On reducing Terrorism Power:  
A Hint from Physics

S. Galam and A. Mauger  
Laboratoire des Milieux Désordonnés et Hétérogènes*  
Université Paris 6, case 86, 4 place Jussieu,  
75251 Paris Cedex 05, France

Abstract  
The September 11 attack on the US has revealed an unprecedented terrorism worldwide range of destruction. Recently, it has been related to the percolation of worldwide spread passive supporters. This scheme puts the suppression of the percolation effect as the major strategic issue in the fight against terrorism. Accordingly the world density of passive supporters should be reduced below the percolation threshold. In terms of solid policy, it means to neutralize millions of random passive supporters, which is contrary to ethics and out of any sound practical scheme. Given this impossibility we suggest instead a new strategic scheme to act directly on the value of the terrorism percolation threshold itself without harming the passive supporters. Accordingly we identify the space hosting the percolation phenomenon to be a multi-dimensional virtual social space which extends the ground earth surface to include the various independent terrorist-fighting goals. The associated percolating cluster is then found to create long-range ground connections to terrorism activity. We are thus able to modify the percolation threshold $p_c$ in the virtual space to reach $p_c^*$ by decreasing the social space dimension, leaving the density $p$ unchanged. At once that would break down the associated world terrorism network to a family of unconnected finite size clusters. The current world terrorism threat would thus shrink immediately and spontaneously to a local geographic problem. There, military action would become limited and efficient.

*Laboratoire associé au Centre National de la Recherche Scientifique
Terrorism has existed since centuries. It designates the use of random violence against civilians in the main purpose to kill them. Until recently, most terrorist attacks have been performed within restricted geographic areas connected to the associated terrorism claim. Well-known European cases of "local terrorism" are Corsica, Northern Ireland and Euskadi. In response, nations have developed appropriate intelligence agencies and special police forces. Various tools have been applied rather independently by each nation without real multilateral cooperation.

The September 11 attack on the USA has revealed a worldwide range of action of a given terrorist network. The response of the United States to this "long-range terrorism" has been a localized military action, the success of which is not yet complete. Moreover it is already understood that follow-up steps are necessary. Nevertheless, defining these steps is far from being clear. Up to now, a lot of focus was put on blaming intelligence services for having missed the planning and the development of the current international terrorism network. As a result, military and intelligence analysts are looking for the right changes, which would make these services more efficient. A solution is expected from an optimization of the conventional tools used so far against local terrorism.

But at the very moment, there is no available practical scheme to erase the current worldwide level of terrorism threat. In this work we argue that the tools used so far to fight local terrorism are inappropriate against long-range terrorism. We start from a new approach that has been proposed very recently [1], using the concept of percolation from the Physics of disorder [2]. Indeed in past years Physics has been proven useful in sheds a new light on a series of social problems [3-6]. According to this model, the local and long-range terrorism are the two phases of a percolation transition in the assembly of randomly distributed passive supporters to the terrorist cause. Passive supporters designate people who are not directly involved with terrorism but who would not oppose a terrorist related act in case they could. Most of them are always dormant. Some works did analyze the difficulty in mapping covert terrorist network [7]. The local terrorism corresponds to the disordered phase with only finite sized clusters of connected people. In that case the density p of passive supporters is below the percolation threshold pc. The long-range terrorism corresponds to the case p¿pc, the system is ordered with the existence of an infinite percolating cluster of passive supporters [1]. There, long-range terrorism becomes spontaneously achievable. This range property is independent of the terrorist net itself.
Within the above frame, the September 11 attack reveals the existence of a world percolation of passive supporters. Consequently, the reduction of the world density of passive supporters below the percolation threshold becomes the major strategic goal of an efficient fight against this international terrorism. However, even a few percent reduction of the world passive supporter density would require neutralizing millions of people, either physically or ideologically, making both options non-ethics and totally unpractical within reasonable action. Moreover, it has been shown that it is even not possible to measure the current density of passive supporters collecting massive and systematic ground information [1].

At this stage, the analysis leads to the very pessimistic conclusion that there exists no solution to dismiss the current world level of terrorism threat. The lack of solution comes from the basic idea that, as people are moving on a two-dimensional surface, this is the space to be considered while studying their geographic connectivity. This is precisely stated in the previous percolation model envisioned so far [1], and also implicit in the approach of the people in charge of the fight against terrorism. Accordingly, pc is fixed by the ground topology, which is also fixed. Then the condition p>p_c where the long range terrorism is defeated, can be reached only by changing the density p of the passive supporters. The quandary comes from the fact that, as stated above, it is both impossible and unacceptable to neutralize millions of people.

However, in this paper we propose a new strategic scheme to suppress the passive supporter percolation without dealing with the passive supporters themselves. Indeed, a terrorism cause always produces various independent-fighting goals. We argue these independent terrorist-fighting goals can be represented by a set of independent variables, which in turn extends the geographic space onto a higher dimensionality virtual social space. Only passive supporters populate this space according to their degree of identification. The associated percolation occurs there. Once it happens, the virtual percolating cluster is found to create additional ground pair links on earth surface, which are found to extend beyond the original nearest neighbor distance. The virtual social space dimension monitors the range of these additional ground connections. On this basis the percolation threshold pc in the virtual space can be modified to reach p>p_c by decreasing the social space dimension, leaving the density p unchanged.

Already, classical mechanics tell us that the pertinent space to study the dynamics of a particle is not the real space in which the elements are actually moving, but the so-called phase space in which the particle is reduced to a
representative point. The basic idea is that, at any given time, the state of
the particle is fully determined by the knowledge of not only its position, but
also its velocity. Then, a figurative point with 6 components, which are 3 co-
orodinates in the real space, and 3 velocity components represents the particle.
Here the elements we are dealing with are humans and their respective attitude
towards terrorism. Accordingly, in addition to the geographic coordinates (as
considered in [1]), other social coordinates, which characterize individual atti-
tude towards the terrorism under study must be included. The main terrorism
goal, usually the independence of some geographic area, determines the first
one. Then, as soon as a terrorist group turns active, the corresponding legal
authority sets on some repressive process against it, setting up a second social
dimension, the condemnation of the state repression. At this stage, already
four coordinates characterize any individual in the world. Two determine the
position on earth while the two others measure its respective concern with re-
spect to the main terrorist cause and the repression against it. This set of social
parameters may not be complete. Most terrorist groups relate to additional
dimensions beyond the two mentioned above. For instance, there is often an
ethnic component, which produces an extra dimension to the representative
social space. The determination of these parameters will be discussed later on.

To substantiate our proposal, we need to implement our notion of virtual
space, making explicit the rules to construct it. Considering a discretization of
the earth 2-dimensional surface, we first present a full illustration in the case of
a three-dimensional social space with a population of 64 persons. For clarity,
we choose, as an example, a simple cubic geometry to illustrate our purpose,
but any other geometry is possible. Accordingly the 64 persons are located on
an earth square lattice as shown in Figure (1). Among them, 20 are passive
supporters. Next step is to aggregate the 64 sites by plaquettes of respectively 4
nearest neighbors. It yields 16 distinct groups. To keep on a clear visualization
we proceed considering only the upper two 4-sites groups circled in Figure (1).
They are shown in Figure (2). All the 4 sites of a given plaquette are then
duplicated and distributed along one vertical line, which contains 4 sites as
shown in Figure (3). This vertical direction represents the third dimension,
and the height is an averaged measure of the degree of identification of the
passive supporter to the terrorist cause. There exists one vertical site per
person. However, only passive supporters occupy the vertical sites associated
to their respective plaquette, in addition to their ground sites as shown on
Figure (4). Since many degrees of identification can be met, we postulate
their distribution along the vertical axis is random. In this process, the image
of the 8x8 two-dimensional grid corresponding to the square on earth in fig. 1 is a 4x4x4 cube in the 3-dimensional virtual space. The passive supporters are randomly distributed among the 64 sites of this cubic lattice. In the virtual space we restrict interactions to nearest neighbors (nn) as on the earth lattice. It means that passive supporters develop an additional connection when both sharing a similar degree of identification and belong to nn earth plaquettes. However it is of importance to notice that nn connections in the representative space mean earth connections, which now extend beyond the original nearest neighbor connections on earth. This is illustrated in Figs. (4) and (5): The occupied sites (a)-(f) and (f)-(h) are nearest neighbors in the phase space, and are then linked together. However, they are not nearest neighbors on earth so that these links correspond to additional bonds on the original two-dimensional plane as shown if Figure (5).

At this stage we have shown explicitly how including a third dimension creates some additional connection within the two-dimensional plane, which extends beyond the original nearest neighbor connections. Adding other dimensions to the phase space will have the same effect, i.e. will create new connections on earth, and increase the range of interactions on earth between passive supporters. This is a quite general behavior resulting from the increase of the number $q$ of nearest neighbors when the dimension $d$ of the space increases. In the case of the cubic geometry chosen to illustrate our purpose $q = 2d$. In this case passive supporters are randomly distributed on a $d$-dimensional hypercube, which cannot be illustrated on a figure like in the three-dimensional case. However, the same construction of the image of the passive supporters in the representative space applies, except that the basic unit is larger than the 64 elements, and the plaquettes include more than 4 elements in order to keep constant the hypercubic geometry when $d$ increases. We can now proceed along presenting the model in a more general frame.

Assuming roughly a world population of 6.1 billions, we consider a finite size lattice with $6.110^9$ sites and a nearest neighbor connectivity $q_2$. Each lattice site is occupied by one person. The earth surface being on a sphere we assume periodic boundary conditions. We assume a percentage $p$ of lattice sites occupied by the passive supporters to the terrorist cause. They are randomly distributed.

The total surface of the earth is 510 millions $km^2$, but most of it covers the oceans, making the surface of emerged land about 150 millions $km^2$. The associated square lattice has then a side of length $L = 12247km$. For a population of $N = 6.110^9$ people on a two-dimensional square lattice the number
of side sites (grid points) is \( N_2 = N^{1/2} = 78103 \). It yields a spacing between two nearest neighbors of \( a_2 = L/N_2 = 157m \). When going to a \( d \)-dimensional space while keeping the same earth surface, the number of side sites becomes \( N_d = N_1/d \), making the earth spacing between two nearest neighbors equals to \( a_d = L/N_d \). For \( d = 2, 3, 4, 5, 6 \) and 7 we get for the nearest neighbor spacing in km unit, 0.157, 6.703, 43.823, 135.196, 286.511 and 489.92, respectively. The numbers of site sides are 78103, 1827, 280, 91, 43, and 25 respectively. In simulations, the number \( N_7 \) used to compute the percolation threshold is up to 26, quite close to our finding of 25 [9]. Although the size effects associated to this finite number of \( N_7 \) affect significantly the critical exponents of the percolation phase transition, they have little effect on the percolation threshold itself [9]. We also note that, despite the fact that the percolation transition on an infinite lattice is of second order, pre-transitional effects take place only very close to \( p_c \). A variation of \( p \) with respect to \( p_c \), although too small to be detected by intelligence forces, is then sufficient to switch from the small cluster terrorism to the worldwide scale of the so-called rich-terrorism. Hence the difficulty for intelligence services to predict the event [1].

We are now in a position to discuss our new strategic scheme to oppose the worldwide terrorism threat without acting on the associated passive supporters. It articulates on what determines the value of a percolation threshold, mainly two quantities, the local connectivity \( q \) and the space dimension \( d \). First one measures the number of nearest neighbors for a given site. We assume it is a constant between 5 and 20. The second parameter \( d \) is the number of independent variables needed to localize a point in the associated phase space. It is a geometric parameter characteristic of a lattice. Let us now turn to the percolation threshold. An exact calculation of \( p_c \) is available for very few lattices only. Most thresholds are evaluated from simulations. However, few years ago we have been able to postulate a quasi-exact formula, which yields up to the third decimal all known threshold values [8]. It is a power-law, which writes for site dilution,

\[
p_c = a[(d - 1)(q - 1)]^{-b},
\]

with \( a = 1.2868 \) and \( b = 0.6160 \). It indicates that \( p_c \) is a decreasing function of both \( d \) and \( q \). This law is universal [8]. We have plotted in Figure (6) the variation of \( p_c \) as a function of \( q \) at dimensions \( d = 2, d = 4 \) and \( d = 10 \).

At two dimensions, \( p_c \) varies from 0.55 at \( q = 5 \) down to 0.21 at \( q = 20 \).
Therefore, even with this last very high connectivity of 20, the mean density $p$ of passive supporters must reach 21% of the whole population for the associated terrorism to percolate. It is hard to believe such a massive support can occur in practice. Most qualitative estimates mentioned in newspapers put the level of support to the terrorism cause at around 10%. In that case, at $d = 2$ and $q = 20$, it implies that the regions of the phase space where the local density of representative points can reach $p_c$ are sparse isolated clusters of finite size. But indeed, at $d = 5$ and $q = 20$, we do have $p_c = 0.1$. In that case, the terrorist network can thus percolate with an estimate of 10% of the population to be passive supporters. Long range terrorism thus appears possible at dimension around 5 and not 2. Figure (7) shows the three-dimensional plane of the percolation threshold as function of both $q$ and $d$ under two different angles. It is seen how the threshold shrinks down to 0.054 at $d = 10$ with $q = 20$. Already at $d = 3$ we have $p_c = 0.36$ at $q = 5$ and $p_c = 0.14$ at $q = 20$ which is a substantial decrease from respectively 0.55 and 0.21 but still too high to be reached.

Above results clearly show that modifying the dimension of the space has drastic effect on the value of the percolation threshold. Therefore it allows a strategic reversal of cracking down the worldwide terrorist threat, while preserving an ethic attitude, with an unchanged value of the density $p$ of passive supporters. And indeed, at contrast with local terrorism, the novelty of the current long-range terrorism has been its ability to generate several additional dimensions to its representative space. Among others, it embeds a religious dimension, a social dimension, an historical dimension and a world bipolarization dimension. It is then quite realistic to reach such a high dimension like $d = 8$ giving $p_c = 0.16$ and 0.06 for respectively $q = 5$ and 20. Now, only 6 percent of support are enough to get a world percolation cluster, a small figure that sounds reasonable. In addition, the nn spacing in the model corresponds to the maximum range of interaction on earth (see Fig. 5 for the illustration at $d = 3$). Passive supporters separated by a distance less than this nn spacing are not necessarily connected (bond $a-h$ in Fig. 5 for instance). However, some of them are indeed connected (bond $a-f$ for instance) at such a distance comparable with the size of a state, i.e. few hundreds of kilometers, for $d \geq 5$. It means that a few passive supporters can be very efficient at $d \geq 5$, even if the number of passive supporters is very low.

Therefore, we can conclude that the relevant strategy to get rid of massive terrorism is to decrease $d$, as $p_c$ is very sensitive to this parameter after Eq. (1) and Figs. (6) and (7). Formally decreasing $q$ at fixed $d$ would be in principle
also efficient but it would imply in practice acting on the people, which is not doable. At contrast decreasing $d$, while out of the scope of both the physicist investigation and the military action, is accountable for economical, cultural and political fields. It does mean that the conventional tools like intelligence services have a reduced strategic importance against terrorism. The basic reason is that, if politics can successfully reduce the key parameter $d$, they will only make impossible an infinite percolating cluster figuring the long-range terrorism, to the benefit of the situation of finite isolated clusters for which the conventional tools have proven to be useful. The war against terrorism thus requires the simultaneous efforts of both politics to increase $p_c$ and optimized conventional tools to minimize $p$ within finite size clusters.

In conclusion, we would like to point out that we have listed only some of the parameters acting as dimensions in the social space associated to the terrorism problem. At this stage, the social space is not yet fully identified. Actually it belongs to Social Sciences to identify all the parameters, and define a protocol for their quantitative evaluation. Still an exhaustive list will only provide us with a complete set of parameters, which are not necessarily independent. The next step will then be to check the independence or quantify their interaction following the procedures established in Differential Psychology, this work being the analog of an orthogonalization process in mathematics. Only this approach will allow for the complete determination of the phase space, through a complete set of independent variables. The present paper is then a preliminary work, and we are then eager to see the community of Social and Political Sciences to work on this subject within a multi-disciplinary approach to make it quantitative. However, let us point out that the model already gives an important insight on the winning strategy against the terrorism: attention should not be focussed on breaking the support for terrorism. Instead, the winning strategy lies in a reduction in the dimensions of the social space in which this support is exerted.

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2 References

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3 Figure captions

Fig. 1: A schematic view of 64 persons on a square earth surface with 20 passive supporters in black circles, others 44 being in gray circle. People are aggregated into plaquettes of 4 nearest neighbors as shown for the upper left 16 ones.

Fig. 2: Nearest neighbor bonds on the earth surface before the establishment of the representational social space.

Fig. 3: Construction of the third dimension associated to the 8 square lattice sites of Figure (2). For each plaquette of 4 sites, the associated vertical line contains 4 sites to rank the averaged degree of identification to the terrorist goal.

Fig. 4: The representational social space (upper part) with only passive supporters occupying their respective sites. Other sites are empty. Below is the two-dimensional earth space.

Fig. 5: Earth configuration after the establishment of the representational social space. Two more additional links connecting respectively passive supporters (a)-(f) and (f)-(h) have been created. Their respective range goes beyond the original nearest neighbor range.

Fig. 6: Variations of the percolation thresholds as function of the connectivity $q$ from $q=5$ to $q=30$ at respectively $d=2$, $d=4$ and $d=10$. The horizontal line $p_c=0.1$ shows when percolation occurs for density $p=0.10$.

Fig. 7: The three-dimensional plane of the percolation threshold as function of both $q$ and $d$ for respectively $q=5$ to $q=20$ and $d=2$ to $d=10$. The intersection with the plane at $p_c=0.10$ is shown. Above the plane, terrorism is localized geographically while below it is long ranged.
New additional bonds on the earth created from the representational social space.
Connectivity

Percolation Threshold

\[ \text{Dimension } d = 2 \]
\[ d = 4 \]
\[ d = 10 \]

\[ P_c = 0.1 \]
