**A Ten Step Process for Forensic Readiness**

Abstract

A forensic investigation of digital evidence is commonly employed as a post-event response to a serious information security incident. In fact, there are many circumstances where an organization may benefit from an ability to gather and preserve digital evidence before an incident occurs. Forensic readiness is defined as the ability of an organization to maximize its potential to use digital evidence whilst minimizing the costs of an investigation. The costs and benefits of such an approach are outlined.

Preparation to use digital evidence may involve enhanced system and staff monitoring, technical, physical and procedural means to secure data to evidential standards of admissibility, processes and procedures to ensure that staff recognizes the importance and legal sensitivities of evidence, and appropriate legal advice and interfacing with law enforcement. This paper proposes a ten step process for an organization to implement forensic readiness.

**Introduction**

Digital forensic investigations (DFIs) are commonly employed as a post-event response to a serious information security or criminal incident. They typically consider the case when the PC of a suspect has been seized. The hard-drive is imaged and an investigation proceeds to search for traces of evidence. The examination is conducted in a systematic, formalized and legal manner to ensure the admissibility of the evidence. The process of a digital forensic investigation is subject to considerable scrutiny of both

the integrity of the evidence [Sommer 1998], and the integrity of the investigation

process [Stephenson 2002, 2003b].

This scenario of a DFI, and most discussions of the forensic process, tends to ignore what happens to the object of the investigation prior to the decision to undertake an investigation. The necessary evidence both exists, and hopefully is found by the DFI, or it does not exist and a suspect cannot be charged and prosecuted. This is the law enforcement view of a DFI. It begins when a crime has been committed or discovered and investigators attend a crime scene or wish to seize evidence [ACPO 2003, ENFSI

2003] the quality and availability of evidence is a passive aspect of the DFI.

In a business context however, there is the opportunity to actively collect potential evidence in the form of log files, emails, back-up disks, portable computers, network traffic records, and telephone records, amongst others. This evidence may be collected in advance of a crime or dispute, and can be used to the benefit of the collecting organization.

Recourse to litigation is generally a last resort for most businesses, so why should an

Organization be concerned about potential evidence and related disputes? Digital

evidence could help manage the impact of some important business risks. Digital

evidence can support a legal defense; it could support a claim to IPR; it could show that

due care (or due diligence) was taken in a particular process; it could verify the terms of

a commercial transaction; and it could lend support to internal disciplinary actions.

There are many situations where a simple dispute or information security event may

become more serious. If the evidence has not been gathered to begin with, it may be

too late to do so later in the process. Therefore, it is necessary from the outset to

consider the importance of evidence and to be prepared to gather it for a wide range of

scenarios.

Being prepared to gather and use evidence can also have benefit as a deterrent. A

good deal of crime is internal. Staff will know what the organization's attitude is toward

the policing of corporate systems. They will know, or will hear rumors, as to what type

of crimes may have been successfully or unsuccessfully committed, and what action

may have been taken against staff. A company showing that it has the ability to catch

and prosecute this type of insider attacker will dissuade them, much like the shop sign

“We always prosecute thieves.”

Information security programmers often focus on prevention and detection measures.

From a preventative information security perspective there is little need for digital

evidence. From a business perspective, however, there are a number of scenarios

where collecting appropriate digital evidence would be beneficial. Thus, there is a

business requirement for digital evidence to be available even before an incident

occurs. What exactly this requirement is, how it is met, and how organizations can

exploit digital evidence has not previously been considered in detail.

Forensic Readiness

The business requirement to gather and use digital evidence has been recognized in a

number of recent papers. Yasinsac and Manzano (2002) note that enterprise policies

can enhance computer and network forensics. They propose six categories of policies

to facilitate DFI. Their categories are designed to help enterprises deter computer crime

and position themselves to respond to successful attacks by improving their ability to

conduct DFI:

• Retaining Information;

• Planning the Response;

• Training;

• Accelerating the Investigation;

• Preventing Anonymous Activities;

• Protecting the Evidence.

Wolfe-Wilson and Wolfe (2003) discuss management strategies for implementing

forensic security measures. They stress the need for an organization to be in control of a DFI and to have planned procedures in place to preserve digital evidence and to instigate a forensic investigation. They note important links with the Business Continuity Plan and Incident Response procedures. The paper also notes the role of forensics within an overall security policy and strategy.

Carrier and Spafford (2003) present an investigation process model which, whilst focusing on the investigation itself, also recognizes a readiness phase to ensure that the operations and infrastructure are able to fully support an investigation. as follows:

Tan (2002) introduced the concept of forensic readiness to cover two objectives:

• Maximizing an environment’s ability to collect credible digital evidence;

• Minimising the cost of forensics during an incident response.

The problem was approached from the need to reduce the time and costs of a forensic examination. Tan quotes the example of the HoneyNet project forensic challenge

http://www.honeynet.org/challenge/results/index.html) where half an hour of attacker time required an average investigation time of 48 hours. Tan also discussed technical aspects such as time-stamping, system hardening and compromised kernels, and noted five factors that affect evidence preservation and investigation time:

• How logging is done;

• What is logged;

• Intrusion detection systems;

• Forensic acquisition;

• Evidence handling.

The message from Yasinsac and Manzano (2002) and Wolfe-Wilson and Wolfe (2003) suggests there is a broad organizational role in the forensic readiness process. Tan, in effect, presents the idea of system forensic readiness as one part of overall enterprise forensic readiness. Viewed from an enterprise perspective, forensic readiness can be seen as the ability of an organization to maximize its potential to use digital evidence when required.

Digital evidence is required whenever it can be used to support a legal process. An organization, therefore, requires access to the evidence that will be able to support its

position in such an event. This is not as easy as it might seem; relevant evidence is

unlikely to exist by default. In any computer security incident there will be a tendency to

focus on containment and recovery, as these are the foremost business critical issues.

However, in stressing these, any evidence that might be required may be damaged,

discarded or simply ignored [Tan et al 2003]. There is a trade-off to be made between

recovery and evidence. A lot of information is also lost or discarded as part of normal

business practice. To succeed in a legal process, it is therefore essential that the

organisation has actively gathered the evidence it is likely to require. Moreover, it is vital

to have the capability to process evidence cost-effectively, and to have suitably trained

staff who know how to ensure potential evidence is preserved. The organisation also

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needs to be able to make appropriate and informed decisions in the light of the business

risk.

In a forensic readiness approach, this incident preparedness becomes a corporate goal

and consists of those actions, technical and non-technical, that maximise an

organisation’s ability to use digital evidence. Any computer data may become used in a

formal process and may need to be subject to forensic practices. The ability of an

organisation to exploit this data is the focus of forensic readiness.

In this paper, a number of issues are introduced which help take this concept further:

1) Within organisations there is concern with a wide range of crimes and disputes, such

as fraud and theft, that may be addressed with digital evidence - not just information

security defence against criminal hackers;

2) An organisation can be involved with all aspects of an investigation - not just the

digital forensics;

3) An organisation will assess the costs of additional measures to prepare for DFIs

compared with the potential benefits; in general, investigations should be cost-

effective not just technically feasible;

4) In a corporate environment there is a wide range of potential evidence sources;

digital evidence must be actively sought, not passively used;

5) In a corporate environment, staff configuring audit logs may not be aware of the

“high-level” crimes and business issues that logging could be used to detect;

6) To collect useful evidence an organisation needs to target its collection capability on

the risks to the business; it is not a technical issue of what should be recorded in

logfiles;

7) Monitoring to detect an incident can encompass a wide range of techniques

including CCTV, door swipes, and honeypots. It is not just a case of applying an

intrusion detection system;

8) To collect admissible evidence, the organisation needs to review the legality of any

monitoring; it is not a technical issue of what can be ‘sniffed’ or traced;

9) The requirement for evidence implies that all forms of potential evidence should be

considered, such as CCTV cameras, personnel records, access control systems etc.

- not just logfiles and hard disks;

10) A wide range of staff may become involved in an investigation and will need to

understand their roles within it; it is not just a job for the forensic investigator or

system managers;

11) When an incident occurs, the appropriate response must consider the options for

forensic investigation and evidence preservation, not just the immediate business

continuity needs of containment, eradication and recovery;

12) A major criminal incident may involve the police. Prior discussions with them can

facilitate the interaction when an incident occurs;

13) A major incident may become public knowledge and have reputation and share-price

ramifications, so company lawyers and media managers may be involved. It is not

just an internal departmental issue;

14) The preservation of digital evidence may be required for corporate governance or

regulatory enforcement; it is not just an internal company issue

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In the context of enterprise security the definition of forensic readiness can be

broadened to:

The ability of an organization to maximize its potential to use digital evidence whilst minimizing the costs of an investigation.

Excluded from this definition are preventative and recovery measures. It is assumed

that appropriate information security defenses, such as system hardening, are implemented and revised as part of any security incident. Similarly, it is assumed that a competent Computer Security Incident Response Team (CSIRT) is available [Schultz and Shumway 2002]. Forensic readiness is incident anticipation compared with incident response. Forensic readiness concerns itself with enabling the business requirement to use digital evidence. Information security, in general, concerns itself with ensuring that the business utility of information systems is maintained, and this includes ensuring the business requirement for digital evidence is met.

The Costs and Benefits of Forensic Readiness

If forensic readiness is an enterprise issue, then the extent to which it can be pursued

will depend on the organization obtaining value for money for any investment. The

Foremost issue in understanding the need for forensic readiness is a risk assessment.

An extant risk assessment for something like BS 7799 or ISO17799 will be a valid

starting point, but may not assess all the situations where digital evidence may be

required. An asset register is certainly needed with an indication of the attractiveness of

targets to the various types of crime such as fraud, malicious damage, and IPR theft, as

well as an understanding of the impact on the company should such an event take

place.

Any information security defensive measures based on a risk assessment will always

leave a residual risk. Often this is because users are trusted not to cause a security

incident. In the long run, such an assessment may be correct and stringent defensive

measures may not be required. In forensic readiness, however, it is necessary to

assume that an incident will occur, even if a risk assessment says it should not. This is

especially true of situations where the risk is highest from insiders. It may be infeasible

to deploy preventative measures, especially where staff have to be trusted with high

value assets, but effective deterrence may be achieved with forensic readiness.

Depending on the impact of such an event, an organisation may need to put in place

measures to identify any miscreant and obtain the evidence required to take appropriate

action against them. Once an organisation recognises that it requires some form of

investigative capability, the next step is to ensure the efficiency and competency of that

capability.

From the discussion above and the objectives of forensic readiness it is evident that

good forensic readiness can offer an organisation the following benefits:

• Evidence can be gathered to act in the company's defence if subject to a lawsuit;

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• Comprehensive evidence gathering can be used as a deterrent to the insider

threat (throwing away potential evidence is simply helping to cover the tracks of a

cyber-criminal);

• In the event of a major incident, an efficient and rapid investigation can be

conducted and actions taken with minimal disruption to the business;

• A systematic approach to evidence storage can significantly reduce the costs

and time of an internal investigation;

• A structured approach to evidence storage can reduce the costs of any court-

ordered disclosure or regulatory or legal need to disclose data (e.g. in response

to a request under data protection legislation);

• Forensic readiness can extend the target of information security to the wider

threat from cyber crime, such as intellectual property protection, fraud, or

extortion;

• It demonstrates due diligence and good corporate governance of the company's

information assets;

• It can demonstrate that regulatory requirements have been met;

• It can improve and facilitate the interface to law enforcement, if involved;

• It can improve the prospects for a successful legal action;

• It can provide evidence to resolve a commercial dispute;

• It can support employee sanctions based on digital evidence (for example,

proving violation of an acceptable use policy).

The costs of implementing forensic readiness may be significant, particularly in an

organisation with immature information security management processes. However, the

costs are significantly ameliorated if the organisation has already performed a

comprehensive risk assessment, implemented a business continuity plan, and has

programmed information security into staff training. In a more security-aware

organisation, forensic readiness can add value to many existing processes and

leverage such activities as incident response, business continuity, and crime prevention.

In any event, the issues raised by the need for forensic readiness need to be brought to

senior management or board attention. Arguably a decision at this level should

authorise an enterprise forensic readiness programme.

The sorts of activities where costs will be incurred include:

• Updates to policies;

• Improvements in training;

• Systematic gathering of potential evidence;

• Secure storage of potential evidence;

• Preparation for incidents;

• Enhanced capability for evidence retrieval;

• Legal advice;

• Developing an in-house DFI capability, if required.

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Technical measures and appropriate products may also be required, for example to

facilitate archiving and retrieval of data or to improve monitoring and logging, but in

general, forensic readiness is a security process which is more procedural and staff-

intensive than technological.

Although it is likely that certain new procedures and policies will be necessary to

implement forensic readiness, it should not entail a whole new set of procedures. In

practice, forensic readiness policies may be achieved through incremental

enhancement to existing policies, such as data retention, incident response, information

security, and crime prevention. This will allow much more value to be extracted from

them, by targeting specific incidents and crimes that might otherwise have not received

a high priority.

Dealing with Incidents and Evidence

The typical picture of a DFI involves targeting computer media, principally a PC hard

drive, to recover admissible digital evidence. However, a corporate incident and the

subsequent need for evidence may go much further. Melia (2002) states “it is critical for

investigators to understand the distinction between examining such local media and

conducting a full-scale computer-incident forensic investigation.” This reference

principally focuses on computer fraud investigation, but the principle extends to a wide

range of incidents that can impact an organisation, for example:

• Threats and extortion;

• Accidents and negligence;

• Stalking and harassment;

• Commercial disputes;

• Disagreements, deceptions, and malpractice;

• Property rights infringement;

• Economic crime e.g. fraud, money laundering;

• Content abuse;

• Privacy invasion and identity theft;

• Employee disciplinary issues.

This range of disputes is reflected in the range of staff who are potentially involved with

an incident. Forensic readiness actually applies all through the company, as a wide

range of staff will be involved with, impacted by, or responsible for, evidence and

investigations; for example:

• The investigating team;

• The investigation subjects (i.e. suspects);

• Corporate HR department;

• Corporate PR department;

• “Owners” of business processes or data;

• Line management, Profit centre managers;

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• Claimant (e.g. dismissed employee, organisation in dispute, or customer claiming

infringement of Data Protection Act);

• Staff (e.g. colleagues of people under investigation);

• Corporate security;

• IT staff;

• Legal advisers.

There are also potential dependencies and interactions with external organisations:

• Police (not necessarily local force, especially if defending against allegations

from overseas, or if the organisation is multi-national);

• Other law enforcement authority (e.g. HM Customs and Excise, Trading

Standards or Serious Fraud Office);

• Overseas prosecution authority or court;

• Trade Union / Staff Association representatives;

• Internal or external auditors;

• Regulatory authorities (e.g. Financial Services Authority, Data Protection

Commissioner, Bank of England);

• Customers, suppliers, partner organisations;

• Facilities management organisations (e.g. companies to whom IT or building

security has been out-sourced);

• The media – due to the need to manage the PR impact of any incident.

Therefore, forensic readiness requires and enables a corporate approach to digital

evidence. Organisations need staff trained in the sensitivities of evidence, in company

investigation policy, and the external interface. Implementing forensic readiness

requires an understanding of the possible evidence sources, how to gather evidence

legally and cost-effectively, when to escalate a suspicious event into a formal forensic

investigation, and how to put together a case with the possible involvement of law

enforcement agencies.

A further conflict can arise when it comes to incident response. Post-incident

containment, eradication, and recovery (CER) activities are focused on as the most

important business issues. However, a rapid recovery exercise may overlook or delete

data that could be useful in identifying the causes (and culprits) of incidents. On the

other hand, retrieving evidence and handling an investigation in a forensic manner may

impose cost and time delays on incident recovery. A digital investigation must therefore

be seen as a trade-off between evidence preservation, and CER. Good forensic

readiness can allow the impact on CER to be minimised. Forensic readiness can be

tested as part of business continuity and disaster recovery exercises

10 Steps to Forensic Readiness

For enterprise forensic readiness to progress, the above discussion must be presented

in a way that will facilitate a practical implementation for organisations. Firstly, proposed

the goals of forensic readiness are as follows:

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• To gather admissible evidence legally and without interfering with business

processes;

• To gather evidence targeting the potential crimes and disputes that may

adversely impact an organisation;

• To allow an investigation to proceed at a cost in proportion to the incident;

• To minimise interruption to the business from any investigation;

• To ensure that evidence makes a positive impact on the outcome of any legal

action.

The following ten steps describe the key activities in implementing a forensic readiness

programme.

1. Define the business scenarios that require digital evidence.

2. Identify available sources and different types of potential evidence.

3. Determine the evidence collection requirement.

4. Establish a capability for securely gathering legally admissible evidence to meet the

requirement.

5. Establish a policy for secure storage and handling of potential evidence.

6. Ensure monitoring is targeted to detect and deter major incidents.

7. Specify circumstances when escalation to a full formal investigation (which may use

the digital evidence) should be launched.

8. Train staff in incident awareness, so that all those involved understand their role in

the digital evidence process and the legal sensitivities of evidence.

9. Document an evidence-based case describing the incident and its impact.

10. Ensure legal review to facilitate action in response to the incident.

The assumption is made that appropriate defensive (preventative) security measures

are in place in accordance with a risk assessment and that the risk assessment has

sufficient information to understand the risks to the organisation from incidents where

digital evidence may be required.

The remainder of this paper gives a brief description of each of the ten steps.

1. Define the business scenarios that require digital evidence.

The first step in forensic readiness is to define the purpose of an evidence collection

capability. The rationale is to look at the risk and potential impact on the business from

the various types of crimes and disputes. What is the threat to the business and what

parts are vulnerable? This is, in effect, a risk assessment, and is performed at the

business level. The aim is to understand the business scenarios where digital evidence

may be required and may benefit the organization in terms of:

 Reducing the impact of computer-related crime.

Organisations are at risk from a wide variety of computer-related crime. The

risks from computer-related crime should be assessed using any extant

assessments of risks to crime. Further analysis can consider the various

classes of threats to information systems [Jones and Sutherland 2003]. A

threat assessment is an assessment of the potential for a crime to be

committed. Crime by insiders also needs to be carefully assessed [Schultz

and Shumway 2002]. Issues to consider include: Where are people trusted?

Where is the money? Where are critical points of failure? A vulnerability

assessment is also required, not in terms of IT vulnerabilities, but process

vulnerabilities and the attractiveness of targets to criminals.

• Dealing effectively with court orders to release data.

Depending on the business of the organisation the types of evidence likely to

be required by a court may vary. Some will be common to all organisations,

such as email. The likelihood of such evidence being required should also be

assessed: Is it a particularly litigious business sector? Are there any

particularly sensitive or controversial activities that might lead to a court case?

• Demonstrating compliance with regulatory or legal constraints.

This requirement can be business-specific, for example the Basel2

regulations for banks, but with the introduction of laws governing issues, such

as electronic document retention [Patzakis 2002], it is becoming increasingly

important. A further example might be to provide evidence of controls and

company communications that show due care in circumstances that have the

potential for negligence claims.

A key legal requirement in most jurisdictions is that potential evidence must

not be destroyed. The duty to preserve evidence may arise when litigation is

filed or can be reasonably anticipated. Spoliation may be a criminal offence,

so an ability to implement a particular evidence preservation process at short

notice (which may not be required at other times) could be valuable.

• Producing evidence to support company disciplinary issues.

Typically, this may be showing contravention of the company internet

acceptable use policy, but there are many other issues where an organisation

could use digital evidence, such as door swipe logs and phone logs, to

support a case in a disciplinary procedure.

• Supporting contractual and commercial agreements.

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Commercial and contractual disputes with customers, suppliers and partners

may require detailed documentary support for their resolution. Many such

interactions are purely electronic, so finding ways to preserve the terms and

conditions, and dates of agreements can be extremely useful in averting

losses and in successfully exploiting arbitration procedures and alternative

dispute resolution.

• Proving the impact of a crime or dispute.

In many cases it may be necessary to show how much damage has been

caused by an incident or criminal act. This may require evidence gathering in

its own right, for example, logs to show downtime, records of staff overtime,

costs of new equipment, and business lost.

In assessing these scenarios, this step provides an indication of the likely benefits of

being able to use digital evidence. If the identified risks, and the potential benefits of

forensic readiness, suggest a good return on investment is achievable, then an

organisation needs to consider what evidence to gather for the risk scenarios.

2. Identify available sources and different types of potential evidence.

The second step in forensic readiness is for an organisation to know what sources of

potential evidence are present on, or could be generated by, their systems, and to

determine what currently happens to the potential evidence data. Computer logs can

originate from many sources [Melia 2002]. The purpose of this step is to scope what

evidence may be available from across the range of systems and applications in use.

Some basic questions need to be asked about possible evidence sources, including:

• Where is data generated?

• What format is it in?

• For how long is it stored?

• How is it currently controlled, secured and managed?

• Who has access to the data?

• How much is produced?

• Is it archived? If so where and for how long?

• How much is reviewed?

• What additional evidence sources could be enabled?

• Who is responsible for this data?

• Who is the formal owner of the data?

• How could it be made available to an investigation?

• To what business processes does it relate?

• Does it contain personal information?

Email is an obvious example of a potential rich source of evidence that needs careful

consideration in terms of storage, archiving, auditing, and retrieval. But this is not the

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only means of communication used over the Internet. There is also instant messaging,

web-based email that bypasses corporate email servers, chat rooms and newsgroups,

and even voice over the Internet. Each of these may need preserving and archiving. A

worst case scenario has some of this traffic encrypted.

The range of possible evidence sources includes:

• Equipment such as routers, firewalls, servers, clients, portables, and embedded

devices;

• Application software, such as accounting packages for evidence of fraud, ERP

packages for employee records and activities (e.g. in case of identity theft),

system and management files;

• Monitoring software such as Intrusion Detection Software, packet sniffers,

keyboard loggers, and content checker;.

• General logs, such as access logs, printer logs, web traffic, internal network logs,

Internet traffic, database transactions, and commercial transactions;

• Other sources, such as CCTV, door access records, phone logs, PABX data,

telco records and network records, call centre logs or monitored phone calls, and

recorded messages;

• Back-ups and archives, for example, laptops and desktops.

The collection of evidence can also be put into two categories.

• “Background” evidence (data gathered and stored for normal business reasons).

• “Foreground” evidence (data specifically gathered to detect crime, or to identify

criminals).

The gathering of foreground evidence is usually referred to as “monitoring,” as it

typically involves analysing what people are doing by the real-time monitoring (e.g. IT or

surveillance). Monitoring is generally regulated by laws such as those concerning

privacy and human rights and while it is clearly necessary to monitor in order to fight

crime, expert legal advice in the local country or jurisdiction is required to ensure it is

done legally.

The strength of background evidence is sometimes founded in that it has been collected

according to standard documented business procedures.

While the aggregation of evidence from the various sources will help the availability of

evidence during an investigation, it may also become a potential vulnerability. The

security of this data store will be extremely critical and should be subject to stringent

technical and personnel security.

As Data correlation and event corroboration are desirable, this thorough examination of

sources should allow any useful cross-correlations to be identified. Whether or not

multiple sources will actually be collected will depend on the evidence requirement to be

identified in step 3.

3. Determine the Evidence Collection Requirement.

It is now possible to decide which of the possible evidence sources identified in step 2

can help deal with the crimes and disputes identified in step 1 and whether further ways

to gather evidence are required. This is the evidence collection requirement. The

purpose of this step is to produce an evidence requirement statement, so that those

responsible for managing the business risk can communicate with those running and

monitoring information systems through an agreed requirement for evidence.

One of the key benefits of this step is joining IT with the needs of corporate security. IT

audit logs have been traditionally configured by systems administrators independently of

corporate policy and where such a policy exists, there is often a significant gap between

organisational security objectives and the ‘bottom-up’ auditing actually implemented

[Ahmad and Ruighaver 2003]. The high-level audit policy proposed by Ahmad and

Ruighaver corresponds in many respects to this evidence collection requirement.

The evidence collection requirement is moderated by a cost benefit analysis of how

much the required evidence will cost to collect and what benefit it provides (see above).

The critical question for successful forensic readiness is whether it can be performed

cost effectively.

• Can evidence be gathered without interfering with business processes?

• Can an investigation proceed at a cost in proportion to the incident?

• Can an investigation minimise interruption to the business?

• Can the evidence make an impact on the likely success of any formal action?

• Can the evidence be gathered legally without infringing employee rights?

The costs of the evidence gathering process that need to be taken into consideration

when deciding how much potential evidence can be collected are:

• Cost of monitoring (including tools and staff-time);

• Cost of secure storage;

• Cost of organising potential evidence – by classifying, indexing and preparation;

• Cost and implications of retrieval if evidence is demanded by a court;

• Cost of investigations especially if external incident response team or forensic

examination resources will be used.

By considering these issues in advance and choosing storage options, auditing tools,

investigation tools, and appropriate procedures it is possible for an organisation to

reduce the costs of any investigations.

In addition to the actual data, several other factors influence the utility, reliability and

availability of potential evidence.

• Meta-data

Raw data is difficult to use as evidence out of context. The date and time of the

creation and modification of a file can be critical in terms of providing evidence of

an action and allowing it to be correlated with other forms of evidence, such as

witness statements. Unfortunately, time stamps can be over-written and the

clocks on PCs are often inaccurate. Cryptographic time-stamping services are

available, along with network time synchronisation products which can help to

alleviate this. Weight can also be given to data through the use of digital

signatures to authenticate the creator (or sender) or recipient of a file. The use of

hashes can similarly demonstrate the integrity of a file’s contents.

• Corroboration and Redundancy

The various logs may each contain indications of the same event or activity.

Duplication may provide a form of corroboration if, for example, independent

monitoring detects similar activity or independent confirmation of the involvement

of a suspect. Duplication also provides an element of redundancy should any

evidence become corrupted, tainted or in some way inadmissible. There may

also be instances where evidence collected over a period of time may lessen the

need to perform a full-scale forensic analysis of a suspect’s hard disk [Melia

2002]. For example, in the case of an employee, the evidence may be sufficient

to encourage them to resign, if the employee knows that the organisation has

seized his PC, which can provide corroboration of the evidence gathered through

other means.

• Associations and Cause and Effect

Evidence should not only indicate what happened, but how, when and by whom.

Various pieces of evidence may need to be linked to provide the causal link

between the perpetrator and the damaging activity. Ahmad (2002) proposes a

forensic chain-of-evidence model covering access control logs, source operating

system event logs, network application logs, network traffic logs, and the target’s

operating system log. Associating events in the various logs allows a complete

trace of how the incident took place and of the identity or location of the source.

More recently there have been cases of not guilty verdicts based on concerns

that Trojan horses may have been responsible, not the alleged perpetrator.

Suitable evidence gathering might be able to show whether or not this was

actually the case.

 • Length of time of storage of data

In many instances the length of time data need to be kept is specified by

regulators or law. Certain types of data need to be stored for differing periods of

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time, depending on these rules. This should be specified in a data retention

policy. Choosing how long to store data which may be of potential evidentiary

value is a separate issue related to the cost and benefit assessment. A

recommendation to store emails and firewall logs for a number of years is not

atypical, if, for example, an organisation wants to be in a position to track the

progression of a possible large scale fraud or to prove an employee’s continued

violation of corporate acceptable use policy. One particular issue is that of re-

cycling back-up tapes. Much information is being lost each time a tape is re-

used. The length of this cycle should be reviewed, bearing in mind the potential

investigative and evidential value of any data being lost. Furthermore if there is

an incident, it may be prudent to suspend re-use of back-up tapes to avoid loss

of useful information or to show a court that there is no attempt to hide evidence.

• Size of Evidence

As well as the cost implications of gathering large-scale sources of evidence

there is the issue of how to sift them, how to search them, and how to compress

them. Yasinsac and Manzano (2002) recommend utilising data indexing and

information fusion (e.g. products that allow multiple sources to be correlated).

The organisation needs to consider data mining issues and how to summarise

and categorise potential evidence.

• Hardware

Some hardware that may harbour potential evidence is not or cannot be routinely

monitored, for example PDAs and mobile phones. There is a particular issue

when someone leaves the organisation: Should the former employee’s hard disk,

laptop, mobile phone and PDA be preserved in any way in case a need to

investigate arises?

4. Establish a capability for securely gathering legally admissible evidence to

meet the requirement.

At this point the organisation knows the totality of evidence available and has decided

which of it can be collected to address the company risks within a planned budget. With

the evidence requirement understood, the next step is to ensure that it is collected from

the relevant sources and that it is preserved as an authentic record.

There are two preliminary checks to be made:

1) Can the evidence be gathered without interfering with business processes?

2) Can the evidence be gathered legally?

At this stage legal advice is required to ensure that the evidence requirement can be

met in the manner planned. For example, does it involve monitoring personal emails,

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the use of personal data, or ‘fishing trips1

’ on employee activities? In some countries,

some or all of these activities may be illegal. Relevant laws, in the areas of data

protection, privacy, and human rights, will inevitably constrain what can actually be

gathered.

In the UK the information commissioner has stated:

• Monitoring should be targeted at specific problems;

• It should only be gathered for defined purposes and nothing more;

• Staff should be told what monitoring is happening, except in exceptional

circumstances.

Pemble (2003) gives an overview of a typical set of problems and suggests how they

may be addressed in the UK.

Logs can be forged, and evidence can be manipulated or planted to incriminate others,

so appropriate security measures are required. Remote logging should be used, as

local logs are too vulnerable. Using the two together can expose attempts to hide or

change evidence, for example, if there is a discrepancy between them or if one of them

decreases in size. Tools which check file integrity, such as Tripwire, can also be used.

Remote logging also enables a centralised repository to be assembled where broad

investigations can be performed to look for correlations across multiple independent

data sets. Secure logging tools are under development, e.g. based on IETF RFC 3195

known as syslog-reliable, [New and Rose 2001] which supports encrypted and

authenticated event message delivery. Brezinski and Killalea (2002) have produced

guidelines for system management staff for evidence collection and storage.

Physical security of data, such as in back-up files or on central log servers, is important

from the data protection point of view, and also for secure evidence storage. As well as

preventative measures, such as secure rooms and swipe card access, it is prudent to

have records of who has access to the general location and who has access to the

actual machines containing evidence. Any evidence or paperwork associated with a

specific investigation should be given added security by, for example, storing in a safe.

Additional security of logs can also be achieved through the use of WORM storage

media.

5. Establish a policy for secure storage and handling of potential evidence.

The objective of this step is to secure the evidence for the longer term once it has been

collected and to facilitate its retrieval if required. It concerns the long-term or off-line

storage of information that might be required for evidence at a later date.

This step correlates to Point F, protect the evidence, of Yasinsac and Manazano (2001).

They propose measures such as exercising rigid control over administrator access to

1

 Ad hoc opportunistic searches, without justification, for potentially incriminating activities or communication.

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systems housing potential evidence, encrypting evidence files and any transfers, using

strong integrity checking, and periodic audits. Physical security measures should also

be considered, such as access control using card swipes (and accesses should be

logged), safes, and multiple copies in different storage locations.

A policy for secure storage and handling of potential evidence comprises security

measures to ensure the authenticity of the data and also procedures to demonstrate

that the evidence integrity is preserved whenever it is used, moved, or combined with

new evidence. At all times it must be in a tamper-proof (or tamper-evident state). This

corresponds to the use of evidence bags in the physical world. Access to the evidence

is controlled and anyone requiring an evidence bag must sign it in and sign it back with

the contents unchanged. In the parlance of investigators this is known as continuity of

evidence (in the UK) and chain of custody (in the US). The chain of custody also

includes records of who held, and who had access to, the evidence (for example from

swipe control door logs). Ceresini (2001) gives an overview of implementation

considerations including policies and procedures for maintaining the forensic viability of

log files.

A significant contribution to the legal collection of evidence is given by the code of

practice on the legal admissibility and weight of information stored electronically,

published by the British Standards Institution (Allen et. Al. 1999). This document

originated from a perceived need for evidence collection in the paperless office. The

problem it addressed is if all paper documents are scanned, can the paper sources be

thrown away without loss of evidential usability? The current edition broadens the scope

to all information management systems, such as those where information is transmitted

over networks, so that messages from EDI and email systems can be stored under the

code.

The code is structured according to five principles of good practice for information

management.

• Recognize and understand all types of information.

• Understand the legal issues and execute “duty of care” responsibilities.

• Identify and specify business processes and procedures.

• Identify enabling technologies to support business processes and procedures.

• Monitor and audit business processes and procedures.

These principles are reflected in the code in sections comprising:

• Information Management Policy;

• Duty of care;

• Procedures and processes;

• Enabling technologies;

• Audit trails.

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Certainly, adherence to the code does not guarantee admissibility and it does not

appear to have been tested in court, but it does attempt to define best practice. It

covers issues such as “system planning, implementation, initial loading, and procedures

for the use of a system including workflow.” It also discusses issues that relate to

demonstrating that systems have been running properly in order to provide confidence

in the integrity of potential evidence. It points out that methods of storage, hardware

reliability, operation and access control, and even the programs and source code, may

be investigated in order to determine admissibility. A closely related international

standard is being developed as ISO 15801.

The required output of this step is a secure evidence policy. It should document the

security measures, the legal advice, and the procedural measures used to ensure the

evidence requirement is met. The likely admissibility and weight of any evidence

gathered rests upon this document.

6. Ensure monitoring and auditing is targeted to detect and deter major

incidents.

In addition to gathering evidence for later use in court, evidence sources can be

monitored to detect threatened incidents in a timely manner. This is directly analogous

to Intrusion Detection Systems (IDS), extended beyond network attack to a wide range

of behaviours that may have implications for the organisation. It is all very well collecting

the evidence, but this step is about making sure it can be used in the process of

detection. By monitoring sources of evidence triggers that mean something suspicious

may be happening can be detected.

The critical question in this step is when should an organisation be suspicious? IDS are

commonly used to detect suspicious network events and penetration attempts and to

alert system managers to the threat. Network staff will know what they are looking for

and will set the IDS rules to trigger when certain activities happen. IDS provide real-time

monitoring of a certain set of incidents, which are often linked to a real-time response

from the company, such as a pager message. Honeypots are another device that can

provide a trigger of a suspicious event and provoke a preliminary investigation. Event

correlation (Chen et al 2003) can be used to meet the high level audit requirement

discussed in step 3.

Auditing is commonly used to refer to the review of records after they have been

generated. Security auditing tools can be deployed to analyse a range of data which

can be reviewed on a near-real-time basis or in an annual security audit. The frequency

of such auditing needs to be related to the business risk discussed above.

In monitoring and auditing, the types of activities recognised as suspicious will be

different for different business needs. For example, a forensic accountant may look for

specific patterns in financial data to trigger suspicion of fraud or theft. Content checking

may be used, for example, to identify IPR leakage or data theft. A suspicious event

might be multiple emails on a sensitive subject from a person who is not actually

involved in the subject.

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A suspicious event has to be related to business risk and not couched in technical

terms. Thus, the onus is on managers to explain to those monitoring the data what they

want to prevent and the sort of behaviour that IDS and Honeypots might be used to

detect. This should be captured in a “suspicion” policy that helps the various monitoring

and auditing staff understand what triggers should provoke suspicion, to whom to report

the suspicion, whether heightened monitoring is required, and whether any additional

security measures should be taken as a precaution.

What exactly is audited, and what counts as suspicious will vary with time. The

suspicion policy needs to be updated as new IPR is generated, new business

processes are implemented, and new business relationships need to be protected. The

policy should also be influenced by corporate intelligence of the evolving threat and

modus operandi that the organisation should be aware of.

Each type of monitoring should produce a proportion of false positives. The sensitivity of

triggers can be varied as long as the overall false positive rate does not become so high

that suspicious events cannot be properly reviewed. Varying triggers also guards

against the risk from someone who knows what the threshold on a particular event is

and makes sure any events or transactions he wishes to hide are beneath it.

7. Specify circumstances when escalation to a full formal investigation (which

may use digital evidence) is required.

Some suspicious events can be system generated, such as by the rule-base of an IDS

or the keywords of a content checker, and some will be triggered by human

watchfulness. Each suspicious event found in step 6 needs to be reviewed. An event

will require escalation if it is clearly serious enough, or it will require enhanced

monitoring or other precautionary measures, or it is a false positive. The purpose of this

step is to decide how to react to the suspicious event.

The decision as to whether to escalate the situation to management will depend on any

indications that a major business impact is likely or that a full investigation may be

required where digital evidence may be needed. The decision criteria should be

captured in an escalation policy that makes it clear when a suspicious event becomes a

confirmed incident. At this point an investigation should be launched and policy should

indicate who the points of contact are (available on a 24x7 basis) and who else needs to

be involved.

As with steps 3 and 6, the network and IT security managers and the non-IT managers

need to understand each other’s position. What level of certainty or level of risk is

appropriate for an escalation? What strength of case is required to proceed? A

preliminary business impact assessment should be made based on whether any of the

following are present:

• Evidence of a reportable crime;

• Evidence of internal fraud, theft, other loss;

• Estimate of possible damages (a threshold may induce an escalation trigger);

• Potential for embarrassment, reputation loss;

• Any immediate impact on customers, partners or profitability;

• Recovery plans have been enacted or are required;

• The incident is reportable under a compliance regime.

Some threshold on the potential for damage could be used as an indicator of whether to

escalate matters (see for example Endorf (2003)). Any information about the skill-level

or intent of any miscreant, or indication of the target or vulnerability under threat is also

required. In information security terms we might be looking for signs of:

• Reconnaissance – if a high level of skill or knowledge of sensitive resources is

used, then consider escalating.

• Compromise – if an attack shows knowledge of the organisation, sensitive

resources, or appears focused on a particular objective, then consider escalating.

If unable to prevent in future (e.g. patch the vulnerability), then escalate.

• Exploitation – escalate, unless trivial or closed-down.

Before proceeding with escalation or calling out the Computer Security Incident

Response Team (CSIRT), two further questions need to be answered to assess the

impact on the organisation of the response itself:

• Can an investigation proceed at a cost in proportion to the size of the incident?

• How can any investigation minimise disruption to the business?

At the outset of an investigation it will be unclear what the impact of the incident is likely

to be and the amount of effort needed to investigate it. When it comes to an actual

forensic examination, organisations need ready access to the necessary skill sets within

a CSIRT. If this involves buying in the skills from a specialist company, their skills need

evaluating, as do the standards they follow, their professionalism and security. This

needs to be done before an incident occurs or else the most convenient company, not

the most effective, may get the work.

The escalation procedure drawn up under this step should involve a decision-maker,

sometimes referred to as an investigation manager, who can decide on whether to call

out the CSIRT and make business-critical decisions such as whether law enforcement

need to be involved. A decision maker is also required in case it is necessary to shut

down operational systems and to determine whether an emergency disconnect or a

managed disconnect is appropriate for an on-line system.

At all times those involved should implement a “need to know” policy. They should be

particularly aware whether any staff, such as “whistle blowers” and investigators, need

to be protected from possible retaliation by keeping their names and their involvement

confidential.

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8. Train staff, so that all those involved understand their role in the digital

evidence process and the legal sensitivities of evidence.

A wide range of staff may become involved in a computer security incident. The aim of

this step is to ensure that appropriate training is developed to prepare staff for the

various roles they may play before, during, and after an incident. It is also necessary to

ensure that staff are competent to perform any roles related to the handling and

preservation of evidence.

Some issues relevant to all staff if they become involved in an incident. Such general

advice includes:

• Keep written (paper-based) notes which are dated, timed and signed;

• Report as necessary and only to those staff with a need to know;

• Do not use compromised systems (e.g. email);

• Know how not to taint evidence;

• Know what laws and regulatory principles to be aware of.

A wide range of staff will be involved with, impacted by, or responsible for, evidence and

investigations. The following groups will require more specialised awareness training.

• The investigating team

• Corporate HR department

• Corporate PR department (to manage any public information about the incident)

• Owners” of business processes or data

• Line management, Profit centre managers

• Corporate security

• System administrators

• IT management

• Legal adviser;

• Senior Management (potentially up to board level)

After the escalation of an incident a multi-disciplinary team drawn from the above is

likely to be convened. These staff may not know each other well or have a great deal of

interaction on a day to day basis, but fast and effective teamwork is essential. They will

have differing priorities and potentially different interpretations of company policy. Often

there will be no clear lines of authority and extensive negotiation will determine the

course of action. This will affect middle managers on a frequent basis and they will

require support and training to understand the decision points, to make the right

decisions, and to avoid tainting evidence or prejudicing a case. Role-play training is

ideally suited to this scenario.

A key role for the organisation when a CSIRT is called in is the “liaison manager” or

“incident handler.” A CSIRT, whether internal or external, needs a single point of contact

to manage communications with the organisation and to ensure that any requirements

for facilities or resources to expedite the investigation are met.

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Training may also be required to understand the relationships and necessary

communications with external organisations that may become involved such as:

• Police (not necessarily local force, especially if defending against allegations

from overseas, or if the organisation is multi-national);

• Other law enforcement authority (e.g. in the UK, Customs and Excise, Trading

standards, Serious Fraud Office);

• Overseas prosecution authority or court;

• Trade Union / Staff Association representatives;

• Internal or external auditors;

• Regulatory authorities (e.g. Financial Services Authority, Information

Commissioner, Bank of England);

• Customers, suppliers, partner organisations;

• Facilities management organisations (e.g. companies to whom IT or building

security has been outsourced);

• The media.

9. Present an evidence-based case describing the incident and its impact.

The aim of an investigation is not just to find a culprit or repair any damage. An

investigation has to provide answers to questions and demonstrate why those answers

are credible. The questions go along the lines of who, what, why, when, where and how

[Endorf 2003]. Credibility is provided by evidence and a logical argument. The purpose

of this step is to produce a policy that describes how an evidence-based case should be

assembled. A case file may be required for a number of reasons:

• To provide a basis for interaction with legal advisers and law enforcement;

• To support a report to a regulatory body;

• To support an insurance claim;

• To justify disciplinary action;

• To provide feedback on how such an incident can be avoided in future;

• To provide a record in case of a similar event in the future (support to the

corporate memory so that even if there are changes in personnel it will still be

possible to understand what has happened);

• To provide further evidence if required in the future, e.g., if no action is deemed

necessary at this point, but further developments occur.

The following are possible components of a case file.

• Incident description – what happened? How was it detected?

• The hypothesis –how was the incident caused? Has the perpetrator been

identified? located?

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• The evidence – includes the location if an appropriate digital record is not

included, paper files, details of interviews, signed witness statements, physical

evidence, etc.

• The argument – shows that the evidence ‘proves’ the hypothesis

• The impact: damage or potential damage to the organisation – including any

evidence to support the damage assessment.

The case file should be stored securely and subject to access control, as is the case for

any evidence.

Two further issues arise during the writing-up process. The investigation may have

found inculpatory evidence (indicating a person’s guilt), it may also have found some

exculpatory evidence (indication of innocence). A case is rarely “cut and dried.” An

organisation must have a clear policy for handling such exculpatory evidence. At some

point such evidence could be the subject of a court disclosure order. Suppressing it may

not be possible and may well be illegal. In practical terms it may be required if the

conclusion of the investigation turns out to be wrong.

Digital evidence can be difficult for a non-specialist to read and understand. Thus, the

case file should show how to present the evidence e.g. using visualisation tools and

time-line analysis of the incident or of events leading up to it [Stephenson 2003a]. The

evidence may have to convince lay-people on a jury.

Finally, if any mistakes or errors are made during an investigation they should not be

covered up. Errors in the forensic process may weaken the evidence, but as long as

what actually happened is honestly recorded, it may still be useful.

10. Ensure legal review to facilitate action in response to the incident.

At certain points during the collating of the cyber-crime case file it will be necessary to

review the case from a legal standpoint and get legal advice on any follow-up actions.

Legal advisers should be able to advise on the strength of the case and suggest

whether additional measures should be taken. For example, if the evidence is weak, is

it necessary to catch an internal suspect red-handed by monitoring their activity and

seizing their PC?

Any progression to a formal action will need to be justified, cost-effective, and assessed

as likely to end in the company’s favour. Although the actual decision of how to proceed

will clearly be post-incident, considerable legal preparation is required in readiness.

Legal advisors should be trained and experienced in the appropriate cyber-laws and

evidence admissibility issues. They need to be prepared to act on an incident, pursuant

to the digital evidence that has been gathered and the case presented in step 9. Legal

advice should also recognise that the legal issues may span legal jurisdictions, e.g.

states in the US and member states in the EU [RAND 2003].

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Advice from legal advisers will include:

• Any liabilities from the incident and how they can be managed;

• Finding and prosecuting/punishing (internal versus external culprits);

• Legal and regulatory constraints on what action can be taken;

• Reputation protection and PR issues;

• When/if to advise partners, customers and investors;

• How to deal with employees;

• Resolving commercial disputes;

• Any additional measures required.

A key issue for the organisation is, under what circumstances should law enforcement

be contacted? There is a need to be in contact with them in advance to understand their

policies and priorities and how to work together effectively. Their willingness to

prosecute may depend on:

• Severity of crime or scale of impact on the organisation;

• Amount of any financial loss;

• Whether the victim is potentially part of organised crime, or may look for further

opportunities, or has demonstrated serious intent or a novel modus operandi to

commit the crime;

• Manpower constraints and operational priorities.

Concluding Remarks

Forensic readiness is an organisation's ability to use digital evidence when required. Its

aim is to maximise an organisation's ability to gather and use digital evidence whilst

minimising the costs of related investigations. The proposed ten steps to forensic

readiness put digital evidence into a business context and lay out a practical approach

to the policies and practices required for an organisation to achieve a forensic readiness

capability.

Forensic readiness is complementary to, and an enhancement of, many existing

information security activities. It should be part of an information security risk

assessment to determine the possible disputes and crimes that may give rise to a need

for electronic evidence. It is closely related to incident response and business continuity,

to ensure that evidence found in an investigation is preserved and the continuity of

evidence maintained. It is part of security monitoring, to detect or deter disputes that

have a potentially major business impact. Forensic readiness also needs to be

incorporated into security training, particularly for middle managers who have to deal

with an incident in a multi-disciplinary team.

Many organisations, as part of their general information security, incident response and

crime prevention activities, will already perform some of the activities required to

effectively collect and exploit electronic evidence. What is needed in most

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organisations is a systematic and pro-active approach to the gathering and preserving

of evidence to meet their business needs.

Possibly the most significant barrier to forensic readiness is that companies rarely

communicate the business risks well enough to allow those who are monitoring the IT

systems to collect the most appropriate data. The other main risk is that for a variety of

unforeseeable reasons, evidence may be non-admissible or weakened by opposition

lawyers. The field of digital evidence is new and courts are wary of accepting it. Best

practice is still emerging and case law is thin on the ground.

At the end of an incident there is a clear need for the organisation to learn from it. From

a forensic readiness perspective there is an opportunity to assess the adequacy of the

investigation and the utility of the evidence gathered to support it. Lessons learned need

to be relayed to the appropriate people and can help the organisation revise prevention

measures. Learning can also be achieved by tracking evidence recovery within incident

handling and response, in the same way an organisation might track business

continuity.

A good example of where forensic readiness could be applied is e-voting. Most e-voting

development has been concerned with the security of voting software and cryptographic

protocols. What is also required for public confidence in e-voting is the ability to

preserve evidence that the process worked as expected, and evidence of the output of

the e-voting process.

A cautionary tale serves to illustrate the state of forensic readiness in one organisation.

Wilding (2003) reports an occasion when he was asked to look into investigating an

employee suspected of stealing software, customer databases, and marketing and

business plans. The employee had been on “gardening” leave for six weeks, without

any evidence to support the company suspicions. Unfortunately a litany of errors had

virtually eliminated the chance of finding any incriminating evidence. The suspect had

been allowed to keep his laptop, PDA and mobile phone. His desktop PC had been re-

formatted, a new operating system had been installed and then given to another

employee. His files on the fileserver had been removed and his mails on the mail-server

had been deleted en masse. Back-up tapes potentially containing the files had been re-

cycled. Email could not be retrieved. Remote access accounts were kept active. His

desk had been cleared. Forensic readiness would allow an organisation to avoid these

mistakes.

Finally, this paper has shown that forensic readiness has benefits for business, but law

enforcement will also gain from its widespread implementation. In many cases

corporate systems are the eyes and ears of high-tech police. Organisations that

understand the digital evidence process can establish an effective relationship with the

relevant law enforcement agencies. With their co-operation, law enforcement agencies

will have a better chance of understanding the scope, scale, and nature of hi-tech crime,

and obtain the evidence they need to prosecute it successfully. Forensic readiness

provides a win-win scenario for business and law enforcement.

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