The Open Toolbox for Domestic Disaster Response

The role of a Federal or other national emergency response capability is to handle whatever happens, from meteor strike or other global catastrophe through to contingencies like pandemic influenza and some classes of more routine events. The open ended nature of the threat is part of what makes high level capabilities in these areas so expensive and difficult to maintain.

The Federal capacity to meet the contingencies which lie before us is not strong enough to provide for every eventuality. Pandemic flu presents a spectrum of credible threats many of which overwhelm the capacity of nearly any organization to ensure continuity of services to its population.

Furthermore, the stable and highly interdependent nature of industrialized societies makes them extremely vulnerable to broad field disruptions which hit everywhere at once. In such a crisis, the highly interlinked economic, industrial and infrastructure systems cannot be re-stabilized by using protected areas of the grid to pull the problem areas back online because there are no unaffected areas. Systemic risks present unprecedented threats to industrial countries, particularly to the populations in the cities which are entirely dependent on external supply chains for their welfare. In short, ours is a fragile abundance.

The number one stressor on American society as of October 2008 is the financial crisis. But this is today's crisis. Yesterday - and tomorrow - the primary threat might be biological terrorism, nuclear weapons, novel diseases, asteroids from space or as-yet-undiscovered problems. The only stable thing we have to work with in this changing context is human biophysics. There are essentially six ways to die prematurely: overheating, hypothermia, hunger, thirst, illness and injury. In most contingencies, if people can be kept safe from these six existential threats, nearly all other damage, inconvenience and loss can be dealt with over time.

Infrastructure systems protect us from these existential threats by purifying our drinking water and carrying our waste, heating and cooling our homes. Social structures minimize our risk of injury and treat our illnesses. Infrastructure is what increases the carrying capacity of the lands we live on to support great cities, and the infrastructure matrices are our vital life support systems.

What We Can Learn From Free Software

Free and open source software (FOSS) showed that mass collaboration between individuals and organizations cooperating on the level playing field created by the GNU Public License was capable of not only rivaling, but also augmenting, the effectiveness of the best software development houses in the world. Companies like IBM have come to rely on and contribute to FOSS projects as part of their daily business. The result has been an enormous creation of wealth as the cost of essential software infrastructure drops towards zero because the tools are widely and freely available and are constantly improving. Businesses tend to play less for software infrastructure over all, leaving more resources for development. The economic effect can be seen as parallel to the industrial and domestic benefits brought about by widespread electrification. The resulting drop in the cost of energy enabled whole new classes of business. Cheap energy was a revolution.

This model of equal collaboration between individuals, companies, academic institutions, non-profit organizations and sometimes government has several interesting features which may be extremely useful and relevant to contingency management practices in many scenarios. The STAR-TIDES project is one such open collaboration in the disaster response and development arena including such diverse players as National Defense University, a broad assortment of private enterprises, private individuals from many walks of life, NGOs, and at least one FOSS-style disaster relief project.

The Hexayurt Project

The Hexayurt Project was started in 2002 by Vinay Gupta, the inventor of the Hexayurt. A Hexayurt (see next page) is a simple disaster relief shelter with several useful properties, including flexible manufacture from very common materials, extreme durability, good price-performance ratio and a public domain/ "Linux of housing" approach that was self-consciously copied from the FOSS software projects. The Hexayurt Project used many of the same working practices as open source software, including many of the same basic technological tools - wikis, mailing lists, extensive use of user-created content sites like Youtube for communications, and a rough, guerilla feel to media.

Over five years of testing and demonstration, the Hexayurt is now entering mass replication. In the same way that software like Linux was hard to use initially, and required great technical expertise to install and manage, the Hexayurt has gone through a number of simplifications. As training materials have improved and public awareness has increased, the Hexayurt has now become vernacular

architecture among diverse groups. Hexayurts have been built on four continents. The best estimate is that several hundred people participated in building or living in a Hexayurt in 2008, up from a few dozens in 2007, and it is likely over a thousand units will be built in 2009 simply through organic technology transfer, not counting possible commercialization of this system or mass housing in a disaster context. From there the sky is the limit.

Hexayurt built by Engineers Without Borders at the Pentagon during the STAR-TIDES 07 event.

What does all of this have to do with disaster relief? It is simple: almost anybody can make a Hexayurt. With limited skills, one may be confined to a small unit with light materials, but a couple of average handyman can make up to six Hexayurts a day that will last as long as the materials they have available. Common materials include the ultra-light weight polyiso insulation board (pictured above,) plastic honeycombs, even plywood and OSB for more permanent structures. The shelters can last for decades with maintenance. In almost any industrial city there is some local panel mass production capacity which can be turned to Hexayurt manufacture in a crisis. The only tooling required is a table saw to cut the standard 4' x 8' (1.2 x 2.4m) boards in half to form the roof pieces, taking only minutes per unit. The Hexayurt requires minimal tooling, skill, materials or labor.

While these homes are certainly not a suburban four bedroom, the modular units can be combined to produce family-sized dwellings suitable for long-term temporary use for as little as $1 per square foot ($50 - $200 depending on size.)

Scalable Decentralized Emergency Shelter Production

Free computer operating systems are boon for many people and companies, including very large ones. Free operating systems enable many projects, and are proving to be very useful for development in some of the poorer regions of the world. People have worked together to create these community-owned freely-available computing resources and, the intellectual labor done, anybody who has the required physical hardware can run the free software on it to produce services.

Housing used to be like this. Building a house was a major undertaking - a year's project or more perhaps. But it was a process that the home owner was the master of in many cases. Settlers used to build a chicken coup and live in it while building a log home for example. They understood and were fully able to operate the culturally standard housing technologies. If people had the materials, they could make a home for themselves. In much of the world, housing is still like this - an essentially open affair. People are the owners and operators of their own building technology, and can make and remake home as a matter of course in the normal cycle of life. However, in our society and our climate, this approach is unfeasible.

The Hexayurt represents a high-tech vernacular architecture: a building system dependent on an industrialized society to produce insulation boards or plywood or other panels, but after the point of raw materials production, the Hexayurt is independent of all heavy equipment or uncommon skill. This technology promises to restore some of the resilience lost by our culture making housing creation the role of credentialed professionals using heavy equipment. It increases the resilience of the population to create their own shelter in disastrous contingencies, in a way which is compatible with modern population densities and skills in a way that a return to log cabins in not. There are not enough trees, but there is more than enough polyiso insulation and plywood.

Freely Copyable Solutions

The Internet is largely built on FOSS software. While there are large proprietary subsystems connect to it, like Google, many of these subsystems, including Google, rely on FOSS components internally. Internet systems scale partly because people buy cheap commodity hardware and load FOSS operating systems on to it, leading to very lean and efficient scaling. People take what works and copy it on to more and more cheap commodity systems as their need for scale increases.

The Hexayurt uses a similar approach to offer a scalable emergency housing solution. People can take a commodity building material, standard sized panels, and “load” a free "design pattern" to turn the panels into a simple home. They can keep doing this, quickly and easily, until either the housing crisis is solved or they run out of panels. The US building supply chain has enough materials within it to build millions of Hexayurts a day if needed.

This scalable housing solution is critical to the ability of people industrial societies to absorb and survive catastrophic contingencies, particularly those of a systemic nature. The combination of “FOSS” design and commodity hardware components (e.g. insulation panels, plywood) is a pattern we know leads to extreme scalability, as with the internet.

Efforts to systematically restore the resilience of a population by increasing their ability to shelter themselves after a crisis have never been needed before. After all, many populations in the world are largely self-sheltering. After disasters people may lack the money to rebuild their homes, but seldom do they lack the ability. Housing is still largely a vernacular art in most places. Furthermore, the materials tend to be simpler - cinderblock and sheet metal, mud and thatch - and less demanding of technical skill than conventional American and European building practices.

However, lacking these options makes industrialized populations vulnerable to mass displacement events like earthquakes because their self-sheltering capacity is reduced to almost zero, and the supply chain is not particularly well suited to self-sheltering efforts. The Hexayurt works with materials in the existing supply chain systems to produce resilience in sheltering where none existed before. Just add knowledge. The extremely low skill required to build a Hexayurt, the materials tolerance, the quick assembly, the lack of patent or copyright claim all point to the Hexayurt as the natural choice for restoring substantial self-sheltering capacity to the populations of the industrialized world as a hedge against systemic disasters and mass displacement events. Until such time as a better option appears, the Hexayurt is the natural choice for replicable, scalable emergency sheltering for extreme crisis situations. After more comfortable sheltering options have been exhausted, it remains a stable, highly available fallback position, and as such is it is a much-needed technology.

Aggregating Demand to Create Efficiency

The typical mode of self-organization among the citizens of industrialized nations is capitalism and, particularly, the for-profit corporation. While the non-profit

sector is historically extremely important in disaster relief and similar situations, the awesome complexity of modern society was largely built in the intersection of free markets and free association in the form of the company. The market is used to aggregate demand into large enough lumps to finance development of efficient systems to produce goods and services. There is no clash between Free and Open products and commercial supply. Many companies sell services based on open source software. The point is that anybody can copy a working system, start a company to copy it more efficiently, modify it, or otherwise scale and adapt the solution to local needs, having to buy only basic physical materials to proceed. There is no bottle neck on scaling a solution due to business constrains expresses as intellectual property licensing.

Therefore, again in keeping with the parallel cases of the GNU-Linux system and the Hexayurt, while the open technology is available to anybody, one might expect to see five classes of commercial entities in the ecosystem around this open technology.

1. **"Red Hat"** type companies which provide implementation support to other individuals, companies or governments which wish to use the FOSS components but do not necessarily have the skill in-house. These companies might simply sell guaranteed Hexayurts, or sell/lease Hexayurts and set them up with with a guarantee and support services.
2. **"Server Farm"** type companies which provide services by renting the supported FOSS components to end users, like web hosting or "Hexayurt Hotels."
3. **"Google"** type companies which build services which utilize the FOSS components, like Google's servers, but then run proprietary services on top of them. These people might run large outdoor events and rent Hexayurts as accommodations, while the actual show people paid to see is on stage.
4. **"IBM"** type companies which will customize and deploy arbitrarily complex systems based on FOSS and proprietary systems depending on what meets the customer needs best, including developing new open components.
5. **“Open Manufacturing”** companies - still in their infancy in the FOSS world - which attempt to go beyond the software level of the system, and reach back into the hardware to produce an entirely open system, free of copyright and patent claims at ever level except under acceptable FOSS licenses. This would be equivalent to the Open Source Ecology goal of producing basic feedstock materials in a fully Free/Open manner.

The possibility clearly exists for a ultra-low cost housing ecology based on FOSS principles to provide unparalleled housing resilience globally. Although the Hexayurt itself is public domain, an arrangement which makes GPL-style copyleft impossible, there are some innovations in infrastructure which may serve as anchors for a patent pool if it can be arranged or simply released into the public domain as the design of the Hexayurt was by Vinay Gupta, its inventor.

Infrastructure systems, which we will not discuss at length, are typically represented by the pipes and wires which flow into homes bringing in energy and clean water and removing waste. In the Open Source Appropriate Technology movement, acceptable and even excellent household appliances exist which purify water, efficiently and cleanly cook food, purify water and generate electricity for lights and small appliances. These systems are provided on a house by house basis in some cases, meaning that the building and its essential services are both portable and can be set up anywhere. There also exists an open design for a folding hexayurt. The folding hexayurt can be erected in less time than it takes to pitch a tent, although it requires some additional manufacturing steps over the conventional Hexayurt.

The scalability which comes from using commodity hardware - off the shelf components like PC computers or insulation or plywood or other panels - in a form which is unencumbered by copyright or patent claims in unparalleled. The simplicity of the hexayurt form makes it mass manufacturable with only table saws, and field-manufacturable with no more than knives in some materials. In some configurations it works better with some unusual components (very wide rolls of otherwise-standard tapes) but the total supply chain availability of those materials is not small because of the way the tape industry functions - large rolls are subdivided into the common 3" rolls, but in a pinch can be cut to the needs of the population if the Hexayurts in question require tape. Some switching time is required but it would become a standard supply chain item quickly.

The Payoff

The is a critical US need for an emergency housing alternative which can scale to handle three extremely serious contingencies.

1. **Natural Disaster.** Earthquakes, flooding, wildfires and similar regional natural disasters may displace low millions of people and leave entire cities uninhabitable for weeks or months.
2. **WMD terrorism.** Worst-case scenarios could displace 20 million people or more.
3. **Pandemic flu.** A pandemic could require the ability to scale housing and hospital accommodations all over the country at critical installations and quarantine sites, including tens of millions of stranded travelers, people who cannot return home because of contamination risks (such as nurses, doctors and EMTS,) critical infrastructure workers who are quarantined at their facilities and so on. The ability to house people at their current safe locations may help protect critical infrastructure, slow the spread of infection, and keep people alive.

Economic migrancy and vagrancy are also extremely real concerns although the number of people who might be affected by these situations is unknowable. In the great depression, millions of people could not live in ordinary housing because of the economic conditions. A scalable ultra-low-cost housing solution might provide a great deal of buffering and protection to at-risk populations in the probable event of a severe economic disruption.

There are three questions before us.

The first is how to propagate this technology into the developing world, where clearly there are an amazing array of situations where a cheap, durable, locally replicable housing technology could have amazing social and personal benefits, particularly in post-disaster and refugee settings.

The second is how the US population can organize to radically increase their own housing resilience in the face of natural disaster and other threats. The more of the population that can self-shelter, or buy sheltering services from Free/Open Source Shelter companies (helping to ensure scalability and fair prices) the less load will be put on municipal, State and Federal resources.

The third question is what can we do about US homelessness? A Hexayurt of reasonable size for one person can be constructed for $50 with materials from

any building supply store. Right now, a combination of building codes and other bureaucracy makes it illegal almost everywhere for a person who has become homeless to simply self-shelter. But social relief resources are inadequate to address the real needs of the homeless population in almost all cases. While nobody likes Hoovervilles, the conditions inside of any urban homeless shelter will generally give almost anybody a severe pause for thought before imagining themselves in that situation, particularly for extended periods. Would allowing people to self-shelter if they are able, and even training people and providing land for them to exercise their own self-reliance be the answer to homelessness for some part of the homeless population?

If the economy cannot house these people, and government resources cannot provide universally available beds in organized municipal homeless shelters, maybe it is time to consider self-sheltering and supported (i.e. subsidized) self-sheltering options.

I hope you will join with me in reconsidering the options for disasters, where the primary impediment to housing is logistical, and homelessness, where the primary impediment is economic.

We believe that a relatively modestly funded program could revolutionize the national housing options in America in the hardest cases we have, where the existing options have been demonstrably failing hundreds of thousands of citizens a year for decades. We need funding and cooperation from municipal, state and federal government to implement these solutions for America.

To discuss implementation of these concepts please contact us at The Open Toolbox.

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