according to contract.'*

The transition requirements, in particular training pilots to operate the new service, introduced a new factor that impacted availability and responsibility for managing this became another potential point of conflict.

5.2.2 Explaining reduced levels of availability

According to the outgoing operator, the reduced availability in the contract implementation phase was rooted in the procurer's lack of understanding of what was required to keep availability at an adequate level. In the words of one of the outgoing operator interviewees,

> *They should have understood, or understood but didn't care, that [the incoming operator] never would meet the requirements, which said that July 1st 2019 availability was going to be at [the predefined] level and that everything was in place. It was simply impossible for [the incoming operator]. And everyone associated with aviation knew that. Or everyone who is competent in this field. So that was the main problem.*

Furthermore, the outgoing operator claimed that their competitor won the new contract on incorrect grounds and the calculations regarding the resources needed to meet the availability requirements were an important part of this. According to the outgoing operator, the competitor had gambled that they could save costs by keeping the number of employed pilots at a minimum and relying on them to take on extra shifts to a larger extent than in the previous contract.

5.3 The incoming operator

5.3.1 Availability perceptions

To the incoming operator, availability is a valuable indication of the delivery level they are at and whether they need to adjust to ensure future preparedness. In this way, availability is an important operational measure for them but there is also a clear political dimension. They see availability as a parameter which gives the public an indication of whether they can be transported in medical emergency situations. As one interviewee phrases it:

> *It's maybe the only parameter which says something to people. If we have low availability in Brønnøysund for four days, it means that we actually don't have an airplane available in Brønnøysund. If you become acutely ill we have to get hold of an airplane from somewhere else. And of course, these are national resources, and resources are moved around. But it says something, it's a signal to the population in that region that this is what the numbers look like.*

Illustrative of this claim, the incoming operator uses this signal effect of the indicator actively for communicating with the outside world, by publishing availability figures on their Facebook page. One of the interviewees argued that public providers of helicopter services (e.g., the rescue helicopters or police helicopters) should be monitored in the same way: "Well, our availability has always been measured. All of a sudden everyone knew what the availability figures for the air ambulance services were. Maybe then it's right to ask 'why don't other public and private entities do the same?' ". They are of the view that other services should be subject to the same political pressure that they experience.

5.3.2 Availability perceptions in the contract implementation phase

The incoming operator and the procurer organization realized in advance of the new contract period that it would be impossible to have enough fully trained pilots ready and that this would affect availability. As a result, extra crewed aircraft were supplied by the operator and, in addition, the procurer acquired extra helicopters and aircraft. In this sense, whether the functioning of the service was reduced became a question of which resources to include in the overall availability indicator. In the opinion of the incoming operator, preparedness was maintained throughout 2019 and was never critically low. Rather, to them it was a question of how availability was presented by stakeholders, the media and politicians. As one interviewee phrased it:

> *We had placed an extra helicopter in Tromsø, we had an extra helicopter from the Norwegian Armed Forces in Kirkenes, there were two aircraft from another company and in addition we supplied three Swedish resources [aircraft]. There has hardly ever been a better preparedness. But this did not come out. Focus was placed on our grounded aircraft. The total preparedness was considerably better, the ones who yelled and shouted about this knew that. But it was not in their interest to tell the whole story.*

This interviewee was making the point that while they might have been unable to meet their contractual requirements at the start of the contract period, overall, the availability of a means to transport patients for care was very high due to the various contingency arrangements that has been put in place outside their contracted service. Despite this, media reports focused on availability in the narrow sense and reported that targets were not met. According to the operator, this affected the public impression of availability in this period. One interviewee referred to this as "perceived negative preparedness". Another interviewee described the situation like this:

> *I'm sure that if you had talked to 100 lay people… or 1000, which is what you normally do when you collect data…. If you had asked them "Where do you think, in percent, the level of preparedness was at during the last half year of 2019?" Ask that question to 1000 people in Finnmark, and my guess is you would get something between 30 and 60 percent. How about telling them that actually on average it was over 97, or close to 97*

percent? Then I think the response would be "Oh, I didn't realize that. But once when Agda (generic female name) needed to go to Alta (town in Northern Norway with hospital facilities), the ambulance wasn't there."

This interviewee was of the view that the public perception of the availability of the emergency service was grossly incorrect.

5.4 Pilots

5.4.1 Availability perceptions

Most of the fixed-wing bases are at airports with short runways situated in areas where weather conditions are a limiting factor, meaning that fixed-wing ambulance pilots need to have specialized competence and experience (self identifying reference removed). The interviewed pilots recounted that working in the air ambulance is meaningful but also emphasized that the desire to contribute by transporting critically ill or injured patients must be balanced against aviation safety. When a crew is on duty at a base, the aircraft at this base (given that there are no technical issues) will be registered as available. However, aviation safety conditions surrounding the pilots are also important for whether the aircraft actually can be utilized. This relates to the end of work shifts and duty time restrictions, but also to the judgements of pilots regarding, for instance, weather conditions.

In this way, 'availability' is closely tied to pilot work schedules. To make the work schedule fall into place, operators depend on pilots to work some extra shifts in addition to their obliged workdays. In the transition phase, this was all the more necessary. When the 2019 contract was awarded to a new operator, and future job prospects were uncertain for the pilots, some of them resigned from their positions, affecting availability (self identifying reference removed). In interviews, pilots have recounted that they felt a strong commitment towards the outgoing operator, but that they were exhausted from the uncertainty surrounding the transition process. While some worked extra to compensate for the lack of personnel, others felt that, given the circumstances, this would be too demanding. One of the interviewees described it this way:

Really, it was like puncturing a balloon. It burst, and people didn't have the energy, they were exhausted. And the problem was that this made people talk more about it, making them more mentally worn out. People weren't capable of working overtime, they didn't come in their spare time [i.e., take extra shifts], they talked about it during the flights.

When negotiations between the incoming operator and the pilots' trade union over a collective transfer of employees failed in April 2018, all on-duty pilots were reported as 'unfit for flight' by the Nominated Person Flight Operation due to their stress levels in the immediate aftermath of the negotiation failure. They could report as fit again on an individual basis when they felt ready. In interviews, pilots have expressed that this was a necessary safety measure given the circumstances. At the same time, some of them also point out how the media focus this created contributed to reaching an agreement with the incoming operator. In the words of one of the pilots,

There were a lot of coincidences leading up to reaching an agreement, but amongst other things, the grounded aircraft created a media storm and several pilots and other stakeholders wrote about the process. This resulted in a hearing [in Parliament], which in turn led to us reaching an agreement.

The situation calmed when an agreement over the collective transfer of pilots was reached. However, the pilots were discontented with some aspects of the agreement and the process leading up to it. It took a long time and several profound changes in the employer-employee relation before the pilots felt the same type of commitment towards the incoming operator. One of the pilots describes it this way:

[The outgoing operator] was really in our hearts. And being proud of our employer, everyone made an extra effort and turned up on short notice and worked a lot in their spare time. Working for [the incoming] operator, there was a lot of discontent in the beginning and a lot of insecurity since we didn't really feel appreciated. […] When we were on duty we did our tasks just like at [the outgoing operator's] and we worked overtime too, but we didn't work extra shifts for [the incoming operator] in the beginning.

In this way, availability had become a factor that the pilots could use in negotiating with their new employer.

6. DISCUSSION

6.1 Availability as a boundary object

As a boundary object, availability has different meanings in the social worlds of different organizations and groups. Availability, for the procurer, has two faces: one faces ‘up and out’, the other ‘down and in’. Availability is used to assess the performance of the procurer organization by external parties, such as the owners, the media and government; and availability is also a primary parameter that the procurer uses to look inwards to assess the performance of the fixed-wing aircraft operator. Although availability is defined more narrowly in the latter context, focusing on availability performance data becomes a way of managing the procurement relationship with the contractor, and communicating what performance is required from them. And, as external and public scrutiny of availability performance increased, the procurement organization increasingly engaged with availability as an object of inquiry, or epistemic object (Miettinen and Virkkunen, 2005), which invited further scrutiny and triggered closer examination of the activities of the operator. Availability, as a boundary object, therefore acted as a bridge that translated increased public and political attention into more intensive and inquisitive scrutiny by the procurer organization of actual operational activities. That is, availability is transformed into "an interpretive device that is used to do epistemic work" (Macrae, 2014, p206) in the spaces between different organizational actors.

The outgoing and incoming operators share several perceptions of availability, some externally facing and some internal. Firstly, availability is understood to be an important indicator of preparedness and so directly linked to public safety i.e., the ability to transport ill patients at short notice. In this context, the operator seeks to maximise availability. Despite its functional importance, operators are also well aware of the external political dimension of availability when it comes to published data and public perceptions regarding operator performance and public safety. They also resent the blurring of the definition of availability knowing that overall system performance and so public safety is a function of much more than simply their fixed-wing aircraft data. This manifested itself differently for the two operators. For the incoming operator, availability became a source of public and political misinterpretation. For the outgoing operator it became a source of conflict with the procurer which says more about the procurement process than public safety.

Despite the (somewhat imperfect) way that availability can represent safety for the operators, availability is also used internally as an operational parameter that becomes enrolled in efforts to optimise the financial side of service provision, managing resources in a way that minimises cost whilst meeting contractual availability obligations. In this context, lower availability is cheaper to provide, but the contract sets a minimum requirement at which financial penalties arise. This provides financial incentive to ensure that resourcing levels and activities such as maintenance and training are organized so that minimum requirements are met.

These uses of availability sat somewhat uneasily with another: that managing this complex service delivery to meet the availability target was also a source of professional pride linked to the provision of a high-quality service to the public. The way that operators relate to these two aspects of availability—optimising around a financially beneficial minimum floor level or working to enhance the professional pride of delivering effectively for the public—may, in themselves, offer rich proxy indicators of the organizational and cultural approach to safety performance within different organizations. The inherent ambiguity of boundary objects, such as the availability metric,

and the ways that organizations interpret and organize around these potentially offer a revealing lens into an organization's engagement with safety and performance indicators more broadly.

For the pilots, professional pride lies partly in high performance through overtime working and negotiating the situated judgements that underpin go/no go decisions. Another key aspect is the value ascribed to aviation safety more generally and the provision of an important public function – safely flying patients from remote areas to locations where they can be treated. At the same time, pilots understand availability is important to others and their contributions are critical in meeting politically-motivated availability targets. This gives them a source of power that can be, and has been, used during the transition period in their collective negotiation over terms and conditions linked to the move to a new operating company. In this sense, indicators are not necessarily 'apolitical'; how they are used also depends on the interests of the different social groups.

Prior to the contractual transition period, the procuring organization had the capacity to manage differing perceptions of availability in their relationships with the owner and with the contracted service provider. The increased pressure on the system during the transition has shown the fragility of this indicator as a measure of public safety due to the multiple meanings of availability in different social worlds.

Table 2. Overview of different meanings of availability.

	Procurer	**Outgoing operator**	**Incoming operator**	**Pilots**
Measure of procurer performance	X			
Measure of contracted performance of operator	X	x	x	
External measure of preparedness	X	x	x	x
Source of public and political misinterpretation			x	
Source of conflict		x		
Way to optimise operations		x	x	
Source of professional pride		x	x	x
Source of power				x

6.2 Availability as an indicator of system performance

As described above, availability came to be seen, publicly, primarily as a measure of preparedness. It is interesting to consider how well this single parameter performs in this role. Given its status as a historical average, availability is also fundamentally a lagging, outcome indicator with all the limitation that come with that. An outcome here means the temporary 'end result' (Reiman and Pietikäinen, 2012) of this part of the supply chain and its contribution to the overall health care systems' quality and patient safety outcomes. We also see that requirements can be specified in different ways. A minimum availability percentage sounds simple, but the time period over which it is averaged makes a difference. As we saw, according to procurer representatives, the outgoing operator used this flexibility to reduce services on some occasions in order to save money if they were ahead of the minimum target with the end of the period approaching. From the perspective of the procurer and the public, this form of 'managing the measure' is unlikely to be desirable. On the other hand, a simple percentage is highly recognizable to stakeholders outside the system, who may think this gives them a clear and immediate understanding of system performance—even if this is not really the case.

The availability of aircraft to perform successful patient transport from remote bases is a function of many things other than the operator being able to provide an aircraft with the appropriate crew.

There are factors outside the operator's control—such as, most obviously, weather. These factors, being fundamental for aviation safety, are a limiting factor for patient transport which appeared to be overlooked in the public debate. There are also other ways in which an emergency transport service can be provided as demonstrated by the range of contingency measures that were in place immediately following the contract transition—and that the incoming operator drew on to claim that availability performance was never placed in jeopardy, despite the adaptative and resilient performance required from multiple other parties to ensure this was the case. In summary, operator performance (as reflected by the availability measure) came to be seen as an indicator of public safety in spite of other factors both limiting and enabling patient transport by air.

The problems with availability as a measure of system performance have already been reported. In a supervision report of the fixed-wing ambulance service conducted by (Norwegian Board of Health Supervision, 2021), the gap between contracted availability and actual availability is problematized. Furthermore, the report identifies challenges to patient transport which are not sufficiently taken care of in the air ambulance today. Amongst other things, these include challenges in the interfaces between different parts of the patient transport chain. Also, it identifies a lack of knowledge regarding the service as a whole, including total transport time for patients.

If availability is a poor measure of overall system safety, then why do key stakeholders focus on it so much? Using boundary object theory, we see that a broad output indicator such as availability can have leading qualities in practice and thus be more effective at promoting positive change than might be predicted. The indicators' appeal to different social groups allows for discussion and a subsequent reflection and adaptation of how the indicator is used by the organization or social group that defined it in the first place. This underlines that although safety monitoring systems may have gradually evolved rather than being intentionally designed (O'Connor et al., 2021), this evolution can be a reflexive process resulting in an improved application of the indicator. Social groups may not be in complete agreement about system performance, but an indicator that becomes an effective boundary object introduces stability into the system. Despite its weaknesses, availability has some advantages as a performance indicator that only become clear through the lens of boundary object theory.

6.3 Implications

The fixed-wing ambulance case exemplifies how, for critical services receiving considerable public attention being delivered within a complex network of organizational actors, indicators originally developed for internal monitoring and contract management can become malleable, contested and highly visible symbolic objects of organizational, professional and public interest. In our case study of the fixed-wing service procurement, the procurer organization intended to make the management of availability finer grained and not expressed as a percentage, but public awareness of the reduced preparedness led to an interest in comparable figures. In this sense, a challenge with indicators is not only that they favour easily measurable factors (Groene and Sunol, 2014; Oswald et al., 2018), but that they are potentially overvalued because they appear tangible and comprehensible to the outside world. Furthermore, when public interest in the indicators increases, organizations may be pushed towards prioritizing measures affecting the indicators at the expense of other measures and activities that may have more tangible linkages to safety performance.

When indicators become the focal point of contests and negotiation, it follows that more complex and less measurable factors are overshadowed or made invisible. Pronounced examples of this from the fixed-wing ambulance case, which are likely to be relevant also to the delivery and governance of other inter-organizational critical services, are interface issues related to coordination and joint responsibilities between the different parties responsible for delivering the service (e.g., Almklov and Antonsen, 2014; Cedergren et al., 2018). Coordination issues have been recognized as a pressing matter internally in the air ambulance service (Luftambulansetjenesten HF, 2017) and

have, along with the lacking wholistic responsibility for the service, been identified as important factors for decisive delays in patient transports (Norwegian Board of Health Supervision, 2021). The quality, safety and performance of the total output of the patient transport chain is however more difficult to monitor than the availability of crewed aircraft.

Moreover, our research has also shown how focusing performance management activities and financial incentives on outcome indicators such as availability can create complex and counter-intuitive problems that reveal some of the inherent tensions in managing the safety of critical services by aid of such means. This is particularly the case when using the threat of imposing significant financial penalties on an operator as an incentive to improve performance. On the one hand, if people interpret an indicator as a threat, this may create pressures within an organization to 'game' the indicator and hide bad news to avoid a potential penalty (Bevan and Hood, 2006; Hood, 2006). This is commonly referred to as Goodhart's Law: transforming an indicator into a target can render it useless as an indicator (Hood and Piotrowska, 2020). On the other hand, in the arena of critical services, it may be self-defeating to impose a significant financial penalty on an operator, as that penalty may then reduce the resources available to address risks and improve safety or at the extreme may bring about the financial failure of an operator, which in turn has implications for the provision of critical services—particularly in sectors such as healthcare where there are limited or no options for alternative providers to rapidly step in (Murray et al., 2014). The network of meanings, interpretations and incentives that an indicator is embedded within can therefore lead to that indicator working in both unintended and unexpected ways.

Furthermore, critical service provision like that of the fixed-wing ambulance necessitates effective decision-making of individuals in different parts of the service chain. Pilots considering a patient transport mission are an example of this. Firstly, individual professional judgement regarding, for instance, weather conditions are critical to the safe operation of the service and directly impact availability. Secondly, when transport missions are likely to exceed pilot's regulated working hours, individual pilots must carefully appraise the importance of the mission against their professional capability of working overtime. Our analysis of availability as a boundary object identifies that factors influencing such judgements may become invisible, or put under considerable pressure, when availability is treated as a single, undifferentiated indicator and focus of performance management. This resembles the difficulties of including organizational qualities in outcome indicators which have been identified by other researchers (e.g., Kongsvik et al., 2010).

7. CONCLUSIONS

This case study of the Norwegian air ambulance service explores the array of challenges that must be negotiated when defining and using system performance indicators within complex supply chains. Studying these indicators as boundary objects allows for a wider understanding of how indicators are embedded in a social and relational context. While it is widely accepted that indicators are proxies for the performance they intend to reflect, conceptualising them as boundary objects allows more nuanced and sophisticated exploration of how these indicators, and the performance that they are intended to indicate, is interpreted and negotiated between different professional groups. Moreover, as our analysis has shown, these interpretations and negotiations become embedded in the evolving patterns of how a particular indicator is used and evaluated within and between organizations. This points to an important and promising, but currently under-explored, perspective on safety indicators: how indicators are shaped by their social and relational context, and the social and organisational work that surrounds and is informed by them, is a critical question in both understanding how safety indicators 'work', and also how they might be better constructed and developed in future.

Accordingly, this study indicates that there would be much value in further exploring and applying boundary object theory to investigate performance indicators in a range of safety domains. Such

studies should seek to go beyond the specific technical design and definition of indicators, and should more expansively engage with the social and organisational work that is done to, and through, safety indicators in ongoing efforts to understand and manage the safety of complex systems. Importantly, the analysis developed in this study highlights how the organisational utility of an indicator is not necessarily tied to consensus in definition or interpretation; indeed, the interpretive flexibility that indicators afford can be an important source of organisational coordination as well as a stabilising mechanism that allows different, and sometimes competing, cognitive communities to productively organise around a common safety objective. What would seem particularly important to extend our understanding is a better account of how these processes unfold over time within and between organisations and different professional groups. Our study here offers a temporally constrained view of a single safety performance indicator during a confined time period. To further develop and apply the conceptual apparatus of boundary object theory in the realm of safety indicators will require more extensive studies of a variety of these objects and the work that goes on around them in different organisational settings and industrial contexts; and it will require even more expansive studies across time and organisational space (Macrae, 2019), to understand how indicators—and the ways in which they are interpreted, contested, negotiated and stabilised—unfold over time and at different levels of and scales of organisational activity.

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