Preventing cascades of failure: Practical advice for resilience

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Issues to be covered

- **Background: A touching faith…**

- **What might be the key design criteria?**

- **Scoping the potential customers…**

- **How might this be engineered…?**

- **What might be the charging model?**

- **Summing up - final thoughts.**

Background: A ghost at the feast?

Over the last ten years, a great deal of excellent work has been carried out across many sectors to:

- **Move to 'just in time' manufacturing;**

- **Remove warehousing;**

- **Cut out 'fat' removing excess staff.**

Industries have become much more efficient and productive - 'running lean'. However this success contains an implicit assumption - that the basic infrastructure (energy, communications, transportation, …) remains secure and reliable.

However, the more 'efficiently' we operate the less 'slack' there is in our systems to cope with major disruption…

Background: Unconstrained interdependency…?

- **Ten years ago, the energy companies operated large Private Mobile Radio (PMR) networks to co-ordinate their maintenance and restoration teams. These PMR systems gave wide coverage from hill-top sites and had ample backup power.**

- **Those systems have gradually been shut down in favour of the lower cost alternative - use of the public cellular communications operators, albeit with a smattering of satellite 'phones.**

- **Electricity and gas distribution are thus intrinsically dependant on the cellular providers. However as we shall see the cellular operators are intrinsically dependant on the smooth running of the electrical grid…**

As time passes the different elements of our key infrastructure become subtly more interdependent…

Background: Cellular integration rules OK?

- Similar private networks were also once used for co-ordination in various other industries such as private security and logistics - now largely replaced by cellular phones…

- Even the traffic sensors which funnel data for avoiding jams and blockages are dependant on a secure electrical supply….

- The disparate mobile networks of the UK emergency services have been integrated into a single integrated network - 'Airwave' currently with limited power back up…

Do we have a 'vicious' circle of mutual interdependence in key elements of infrastructure?

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Background: A vital flaw…

- In the UK, cellular networks were never designed to be fully resilient, either against power failure or overload:

  - Back up power arrangements are limited. Many smaller sites have no power backup.

  - Typical overload margins designed in might be 20%.

- This is <u>not</u> a criticism, simply a statement of fact, resilience was not part of the original requirements.

However if you asked the average UK citizen if they would expect their mobile phone to work during a power failure or other emergency they would likely say "yes"…

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Background: Power resilience for cellular networks

- A typical public cellular network has three categories of sites:

- Tier One: Major nodal sites through which many dependant sites are connected. These have battery back-up and generator backup on site. They are highly resilient.

- Tier Two: High capacity and wide coverage cells. These have four hours of battery backup only…

- Tier Three: Sites providing local coverage particularly to give capacity in urban areas. These have no power back up at all.

Public cellular networks are designed to cope well with localised power failures but would be severely impaired by wide area power failure.

Background: Some 'Airwave' challenges

Whilst I was CEO, the UK Radiocommunications Agency was able, through negotiation with NATO, to provide clean UHF spectrum for 'Airwave' in the 380-400 MHz band.

- The advantage in having ease of mobile inter-communications between key services such as police, fire and ambulance is clear. However integration also carries the risk of creating single points of failure…

- Power backup duration for Airwave base stations is limited and would not satisfy the UK Cabinet Office generic business continuity planning assumptions: "loss of mains electricity supply for up to three days (locality) or 24 hours (region)".

Sadly, when it comes to determining priorities, more police on the beat may be more attractive than backup power…

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Background: The potential for cascade failure…

The really frightening prospect is cascades of failure:

- Power fails to a major area of a city or region (not necessarily terrorism often just simple maintenance mistake…)

- Key mobile communications networks rapidly degrade in the effected region due to minimal backup power at local base stations.

- Emergency services networks fail, again due to lack of backup power somewhere in their chain.

- Broadcasting fails, again due to lack of backup power somewhere in their chain.

In the absence of normal sources of news and personal contact, all these lead to potential major civil disorder. Resilient mobile communications could block this cascade…

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What might be the key design criteria?

Once cellular networks were considered just an interesting add on to fixed networks. Now in the UK (and often elsewhere), the number of cellular phone connections significantly exceeds the number of fixed line connections*. For a resilient cellular overlay, the key criteria should probably mimic the core fixed network:

- enough backup power for three days at base stations;

- overload margins of at least 100%; and

- No single points of failure in transmission or control.

*UK/Ofcom data for Q4 2004. Total number of UK fixed lines 33.7M, Total number of cellular connections 57.8M

Source: http://www.ofcom.org.uk/research/cm/cm05/telecom_appendix.pdf

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Scoping the potential customers…

There will be many potential customers in both the public and private sectors, where the implications of 'Critical National Infrastructure' (CNI) support extend.

Sector	SIC	Employ--ment (K)	% need	Accessible market (K)
Transport/Storage/Communications	60-64	1,563.1	50%	781.5
Electricity, Gas & Water Supply	40-41	102.2	75%	76.6
Radio, TV and News Agencies	92.2-92.4	79.3	20%	15.9
Financial Intermediation	65-67	1,062.3	15%	159.3
Manufacturing	15-36.1	2,990.8	10%	299.1
Health & Social Work	85.1-85.3	3,225.3	10%	322.5
Public Administration and Defence		1,477.1	5%	73.8

Indicative accessible UK market: 1,729 K

Source: UK Office for National Statistics: Labour Market Trends April 2006

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How might this be engineered: Key questions…?

A resilient overlay on an existing cellular network?

• Dedicated SIMs that allow 'phones and other devices to access both the resilient overlay and the base network?

• Minimal use of 'pico' and 'micro' cells within the overlay to reduce backup power costs and maximise wide area coverage, at the cost of spectrum efficiency?

• Based on '3G' or '2G' technology?

• Using new dedicated spectrum or a 'carve out' from existing spectrum as conventional users migrate from 2G to 3G?

• What range of services (beyond voice) to be supported?

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What might be the charging model?

- Sold as "just like a normal cellular device" but with enhanced resilience?

- Enhanced monthly rental but 'normal' call charges in conventional use? (No scope for 'pay as you go'…!)

- Enhanced call charges when basic network unavailable, or during tests and exercises?

- Regulatory support from sector regulators (e.g. energy, communications, broadcasting, water supply, financial services …) requiring the availability of resilient mobile communications to key personnel within their sectors?

- Scope for incremental sales to private users?

- Market and brand differentiation against less resilient operators?

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Some final thoughts....

- **Communications has a key role in blocking cascades of infrastructure failure.**

- **'Mobile' has now surpassed 'fixed' as the access network of choice under many circumstances, yet UK mobile networks were never designed for emergency resilience.**

- **Perhaps, in the head-long rush to move up the supply chain into content, operators are overlooking an opportunity in their core market?**

- **Surely market forces rather than regulation are a better solution to driving up emergency resilience?**

Slides can be downloaded from:

www.profjimnorton.com/survivejn.pdf