FSB FINANCIAL STABILITY BOARD

Effective Practices for Cyber Incident Response and Recovery

Consultative Document

20 April 2020

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The Financial Stability Board (FSB) is seeking comments on its consultative document on *Effective Practices for Cyber Incident Response and Recovery*.

Background

Enhancing cyber resilience has been a key element of the FSB's work programme to promote financial stability. In 2017, the FSB took stock of financial sector cyber security regulations, guidance and supervisory practices.[1] This work identified, among other things, a need to enhance communications between authorities and the private sector. To facilitate more effective communication, the FSB developed a *Cyber Lexicon* in 2018 to support the work of the FSB, standard-setting bodies, authorities and private sector participants to address financial sector cyber resilience.[2]

Given the interconnectedness of the financial sector, the FSB agreed in 2018 to develop a toolkit to provide financial institutions with a set of effective practices to respond to and recover from a cyber incident to limit any related financial stability risks.

Questions for public consultation

The FSB invites comments on the consultative document and provides the following specific questions as a guide. Please provide details and supporting information where possible.

General

1.1. Have you learnt any lessons from the COVID-19 pandemic and related cyber activity that will contribute to your cyber incident response and recovery practices?

1.2. To whom do you think this document should be addressed within your organisation?

1.3. How does your organisation link cyber incident response and recovery with the organisation's business? Does your organisation follow international standards or common frameworks? If so, which international standards or common frameworks?

1.4. Does your organisation structure its cyber incident response and recovery activities along the seven components set out in the FSB toolkit? Please describe any additional components your organisation considers.

1.5. Based on your organisation's experience, please provide any additional effective practice(s) for any of the tools. Please list the number of the tool (e.g. Tools 1 – 46) and describe the effective practice(s).

1.6. Based on your organisation's experience, please provide additional examples of effective practices listed in the boxes (e.g. Boxes 1-6).

1.7. What role, if any, should authorities play in supporting an organisation's cyber incident response and recovery activities?

1. Governance

1.1. To what extent does your organisation designate roles and responsibilities as described in Tool 3? Does your organisation identify these roles by business line, technology application or department?

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[1] FSB, Summary Report on Financial Sector Cyber security Regulations, Guidance and Supervisory Practices, October 2017.

[2] See FSB, Cyber Lexicon, November 2018.

1.2. How does your organisation promote a non-punitive culture to avoid "too little too late" failures and accelerate information sharing and CIRR activities?

2. Preparation

2.1. What tools and processes does your organisation have to deploy during the first days of a cyber incident?

2.2. Please provide an example of how your organisation has enhanced its cyber incident response plan over the last 12 months.

2.3. How does your organisation monitor, manage and mitigate risks stemming from third-party service providers (supply chain)?

3. Analysis

3.1. Could you share your organisation's cyber incident analysis taxonomy and severity framework?

3.2. What are the inputs that would be required to facilitate the analysis of a cyber incident?

3.3. What additional tools could be useful to analyse the effectiveness of cyber incident response and recovery activities and the severity, impact and root cause of cyber incidents?

3.4. What sector associations does your organisation participate in and what benefit does your organisations accrue from that participation?

4. Mitigation

4.1. Besides reducing impact to business and system security, what are other considerations that need to be taken into account during mitigation?

4.2. What tools or effective practices does your organisation have related to mitigating the impact from: (i) data breaches (ii) loss of data integrity and (iii) ransomware events?

4.3. What tools or practices are effective for integrating the mitigation efforts of third-party service providers with the mitigation efforts of the organisation?

4.4. What additional tools could be useful for including in the component Mitigation?

4.5. Are there situations in which effective practices for mitigation and restoration activities of the organisation are the same or overlap substantially? If yes, please provide examples.

5. Restoration

5.1. What tools and processes does your organisation have available for restoration?

5.2. Which tools, plans, practices and metrics does your organisation use to prioritise restoration activities?

5.3. How does your organisation minimise undesirable outcomes of restoration activities, such as restoring affected data?

6. Improvement

6.1. What are the most effective types of exercises, drills and tests? Why are they considered effective?

6.2. What are the major impediments to establishing cross-sectoral and cross-border exercises?

6.3. Which technological aids and tools does your organisation consider most useful to improve cyber incident response and recovery?

7. Coordination and communication

7.1. Does your organisation distinguish "coordination activities" from broader "communication" in general? If yes, please describe the distinct nature of each component.

7.2. How does your organisation address the possibility that email or traditional communication channels will be unavailable during a cyber incident?

7.3. Apart from regulatory/compliance reporting, what other information does your organisation consider useful to share with authorities?

Responses to this consultative document should be sent to CIRR@fsb.org by Monday 20 July 2020. Responses will be published on the FSB's website unless respondents expressly request otherwise.

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Executive Summary

Cyber incidents[3] pose a threat to the stability of the global financial system. In recent years, there have been a number of major cyber incidents that have significantly impacted financial institutions and the ecosystems in which they operate.[4] A major cyber incident, if not properly contained, could seriously disrupt financial systems, including critical financial infrastructure, leading to broader financial stability implications.

Efficient and effective response to and recovery from a cyber incident by organisations in the financial ecosystem are essential to limiting any related financial stability risks. Such risks could arise, for example, from interconnected IT systems between multiple financial institutions or between financial institutions and third-party service providers, from loss of confidence in a major financial institution or group of financial institutions, or from impacts on capital arising from losses due to the incident. Organisations that are resilient to cyber incidents will be crucial for a smooth functioning of the financial system and in engendering financial stability.

The Financial Stability Board (FSB) has developed a toolkit of effective practices that aims to assist organisations in their cyber incident response and recovery (CIRR) activities. Organisations' respond function executes the appropriate activities in reaction to a detected cyber event, while the recover function carries out the appropriate activities to restore any capabilities or resume services that were impaired due to a cyber incident.[5] The toolkit draws from survey responses by national authorities, international organisations and external stakeholders;[6] a review of existing standards and case studies of cyber incidents; engagement with external stakeholders at workshops and bilateral meetings; and insights drawn from national authorities based on their supervisory work.

Enhancing cyber incident response and recovery at organisations is an important focus for national authorities. National authorities are in a unique position to gain insights on effective CIRR activities in financial institutions from their supervisory work and their observations across multiple organisations or peer analysis that can help suggest areas that both authorities and organisations can enhance. In addition, authorities have an important role to play in responding to cyber incidents that present potential risks to financial stability. For example, authorities can consider the sector-wide implications of a cyber incident, including any market confidence issues arising through, for example, social media, news media and market reactions. Authorities are also appropriate bodies to, when necessary and appropriate, support

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[3] A cyber incident is a cyber event that:
(i) jeopardizes the cyber security of an information system or the information the system processes, stores or transmits; or
(ii) violates the security policies, security procedures or acceptable use policies,
whether resulting from malicious activity or not. See FSB (2018) Cyber Lexicon, November, page 9.

[4] The twin episodes of the NotPetya and the WannaCry ransomware attack in 2017, for example, showed the potential of cyber incidents to be both widespread and devastating.

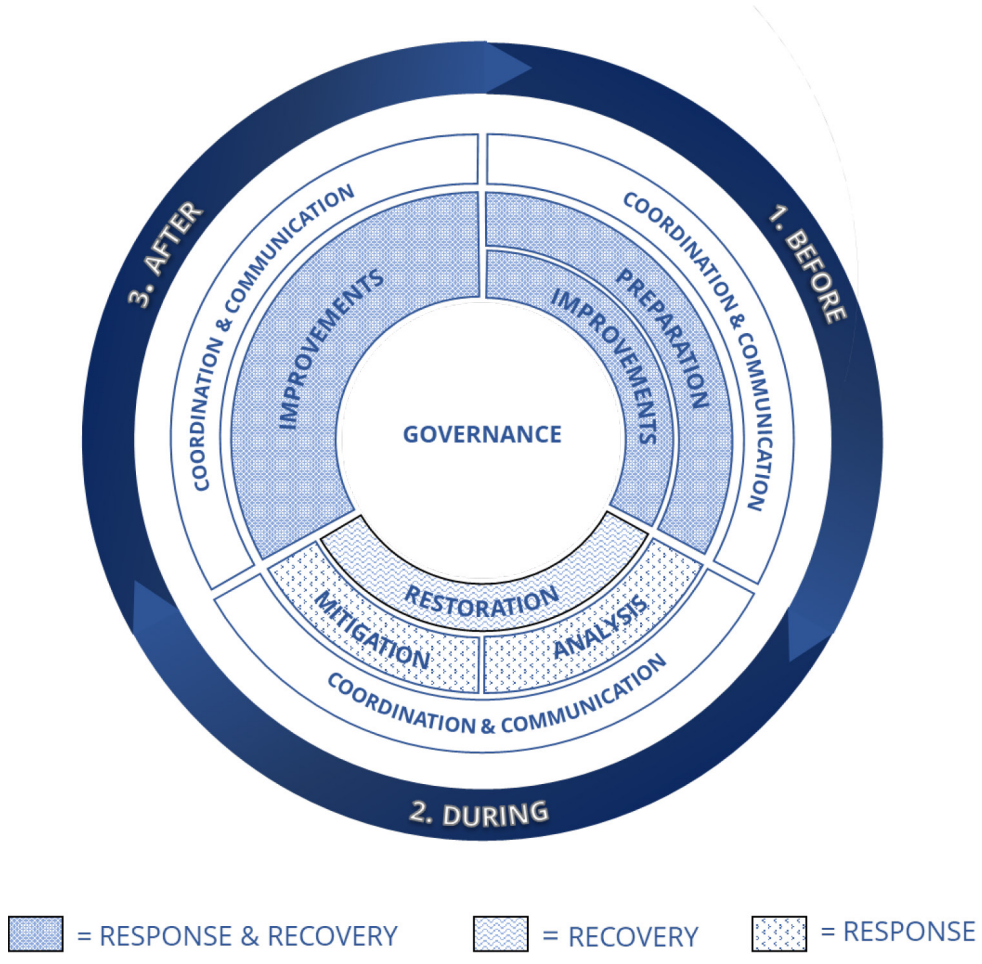
[5] See FSB (2018), Cyber Lexicon, November, page 12 for definitions of the Respond and Recover functions.

[6] For example, see FSB (2019), Cyber Incident Response and Recovery: Survey of Industry Practices, July.

organisations in sharing of information to protect against threats that could have a detrimental impact on financial stability. Thus, authorities may consider this toolkit of effective practices in their interactions with financial sector participants, particularly with those experiencing a cyber incident.

The toolkit, structured across seven components, comprises 46 effective practices that organisations have adopted while taking into account jurisdictions' legislative, judicial and regulatory frameworks, the size of the organisation affected by a cyber incident and the type of organisation that is affected. The toolkit may also be useful for authorities as they consider the approaches they may undertake with respect to regulation or supervision, or in responding to a cyber incident within the sector. The effective practices are meant to serve as a toolkit of options rather than applied in a one-size-fits-all manner, as not all practices are applicable to every organisation or in every cyber incident. The toolkit does not constitute standards for organisations or their supervisors and is not a prescriptive recommendation for any particular approach. An effective practice will evolve over time as the cyber threat landscape changes, particularly as organisations move toward more reliance on third-party service providers (e.g. cloud services), and industry and authorities alike learn from their experiences and additional insights are garnered.

Figure 1: Illustration of CIRR components



1. Governance

Governance frames the way in which CIRR is organised and managed. It aligns CIRR activities with goals set for continuity of business operations, sets the organisational structures and roles required to coordinate response and recovery across internal functions, business lines, firms, jurisdictions or even sectors. Governance involves defining the decision-making framework with clear steps and measures of success, and allocates responsibilities and accountabilities to ensure that the right stakeholders are engaged when a cyber incident occurs. Governance also encapsulates the commitment to supporting CIRR through adequate sponsorship and promoting positive behaviours when dealing with, and following, a cyber incident.

1. **Organisation-wide governance framework.** The CIRR governance structure is part of the broader organisation-wide governance framework. CIRR objectives and priorities are aligned with the organisation's risk management framework and are communicated and understood throughout the organisation. The board is ultimately responsible for overseeing the management of CIRR activities, while senior management oversees the implementation of the policies, procedures and controls that support the CIRR process. Senior management engages with business and technical functions within the organisation to develop, exercise, maintain, manage, support and improve CIRR objectives and plans consistent with organisational needs.

2. **Role and responsibilities of the board.** An organisation's board challenges the planning activity of the organisation, and provides a broader view of the ecosystem in which the organisation operates. The board empowers senior management to take decisions to deploy CIRR activities and works with senior management to enhance the effectiveness of CIRR activities. In particular, the role of the board is to oversee senior management's implementation of the organisation's CIRR objectives, and allocation of certain roles for CIRR activities that are empowered to make decisions and take action. The board with executive authority as well as senior management form the group of decision-makers to steer the organisation out of the crisis. Board and senior management also have the responsibility of implementing the required improvements, including the funding and overseeing the set-up of new solutions within an acceptable timeframe.

3. **Roles, responsibilities and accountabilities for CIRR.** Organisations clearly define the roles, responsibilities and accountabilities for various CIRR activities to one or more named individuals that meet the pre-requisite role requirements.[7] Potential conflicts of interest are minimised by ensuring a separation of implementation and oversight roles where possible. Apart from staff who are responsible for the various CIRR activities, organisations identify key roles (among others) to assist in managing the cyber incident. The roles are part of the multidisciplinary incident coordination team:

    - *Incident Owner*: An individual is responsible for handling the overall CIRR activities according to the incident type and services affected. The Incident Owner is delegated appropriate authority to manage the mitigation of the incident. "Unity of command" is established by ensuring that incident responders report only to the Incident Owner for task assignment. The Incident Owner can minimise the potential

[7] For instance, organisations could use a RACI matrix, which is a tabular format for documenting the allocation of Responsible, Accountable, Consulted and Informed roles.

for respondents to receive conflicting orders or information from different stakeholders, thereby improving the flow of information and aiding the coordination of response and recovery efforts.

- *Media Spokesperson*: An individual is responsible for managing the communications strategy within a pre-determined cross-functional communication team, which may draw from areas such as affected business lines, human resources, press and communication offices, legal, technology and cyber security. Based on the incident type, the team may additionally enlist the assistance of other in-house specialists. To avoid confusion arising from information asymmetry, the Media Spokesperson consolidates relevant information and views from subject matter experts and the organisation's management to update the media with consistent information and message. The Media Spokesperson is authorised to make strategic use of conventional and social media, fully consistent with the organisation's official communication channels predefined in the Communication Plan.
- *Scribe/Independent Observers*: Organisations appoint individuals as independent observers to evaluate the effectiveness of CIRR activities during tests and actual incidents. These individuals are responsible for maintaining an accurate record of the cyber incident throughout its different phases, as well as documenting actions and decisions taken during and after a cyber incident. In some cases, they can utilise voice or video recording. The record serves as an accurate source of reference for the organisation and promotes understanding and effectiveness of the response and recovery actions taken. In addition, the record facilitates after-action reviews to improve future CIRR activities.

4. **Executive sponsorship.** Staff proactively engages senior management on CIRR activities to promote awareness, seek executive-level guidance and share accountability for success. Executive sponsorship can be in the form of financial and non-financial support and is essential to the implementation and execution of effective CIRR activities.

5. **Culture.** Senior management demonstrates commitment by creating an organisational environment where staff are encouraged to report or escalate cyber incidents to management. Organisations promote such an environment through structured training programmes that encourage learning from mistakes, management leading by example and rewarding staff who demonstrate desired behaviours.

6. **Funding**. The Board and senior management view CIRR not simply as a cost to be borne, but as an investment to ensure the security and reliability of financial services; achieving excellence in containment and restoration from cyber incidents is a necessary competitive element for an organisation. Board and senior management allocate sufficient budget to CIRR, including for technology tools and other support, training and communication programmes at all levels of the organisation. CIRR spending is assessed based on the commensurate risks associated with protecting and assuring continuity of critical functions, and potential implications for financial stability. Peer comparison (or benchmarking) can help identify areas where funding should be channelled.

7. **Human resources.** Organisations ensure that CIRR functions are adequately staffed and the competencies of relevant personnel are maintained and regularly enhanced through structured training programmes, internal job rotations (e.g. between Red and Blue teams)

or exchanging staff between organisations, jurisdictions and sectors to broaden their experience and knowledge.

8. **Metrics.** Organisations establish metrics to measure the impact of a cyber incident and to report to management the performance of CIRR activities.

Box 1: Examples of metrics used by industry

- Metrics to measure impact of a cyber incident
  - Duration of unavailability of critical functions and services
  - Number of stolen records or affected accounts
  - Volume of customers impacted
  - Amount of lost revenue due to business downtime, including both existing and future business opportunities
  - Percentage of service level agreements breached
- Performance metrics for incident management
  - Volume of incidents detected and responded via automation
  - Dwell time (i.e. the duration a threat actor has undetected access until completely removed)
  - Recovery Point objectives (RPO) and recovery time objectives (RTO) satisfied

2. Preparation

The Preparation component establishes and maintains capabilities to respond to cyber incidents, and to restore critical functions, processes, activities, systems and data affected by cyber incidents to normal operations. While preparation is a phase before an incident, it significantly and directly influences the effectiveness of CIRR activities.

9. **Policies.** Organisations have written policies that describe the involvement of the organisation's functions in the CIRR process. The policies are developed based on the regulatory, legal and business requirements and are enforced at all levels of the organisation, with coherence across relevant jurisdictions where the organisation operates. The policies include a clear communication strategy and plan, which describe whom to inform of the cyber incident within a given timeframe, the information to be furnished and the channel used for notification. Organisations establish a list of internal and external stakeholders to be informed depending on identified scenarios and criteria, such as on the severity of the incident as well as any required regulatory and statutory notifications.

Box 2: Examples of internal and external stakeholders

- **Internal stakeholders** are involved in multidisciplinary CIRR activities according to the type of cyber incident and the criticality of their function as well as those that need to be informed of the incident. These include:
  - board members, senior executives
  - business lines
  - technical support teams
  - public relationship officers
  - legal and compliance officers
- **External stakeholders** that may be impacted or that need to be involved in CIRR activities depending on the type of cyber incident. These include:
  - financial counterparties
  - financial market infrastructures (FMI)
  - clients
  - third-party service providers
  - relevant authorities
  - general public

10. **Plans and playbooks.** Organisations establish and maintain plans and playbooks that provide well-defined, organised approaches for CIRR activities, including criteria for activating the measures set out in the plans and playbooks to expedite the organisation's response time. Plans and playbooks are developed in consultation with business lines to ensure business recovery objectives are met, and are approved by senior management before broadly shared across the organisation. They are reviewed and updated regularly to incorporate improvements and/or changes in the organisation. Organisations enlist internal or external subject matter experts to review complex and technical content in the playbook, where appropriate. Organisations develop a number of plans and playbooks for specific purposes (e.g. response, recovery, contingency, communication) that align with the overall cyber resilience strategy and use a common language. Plans and playbooks cover the initial hours and days of a cyber incident, which usually are the most critical period. Plans and playbooks are tailored to the organisation's structure, complexity and business activities so that a "one-size fits all" approach is avoided.

11. **Communication strategies, channels and plans.** Organisations establish their communication strategies for internal and external stakeholders. They develop a communications plan to address the impact arising from different types of cyber incidents and establish the use of social media platforms and mainstream media. They also prioritise and sequence information sharing with internal and external stakeholders during an incident. This includes differentiating those stakeholders involved in CIRR activities and those that need to be kept informed. Effective prioritisation reduces uncertainty and increases credibility with stakeholders, mutual understanding and constructive approach (i.e. reducing blaming and negative criticism).

12. **Scenario planning and stress testing.** Organisations' plans and playbooks include severe but plausible cyber scenarios and stress tests that are based on high-impact-low-probability events, and include scenarios that may result in failure. Common cyber scenarios include distributed denial of service (DDoS) attack, system intrusion, data exfiltration and system disruption. Organisations regularly use threat intelligence to update the scenarios so that they remain current and relevant. These scenarios and stress tests are regularly assessed in business continuity tests, simulations and tabletop exercises. Such exercises are planned and performed in cooperation with key external stakeholders, such as relevant authorities and third-party service providers.

13. **Security Operations Centre (SOC).** Organisations invest in a SOC, or in other equivalent service, that is tailored to the needs of the organisation to detect, identify, investigate and respond to cyber incidents that could impact the organisation's infrastructure, services and customers. Log collection and monitoring capabilities are built into the SOC. Organisations maintain their asset inventory and network diagrams, and use analytical tools, vulnerability management tools, compliance monitoring tools, correlation tools, machine learning tools and other tools for behavioural analytics to enhance the effectiveness of cyber incident analysis.

14. **Disaster recovery sites.** Organisations replicate critical systems and data on a daily basis to disaster recovery sites and alternative sites (more often in case of business critical data). Backup facilities are diversified geographically and isolated through network and system segmentation to avoid possible concentration risks. In some cases, organisations choose to backup and store critical data in offline or air-gapped systems that effectively shield the data asset from unauthorised access. Organisations invest in (nearly) real-time mirroring to enhance the application recovery capability, appropriate (private) secured connections and integration with the primary facilities. Failover tests and recovery tests are performed regularly to validate effectiveness of these measures for ensuring availability and integrity of data and systems.

15. **Forensic capabilities.** Organisations establish technical and forensic capabilities to preserve evidence and analyse control failures, identify security issues and other causes related to a cyber incident. Organisations develop an effective log retention and analysis framework that is comprised of tools to manage, collect and store system logs. The types of logs to be collected and retention period of logs are pre-determined. In case the organisation does not have its own forensic capabilities, contractual agreements with third-party service providers are established (e.g. forensic retainer services) to support extended cyber forensic investigations, which are immediately activated when needed. Staff who perform forensic work are adequately trained and adhere to robust forensic procedures to safeguard the integrity of the evidence, data and systems during investigations.

16. **Technology solutions and vendors.** Organisations implement technologies to enforce their policies and procedures. For instance, organisations invest in vulnerabilities detection software and automated patching solutions as part of their cyber resilience strategy. They implement commercially off-the-shelf technology solutions to protect systems from cyber threats. To reduce over dependency on a particular technology solution and vendor, organisations pursue a vendor and product diversification strategy.

17. **Supply chain management.** Organisations address dependencies in their supply chain and test the contingency measures. As cyber supply chain risk covers a broad range of areas, organisations include risks from third-party service providers or vendors, poor cyber security practices by suppliers, third-party data storage and software security vulnerabilities in supply chain management or supplier systems. Organisations adopt supply chain risk management to ensure quality of the provided CIRR services. This is achieved through service level agreements (SLAs) with key performance indicators (KPIs) as part of the contract with the third-party service provider to guarantee adequate response during cyber incidents. Organisations look through the SLAs that rely on subcontractors (e.g. n^{th} parties) and ensure they have protections in place.

18. **Third-party cyber services providers**. Organisations proactively acquire third-party services to augment their in-house cyber capabilities. Organisations maintain a record of the third-party service agreements detailing important information such as the scope of the service, the service provider contact information, service validity period and service levels. Organisations pre-designate a primary and an alternate cyber service provider in the event that the former is unavailable to provide immediate support, especially in the case of a system-wide cyber incident.

3. Analysis

Analysis is conducted to ensure effective response and recovery activities, including forensic analysis, and to determine the severity, impact and root cause of cyber incidents to drive appropriate response and recovery activities.

19. **Cyber incident taxonomy.** Organisations utilise (i) a pre-defined taxonomy for classifying cyber incidents according to, for example, the type of incident, threat actors, threat vectors and repercussions; and (ii) a pre-established severity assessment framework to help gauge the severity of the cyber incident. For example, an organisation may rely on indicators such as volume and types of network traffic to identify a DDoS attack. In addition to any applicable statutory or regulatory classifications, these taxonomies help organisations to prioritise CIRR activities as defined in the playbook and direct the organisation's attention and resources to more timely and effective containment and eradication efforts. There is consistency in the understanding of incidents across various parties, as information is communicated with a common language. Severity levels are established to allow for immediate response to a cyber incident as the first hours and few days following an incident are the most critical. This approach allows the execution of CIRR activities even in the absence of complete knowledge of the incident.

Box 3: Examples of CIRR taxonomies

- Information to be used when describing cyber incidents
  - Describe the payload (e.g. malware, virus, worm, hyperlink)
  - Describe the delivery channel used (e.g. email, web browser, removable storage media)
  - Describe the impact (e.g. service degradation/disruption, data leakage, data destruction/corruption, tarnishing of reputation)
  - Describe the intent (e.g. malicious, theft, monetary gain, fraud, political, espionage, opportunistic)
  - Describe the threat actor (e.g. script kiddies, amateur, criminal syndicate, hacktivist, nation state)
- Classification of the severity of cyber incidents
  - Severity 1 incident has or will cause a serious disruption or degradation of critical service(s) and there is potentially high impact on public confidence in the organisation.
  - Severity 2 incident has or will cause some degradation of critical services and there is medium impact on public confidence in the organisation.
  - Severity 3 incident little or no impact to critical services and there is no visible impact on public confidence in the organisation.

20. **System and transaction logs.** Organisations identify and collect the types of logs required for timely analysis and forensic investigation, including their location and owners (e.g. database administrator, server administrator). Analysing logs and configurations enables the response team to determine the extent of a cyber incident. The logs are stored and preserved in a secure and legally admissible manner.

21. **Trusted information sources.** Organisations correlate a variety of internal and external information sources for quick threat and root cause analysis of the cyber incident.[8] For example, organisations join or subscribe to cyber threat intelligence sharing sources (e.g. national/international computer emergency response team (CERT) and sector information sharing platforms) to gather intelligence or recommendations on threats and on analysis of tactics, techniques, procedures (TTPs) and risk mitigation. Organisations also collect data from all computing resources for analysing the cyber incident and possible actions. The integrity of these data is continuously monitored. This includes lists of network-connected devices, running processes, users' sessions, open files, relevant configurations (e.g. network, firewalls) and the contents of memory.

[8] Examples of trusted sources are the multi-lateral information platforms.

4. Mitigation

Mitigation activities are performed to prevent the aggravation of the situation and eradicate cyber threats in a timely manner to alleviate their impact on business operations and services.

22. **Containment.** Organisations activate their containment measures, processes and technologies best suited to each type of cyber incident to prevent a cyber incident from inflicting further damage. Having knowledge about what is the specific threat and an understanding of its possible behaviours would also aid in the decision-making.

23. **Business continuity measures.** Organisations invoke business continuity plans during a cyber incident and resume critical operations based on pre-defined prioritisation process in the event restoration is expected to be protracted. Examples of business continuity measures include activating contingency measures not necessarily fully automated to facilitate the processing of critical transactions while system restoration efforts continue, or activating an alternative service provider if the primary service provider will not be able to recover from an incident within a certain period of time, as agreed in the respective SLA.

24. **Isolation.** Organisations consider the costs, business impact and operational risks when deciding whether to shut down or isolate all or substantial parts of their systems and networks, as opposed to maintaining their business services operations. Options for isolation include disconnecting the compromised systems from the network, adding network traffic blocking rules and obstructing threat actors' physical access to affected systems and networks.

25. **Eradication.** After evidence is collected and preserved, organisations remove all materials and artefacts (i.e. malicious code and data) introduced by the attacker. The process may involve patching and closing all system and network vulnerabilities that had been exploited by the attacker. Organisations utilise antivirus and specialised tools and software to remove malware from the affected assets. Organisations also assess whether such standard measures are sufficient to address the particular cyber incident and level of spread, or whether it is necessary to reinstall or rebuild all compromised assets.

5. Restoration

Organisations repair and restore systems or assets affected by a cyber incident to safely resume business-as-usual delivery of impacted services.

26. **Prioritisation.** Organisations prioritise restoration activities based on business, security and technical requirements. All internal and external stakeholders are updated regularly and made aware of the conditions to be met, or restrictions, before resuming critical operations.

27. **Key milestones.** Organisations define in CIRR plans key milestones to redesign, reinstall and reconfigure systems. Where it is not possible to achieve restoration of all systems, organisations consider defining interim restoration goals or interim measures, such as continuing operations in a diminished capacity instead of full capacity.

28. **Monitoring.** Organisations monitor third-party service providers, the network and systems for abnormal activities during the restoration process for compromised IT assets. Cyber incident escalations and resolutions are tracked and monitored, and updates are provided to the management regularly.

29. **Approved restoration procedures.** Organisations carry out systems restoration based on documented and tested procedures. Where required, deviation from approved and tested restoration procedures are risk assessed, tested and management approved before implementation. This reduces risk of human error that may arise in the manual, multistage recovery of systems and data. To restore affected systems, organisations use uncompromised system images and snapshots that are regularly updated, tested and securely stored to prevent malicious corruption or destruction

30. **Validation.** Organisations validate that restored assets are free of compromise, fully functional and meet the security requirements before returning the systems to normal business operations.

31. **Record activities.** Organisations document and timestamp restoration actions taken from the time the incident was detected to its final resolution. Tools and artefacts (e.g. scripts, configuration changes) used for restoration are recorded for future use or for the improvement of current processes and/or systems. This record facilitates the tracing back of actions taken, reversing actions to reinstate to pre-incident conditions or troubleshooting should the recovery actions be unsuccessful.

32. **Data recovery.** Organisations recover and restore data, including data maintained at third-party service providers, to meet business requirements. To provide assurance on data integrity (i.e. not been tampered or corrupted before restoration), organisations perform checks such as validating checksums and reconciliation to ensure data is consistent between systems when recovering from a cyber incident. In worst-case scenario, organisations plan for the reconstruction of data from external stakeholders such as business partners and customers.

33. **"Golden source" data.** Where appropriate, organisations restore backup data kept in another system with a significantly different operating environment to the main system and ensure that both systems are not directly connected. The "golden source" backup data are securely protected from unauthorised access or corruption.

6. Improvement

Organisations establish processes to improve response and recovery capabilities through lessons learnt from past cyber incidents and from proactive tools such as CIRR exercises. Necessary changes are made to CIRR policies, plans and playbooks to improve the overall process as well as any necessary training and testing. Lessons learnt are used in the selection and implementation of additional controls and mitigation measures.

34. **Exercises, tests and drills.** Organisations conduct tests, such as tabletop exercises and live simulations, to validate the capability of resources and the robustness of their CIRR plans and procedures. Organisations design their tests to incorporate interactions within the organisation as well as with external stakeholders and executive level decision-makers

under simulated conditions. The sophistication of these tests increases with the organisation's cyber security maturity. Organisations set clear and appropriate objectives for tests and exercises (e.g. for developing skills, testing the effectiveness of plans, for "muscle memory") to measure the effectiveness of the tests.

Box 4: Examples of scope and types of test

- Tests could take different forms such as:
  - Modular or playbook exercises involving incident responders and incident management teams to build muscle memory.
  - Live simulations including cyber range, adversarial attack or red/blue teaming exercises, and bug bounty to enhance the actual technical response and recovery capabilities.
  - Executive-level crisis management scenarios to stress decision-making under simulated conditions. This could include developing challenging scenarios, such as dealing with "lose-lose" choices, uncertainty and imperfect information, or requiring the prioritisation of the timing of recovery of competing systems and business lines.

35. **Cross-sectoral and cross-border exercises.** Organisations participate in cross-sectoral and cross-border crisis management and contingency exercises to prepare and enhance coordination among multiple stakeholders in the event of a cyber incident with systemic impact on the financial ecosystems. These exercises include different scenarios to validate the effectiveness of coordination on the response and recovery processes. Organisations are committed to share effective practices and lessons learnt with other participants, which include government and organisations. National authorities may participate in these exercises in the spirit of enhancing cyber resilience.

36. **Technological aids.** Organisations invest in the testing of the capabilities of CIRR systems. Computing sandboxes are one tool that enables organisations to test the CIRR systems' effectiveness against the latest malware by allowing potentially malicious files to be executed in an isolated environment.

37. **External events and sources.** Organisations identify opportunities for improvements to their CIRR activities from various sources: cyber publications; reports on the cyber incidents; information sharing and discussions between peers; trend and threat analysis; regulatory and supervisory initiatives; changes to the environment, such as technological developments; and cyber risk management best practices.

38. **Industry-wide initiatives**. Organisations collaborate with peers, such as in established forums, on sharing industry-wide knowledge, discussing cyber events, skill-sets regarding cyber threats, as well as mitigation strategies against existing and potential cyber security vulnerabilities. Organisations also collaborate with authorities to promote information sharing and effective practices for the overall benefit of the industry. Their active engagement in trusted information sharing arrangements contributes to better

mutual understanding of their key interdependencies in the financial system and enhances the organisation's capabilities to respond to and recover from cyber incidents.

39. **Post-incident analysis.** After the closure of a cyber incident, organisations analyse whether established procedures were followed and whether the actions taken were effective. This analysis may include: promptness in responding to security alerts; timeliness in determining the impact of incidents and incident severity; quality and speed in performing forensic analysis; effectiveness of incident escalation within the organisation; and effectiveness of communication (both internal and external).

40. **Lessons learnt.** Lessons learnt are verified with internal and external stakeholders, including business lines affected by the cyber incident, individuals with CIRR responsibilities and senior management. Organisations translate lessons learnt into remedial actions such as controls and procedures to improve future CIRR activities, and track these actions to closure. Closure includes revised metrics and incorporated procedures in playbooks and training.

7. Coordination and communication

Organisations coordinate with their trusted external stakeholders to maintain good cyber situational awareness and enhance the cyber resilience of the ecosystem. During a cyber incident, organisations communicate on an agreed frequency, as well as in a level of detail, and language appropriate to each stakeholder group, in order to improve their engagement in CIRR activities. Progress and outcomes from the cyber incident analysis are shared with internal and external stakeholders so that actions to contain, mitigate, recover or prevent a cyber incident can be taken and to ensure there are no misunderstandings or rumours that could possibly arise from lack of information. A common, secured and trusted communication channel enhances the efficiency and security of information sharing.

41. **Timely escalation.** Organisations escalate cyber incidents to relevant stakeholders within the organisation to avoid delays in addressing the incident. Timely escalation to the organisations' decision-makers based on the agreed framework is essential for the acceleration of CIRR actions, which include seeking approval and authorisation to implement response and recovery plans. Organisations maintain the accuracy and integrity of information during this process, and avoid hierarchical smoothing of risk as it traverses levels of seniority and functional or organisation boundaries.

42. **Regular updates with actionable messages.** Organisations inform relevant stakeholders about potential business disruptions caused by the cyber incident, response and recovery activities taken and the plans to restore operations**.** The information shared is actionable, accurate, timely and concrete.[9] Each message states the actions that are expected to be taken by each audience. The frequency and intervals of such updates are set in advance

[9] *Actionable* refers to information that leads to implementation of concrete controls or configurations. *Accurate* refers to information that has, to the extent possible, been confirmed to be related to the cyber incident. Information is *timely* when it is distributed at a time when the recipient can take actions that minimise the impact of the incident. *Concrete* information goes to the point of the problem, making it easy to read and share among the stakeholders that need to take actions based on that information.

to manage expectations. Whenever possible, organisations communicate on an expected timeframe and conditions under which critical operations are planned to resume.

43. **Cross-border coordination.** Organisations develop and maintain bilateral or multilateral protocols with relevant authorities according to national legislation. Whenever it is legally feasible and relevant for their operations organisations together with the national authorities develop or engage in cross-border coordination and communications.

44. **Trusted information sharing.** Organisations share information on cyber incidents, effective cyber security strategies and risk management practices through malware information sharing platforms (MISP).[10] Technical information, such as Indicators of Compromise (IoCs) or vulnerabilities exploited, are shared as soon as it is available.

Box 5: Examples of information that could be shared

- A brief summary of the cyber incident
- Classification of information e.g. Traffic Light Protocol
- Key contact of the information provider
- Attack pattern
- Vulnerabilities
- Campaign
- Threat actors
- Course of action

45. **Trusted communication channels.** Organisations use trusted and secure communication channels to facilitate communication with relevant internal and external stakeholders, including authorities.

46. **Cyber incident reporting.** Organisations provide without undue delay useful information to the relevant authorities on (significant) cyber incidents, articulating the type or nature of the cyber incident, the impact of the incident and implications on its business continuity, and explaining the rationale of the response and recovery actions taken to restore critical operations in a timeframe.

[10] MISP is an open source software solution for collecting, storing, distributing and sharing cyber security IoCs and threats about cyber security incidents.

Box 6: Type of information that could be included in the cyber incident reporting to provide useful details

- Date and time of discovery of the incident
- Time elapsed from detection to restoration of critical services
- Who discovered the incident (e.g. third-party service provider, customer, employee)
- Type of cyber incident (e.g. DDoS, malware, intrusion/unauthorised access, hardware/firmware failure, system software bugs)
- Impact of the incident (e.g. impact to availability of services, loss of confidential information) and to which group of stakeholders (e.g. retail and corporate customers, settlement institutions, service providers)
- Affected systems and technical details of the incident (e.g. source IP address and post, IOCs, TTPs)
- Action(s) taken at this time
  - Escalation steps taken
  - Stakeholders informed
  - Response and recovery activities commenced