SMALL WARS JOURNAL

Anticipating Megacity Responses to Shocks: Using Urban Integration and Connectedness to Assess Resilience

By Shade T. Shutters, Wes Herche and Erin King
Journal Article | *Feb 26 2016 - 3:21am*

Anticipating Megacity Responses to Shocks: Using Urban Integration and Connectedness to Assess Resilience

Shade T. Shutters, Wes Herche and Erin King

Introduction

Over half of humanity now lives in cities, a proportion rising to 80% by 2100 [1]. With this rapid demographic shift has come a new type of geographical entity – the megacity [2]. Typically defined as an urbanized area with at least 10 million residents, 28 megacities exist in the world today – almost 10 times as many as the three that existed in 1970. And nearly 40 of these massive human agglomerations will exist just 10 years from now. In parallel with this trend is a diffusion of world power from traditional hegemonic states to networks of diverse types of actors, including non-state entities such as megacities [3].

The rapid emergence of these dense urban areas has led to their prominent role in recent U.S. operations, with urban warfare being an integral part of allied efforts in both Iraq and Afghanistan. Operations in Fallujah, Iraq in 2005 were described as, "the heaviest urban combat Marines have been involved in since Hue City in Vietnam in 1968," [4]. In Afghanistan, a resurgent Taliban has concentrated its attacks on dense urban areas, forcing Afghan security forces into an urban warfare front for which they are ill-prepared [5]. Indeed, Iraq’s recent announcement that it will construct a reinforced wall to surround Baghdad illustrates the ever increasing emphasis of megacities and their security.

Given these recent experiences and prevailing trends there is clearly a need for a deeper understanding of dense urban environments at this unprecedented scale [6, 7]. What, if anything, fundamentally differentiates megacities from other cities? How does a contemporary military force confront an urban system of such immensity? While current military doctrine extends to urban operations, the sheer size of current megacities is beyond the scope of that doctrine. A recent report by the Chief of Staff of the Army’s Strategic Studies Group [8] summarizes the gaps in our understanding of megacities and the potential implications for national security.

The report states that megacities “create a complex security environment which will challenge policy makers and military planners” and that megacities will be the strategic key in future U.S. military interventions. This presents a paradox for strategic planning and operations, framing urban warfare as a “wicked problem” [9-11]. By their nature, complex systems such as megacities cannot be controlled in a traditional military sense, but they can be influenced [12]. It is critical then to understand exactly how to influence the trajectory of these cities and how to anticipate their responses to that influence.

Urban Resilience

A primary objective of better understanding of megacities is to enable a proper evaluation of alternative tactical and strategic options. It is virtually impossible to evaluate a scenario for intervening in a megacity without the ability to anticipate the megacity's response. And the magnitude and nature of a city's response to intervention is intimately related to the city's resilience.

Thus, we focus in this paper on a critical and fundamental attribute of megacities, and indeed of all complex systems – their resilience to shocks [13]. How well can a megacity respond to a shock? How long will that response take? What are its vulnerabilities and weaknesses? What policy interventions can affect its resilience? Quantifying that resilience is a crucial prerequisite for comparative analyses, for assessing the impact of policies, and for planning both strategic and tactical options. It is also central to anticipating whether a disrupted urban environment will eventually recover from a shock or transition into a haven for violent extremists.

Connectedness, integration, and interdependence

Ideally, our understanding of megacities, or any dense urban environment would include a theoretically-grounded, quantification of resilience, which many experts claim is virtually impossible to create [14, 15]. Analysts are thus forced to derive simplistic qualitative notions of resilience. This has led to a prevailing view asserting that tightly connected, highly integrated cities are the most resilient to shocks [16, 8, 17]. Cities such as London and New York, this view claims, will recover from shocks much more readily than the likes of Lagos or Dhaka.

This concept of integration or connectedness and its relation to resilience is sufficiently accepted so that it was used as the basis for the CSA's proposed megacity typology (Figure 1). As Harris et al [8] conclude:

> *Highly integrated systems are characterized by strong formal and informal relationships among its component parts. These relationships manifest as highly ordered hierarchical structures with formalized procedures and norms, and open communication among its various parts. Highly integrated systems are inherently stable, show high degrees of resilience (ability to absorb change) and manage growth in a relatively controlled manner.*
>
> *Loosely integrated systems, on the other hand, lack many of the formal relationships that keep highly integrated systems stable. Weak control and communications systems, and lack of consistent rules for interaction amongst component parts lead to low resilience and unregulated growth. This growth, in turn, contributes more component parts that aren't formally integrated into the system, creating a downward spiral of instability.*

The assertion that higher connectedness of a system increases that system's resilience comes largely from the engineering concepts of robustness and redundancy [18-20], where designed networks and engineered systems must be crafted to withstand shocks [17]. The rationale is that if one part of a system fails, higher connectivity enables the rapid replacement of resources and the uninterrupted flow of information through the system.

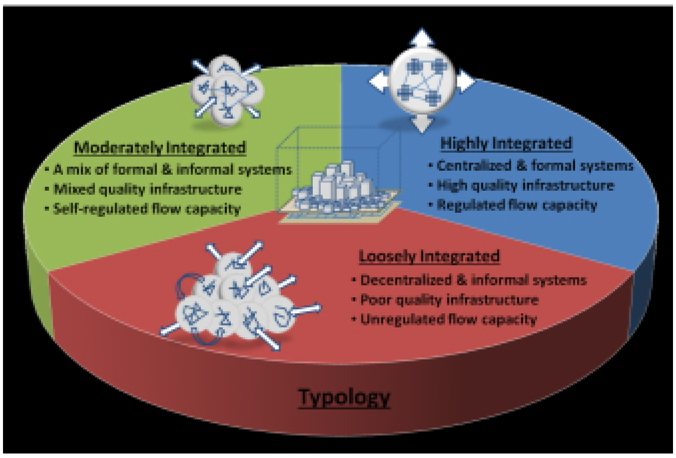

Figure 1: A typology of megacities defined by the level of a city's integration (from [8] p. 14).

Yet this prevailing view is not the only one. A contrary view, outlined in the seminal tome *Panarchy* [21] and originating in ecology-related fields, asserts that highly connected and integrated systems become brittle and susceptible to cascading failures [22, 23]. To better illustrate this counter view, we present a simple organismic analogy to cities.

An analogy from biology

Let us consider an illuminating analogy from the animal kingdom. Though this vantage point will be new to most readers, it is important to understand that an animal is a collection of numerous individual cells: individuals that communicate with each other, coordinate activities, carry out diverse functional tasks, change their behavior in response to their environment, regulate themselves, and depend on one another for survival. In other words, just like a city, an animal is nothing less than a complex adaptive social system [24].

Biologists typically place animals along a continuum of internal complexity with humans at one end (most complex) and sponges at the other (least complex). The human body is made of nearly 200 different types of cells, which form a highly integrated hierarchy of interconnected tissues, organs, and dynamic systems. These systems and their components show an incredible degree of self-regulation, feedback controls, interdependency, redundancy, and defense capabilities. On the other hand sponges have no tissues, no organs, no systems at all, and are composed of only four types of cells. Thus under virtually any conceived scale of integration, connectedness, or interdependency, humans are far above sponges.

But which is more resilient? Consider the shock of discharging a firearm into both a human and a sponge. In humans a small area of localized damage can trigger a series of cascading system failures culminating in the collapse of the entire system and the death of the individual. And the sponge? Some of its cells would die but the system overall would be largely unaffected. With minimal integration between damaged areas and the rest of the animal, unaffected parts continue to function as if nothing had happened. In fact, a sponge can be subjected to chemical or mechanical stresses that virtually disintegrate the animal into a mass of unconnected cells and those cells will soon reconstitute into a single animal. Given this example it is difficult to argue that the highly integrated and hierarchical society of cells forming a human body is more resilient than a lowly sponge. Can the analogous social systems of cities be so different?

Recent empirical evidence

Partly to reconcile this apparent contradiction over the role of connectedness, a recent study attempted to craft a quantitative and anticipatory metric of urban resilience. Using massive government datasets on the economies of U.S. cities, Shutters et al [25] developed a quantitative measure of a city's "tightness" or level of economic integration. Using this metric the authors found that, following the shock of the 2007-2009 "Great Recession," U.S. cities with tightly integrated economies actually had the largest percentage drops in several measures of economic performance. In addition, the highly integrated cities took longer to return to their pre-shock performance levels. In other words, the most integrated cities were the *least* resilient to this global economic shock.

Yet the authors of this study caution that resilience is likely very nuanced and contextual. Factors such as the type of shock, its geographical extent, its duration, etc., will ultimately determine what is and is not a resilient megacity. For instance, a disaster befalling a specific U.S. port city may have cascading impacts on the U.S. economy, but the nature of this geo-specific shock is likely quite different than the global economic shock described above. In any regard, clarifying the impact of increasing connectedness is paramount in today's world of increasing globalization and interdependency [26].

The Key to Urban Resilience

Thus far we have established that understanding the resilience of megacities is critical to planning interventions, evaluating options, and anticipating responses, but that typical thinking about urban resilience is both naïve and conflicted. So what is the way forward?

We believe the key to understanding urban resilience can be summarized in one word – networks. To appreciate this assertion we must first accept that cities are complex adaptive systems. They exhibit emergent properties, evolutionary dynamics, and non-linear responses. But more importantly, cities, like all complex systems, are composed of a network of interacting parts and subsystems. Complex urban systems are virtually defined as a multiplex of interacting complex networks [27-29].

Indeed, modern urban centers, and particularly megacities, are no longer isolated fortresses, but large, highly complex interconnected networks of networks. Those networks include transportation, financial, resource distribution, sewer and water infrastructure, electricity, communication and data, economic trade, social networks, and others. These networks can best be conceptualized as "Level 2" socio-techno systems under the Allenby and Sarewitz [30] framework of technologies and emergent technological systems that have co-evolved as integral parts of human beings and societies. Networks like traffic conduits and electrical delivery can be mapped through physical inspection, including remote sensing. On the other hand, financial and social networks, for example, require tools such as social media analytics and data mining. Still others, such as economic interdependence networks, require careful analysis with tools from information theory and other advanced techniques [31].

Quantifying the dynamics and topological features of these networks is key to understanding both their resilience and that of the complex systems they govern [31-33, 25]. This includes analyzing the diversity of networks embedded in dense urban systems. Thus the tasks at hand include at least two major agendas: (1) determining how the different networks comprising a city are affected by various shocks, and (2) generating the high quality data needed to inform models of urban resilience for developing nation megacities, where current data availability is limited.

Conclusion

Given current global trends in population growth, urbanization, and power dynamics, megacities and other dense urban environments will continue to grow in strategic importance . Thus, it is critical that we enhance our understanding these complex systems. This understanding will require embracing a complex adaptive systems framework focused on the networks that comprise urban systems.

In particular, assessing multiple policy and tactical options requires the ability to anticipate how a megacity will respond to intervention or shocks; and those responses are a function of the resilience of an urban system. Thus, the imperative is to better understand urban resilience, theoretically ground its assertions, and rigorously quantify it for enhanced decision making. We assert that the best way to accomplish these goals is through sophisticated analysis of the multitude of networks embedded within (and existing between) urban systems.

End Notes

1. United Nations Population Fund (2007). *State of the world population 2007: Unleashing the Potential of Urban Growth*. United Nations, New York.

2. Dobbs, R. (2010). *Prime Numbers: Megacities*. Foreign Policy Magazine 181:132-135.

3. National Intelligence Council (2012). *Global Trends 2030: Alternative Worlds*. Office of the Director of National Intelligence, Washington, DC.

4. Garamone, J. (2005). *ScanEagle Proves Worth in Fallujah Fight*. DoD News 11-Jan-2005, available at **http://archive.defense.gov/news/newsarticle.aspx?id=24397**.

5. Smith, J. (2015). *Battle for Kunduz Draws Afghans into Urban Warfare*. Stars and Stripes Oct. 13, 2015, available at **http://www.stripes.com/news/battle-for-kunduz-draws-afghans-into-urban-warfare-1.373072**.

6. Adamson, W. G. (2015). *Megacities and the US Army*. Parameters: The US Army War College Quarterly 45(1):45-54.

7. Felix, K. M. and F. D. Wong (2015). *The Case for Megacities*. Parameters: The US Army War College Quarterly 45(1):19-32.

8. Harris, M., R. Dixon, N. Melin, D. Hendrex, R. Russo, and M. Baily (2014). *Megacities and the United States Army: Preparing for a complex and uncertain future*. Office of the Chief of Staff of the Army, Strategic Studies Group, Arlington, Virginia, USA.

9. Rittel, H. W. J. and M. M. Webber (1973). *Dilemmas in a general theory of planning*. Policy Sciences 4(2):155-169.

10. Camillus, J. C. (2008). *Strategy as a wicked problem*. Harvard Business Review 86(5):98.

11. Bebber, R. (2015). *The Wicked Problem of War*. MOC Warfighter, U.S. Naval War College 5, available at https://**www.usnwc.edu/mocwarfighter/Article_M.aspx?ArticleID=40**.

12. Clark, A. (1999). *Leadership and Influence: The Manager as Coach, Nanny and Artificial DNA*. Pages 47-66 *in* J. Clippinger, editor. The biology of business: De-codeing the natural laws of Enterprise. Jossey-Bass, San Francisco.

13. Kilcullen, D. (2012). *The City as a System: Future Conflict and Urban Resilience*. The Fletcher Forum of World Affairs 36(2 Summer 2012):19-39.

14. Walker, B. and D. Salt (2012). *Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function*. Island Press, Washington, DC.

15. USAID (2013). *The Resilience Agenda: Measureing Resilience in USAID, Technical Note 1866*. United States Agency for International Development, Washington, DC.

16. Norton, R. J. (2003). *Feral Cities*. Naval War College Review 56(4):97-106.

17. Sterbenz, J. P. G., D. Hutchison, E. K. Çetinkaya, A. Jabbar, J. P. Rohrer, M. Schöller, and P. Smith (2014). *Redundancy, diversity, and connectivity to achieve multilevel network resilience, survivability, and disruption tolerance*. Telecommunication Systems 56(1):17-31.

18. Pavard, B., J. Dugdale, N. B.-B. Saoud, S. Darcy, and P. Salembier (2008). *Underlying concepts in robustness and resilience and their use in designing socio-technical systems*. Pages 127-142 *in* E. Hollnagel, C. P. Nemeth, and S. Dekker, editors. Resilience engineering perspectives: Remaining sensitive to the possibility of failure. Ashgate Publishing, Burlington, Vermont, USA.

19. Smith, P., D. Hutchison, J. P. G. Sterbenz, M. Scholler, A. Fessi, M. Karaliopoulos, C. Lac, and B. Plattner (2011). *Network Resilience: A Systematic Approach*. Ieee Communications Magazine 49(7):88-97.

20. Krupa, M. B., F. S. C. III, and A. L. Lovecraft (2014). *Robustness or resilience? Managing the intersection of ecology and engineering in an urban Alaskan fishery*. Ecology and Society 19(2):17.

21. Gunderson, L. H. and C. S. Holling, editors. (2002). *Panarchy: understanding transformations in human and natural systems*. Island Press, Washington, DC.

22. Kauffman, S. A. (1993). *The Origins of Order: Self-Organization and Selection in Evolution*. Oxford University Press, New York.

23. Dorner, D. (1996). *The logic of failure: recognizing and avoiding error in complex situations*. Metropolitan Books, New York.

24. Maynard Smith, J. and E. Szathmáry (1997). *The major transitions in evolution*. Oxford University Press, New York.

25. Shutters, S. T., R. Muneepeerakul, and J. Lobo (2015). *Quantifying urban economic resilience through labour force interdependence*. Palgrave Communications 1(201510):1-7.

26. Ward, D. (2016). *Operational Environment Implications of the Megacity to the US Army*. Small Wars Journal 12(2):02-Feb-2016.

27. Craven, P. and B. Wellman (1973). *The Network City*. Sociological Inquiry 43(3-4):57-88.

28. Batty, M. (2013). *The New Science of Cities*. MIT Press, Cambridge, Massachusetts.

29. Neal, Z. P. (2013). *The connected city: How networks are shaping the modern metropolis*. Routledge, New York, NY.

30. Allenby, B. and D. Sarewitz (2011). *The techno-human condition*. MIT Press, Cambridge, Massachusetts, USA.

31. Ulanowicz, R. E., S. J. Goerner, B. Lietaer, and R. Gomez (2009). *Quantifying sustainability: Resilience, efficiency and the return of information theory*. Ecological Complexity 6(1):27-36.

32. Buldyrev, S. V., R. Parshani, G. Paul, H. E. Stanley, and S. Havlin (2010). *Catastrophic cascade of failures in interdependent networks*. Nature 464(7291):1025-1028.

33. Parshani, R., S. V. Buldyrev, and S. Havlin (2010). *Interdependent Networks: Reducing the Coupling Strength Leads to a Change from a First to Second Order Percolation Transition*. Physical Review Letters 105(4):048701.

About the Authors

Shade T. Shutters

Shade T. Shutters is a research scientist with the Global Security Initiative at Arizona State University, with additional faculty appointments in the Center of Social Dynamics and Complexity, Center on the Future of War, and the Center for Policy Informatics. He holds a bachelor's in finance from Indiana University, a doctorate in theoretical ecology from Arizona State University, and completed a post-doc in applied economics at the University of Vigo, Spain. His research is focused on the dynamics of urban systems and the networks both within and between cities.

Wes Herche

Wes Herche is a research scientist with the Global Security Initiative at Arizona State University, with an additional appointment of senior sustainability scientist in the Global Institute of Sustainability. He holds a bachelor's in geography from Southern Illinois University, an MBA from Thunderbird School of Global Management, and is currently completing a doctorate in sustainability science. His research focuses on energy security and policy. Wes was previously an intelligence analyst with the U.S. National Geospatial Intelligence Agency.

Erin King

Erin King is a staff member of the Global Security Initiative at Arizona State University where she is completing a bachelor's in sociology and a certification in homeland security. Her research interests include a broad spectrum of security issues. Erin previously served as a counterterrorism intelligence intern in Israel with TAM-C Solutions.

Available online at : http://smallwarsjournal.com/jrnl/art/anticipating-megacity-responses-to-shocks-using-urban-integration-and-connectedness-to-asse

Links:
{1} http://smallwarsjournal.com/author/shade-t-shutters
{2} http://smallwarsjournal.com/author/wes-herche
{3} http://smallwarsjournal.com/author/erin-king
{4} http://archive.defense.gov/news/newsarticle.aspx?id=24397
{5} http://www.stripes.com/news/battle-for-kunduz-draws-afghans-into-urban-warfare-1.373072
{6} http://www.usnwc.edu/mocwarfighter/Article_M.aspx?ArticleID=40
{7} http://smallwarsjournal.com/comment/reply/40477#comment-form