ON TURBULENCE: ENTANGLEMENTS OF DISORDER AND ORDER ON A DEVON BEACH

TIM CRESSWELL & CRAIG MARTIN

Department of Geography, Royal Holloway, University of London, London, UK.
E-mails: tim.cresswell@rhul.ac.uk; craigjmartin@virgin.net

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ABSTRACT

This paper considers the importance of the notion of turbulence for the theorisation of mobility. Turbulence, as disordered and unpredictable mobilities, can be contrasted with smooth 'laminar' flow – where everything is moving 'correctly'. This paper borrows from the philosophies of Michel Serres and Manuel DeLanda to think about turbulence as a process which makes visible the always-contingent orderings of infrastructural mobilities. The paper is illustrated with examples from container shipping and, particularly, the grounding of the *MSC Napoli* container ship off the coast of Southern England. Turbulent mobilities are contrasted with the smooth operation of infrastructural mobilities that are supposed to remain silent and invisible. The dramatic and very visible instances of turbulence, that no system can ever predict or make disappear, provide an entry point into the ordering of a mobile world.

Key words: Turbulence, mobilities, infrastructure, order, disorder

INTRODUCTION

Bumper packs of nappies sit next to dog food; tins of spaghetti nestle alongside packs of expensive French perfume. An overturned car lies damaged inside a shipping container. BMW motorcycles are manoeuvred out of containers under cover of darkness. Their potential new owners gleefully straddling them as their friends push them along on makeshift skidboards to prevent them sinking into the shingle. Others stand proudly next to their expensive 'prizes'. The scene resembles a veritable marketplace, with people directing others to the specific location of goods strewn across the beach (Morris 2007, p. 3). Shortly to be posted around the beach are notices from the Receiver of Wreck informing people to return goods scavenged from the beach to the Donkey Sanctuary in Sidmouth, Devon. This incident, the beaching of the container ship, the *MSC Napoli*, off the Devon coast in January 2007, offers a veritable snapshot of distributive space – that phase of contemporary capitalism typically hidden from the consumer gaze. The grounding also represents the entanglement of order and disorder: for some (those beachcombing), it is a welcome eruption of disorder; for others (the vessel's operators) it is a decidedly unwelcome episode that will lead to increased insurance premiums and the cost of the clean-up operations; for the Receiver of Wreck, it is a necessary aspect of their job, the recalibration of the system, just as it will be for the Marine Accident Investigation Branch, charged with investigating the cause of the grounding. These various actors, the objects strewn on the beach, the people charged with recovering the goods, those investigating the grounding itself, among numerous others, are all testimony to the shifting registers of order and disorder, neither of which is permanently stable, always locked into a disjunctive interplay. This is turbulence.

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We argue that the notion of turbulence should be a central concern of contemporary theorists of mobility and the mobile. This argument is part of an ongoing attempt to create a meso-theoretical account of mobility and its relation of power and order, subversion and disorder (Cresswell 2010). A consideration of turbulence offers a valuable means to posit the shifting parameters of the mobile world, where the construction of ordered mobilities (Easterling 1999; Packer 2008) may be analysed alongside the moments where mobilities falter. While turbulence has long been capturing the imaginations of physicists and mathematicians it has only sporadically entered the world of the humanities and the social sciences (see Polley 1997; Summers-Effler 2007). As a conceptual and analytical tool the application of turbulence to social theory also reflects wider debates emerging from complexity theory (Urry 2003), dynamical processes (DeLanda 2002), political theory (Bennett 2010; Connolly 2011), and assemblage theory (DeLanda 2006; Robbins & Marks 2010; Anderson & McFarlane 2011). Overall, these various approaches explore contingent, processual, and heterogeneous formations that are unpredictable in their becoming. They embrace the entanglements of ordering practices and clashing, immanent disorderings. In practice, all attend to non-binary approaches to socio-spatial relations. Assemblage theory, in particular demonstrates how various forces continually construct, deconstruct and reconstruct each other, offering forms of temporary stability coextensive with their potential collapse. We encounter the continual making and unmaking of social processes. While the importance of Deleuze and Guattari's (1986, 1988) development of assemblages should not be underplayed, DeLanda (2006, 2011) has perhaps most thoroughly developed the theory of assemblages. The premise of DeLanda's ontology is realist, but his approach is above all anti-essentialist. That is, the world is constituted by processes, not through the essence of things. Here, then, we are witness to his focus on emergent processes of relation as opposed to the inherent properties of things. For DeLanda we cannot reduce the wholeness of a system to its component parts (also see Bennett 2010). As with the emergent processes of complexity theory 'every sort of entity is an assemblage. This entails that no object is a seamless whole that fully absorbs its components' (Harman 2010, p. 172). There is an endless layering of different assemblages, with no fixed totality. As emergent, the relations between things do not simply add up to a whole. Assemblage theory strips away systemic totalities, and in doing so uncovers 'an endless chain of interlinked forms, each form never fully actualised in its surroundings' (Harman 2010, p. 179).

While the value of assemblage theory to contemporary mobilities research should not be underestimated, we continue to deal with turbulence for two key reasons: one, it foregrounds a set of decidedly mobile metaphors, with particular stimulus coming from fluid dynamics; second, the language of turbulence in the popular lexicon continues to foster an image of negativity: instead we want to dispel such representations and address the complex entanglements of creative, discordant events and eruptions of re-orderings which are fostered by theorisations of turbulence. It is not simply the case that order (or disorder) prevails, rather turbulence produces new forms of complexity and thus, like assemblages, demands that we attend to the shifting interactions between the variegated forces of contemporary mobility. For mobility studies the recognition of turbulence forms part of a wider engagement with the idea and practice of mobility in the modern world (Urry 2000; Cresswell 2006; Hannam *et al.* 2006; Sheller and Urry 2006; Adey 2009). The discussion of this, we suggest, necessarily involves the spatio-temporality of turbulence.

The paper proceeds in the following way. First we excavate the theoretical importance of turbulence in the work of Serres and DeLanda. Here the focus is on the relationship between turbulence and notions of order(ings) and disorder(ings). We argue that rather than seeing turbulence as secondary to ordered motion it is necessary to think of it as an event in the production of transitory order(ings). In the following section we apply these ideas more specifically to mobilities research. The final extended section before the conclusion considers the case of the *MSC Napoli*. This illustrates and (literally) grounds many of the arguments made in the preceding sections, noting in particular how the constant presence of localised

disorderings, as well as their coextensive couplings, resulted in the grounding. We also consider how the post-accident reports may be seen to institute a temporary sense of (illusory) order into the ongoing turbulence of the container shipping industry. In doing so our aim is not to repeat the common mistake of mapping ideas from natural science on to the social sciences and humanities in order to inherit some of the intellectual cache of 'proper' science. Rather we want to think through some of the implications of the idea of turbulence for social and cultural situations. Through such approaches we follow the lead of other scholars attempting to translate conceptual frameworks across different registers, be it with turbulence (Rosenau 1990; DeLanda 1991), assemblage theory (DeLanda 2006, 2011) or indeed parasitism (Serres 2007). As part of a broader project to construct meso-theoretical accounts of mobility we necessarily draw on a number of theorists in this paper. We are not suggesting that all of these theorists always agree with each other (though some of them would be clearly sympathetic). We are simply interested in those aspects of a variety of work that are useful to our consideration of turbulence as a mobile event. The main thrust of this paper concerns theory construction. The case of the *MSC Napoli* is provided in order to both illustrate some of the abstract ideas and to hint at some of the ways turbulence theory may have purchase on the unfolding of events in the world.

TURBULENT THEORY

In 2007 Alan Greenspan, the former chairman of the US Federal Reserve, published his autobiographical account of recent changes in the economic world under the title *The Age of Turbulence*, with an admission, or rather a warning, of how the post 9/11 economy is flexible, open and fast-changing (Greenspan 2007). This use of the term appears to confirm populist conceptions of turbulence as politico-economic turmoil, techno-scientific failure or environmental catastrophe. A more reflexive exploration of the impact of turbulence on global politics has been Rosenau's (1990) *Turbulence in World Politics*. Here Rosenau presents us with a new model of global politics in a post-state-centric world, where the state has been replaced, or at least supplemented, by a number of other spaces of political authority. He tells a familiar story of how traditional forms of authority have become weaker, how previously important collectivities have fractured and how small groups have become more powerful, in terms of their potential to effect change. In particular, Rosenau situates turbulence within the rubric of organisation theory, and in doing so addresses wider models of complexity, most critically where the increasing interconnectivity of the post-state-centric global political system fosters the potential for 'these interconnections to fluctuate more frequently and more rapidly' (Rosenau 1990, p. 59). Interconnectivity is potentially fallible in the face of higher-order complexity: that is, instability is immanent to the increasing interconnectivity of the global (see Dillon 2005). Such accounts mobilise turbulence in similar ways to the everyday or popular definitions. Flexibility, threat, openness, and uncertainty are all part of the equation, as are disorder, complexity, randomness and lack of predictability. At the same time it refers to a feeling of things being out of control, a wilful unruliness, a breakdown in traditional ways of thinking and being. What we make of turbulence depends very much on our investment in the kinds of orderings that turbulence allegedly makes untenable. To some, turbulence is a threat and to others an opportunity.[1]

The work of DeLanda (1991, 1992, 2002) has adeptly navigated the relationship between turbulence and its application to a range of socio-political arenas. Equally, the translation of turbulence theory between the natural and social sciences owes a great deal to the work of the French philosopher, Michel Serres. It is Serres's approach that we primarily address. Perhaps Serres's most prescient text on turbulence is *The Birth of Physics* (Serres 2000 [1977]). Here Serres reconsiders the atomist philosophy of Epicurus and particularly the work of Lucretius in his long poem *On the Nature of Things* (Lucretius 2001). Central to both Lucretius and Serres is the idea of the *clinamen*: a small, almost unmeasurable deviation in movement that becomes the source of all turbulence and thus of all substance and life. For Lucretius it is the interaction of atoms as they fall through the void that is the wellspring of life. Without the

deviation, or swerve, from the fall, 'all would fall downward through the unfathomable void like drops of rain; no collisions between primary elements would occur, and no blows would be effected, with the result that nature would never have created anything' (Lucretius 2001, p. 41). Of central importance to the theory of the clinamen is deviation. Serres's analysis of the Lucretian clinamen stems from his interest in the spontaneous interactions produced by deviation. Rather than atoms requiring some form of external stimuli, it is argued that, 'deviation occurs spontaneously, with no cause and to no end' (Webb 2000 p. x). The swerve may be said to be an unpredictable fluctuation, or what Serres (2000, p. 4) terms a 'fluxion', in the orderly fall of atoms in the void. Emanating from the study of fluid mechanics, the concept of the clinamen is invested in the supposedly orderly movement of laminar flow, where the movement of atoms are in parallel. But for Serres this is not the case in the natural world, where laminar flow is an illusion. It is a dream or a theoretical ideal of order. The image of atoms moving perfectly in parallel and never meeting is a world in which nothing exists. Once an atom begins to move at a slight imperceptible angle collisions happen and turbulence occurs. Turbulence appears to reign.

However, as Serres (2000, p. 27) goes on to argue, 'the physical theory of turbulence contains a paradox'. Although turbulence would seem to suggest that disorder would prevail, the reverse is in fact apparent. The turbulent movement of a fast-flowing river for example, may be formed of intricate orders. When the liquid reaches a certain speed or 'critical point' 'the random flow of a moving liquid gives way to the intricately ordered patterns of turbulence' (DeLanda 1991, p. 7). Within eddies of turbulent flows lie highly ordered formations. It becomes difficult to discern order from disorder. From Lucretius, Serres sees turbulence as both *turba* and *turbo*. The former 'designates a multitude, a large population, confusion and tumult. It is disorder' (Serres 2000, p. 28). *Turbo* suggests a vortex, a 'round form in movement like a spinning top, a turning cone or vortical spiral. This is no longer disorder, even if the whirl is of wind, of water or of storms' (Serres 2000, p. 28). There is a form of metastability, a temporary balance between them. Utilising Plato's example of the child's spinning top from *The Republic,* Serres considers the seeming paradox of both stability and instability in the movement of the top. It is at once in movement, teetering turbulently on its axes, and simultaneously perceptibly stable, the pinnacle appearing ordered: like a liquid in motion its momentum provides stability. We must consider, Serres suggests, how variation emerges from invariance. They coexist, impossible to distinguish them: 'is it stable?' he asks, 'Yes. Is it unstable? Yes, again' (Serres 2000, p. 28).

What does this offer us? Above all it dissolves the supposed universality of equilibrium and order, providing instead a much more complex representation of temporary equilibrium: of fluxions in equilibrium, but equally of the immanent presence of orderliness co-present within such fluxions. DeLanda (1991) extrapolates on the apparent paradox of immanent order and disorder in his discussion of hurricanes. As turbulent weather phenomena they are an example of order emerging out of chaos. However, the spontaneous emergence of temporary order is also the production of disorder in terms of their potential effects. So, the internal operation of the hurricane may be seen as illustrative of spontaneous, emergent order, whereas the external consequences (environmental destruction, loss of property, human life, etc.) are clearly disorderly. Added to this, temporariness points to the problematic of predictability. Where the model of laminar flow might be defined in relation to predilections of classical science for a governable, perfectly functioning system of reversibility, and thus predictability, the onset of turbulence is decidedly unpredictable (see Prigogine and Stengers 1984).[2] This notion is confirmed in the mathematician, Rene Thom's (1975) concepts of catastrophe and singularity. While we may think of catastrophe as a serious breakdown in the order of things, in mathematical terms, catastrophe is what brings things into being. In particular it allows specific, non-predictable things to emerge from relatively small singularities. Opposed to 'reified generalities' (DeLanda 2006, p. 26), singularities are those critical points of localised change or systemic redefinition. These events of intensive change at moments of bifurcation (DeLanda 1991),

defy the calculative logic of predictability and instead are instances of systemic self-organisation, where it is not possible to pre-establish what will occur. It is a dynamic possibility of things becoming different and distinguishable. Once turbulence exists then we move from a universality of sameness to a topology of localised singularities. And this topology of possibility negates the efficacy of all-encompassing and unilinear theory.

> If, through the clinamen, the origin of every event or system is always multiple, then every attempt to reduce change to a unilinear process must necessarily fail. There is, therefore, no universal history, no unilinear development and thereby no single frame of reference within which all events may be encompassed (Webb 2000, pp. xii–xiii).

The political power of this line of thought is not to be underestimated. The turbulent emergence of singularities makes any single frame of reference redundant. To summarise the account of turbulence in Serres then, we can see a shift from thinking about turbulence as a disruption to otherwise smooth flow, to an understanding that order is secondary to turbulence. We can also see how turbulence produces singularities – localised objects and events that are not intelligible within generalising or universalising frameworks (also see Serres with Latour 1995).

TURBULENT MOBILITIES

How might these theoretical tenets of turbulence help us engage with mobility? First perhaps, as a reference to those moments when the smooth operation of the space of flows is disrupted, and when the often-invisible networks of mobility are made visible. This figurative meaning of chaos and confusion draws on the literal meaning of unsteady movement. Turbulence is movement out of permanent order. This is one way in which we can think of the importance of turbulence. But given the implications for higher-level orderings that may occur at moments of singularity we also need to attend to the material mechanisms that analogously attempt to impose some form of enduring order. As Deleuze and Guattari have argued:

> The State needs to subordinate hydraulic force to conduits, pipes, embankments, which prevent turbulence, which constrain movement to go from one point to another, and space itself to be striated and measured, which makes the fluid depend on the solid, and flows proceed by parallel, laminar layers (Deleuze & Guattari 1988, p. 363)

Mobility, they suggest, does not happen evenly over a continuous space – it follows imposed conduits. Attempting to produce order and predictability is not only a matter of fixing in space but of channelling motion – of producing correct mobilities through the designation of routes. This is the imposition of calculability on the unpredictability of singularities. Following Serres we might think of mobility as a primal state rather than as an outcome that is channelled. In the social sciences it is commonplace to think of mobility as secondary to forms of sedentarism. Refugees move to escape the conditions of home, migrants weight the various utilities of home and destination, transport planners attempt to arrange space in order to minimise the dysfunctional 'dead time' of travel. These are all but symptoms of a deeper ideology that invests in stability and sees mobility as a symptom. In Serres's work, mobility and fluidity are the general state of things rather than an exception in a solid world (also see Mol & Law 1994). 'Solid bodies' we are told 'are just exceptionally slow moving fluids' (Webb 2000, p. xi). Any image we may have of the sedentary is an illusion. Once again we have to reverse our preconceptions. Any seemingly settled order is simply a contingent moment that will soon slip back into the turbulent unfolding of the world.

At a more practical-political level it is clearly possible for people to intentionally introduce turbulence to systems of mobility – or, more accurately, to interfere with the systems of ordering that make the world appear less turbulent than it is. And indeed they do. In the space of flows, rather than the space of places, particular kinds of struggles predominate. This is not solely the struggle of tactical mobilities against strategic territorialisation (De Certeau 1984). This is a struggle over mobility itself in a world in which the powerful are producing the effects of power through the space of flows (Castells 1996). In this world the 'weak' can

create turbulence, those singular moments of deviation. We can think of the actions of Somali pirates attacking the shipping lanes of commodity mobility, or the parasitic harnessing of extant commodity routes utilised by tobacco smugglers (HM Treasury/HM Revenue & Customs 2006). This also moves beyond the solely human ability to produce instability, for as Actor Network Theory and other recent theorisations (Thrift 2004) demonstrate, more-than-human agency can introduce systemic deviations. We might think of natural forces (Cresswell 2006; Langewiesche 2006; Protevi 2009), or material recalcitrance. As with the conceptual basis of turbulence theory the realist ontology of matter-independence (see DeLanda 2009), begins to situate the potential insubordination of the material to systemic orderings. Turbulent materiality is not thinking about the solid and concrete (Anderson & Wylie 2009), but about the space between chaos and order where each is immanent to the other. Thinking about matter as turbulent allows an engagement with matter that sees it as lively, vibrant and ongoing (Bennett 2004, 2010; Thrift 2004). Addressing such spaces and singularities of turbulence as conditional to mobility has an interesting effect on the world Castells describes in his outline of a 'network society'. This world-image is one of 'smoothness' based on infrastructural power. In a valuable exploration of the 'smoothing machine' of contemporary capital Bogard (2000) offers a conceptualisation of smoothness, and one that builds on Deleuze and Guattari's (1988) notions of smooth and striated space. Bogard (2000) notes how their rendering of such spaces is driven by the intermixing of the two, rather than their opposition. In this situation the striation of smooth space leads to the emergence of new smooth spaces. That is, they continually interact and intersect, producing one another.

For our elaboration of turbulent mobilities the infrastructural orderings in Castells' space of flows, right down to the familiar towels hanging in the hotel bathroom, are the result of constant and watchful effort to recalibrate the potential deviant bifurcations of the mobile world. But once more we have to pause and listen to Serres. Recall his suggestion that ordered flow can emerge from turbulence and not the other way around. As a result we see that figuring mobility by addressing such deviations in the calculative space of ordered mobilities – including all the effort of constant maintenance needed to make things work (Graham & Thrift 2007) – suggests the institutional logic of prioritising turbulence. One such arena where this is the case is that of logistics and supply chain management (Cowen 2010). At first this appears predicated on the possibility of laminar flow. Turbulence seems to be its antithesis: chaotic, unpredictable and beyond any calculus. But of course, as we have seen the two are logically related: *turba* and *turbo*. Turbulence cannot happen except in relation to ordered motion. As Rosenau suggested via organisation theory, the more the calculative logic of logistics attempts to predict and control turbulence through evermore complex forms of global interconnectivity, the more likely it is that turbulence will erupt and interrupt the workings of the mobility machine, but also underline its inherent complexity. These are the ceaseless, ongoing disruptions and recalibrations of contemporary mobilities. As Serres (2000, p. 27) states: 'order or disorder, it is difficult to decide'.

ERUPTIONS OF TURBULENCE: THE BEACHING OF THE *MSC NAPOLI*

As the above sections have tried to articulate, research on mobilities needs to think through the implications of turbulence. Conceptualising turbulent mobilities should facilitate considerations of the entanglements of stasis and movement (Martin 2010), as well as the friction between different forms of mobility (Cresswell 2010). As mobilities of all kinds multiply and collide, becoming more complex and more central to the world we inhabit, so, by implication, do the entanglements of order and disorder, manifested by the complexity of interactions between various actors in the mobilities assemblage. The opening vignette concerning the beaching of the container ship, the *MSC Napoli* off the coast of Devon in Southwest England testifies to this (also see Cook and Tolia-Kelly 2010).

On 18 January 2007 the container ship, the *MSC Napoli,* was damaged in a storm off the South coast of England. Its 26 crew took to the

lifeboat and were rescued. The ship, once one of the largest container ships in the world with a capacity to hold over 4,000 containers (MAIB 2008), was towed towards Lyme Bay and the port of Portland. Fearing the ship would break up, on 20 January the *MSC Napoli* was beached in the relatively sheltered waters of Branscombe Bay, off the coast of Devon. There were 2,318 containers on board, 700 of which were stowed on deck and just over 110 of these were washed overboard. Fifty containers and their contents washed up on beaches along England's South coast over the next few days (Mercer 2009).[3] Most were on Branscombe Beach. Between the 21 and 23 January, large crowds gathered on the beach and began to salvage the contents of the smashed containers: the nappies, dog food, motorcycles described at the outset. While the contents of the open containers was classified as salvageable goods, and thus governed by the 28 day rule whereby salvors have this time to report their finds to the Receiver of Wreck, the beach itself was deemed a 'crime scene' after sealed containers were broken into. During the week of these events the media was full of wide-eyed reports that fixed on the kinds of things being scavenged, resulting in, what the main inquiry termed a 'mendacious, national, and ultimately frightening interest in the prospect of illegal profit' (Mercer 2009, p. 13). By 24 January the beach was cordoned-off by the police in an attempt to reinstate order.

How are we to make sense of this literal and figurative turbulence? Of course, the incident speaks to the wider, popular conceptions of turbulence as a form of turmoil and disaster. This is clearly demonstrated by the effects on the marine ecosystem (302 tonnes of oil was lost from the ship; Mercer 2009), incidents of criminality, the economic costs to the shipping line, as well as resultant increases in insurance premiums to the shipping industry as a whole. But is it possible to conceptualise this through the specificities of turbulence theory? We identify a potential approach to this question that bears upon the combinatory forces of order and disorder.

First, let us consider the singular moments of localised deviation and spontaneous interaction, as conceived by Serres. In representational terms the flotsam washed-up on the shore at Branscombe Bay is symbolic; it is a visible marker of global complexity and the liveliness of matter (Bennett 2004). Subsumed within the ruined edifices of smashed shipping containers and their strewn contents are the interactions of the system. But rather than such interactions being stable, the flow of fluxes through the system (De Landa 1992) produce uncertain, unpredictable combinatory forces of natural and material deviation, alongside systemic weaknesses. According to the investigation carried out by the Marine Accident Investigation Branch (MAIB 2008) there were a number of contributing factors that led to the accident. Overall, the ship 'encountered heavy seas, causing [it] to pitch heavily' (MAIB 2008, p. 1), and due to a material failure in the engine room the hull suffered a catastrophic failure, causing a large vertical fracture on both sides of the ship, leading to its abandonment. The first we might term a form of 'natural agency' which may be said to lie outside of systemic control; the second, we might call (after Bennett 2004) 'recalcitrant materiality' in terms of non-human contributory factors. However, the report states that no single factor was deemed responsible, highlighting the contingent interactions of the system. While the ten central contributing factors are listed in separation (MAIB 2008), the revealing aspect of the report concerns the distributed nature of these factors. Like Bennett's (2010) analysis of the North American electricity blackout of 2003, the lead-up to the beaching of the *Napoli* was a result of a series of critical failures, including; the lack of safety margins in the design of the ship's structure, which can affect the impact of whipping effect along with bending moment of the hull; the speed of the vessel during the incident; the design of the ship itself, such as the placement of the engine room; as well as 'discrepancies in the declared weight of the containers' (MAIB 2008, p. 45).

These are telling reminders of how even the most stringent means to protect the commodity distribution system from disruption cannot account for the immanent presence of turbulence within any system. But there is an important adjunct to this aspect of the argument beyond the fact that there was a deviation or swerve in the smooth, laminar flow of commodity mobility. What turbulence theory enables

us to garner from this is not simply that such occurrences act independently of one another, rather that they *spontaneously collided at critical points of bifurcation*. The heavy pitch resulting from heavy seas was a contributory factor in the hull failure, however the singularity of this instant depended on the spatio-temporal 'collision' with the other contributory factors, including the speed of the vessel and weaknesses in the ship design. To follow DeLanda, (1991) this was a bifurcation, a spontaneous mutation of the system resulting from the confederation (to use Bennett's term) of order and disorder. Although Webb's (2000, p. viii) assertion that Serres's work on Lucretian atomism fosters the importance of 'unexpected kinships' may seem counterintuitive in light of such an accident, it does highlight one of the central theses of turbulence theory: 'the irreducible complexity in the order of events' (Webb 2000, p. xii), and the lack of predictability and stability in such unfolding circumstances. The increasingly complex networks and systems of contemporary mobilities have turbulence or error built into them.

This much is clear from the MAIB report: all of the contributory factors are testament to disordering presences that manifest themselves when the singular moments of combination occur, even though they are ever-present. They create their own turbulence through the complexity of interactions. From this we might add that all infrastructures of mobility have the logic of 'normal accidents' immanent to them (Perrow 1999). To be sure, the concept of the accident, as demonstrated by the beaching of the *MSC Napoli*, is a telling one in relation to turbulence theory. While work on the 'accident' has been articulated in a variety of fields such as human geography (Hewitt 1983), sociology (Perrow 1999) and risk management (Hood & Jones 2001), it is the more recent work in cultural and social theory (see Virilio 2007) that proves most relevant to turbulence. The notion of the accident or the disaster (Furedi 2007), may seem to adhere to the populist rendering of turbulence as disruption, however Virilio's work in particular exhibits a closer affinity between turbulence theory and the accident than the popular notion implies. The technological, like the natural accident, can be said to adhere to a mode of viewing error as illegitimate. There are, however, some distinctions to be made between the natural and artificial accident. In particular the technological accident is a specific case of the close proximity between the accident and normative operation, between perceived disorder and order. According to Virilio (2007, p. 9) the critical difference between the 'natural' calamity and the 'artificial', man-made accident is that the latter is technologically determined. With the technological accident a variety of tropes specific to Modernity become evident, but for the present argument in particular the role of standardisation is paramount (Bowker & Star 2000; Egyedi 2001). Where the rise of standardised mass-production methods led to a proliferation of cheap commodities, as well as the ability to distribute these through standardised modes of transport (i.e., containerisation), if we accept Virilio's dictum then such systems ultimately lead to the repetition of the standardised accident. That is, the technological accident is one that is determined by the standardised mechanisms of technology itself, leading to the spread of the accident through the entire system. This notion of the ever-present accident opens up another facet of turbulence: that of its potential for deliberate opening up of often-invisible systems in a directly political way. Turbulence can de-naturalise infrastructural systems and open them up to scrutiny – making the previously taken-for-granted mutable. In doing so it points to our second postulation regarding the value of turbulence for studying mobilities.

We want to follow the approach of Virilio (2007) and suggest that the grounding of the *MSC Napoli* may posit the notion of turbulence as a 'creative' fluctuation. Again, although it may appear rather distanced from the effects of the beaching, the 'creative' potential of turbulence is demonstrated by this accident, in that it reveals the distributive space of capitalism, thus demonstrating a potential politics of turbulence (also see Anderson & Wylie 2009). The hidden infrastructures of spatio-temporal domination are often only revealed through the productive eruption of turbulence or the accident, indexed, in this case, by the flotsam washed onto the shores of the south coast. Turbulence literally punctured the veil that screens-out infrastructural activity, exposing

the stringent practices and procedures in place to try and maintain the flow of commodities.

The potential of turbulence in epistemological terms resides in its ability to produce new ways of looking at the world, albeit with often devastating effects. The standardised shipping containers, carried by the *MSC Napoli,* are part of the global infrastructural apparatus of containerisation that brings us the 'stuff' we purportedly need – the motorbikes, the nappies, or the dog food. The sudden appearance of these things, together, on a beach, seems riotous, chaotic, unexpected, or turbulent in the populist lexicon. But this juxtaposition is the very nature of the distributive space of consumer capitalism – a space that has been subjected to remarkably little critical scrutiny, with the main focus on logistics (see Easterling 2005; Cowen 2010). Containers are piled high on thousands of ships as they crisscross the world. They accumulate, however briefly, in massive container ports. Then they move onto trains or trucks from port to warehouse and from warehouse to shop. The vast majority of things that travel the world do so in containers yet they remain a remarkably invisible part of the social, political and cultural landscape. When we see them we have no idea what it is inside. Their invisibility is a marker of the systemic developments of containerisation since the 1950s (see Broeze 2002; Levinson 2006).

In part, their ability to traverse the shipping lanes, roads and rail networks of global distributive space is a result of the standardised, homogenous and uniform qualities of the wider systemic design strategies of containerisation. The infrastructural efficiencies of commodity distribution are premised on a supposedly seamless system of interaction: between, the containers themselves and their movement across a variety of interfaces. This is where the politics of such apparent efficiencies or orderings are revealed. Both accident reports note that a contributory factor was the discrepancy between the weights declared by the packer or shipper of containers and their actual weight, thus leading to the potential overloading of the vessel (Mercer 2009).[4] Although the MAIB report acknowledges that it was difficult to ascertain the total weight of the containers onboard at the time of the accident due to waterlogging (MAIB 2008), it does however reveal the extent of undeclared container weight. Some 20 per cent of the containers stowed on deck 'were more than 3 tonnes different from their declared weights' (MAIB 2008, p. 29). As a result the loading software could not accurately ascribe a correct or stable loading position for individual containers. Further to this, the MAIB report (2008) notes that 7 per cent of the on-deck containers were incorrectly positioned when compared with the planned loading positions, leading to potential instability. Although such situations may be due to human error, there is an important codicil to this. Practices of under-declaring the weight of containers is seen as endemic to the container shipping industry, for reasons of lessening import duties (MAIB 2008; also see Nordstrom 2007), and overloading ships to improve economies of scale.[5] This latter point is further proven when the issue of speed is contemplated. Speed is considered central to the distributive space of capitalism, as identified by the original research into the potential benefits of containerisation (McKinsey & Co. 1966). However, speed was a key contributory aspect of the *MSC Napoli*'s hull failure. If the speed of the vessel had been reduced during its engagement with the heavy seas the potential failure of the hull would have been reduced. Rather tellingly the MAIB report (2008, p. 43) outlines how the schedule-driven ethos of the container transport industry results in the will 'to carry as much as possible as quickly as possible'. These issues point to the political implications of turbulence for mobility studies. While the propagated image of containerisation and the wider supply chain management industry is one of increasing efficiencies (cf. Paché 2007), the unfolding events resulting in the beaching of the *Napoli* highlight a profoundly more complex image of such mobilities, where turbulent inefficiencies are pervasive presences, resulting in part from the desire for economic gains provided by the apparent ordering strategies of containerisation. To return to our earlier point: disruption is intrinsic to the mobilities assemblage.

So are the entanglements with reordering strategies. This much is clear from Bogard's arguments concerning the smoothness of striation and the striation of smoothness. It is also evident in Serres's teetering spinning top. Our

final position comes from Rosenau's (1990, p. 48) argument that 'all disorder we observe is, in fact, ordered, if not orderly'. While again determined by the point of observation (Serres 2007), this is perhaps proven by the procedures of re-stabilisation instituted by the post-accident investigations into the *MSC Napoli* carried out by the Marine Accident Investigation Branch (MAIB 2008), and the main public inquiry (Mercer 2009). Both reports testify to the central argument of turbulence theory: that order can emerge from chaos. The findings of the MAIB report are decisive in terms of attempting to reformulate the system so that the potential for similar accidents to occur in the future are reduced. Indeed, the MAIB report acknowledges that as a result of the *MSC Napoli* accident the structural inefficiencies of this particular class of container vessel led to some 1,500 similar ships being screened and for a recommendation that 'technological aids for measuring hull stresses on container ships' be developed (MAIB 2008, p. 1). Equally the eight recommendations of the full *MSC Napoli* public inquiry (Mercer 2009), further evidence the attempts to reassert a form of systemic stability, where potential incidents in the future are managed centrally. In this it differs from the stated aims of the MAIB more broadly, which is 'the prevention of future accidents through the ascertainment of its causes and circumstances' (Merchant Shipping Regulations 2005, p. 4; also see Anonymous 2008). By contrast the public inquiry suggests that to assume 'that it [a maritime accident] will never happen again is not a sensible contemplation' (Mercer 2009, p. 3). Instead it focuses on the need for preparedness where 'a half-decent contingency plan must prepare everyone concerned for the worst' (Mercer 2009, p. 3). In this aspect the public inquiry adheres to Anderson's (2010) definition of preparedness as the preparation for the aftermath of events. Most notably with regard to this is the identified need to reformulate the National Contingency Plan (MCA 2006), to ensure that the authority for control is made clear to the parties involved, a situation made all the more striking by the differentiation between land and sea-based incidents (Mercer 2009). So while the reports approach the recalibration of the system from somewhat different perspectives, they both adhere to the central problematic of instituting higher-levels of order that emerge from turbulence. The findings from both reports represent systemic reconstitution, reorganisation and re-stabilisation (Wolfe 2007).

However, the theoretical implications of turbulence are once more telling, and this leads to our final brief point. While both reports recognise systemic failings they still promote a worldview premised on the potential for smooth laminar flow, and stabilisation. They problematically assume that stability can be reformulated through the coherent dissection of the singularity of the accident, illustrated through the use of individualised recommendations. In the case of the MAIB report the 16 overall key contributing factors are identified, leading to a situation where the multiplicity of non-coherent facets and 'unexpected kinships' of the accident are subsumed by a coherent set of 'reasoned' means to deal with the complex event of the accident (see Law 2004). It is arguable whether the reports, as modes of address, can 'get at' the unfolding, localised and emergent kinships. Indeed as Law points out with regard to the report on the Ladbroke Grove rail disaster in London, such an approach adheres to the perspectival position that 'a coherent account of the world is possible even at moments when things have gone dreadfully wrong' (Law 2004, p. 96). In this sense the reports into the beaching of the *Napoli* foster a sense of generality in the face of localised uncertainties. Instead, if we conceive such emergent, turbulent relations as inherent to mobility then we can acknowledge the presence of continuous, ongoing tensions in the armature of mobility as opposed to the re-optimisation of stable orderings. Akin to the earlier analogy of the spinning top, this aspect is a question of an epistemologically framed notion of perspective.

CONCLUSIONS

To finish then, we wish to outline the key reasons we believe account for the importance of using turbulence to theorise mobility. First it is necessary for us to think of turbulence as disordered motion – as mobility that defies expectation and lies beyond the calculus of prediction and pre-emption (cf. Anderson

2010). A good deal of effort has gone into the analysis of how exactly mobility has been made abstract, knowable, legible and controllable. Whether it is automobility (Merriman 2007; Packer 2008), air travel (Adey 2010) or the development of logistics (Cowen 2010), forms of control, rationalisation and order have been central to work in the mobility turn (Cresswell 2006). To more fully understand mobility and to properly delineate a politics of mobility we need to take the 'event' of unpredictable mobility seriously (cf. Czerwinski 1998; Power 2004; Clegg *et al.*, 2005).

Connected to this observation is the second point: that it is necessary to think of turbulence theoretically because it allows an ontology that makes order and stasis secondary to mobility and disorder. If we follow the logic of Serres, then forms of relative stasis and order arise out of turbulence. Without turbulence nothing can come into being, hence its 'creativity'. So rather than thinking about turbulence as exceptional moments of disorder we can shift our viewpoint and think about order as the product of maintenance (Graham & Thrift 2007), attempted pre-emption and preparedness (Anderson 2010; Lakoff & Collier 2010).

Our third reason to take turbulence seriously arises from the observation that the un-modellable nature of turbulence means that it produces instances of assemblage that occur only once – singularities. This mitigates against the approaches of classical science emphasising universality and generality, while underlining the importance of the specific and the localised. Thinking about turbulent mobilities provides a theoretical cut into a theorisation of the unrepeatable and unpredictable, with its attendant bearings on the possibility of pre-emption.

Fourth, turbulence, as a key aspect of mobility, helps us to think about emerging geographies in a mobile and interconnected world. It takes us beyond the division of the world into an old 'space of places' and a new 'space of flows' as developed by Castells (1996) and asks us to think of a world permanently in a state of unfolding though processes of ordering and disordering – a world in need of continuous maintenance that is marked by eventfulness and forces of territorialisation and de-territorialisation (Murdoch 2006; Graham 2009).

All of these connect to our final assertion. Turbulence describes a political impulse that attunes to uncertainty and chance (Anker 2009). Retallack's (2003) suggestion that we attend to the swerve of events entails a politics that does not assume turbulence as a moment of breakdown – a fundamentally bad thing – but rather an event of creative potentiality. Moments of turbulence in quite literal mobilities produce sudden visibilities in systems that would otherwise remain mostly invisible and taken-for-granted.

Above all these suggest a de-emphasis on order and security. Where traditionally order was seen as the norm, and disorder the abnormal – following the theories of complexity this has shifted. As such we move away from an emphasis on ordered upkeep toward the ongoing 'transitions and bifurcations' (Latour 1987, p. 94), the interferences and interrelations between order and disorder, typified in this case by the grounding of the *MSC Napoli*. Overall then it is suggested that the recognition of turbulence as an ever-present force is a valuable means to consider mobility. With this in mind we can recognise that mobility is a generative process of constant failure and re-calibration – a meshwork of competing allegiances.

Notes

1. There is an important difference between the approach that a scholar such as Rosenau takes to turbulence, in comparison with more contemporary political theorists (see Connolly 2011). *Contra* Serres – who argues that turbulence produces the world – Rosenau's underlying premise appears to be that the study of turbulence can assist in reasserting an underlying structural order. Above all this raises the issue of the epistemology of viewpoint (see Serres 2007).
2. As Webb suggests (2000, p. ix) it is here that we are privy to the historical folding of Lucretian atomism and the 'elements of uncertainty and openness characteristic' of modern physics.
3. The main *Napoli* inquiry (Mercer 2009), noted that one month after the beaching there were a total of 111 containers lost overboard, with 58 on the beach at Branscombe, six washed ashore to the east of Branscombe, nine on the seabed and a further 38 unaccounted for. As late as December

2008 the report states that 'industrial mop-heads like large sea urchins littered the beach' and that 'cargo will probably continue to be located ashore and on the sea bed of Lyme Bay for some years' (Mercer 2009, p. 25).

4. The MAIB report (2008), while noting the discrepancies in declared container weights, does however state that this would not have directly led to the fracture of the hull. It does claim that this will have reduced the safety margins in place.
5. In a further aspect identified by the MAIB report (2008), although not deemed central to the hull failure, fillet welds in the vicinity of the crack had previously been repaired. However, due in part to the different histories of the ship's register, it was not possible to trace the history of repair. This highlights the complex economic biographies of individual vessels.

REFERENCES

Adey, P. (2009), *Mobility*. London: Routledge.

Adey, P. (2010), *Aerial Life: Spaces, Mobilities, Affects*. Malden, MA: Wiley-Blackwell.

Anderson, B. (2010). Preemption, Precaution, Preparedness: Anticipatory Action and Future Geographies. *Progress in Human Geography* 34, pp. 777–798.

Anderson, B. & C. McFarlane (2011) Assemblage and Geography. *Area* 43, pp. 124–127.

Anderson, B. & J. Wylie (2009), On Geography and Materiality. *Environment and Planning A* 41, pp. 318–35.

Anker, M. (2009), *The Ethics of Uncertainty: Aporetic Openings*. New York: Atropos Press.

Anonymous (2008), Author interview with Principal Investigator, MAIB. 13 March.

Bennett, J. (2004), The Force of Things: Steps toward an Ecology of Matter. *Political Theory* 32, pp. 347–372.

Bennett, J. (2010), *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.

Bogard, W. (2000), Smoothing Machines and the Constitution of Society. *Cultural Studies* 14, pp. 269–294.

Bowker, G.C. & S.L. Star (2000), *Sorting Things Out: Classification and its Consequences*. Cambridge, MA: MIT Press.

Broeze, F. (2002), *The Globalization of the Oceans: Containerization from the 1950s to the Present*. St. John's, Newfoundland: International Maritime Economic History Association.

Castells, M. (1996), *The Rise of the Network Society*. Cambridge, MA: Blackwell Publishers.

Clegg, S.R., M. Kornberger & C. Rhodes (2005), Learning/Becoming/Organizing. *Organization* 12, pp. 147–167.

Czerwinski, T. (1998), *Coping with the Bounds: Speculations on Nonlinearity in Military Affairs*. Washington, DC: National Defense University.

Connolly, W.E. (2011), *A World of Becoming*. Durham, NC: Duke University Press.

Cook, I.J. & D.P. Tolia–Kelly (2010), Material Geographies. *In*: D. Hicks & M. Beaudry, eds., *Oxford Handbook of Material Culture Studies*. Oxford: Oxford University Press.

Cowen, D. (2010), A Geography of Logistics: Market Authority and the Security of Supply Chains. *Annals for the Association of American Geographers* 100, pp. 1–21.

Cresswell, T. (2006), *On the Move: Mobility in the Modern Western World*. New York: Routledge.

Cresswell, T. (2010), Towards a Politics of Mobility. *Environment and Planning D: Society and Space* 28, pp. 17–31.

De Certeau, M. (1984), *The Practice of Everyday Life*. Berkeley, CA: University of California Press.

Delanda, M. (1991), *War in the Age of Intelligent Machines*. New York: Zone Books.

Delanda, M. (1992), 'Nonorganic Life'. *In*: J. Crary & S. Kwinter, eds., *Zone 6: Incorporations*, pp. 129–166. New York: Zone Books.

Delanda, M. (2002), *Intensive Science & Virtual Philosophy*. London: Continuum.

Delanda, M. (2006), *A New Philosophy of Society: Assemblage Theory and Social Complexity*. London: Continuum.

Delanda, M. (2009), Material Evolvability and Variability. *In*: L. Spuybroek, ed., *Research & Design: The Architecture of Variation*, pp. 10–17. London: Thames & Hudson.

Delanda, M. (2011), *Philosophy and Simulation: The Emergence of Synthetic Reason*. London: Continuum.

Deleuze, G. & F. Guattari (1986), What is an Assemblage? In: Deleuze, G. & F. Guattari, eds., *Kafka: Toward a Minor Literature*, pp. 81–88. Minneapolis, MN: University of Minnesota Press.

Deleuze, G. & F. Guattari (1988), *A Thousand Plateaus: Capitalism and Schizophrenia*. London: Athlone Press.

Dillon, M. (2005), Global Security in the 21st Century: Circulation, Complexity and Contingency. *In*: C. Browning, ed., *The Globalization of*

Security: ISP/NSC Briefing Paper 05/02, pp. 2–3. London: Chatham House.

Easterling, K. (1999), *Organization Space: Landscapes, Highways, and Houses in America*. Cambridge, MA: MIT Press.

Easterling, K. (2005), *Enduring Innocence: Global Architecture and its Political Masquerades*. Cambridge, MA: MIT Press.

Egyedi, T. (2001), Infrastructure Flexibility Created by Standardized Gateways: The Cases of XML and the ISO Container. *Knowledge, Technology, & Policy* 14, pp. 41–54.

Furedi, F. (2007), The Changing Meaning of Disaster. *Area* 39, pp. 482–489.

Graham, S., ed. (2009), *Disrupted Cities: When Infrastructure Fails*. London: Routledge.

Graham, S. & N. Thrift (2007), Out of Order: Understanding Repair and Maintenance. *Theory, Culture and Society* 24, pp. 1–25.

Greenspan, A. (2007), *The Age of Turbulence: Adventures in a New World*. London: Penguin.

Hannam, K., M. Sheller & J. Urry (2006), Mobilities, Immobilities and Moorings. *Mobilities* 1, pp. 1–22.

Harman, G. (2010), The Assemblage Theory of Society. In: G. Harman, ed., *Towards Speculative Realism: Essays and Lectures*, pp. 170–198. Ropley: Zero Books.

HM Treasury/HM Revenue & Customs (2006), *New Responses to New Challenges: Reinforcing the Tackling Tobacco Smuggling Strategy*. Norwich: HMSO.

Hewitt, K. (1983), The Idea of Calamity in a Technocratic Age. *In*: K. Hewitt, ed., *Interpretations of Calamity: From the Viewpoint of Human Ecology*, pp. 3–32. Boston, MA: Allen & Unwin.

Hood, C. & D. Jones, eds. (2001), *Accident and Design: Contemporary Debates in Risk Management*. London: Routledge.

Lakoff, A & S.J. Collier (2010), Infrastructure and Event: The Political Technology of Preparedness. *In*: B. Braun & S.J. Whatmore, eds., *Political Matter: Technoscience, Democracy, and Public Life*, pp. 243–266. Minneapolis, MN: University of Minnesota Press.

Langewiesche, W. (2006), *The Outlaw Sea: Chaos and Crime on the World's Oceans*. London: Granta.

Latour, B. (1987), The Enlightenment Without the Critique: A Word on Michel Serres's Philosophy. *In*: A. Phillips Griffiths, ed., *Contemporary French Philosophy*, pp. 83–97. Cambridge: Royal Institute of Philosophy.

Law, J. (2004), *After Method: Mess in Social Science Research*. London: Routledge.

Levinson, P. (2006), *The Box: How the Shipping Container made the World Smaller and the World Economy Bigger*. Princeton, NJ: Princeton University Press.

Lucretius (2001), *On the Nature of Things* [translated by M.F. Smith]. Indianapolis, IN: Hackett Publishing.

Marine Accident Investigation Branch [MAIB]. (2008), *Report on the Investigation of the Structural Failure of MSC Napoli, English Channel on 18 January 2007*. Southampton: MAIB.

Martin, C. (2010), Turbulent Stillness: The Politics of Uncertainty and the Undocumented Migrant. *In*: D. Bissell & G. Fuller, eds., *Stillness in a Mobile World*, pp. 192–208. London: Routledge.

Maritime & Coastguard Agency (MCA) (2006), *National Contingency Plan for Marine Pollution from Shipping and Offshore Installations*. Southampton: MCA.

McKinsey & Company, INC. (1966), *Containerization – Its Trends, Significance and Implications*. London: McKinsey & Co.

Mercer, I. (2009), *MSC Napoli: The Aftermath of the Beaching off Branscombe, East Devon, 20 January 2007: Report of an Inquiry*. Exeter: Devon County Council.

Merchant Shipping Regulations (2005), *Merchant Shipping (Accident Reporting and Investigation) Regulations 2005*. London: Department for Transport.

Merriman, P. (2007), *Driving Spaces: A Cultural-Historical Geography of England's M1 Motorway*. Oxford: Blackwell.

Mol, A. & J. Law (1994), Regions, Networks and Fluids: Anaemia and Social Topology. *Social Studies of Science* 24, pp. 641–671.

Morris, S. (2007), If You Go Down to the Beach Today . . . You're Bound to Find Something to Steal. *The Guardian*, 23 January, p. 5.

Murdoch, J. (2006), *Post–structuralist Geography: A Guide to Relational Space*. London: Sage.

Nordstrom, C. (2007), *Global Outlaws: Crime, Money and Power in the Contemporary World*. Berkeley, CA: University of California Press.

Paché, G. (2007), Slowness Logistics: A New Time Orientation? *Time & Society* 16, pp. 311–332.

Packer, J. (2008), *Mobility Without Mayhem: Safety, Cars, and Citizenship*. Durham, NC: Duke University Press.

Perrow, C. (1999), *Normal Accidents: Living with High-Risk Technologies*. Princeton, NJ: Princeton University Press.

Polley, D. (1997), Turbulence in Organizations: New Metaphors for Organizational Research. *Organization Science* 8, pp. 445–457.

Power, M. (2004), *The Risk Management of Everything: Rethinking the Politics of Uncertainty*. London: Demos.

Prigogine, I. & I. Stengers (1984), *Order out of Chaos: Man's New Dialogue with Nature*. London: Heineman.

Protevi, J. (2009), *Political Affect: Connecting the Social and the Somatic*. Minneapolis, MN: University of Minnesota Press.

Retallack, J. (2003), *The Poethical Wager*. Berkeley, CA: University of California Press.

Robbins, P. & B. Marks (2010), Assemblage Geographies. *In*: S.J. Smith, R. Pain, S.A. Marston & J.P. Jones III, eds., *The Sage Handbook of Social Geographies*, pp. 176–194. Los Angeles, CA: Sage.

Rosenau, J.N. (1990), *Turbulence in World Politics: A Theory of Change and Continuity*. New York: Harverster Wheatsheaf.

Serres, M. (2000), *The Birth of Physics*. Manchester: Clinamen Press.

Serres, M. (2007), *The Parasite*. Minneapolis, MN: University of Minnesota Press.

Serres, M., with B. Latour (1995), *Conversations on Science, Culture and Time*. Ann Arbor, MI: University of Michigan Press.

Sheller, M. & J. Urry (2006), The New Mobilities Paradigm. *Environment and Planning A* 38, pp. 207–26.

Summers–Effler, E. (2007), Vortexes of Involvement: Social Systems as Turbulent Flow. *Philosophy of the Social Sciences* 37, pp. 433–448.

Thom, R. (1975), *Structural Stability and Morphogenesis: An Outline of a General Theory of Models*. Reading, MA: W.A. Benjamin, Inc.

Thrift, N. (2004), Summoning Life. *In*: P. Cloke, P. Crang & M. Goodwin, eds., *Envisioning Human Geographies*, pp. 81–103. London: Arnold.

Urry, J. (2000), *Sociology Beyond Societies: Mobilities for the Twenty-First Century*. London: Routledge.

Urry, J. (2003), *Global Complexity*. Cambridge: Polity.

Virilio, P. (2007), *The Original Accident*. Cambridge: Polity.

Webb, D. (2000), Introduction. *In*: M. Serres, *The Birth of Physics*, pp. vii–xx. Manchester: Clinamen Press.

Wolfe, C. (2007), Bring the Noise: The Parasite and the Multiple Genealogies of Posthumanism. *In*: M. Serres, *The Parasite*, pp. xi–xxviii. Minneapolis, MN: University of Minnesota Press.