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Debates and politics in safety science

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Safety research as a systematic, scientific subject is fairly young, with the pioneer works of the social science and organisational approaches to safety dating back to the seventies (e.g. [80]). Since then, safety research has developed through different phases, each marked with different focus areas. Hence one often refers to the three ages of safety, each characterised by different foci and different types of attributed causes for accidents and different research scopes[17]. The first, technological age of safety was followed by the age of human factors, after which safety research entered the age of organisational attention including such themes as safety culture and safety management systems. It is particularly after entering the age of organisations that the social science approach to safety really expanded both in terms of volume and perspectives.[1] This development was fuelled by a number of organisational accidents during the 1980s; Bhopal[7], Chernobyl[66], Three Mile Island[60], Piper Alpha(Pat [59] and Challenger[83] are all examples of accidents that spurred substantial research activities with the aim not only to establish the causes of the accidents, but also to develop theories of risk and safety that reflected the developments that had taken place in terms of increased complexity of industrial sociotechnical systems. It was in this period that the social sciences seriously entered the arena of safety research. Surely, the social sciences was already represented, Barry Turner [80], [81], [82] and Charles Perrow [60] – both sociologists – had at this stage already contributed with strong empirically informed theoretical frameworks that still enjoy a central position in the field of safety research, and in light of that they should be considered pioneers in the social studies of risk. Until the 1980s, the field of safety research had largely been dominated by contributions from engineering and psychology, and foundational contributions from Reason [67,68] and Rasmussen [64,65] have kept on gaining momentum and influencing the thoughts of safety scholars up till today. However, from the 1980s onward, safety science increasingly attracted scholars with background from sociology, anthropology, organization and management science. Examples are the sociologist Diane Vaughan with her ethnographic studies in NASA following the Challenger accident[83], sociologist Andrew Hopkins' study of the gas plant explosion at Longford [28], the organizational theorist Karl Weick with his works on organisational sensemaking[89], and the Berkeley research group and their work on High Reliability Organisations (HRO) [40,41,[90], [91], [92]].

Among the most recent contributions to the field of safety research that has achieved status as a school of its own is Resilience Engineering[[23], [24], [25], 27,56], developed and nurtured by Erik Hollnagel, David Woods, Sidney Dekker, Jeffrey Braithwaite, Jean Pariès and others,[2] with the derivative concepts of Safety II (and Safety I), contrasting conceptually and qualitatively different approaches to safety [14,20,22,26,79].

Along with the increased research activity and increased public interest in safety, debates between different perspectives became important for the nurturing and scaffolding of research communities that subscribed to the different perspectives. In this paper I shall look into three such debates; that between Normal Accident Theory and High Reliability Organisations, that between High Reliability Organisations and Resilience Engineering, and the debate over Safety I/Safety II. The article summarises these debates as they appear as different orientations and traditions to safety.

The core arguments of these debates is well known matter, and they have been remarkably stable over the years, indicating that there are still unresolved issues there. On the other hand, much criticism has been raised about these debates, about the lack of precise definition of core concepts and whether there really are significant and sufficiently defined differences between the foundational assumptions in the respective traditions: that allowed or conceivable variations in behavior of systems is insufficiently accounted for when referring to accidents as normal or abnormal; that the role of public visibility of high reliability organisations is neglected, thus also how normal accidents return as public attention decreases; that success is insufficiently defined, and when boundaries for success are defined Safety II reverts to Safety I; that RE has so many similarities to HRO that it is hard to see that it represents something new; that when people continue to make reference to NAT, it is not because that work supports their arguments but simply to establish that they are aware of the relevant literature; and that research/science and business are so

intertwined that there is an additional rationale for advertising scientific differences (see e.g. [[2], [3], [4], 29,58]).
I do not take a stance to this criticism here, but instead I ask: What if there are more and other things to these debates than has so far been explicitly exposed? What if there are some more foundational issues at stake, that can be excavated from these discourses? The article pursues this challenge by discussing how the debates hide fundamentally different perspectives on *complexity, events* and *uncertainty*. In this discussion, the article draws on literature from outside the traditional safety library, in particular writings on workplace studies (e.g. [76,78]) and Actor Network Theory (e.g. [18,46]). The consequence of the analysis is operationalised into three propositions for future safety science research.
In the article I shall develop a richer understanding of these central debates that are played out in the research literature. Central journals including Safety Science and Journal of Contingencies and Crisis Management, in which there are also special issues to be found ([39,50,88]), explicitly facilitate the debates. Other, less systematic facilitation for the debates can also be found in the literature, and I shall adopt the pragmatic approach of accounting for them where they appear most visible.
The paper is structured such that first, historic and contemporary debates within the safety science community are presented. I label these debates overexposed, certainly not with reference to the quality of the debates or the arguments that are held, but due to their persistence despite a lack of progress and a tendency to stabilize and stall at a very early stage. Thereafter, I shall, following a mode of reasoning inspired by Actor Network Theory, lend words to some tacit themes that claim higher criticality than the core issues of the 'standard' debates. I label these themes underexposed, certainly not with reference to any sort of scientific superiority, but because they represent turns that the safety science discourse may take if it is opened up again and reach out from the sometimes self-referential scientific field. But before I proceed with this, I shall briefly account for the theoretical perspectives that engage into these debates, and the justification for bringing perspectives from Science and Technology Studies into safety science research.

1.1. Highly profiled theories of organisational safety and risk

Three approaches to safety have acquired a central place in safety science research, due to the combination of two achievements – that of formulating a foundational theory of safety (or why some organisations fail and others succeed), and that of constructing or taking actively part in debates where the different theories or perspectives are put up against each other; while many pioneers have a share in what was to become a recognizable field of safety science from the 1980ies and onward, the perspectives of Normal Accident Theory, High Reliability Organisations and Resilience Engineering have a special status with respect to prevalence and attention. Their core messages as widely known by now:

According to Normal Accident Theory systems with tight coupling – with tightly prescribed steps and invariant sequences that cannot be changed, implying that interruptions propagate rapidly through the system, and that there is little slack and little room for improvisation – require a control mode that is centralised. Systems with complex interactions – where accidents tend to stem from "mysterious interactions of failures" ([61], 10) – require a decentralised control modus. These requirements are sometimes sources for organisational contradictions; since sociotechnical systems cannot be centralised and decentralised at the same time, systems that are both tightly coupled and interactively complex cannot in the long run be managed in a safe manner.
High Reliability Organisations are characterised by two distinct features: organisational redundancy – both structural and cultural – and the ability to reconfigure spontaneously and more or less seamlessly rearrange from a modus of centralised control to a management mode of decentralised control when experiencing a crisis and going from a normal work mode to a mode of crisis management [40,41]. Another description of HROs are their five characteristics of collective mindfulness – *preoccupation with failure, reluctance to simplify interpretations*, s*ensitivity to operations, commitment to resilience*, and *underspecification of structures* [93].
Resilience Engineering is inspired by the ecological references to resilience, and if one is to speak of the essence of resilience, itis "the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress" ([27], 16). As RE has its roots in cybernetics thinking, central themes are *adaptation, variability* and *functional resonance*. The recommendation of RE to study and learn from that which goes right has given rise to an alternative definition of safety – *Safety II* – the "system's ability to succeed under varying conditions" ([26], 4). The counterpart to Safety II is labelled *Safety I*, defining safety as the absence of undesirable events and accidents, and freedom of unacceptable risk.

1.2. Science and Technology studies perspectives in safety science research

As with Safety science, one might say that Science and Technology Studies (STS) is a young academic field. Growing out of the early orientations towards the sociology of knowledge (e.g. [10,38]), it manifested itself strongly with the early contributions from e.g. Latour and Woolgar [47], Pinch and Bijker [63] and Callon [12], some of who were also central in the development of Actor Network Theory (ANT) [43,46] – a branch of STS. Since then, STS perspectives has become naturalised in many of the more established disciplines and fields, for example sociology, geography, and computer science.
STS perspectives and methods have not been completely absent in safety science, but it would be an exaggeration to say that they have been numerous and very visible. One prominent example, however, is the works of Diane Vaughan (e.g. [83], [84], [85]), where the relevance of STS for safety research is convincingly demonstrated. Other authors who have successfully adopted STS perspectives in their writings include – but are surely not limited to – Le Coze [53], Almklov and Antonsen [5,57]. Personally, I have found significant resonance in the methodologies and the mode of reasoning in Actor Network Theory (ANT). The liquid characteristic of ANT lending it a status located somewhere in the intersection between ontology, theory and methodology of phenomena where the social and the material is tightly coupled, makes it useful in the exploration of sociotechnical systems and

sociotechnical work in a context of risk and safety [30,32, 33, 34, 35].

The way established issues and themes are treated in ANT works is often different – and sometimes surprising – from the common treatments, and not seldom this is done with a critical and renewed view on what analytical concepts represent and what empirical findings are really cases of – as for example in studies of complexity [77], modes and methods of scientific work [42,44] and the ontology of risk and uncertainty [18,45,46,48]. Besides alternative and often constructivist approaches to established subjects, the ANT catalog offers a substantial repertoire and track record on empirical research methods particularly on social aspects of technology, and material aspects of the social. It has always been an ambition for safety research to traverse this bridge, safety science indeed having been an interdisciplinary field from the very beginning, but the field as such is still struggling to be able to stand safely with feet both in the social tradition and in the engineering tradition simultaneously. ANT was developed with exactly such an ambition, and has much to offer safety science in this respect.

ANT research is always looking for controversies, as they represent cracks where light gets in and makes visible what phenomena/systems are made up of.[3] Such controversies need not be major – they may not even have to be explicated, and may thus have to be actively searched for. In the following I shall do exactly that; heat up some controversies that may lie hidden in the shadows of some less heated debates in safety science. The aim is to inspire to creative search for doors to new rooms in safety science research, where we may find new questions and answers relevant for the old world of industrial and organisational safety, but also for the new world of societal resilience that is being gestalted as we speak.