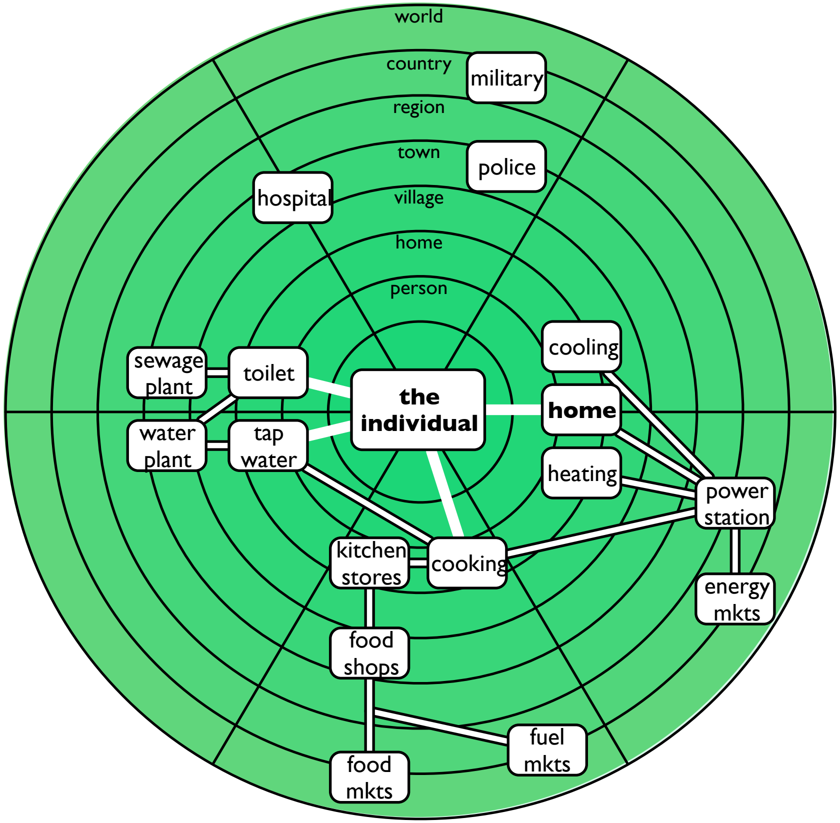

simple critical infrastructure map (SCIM)

Dealing in Security

understanding vital services and how they keep you safe

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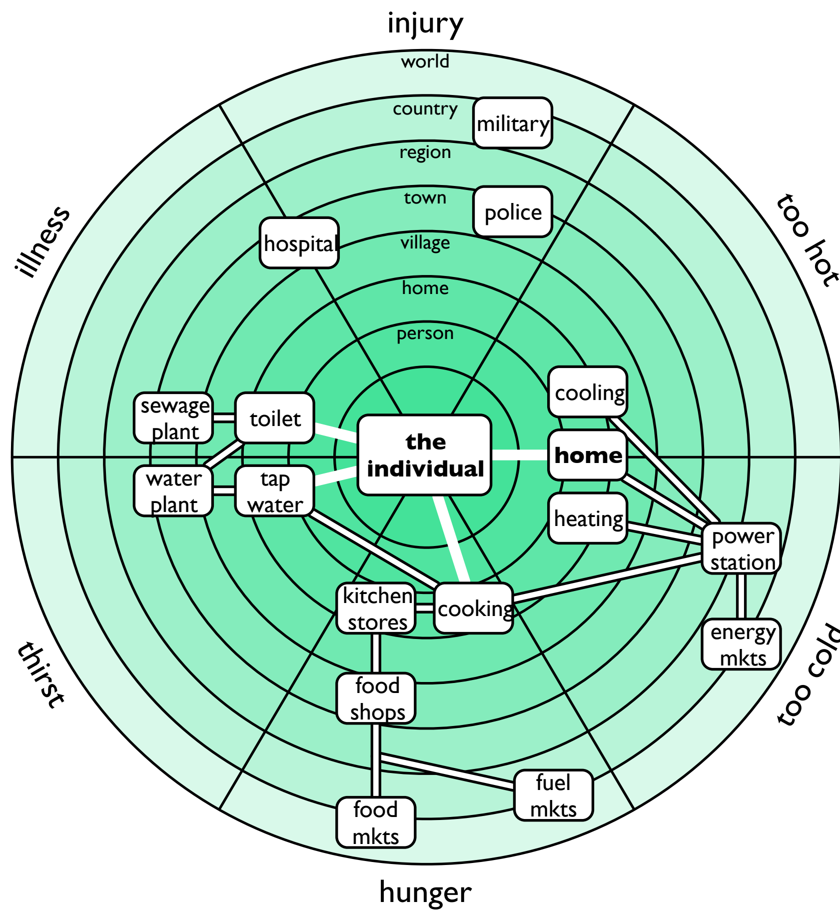
SCIM: Individual

This example *simple critical infrastructure map* shows how a typical western individual is protected from the *six ways to die* by the *layers of infrastructure*.

SCIM:I maps can be drawn to prepare action plans as part of a risk assessment process. The map can show the details of infrastructure in a particular area.

Crisis responders can update maps during an infrastructure failure to identify key response priorities and protect the public.

The public can draw their own maps to identify their vulnerabilities to infrastructure failure. National and municipal agencies can help by making standard maps of their services available.



Six ways to die (6WTD)

There are six basic ways in which people die, and three sets of essential services which protect them.

Shelter protects from:
1. Too Hot
2. Too Cold

Supply protects from:
3. Hunger
4. Thirst

Safety protects from:
5. Illness
6. Injury

Good physical infrastructure and social services bring these risks down to acceptable levels. In a crisis the challenge is to reduce these risks by restoring essential services.

Shelter
Shelter refers not just to the home, but to the essential services like power, cooling, heating and so on that make it habitable year round. Not all homes have these services, and not all climates require them.

Supply
We all need regular food and water to stay alive. These essential supplies are provided in very different ways in different parts of the world - plumbing versus water carriers, for example.

Safety
Protection from illness and injury is provided by health care, public health, hospitals, sanitation infrastructure, police, security services and the military.

In the developing world, the six risks are increased by a combination of poor physical infrastructure, poverty, and in some areas social instability.

In most crises in the developed world the short term pressures on infrastructure systems do not threaten lives. However, in more severe times of crisis, or in developing world disasters, infrastructure failures can be even more dangerous than the original disaster. Water and sanitation issues are particularly problematic.

Simple critical infrastructure maps (SCIM) are a reasonable way of building a simple, realistic model of critical infrastructure systems.

SCIM

What is infrastructure?

Unless you are a professional in the infrastructure field, infrastructure's number one job in your life is to be invisible.

The system of pipes and wires which lets your toilet flush and your lights shine, which powers the computer and the stove, is intended to function perfectly 365 days each year, 24 hours each day.

Relatively short outages draw our attention. A quarter second power outage loses work on our computer. A two day water problem due to a burst pipe feels like a return to the medieval age. Infrastructure is universal, invisible and frequently very, very expensive and difficult to repair.

Look at the room you are in. If you are in a western office or home, there are three major infrastructure systems around you.

Electricity comes from distant generation factories and is carried over a fragile grid.

Drinking water comes from a reservoir or well, and is purified in another factory and piped to you.

Sewage is carried away over a separate system of pipes using more fresh water.

Natural gas, storm water, communications including internet fill out the basic package.

The most essential function of infrastructure is to protect us from the hazards of the natural environment. Heating our homes, providing us with safe water to drink and carrying waste are the most basic functions of the infrastructure systems around us.

Other functions, like providing electrical power to machines and light are primarily quality of life improvements which compliment the basic health-protection services which infrastructure generates.

Infrastructure is a public health system. It is from this perspective we will examine it further.

SCIM

Layers of infrastructure

As previously noted, infrastructure is expensive. Making a service like electricity available can be very expensive. One approach to reducing those costs is to build big, efficient systems like power stations. But this requires a large organization to raise the capital required to construct the system, and a long period of stability to pay for it.

Part of the success of the developed world is that it has successfully financed and deployed complex infrastructure systems, making basic services like electricity available, cheap and near-perfect. It involves science, technology, engineering, law, finance, a large and sophisticated manufacturing base, educated workers and many other systems to produce cheap and effective services.

The ownership arrangements around essential services like electricity are often fiendishly complex mixtures of market relationships, law and governance.

A typical arrangement is something like this. A government generates a contract to provide services, operate sections of a national grid. Companies bid to operate local power stations and sell power into the grid. Quality and standards are sometimes set by professional bodies which are not bound to any given nation state. These, plus fuel contracts, transportation contracts, health and safety regulations, anti-trust laws and so on comprise the complex system of ownership which lets you turn on a light switch.

In general there are seven common layers of infrastructure ownership.

1. **Individual**
2. **Household**
3. **Neighborhood / Village**
4. **Municipality / Town / City**
5. **Region**
6. **Country**
7. **International**

Above the household layer infrastructure systems typically have complex and sometimes conflicted relationships between their owners, users and guards. Small-scale systems often have much simpler financial and administrative models, making them easier to deploy in distressed environments.

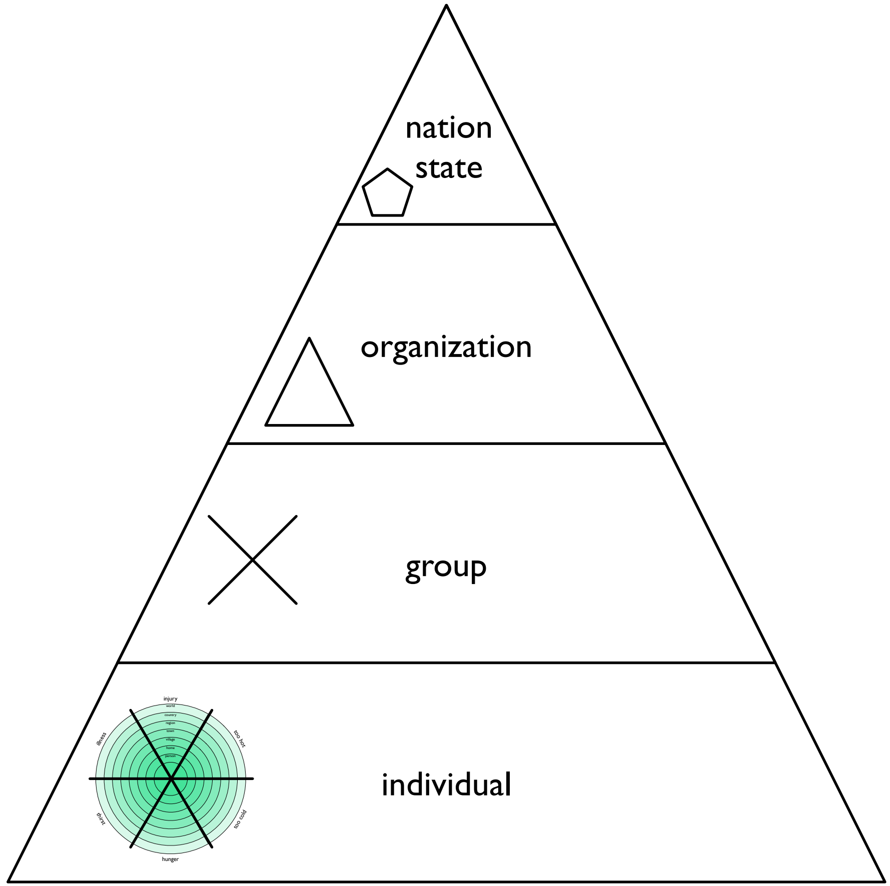
Four tiers of cooperation

Individuals, *groups*, *organizations* and *nation states* are the *four tiers of cooperation* possible when individuals work together. Each tier requires its own infrastructure plus the infrastructure of the *tiers of cooperation* it rests upon.

Individuals make up *groups* using infrastructure to enable connection and cohesion.

Individuals in *groups* sharing common purposes form *organizations* which require social infrastructure to maintain their effectiveness.

Individuals, working together in *organizations* and *groups*, form the *nation state* which requires infrastructure to provide services for the benefit of *individual* citizens.



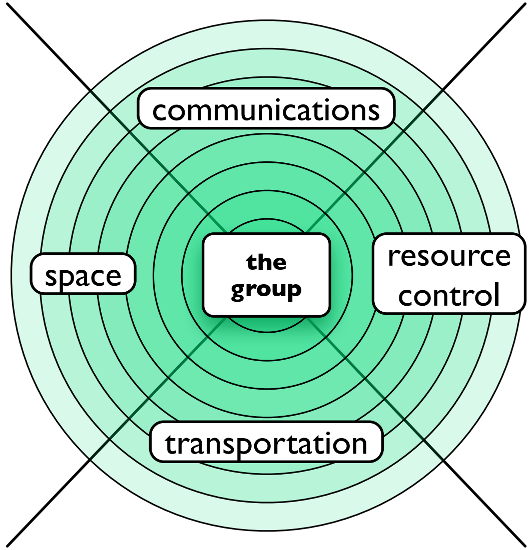
SCIM

SCIM: Group

A *group* is any collection of people. It could be as few as two. Typical groups include families, fellow travelers on a bus or a plane, or any social group.

Groups have complex psychology related to inclusion and exclusion and degrees of allegiance to one group or another. A lot has been written about those matters, and they are beyond our scope here.

The basic requirements for a group to exist are fairly similar. Most groups require communications,, transport and space. They use infrastructure like offices, cell phones and car pools. Internal systems keep resources available where they are needed.



Some groups are structured so they can function with less dependence communications, transportation or space.

1. Communications
A group has to be able to exchange messages (voice, phones, mail, sms) or it cannot act together.

2. Space
Most groups need places to physically gather, like a home for a family or a local cafe for a set of friends.

3. Transportation
Groups that do not simply stay in one place need to have members be able to leave and return. Walking counts.

4. Resource Control
Shared resources are used in a way that supports the group.

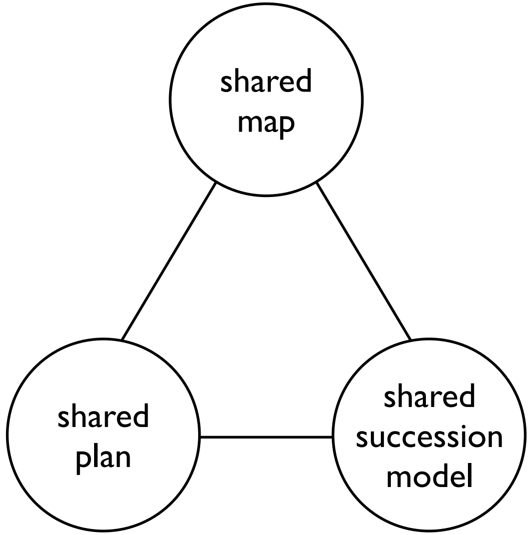
SCIM

SCIM: Organization

An *organization* is a special kind of group with a purpose beyond the combined purposes of the members. Hospitals, police forces, fire brigades, armies and schools are all examples of organizations.

An effective organization has all the needs of a group, plus three necessary pieces of "social infrastructure." These give an organization the coordination and unity of purpose that it needs. Social infrastructure is often as essential to an organization's success as physical infrastructure.

Organizations often require specialized accommodation and equipment to fulfill their purpose. These additional infrastructure needs must also be mapped.



Organizations often require services from other organizations. For example, a hospital may require police and power to be available. These dependencies can be shown effectively on the SCIM matrix (see below.)

1. Shared Map

The people in an organization must share a map of reality - their aims, responsibilities, environment of operation and so on. Some fraying is acceptable, but not much.

2. Shared Plan

From the shared map comes a shared plan, subject to the diffusion of power and responsibility within the organization.

3. Shared Succession Model

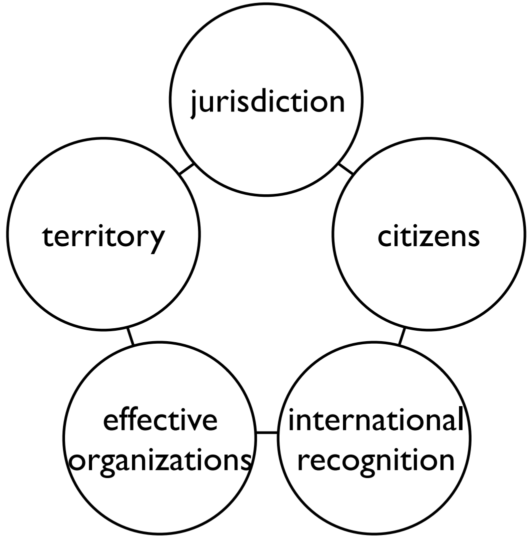
Most importantly, if the current leadership of an organization is not performing, there must be a shared model of how to select new leaders. This can be critical in times of urgent crisis.

SCIM: Nation State

A *nation state* or government is a special kind of social organization which carries vast responsibility and power. Specific infrastructure systems are required to keep a nation state running.

Nation states in crisis can face problems like inability to identify their own citizens, to establish clear jurisdiction, and to control territory. Civil wars are especially destructive because they challenge statehood at its root.

Organizations like the police, military, and court system make the state able to sustain itself and provide services to its citizens. States may also provide infrastructure services like a national grid, ports and airports.



Modern technology can streamline many of these areas. For example GPS and satellite provide accurate territorial maps. CheapID uses biometrics and cryptography to provide identity services to citizens. "State in a box" examines this high tech approach in more detail.

1. Jurisdiction
The state should provide an effective system of law and law enforcement.

2. Citizens
Certain individuals are citizens of the state, while others are visitors. The state should know.

3. Territory
There must be an agreed area in which the state has control.

4. Effective Organizations
These arms of the state collectively define its effectiveness.

5. International Recognition
Required for full sovereignty and entry to international bodies.

SCIM: INAM State Failure Map

Integrated Needs Analysis Matrix (INAM)	too hot	too cold	hunger	thirst	illness	injury	communications	transport	space	resource control	shared map	shared plan	shared succession	jurisdiction	territory map	citizens list	effective institutions	international recognition	additional needs	additional needs	additional needs
individual																					
household																					
village / neighborhood																					
town / city / municipality																					
region																					
country																					
world																					
specific entities																					
e.g. power company																					
or ports / harbors																					

specific data about supplies, needs, interdependencies and so on should be listed in each cell of the INAM spreadsheet

additional needs - for example, electrical power to operate hospital equipment, or supply chains for specific drugs and medical supplies

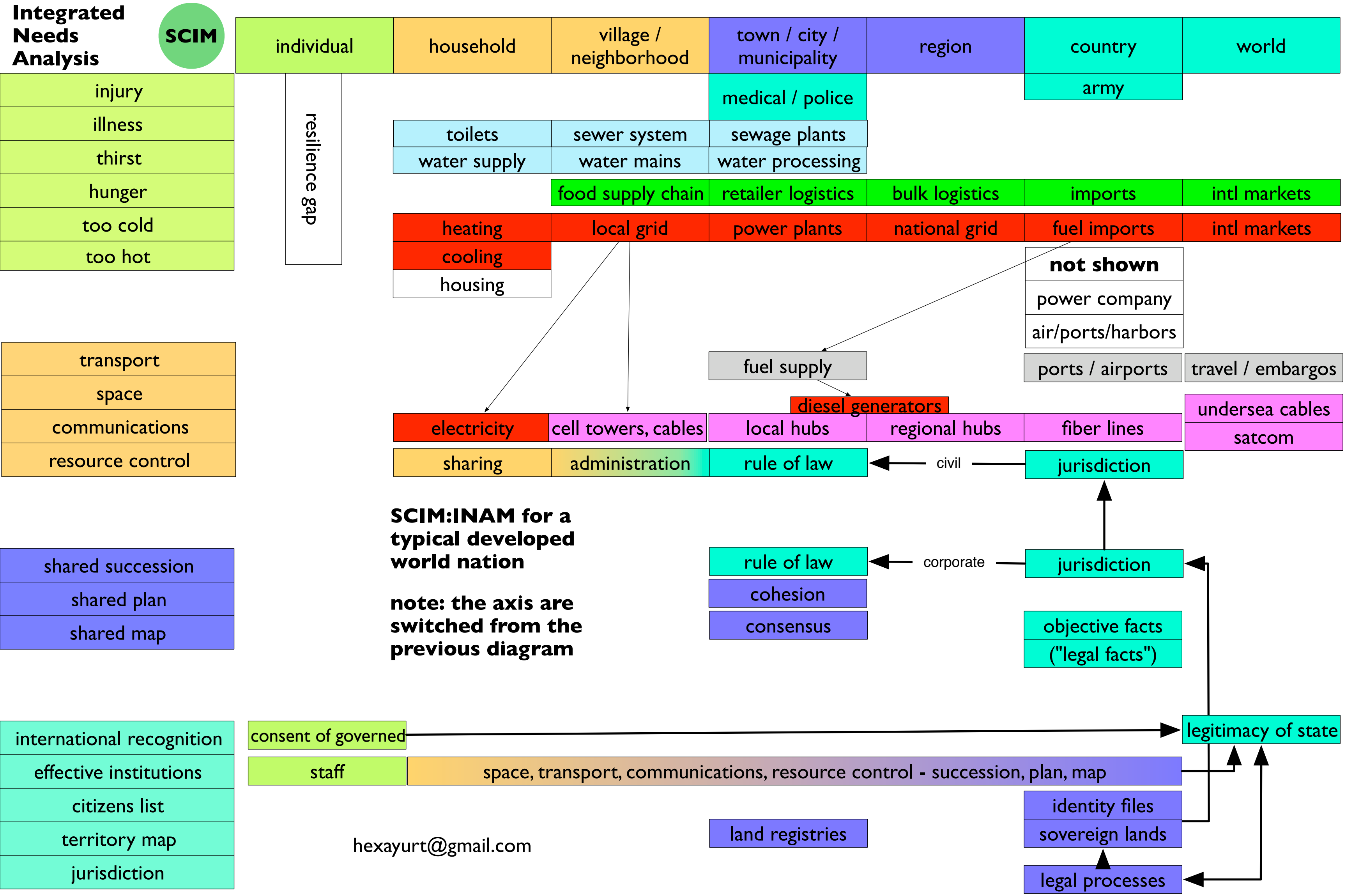
the actual shape of the local power network, water network and so on can be mapped by municipalities and made available to groups wishing to do their own resilience analysis

additional needs combined with specific entities provides a comprehensive mapping framework - across the many levels of control and locality - of the actual system externalities.

The previous simple critical infrastructure maps are drawn for a particular situation for individuals, groups, organizations and nation states. The SCIM Matrix combines data from these to show where all critical resources come from.

For example, a hospital depends on a power company, and its own diesel backup systems. The power company in turn needs fuel.

The INAM matrices can grow quite large when filled in with accurate information about a given situation, particularly when interdependence is taken into consideration - the power and water companies depend on each other in many cases, for example.



Integrated Needs Analysis
SCIM
individual
household
village / neighborhood
town / city / municipality
region
country
world
injury
illness
thirst
hunger
too cold
too hot
resilience gap
medical / police
army
toilets
sewer system
sewage plants
water supply
water mains
water processing
food supply chain
retailer logistics
bulk logistics
imports
intl markets
heating
local grid
power plants
national grid
fuel imports
intl markets
cooling
housing
not shown
power company
air/ports/harbors
fuel supply
ports / airports
travel / embargos
transport
space
communications
resource control
diesel generators
undersea cables
satcom
electricity
cell towers, cables
local hubs
regional hubs
fiber lines
sharing
administration
rule of law
civil
jurisdiction
SCIM:INAM for a typical developed world nation
note: the axis are switched from the previous diagram
shared succession
shared plan
shared map
rule of law
corporate
jurisdiction
cohesion
consensus
objective facts ("legal facts")
international recognition
effective institutions
citizens list
territory map
jurisdiction
consent of governed
legitimacy of state
staff
space, transport, communications, resource control - succession, plan, map
identity files
sovereign lands
land registries
legal processes
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Next Steps

Our organization now offers training and consultancy on *historic risk management*. Simple Critical Infrastructure Maps is part of our library of tools for enabling effective action to be taken on a wide variety of risks, across a range of scenarios.

We are particularly interested in mitigating *state failure* and welcome consulting around failed states.

Planning for *organizational resilience* during dramatic change, particularly for critical infrastructure and service organizations, is another area of profound interest to us. Being able to open effective communication between vendors and consumers of critical infrastructure services is a key area of our practice. Forming a shared language is key.

Authors

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As founder managing director of Plain Software, Mike played a vital role in the development of NHS Direct. He is now a strategic consultant on social, business and government resilience.

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Co-editor of *Small is Profitable* (*The Economist*'s book of the year 2003) and *Winning the Oil Endgame*, Vinay focusses on whole systems response to crisis and change mitigation.

STAR-TIDES

SCIM is the underlying model for the US Department of Defense STAR-TIDES project on crisis response and humanitarian relief. *(see Defense Horizons #70)*

Contact Us

Please get in touch with us to discuss your organization's strategy for dealing with historic risks, and the critical infrastructure implications of those scenarios.

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License

SCIM

Maintaining infrastructure

There are six typical problems maintaining infrastructure. Not all of these problems are external.

1. Neglect
Without proper maintenance, including but not limited to repairing time and wear, infrastructure systems fail.

2. Time and wear
Even if infrastructure maintenance is not neglected systems eventually need to be replaced.

3. Operators
Infrastructure systems require skilled operators to run and maintain them. This may be a very serious issue in pandemics.

4. System Externalities
Some infrastructure systems need inputs from other systems to operate. For example, power plants fail without fuel.

5. Economics
Economic declines can make expensive infrastructure systems inoperable by cutting demand below the level at which the service is financially viable. Multiple systems may be affected simultaneously with serious human impacts and increased overall societal fragility.

6. Violence / Disaster
Natural disaster, war and terrorism can all destroy infrastructure suddenly and unexpectedly. War complicates service restoration because of ongoing violence.

In the event of failure, infrastructure systems cease to operate optimally. This can have three effects:

1. Services become unavailable (*provision*)

2. Service prices rise steeply (*cost*)

3. Service standards drop, such as dirty water and unreliable electricity (*quality*)

These changes can have effects ranging from inconvenience through to widespread death. It depends on the degree to which an area requires infrastructure to keep people alive and society stable.

SCIM

Provision, cost and quality

Infrastructure has three kinds of effects on essential services.

1. Provision
To make a service (like electricity) available where it was previously unavailable.

2. Cost
To reduce the cost of a service relative to other ways of providing it, like centralized water vs. local wells.

3. Quality
To improve the quality of a service, such as by providing pure water rather than river water.

Good infrastructure makes services reliable, cheap and near-perfect. Bad infrastructure is patchy, expensive and of poor quality.

Making essential services like electricity cheap and reliable has very strong economic effects. If every business had to operate a diesel generator during its hours of operation, everything would be much more expensive. The air would be filled with smoke, and junk yards would fill with obsolete generators.

By *centralizing* energy generation, certain kinds of efficiency are created. Coal-fired power stations cause far less pollution than local diesel generators do. Many high-tech power stations working together produce ultra-reliable grid service.

But to get this cheap electricity is very, very expensive. The investment in systems is huge. These costs are met with large, strong economies.

This reduction in service cost by centralization is an example of *economies of scale*. Water, electricity, sewage processing, and natural gas provision have been centralized to cut the cost per unit of essential services.

In distressed environments there are often serious issues with service quality and availability. Water is often contaminated, power is not reliable or has voltage spikes and brownouts, diesel may be dirty. Price per unit of service can be ten or more times what it would cost in a developed world economy.

SCIM

Service delivery paths

Infrastructure services reach users by four *service delivery paths*

1. **Produce** on site(solar)
2. **Grid** services (power, water)
3. **Delivery** (water, gas)
4. **Fetch** (food, batteries)

Consider drinking water. It can be made available in all four ways.

1. A well can produce water on site
2. Grid water can come from the tap
3. A truck can deliver water
4. People can bring the water from a well or river nearby, or buy it in a supermarket. Shopping is the usual model for "fetch" in the developed world.

Not all essential services can be made available using all four systems.

Natural gas, for example, is seldom produced on site, except in the case of biodigesters. But it can come from the grid, delivery, or fetch methods.

Electricity, on the other hand, can be produced on site using solar, wind or microhydro but is very hard to deliver or fetch except in tiny quantities using batteries.

Wireless telecommunications are a special instance of grid services. Although cell phone networks and satellite phones are more robust than wired systems, it is important not to ignore the issues around "backhaul" (long distance cables) and base station / cell tower infrastructure. Wireless systems are not immune to disruption in crisis.

Keeping essential services available to people in a crisis can require careful thinking about real needs - perhaps switching from grid services to local production or resources which can be stockpiled.

Local production can replace resources from a grid. Resources which can be delivered or fetched can be stockpiled in case of supply interruptions. Diesel generators can convert diesel, which can be stockpiled and transported, into electricity which cannot be effectively stored. Solar and wind can substitute for grid services in a stable and sustainable fashion in many areas. Careful system redesign, including use of efficient end-use devices, can promote resilience.

SCIM

Centralization and decentralization

Service centralization comes at considerable cost. Although a single large centralized power station can power an entire town, it can take many years to build and as long as 30 years to pay for itself. If there is a system failure, this large, single point of failure must be repaired quickly. The cost of maintaining ultra-reliable centralized systems can be very high. But in stable times, these systems produce incredibly cheap services.

Decentralized infrastructure like local CHP, solar or wind installations can take advantage of *economies of agility*. They are bought as needed rather than planned decades in advance, scaled to fit needs, can be upgraded piecemeal or moved and generally have much lower risk.

Decentralized infrastructure is the wave of both the past and the future. Old decentralized systems were things like water mills and pit latrines - systems which ran directly from the natural world to provide basic services.

New decentralized infrastructure is systems like solar panels, local water purification (SODIS or SOPAS,), advanced composting toilets, wind energy and so on. Note that many decentralized energy systems can be tied together in a grid configuration but it is not always necessary or profitable to do so.

Many decentralized infrastructure systems run from renewable resources and so provide insulation from fuel price / availability issues.

From an infrastructure mapping point of view, the critical distinction between centralized/decentralized systems is *dependencies*. Centralized systems typically have large and complex networks of requirements to operate, but operate at high efficiency. Whether the input is fuel or chlorine or spare parts, it seems that in general the cost of efficiency is complex dependencies and overall system brittleness.

Decentralized systems typically have few dependencies or none at all, and what dependencies exist are often simple (lubricating oils or distilled water.) This can make decentralized systems more trustworthy in a crisis.

SCIM