# HONG KONG OBSERVATORY

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# The Design of a Workflow Management System to Support Nuclear Emergency Responses at the Hong Kong Observatory

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## ABSTRACT

A Workflow Management System was developed by the Hong Kong Observatory to assist emergency response management and decision guidance at the Observatory's Monitoring and Assessment Centre (MAC) in the event of a nuclear emergency. The system provides an interactive, knowledge-based framework for process control. In accordance with the emergency scenario, the system invokes a series of interactive sequential steps to evaluate the situation, assigns and coordinates tasks, and ensures that appropriate and rational decisions are made by the emergency response staff. This note documents the design and the functions of the system, and describes the workflow behind the routing of tasks.

## 摘要

香港天文台發展了一套工作流程管理系統，用來輔助輻射監測及評估中心在發生緊急核事故時管理應急行動及指導決策工作，該系統以一個具知識基礎及互動式框架控制工作程序。根據事故時的應急情景，系統會啓動一系列互動工序來評估情況，分配及協調工作，確保應急人員能作出合適與合理的決策。本報告記錄了工作流程管理系統的設計及功能，並描述自動分配工作背後的工作流程表。

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# 1. INTRODUCTION

## 1.1 The Role of the Hong Kong Observatory in the Daya Bay Contingency Plan

In the unlikely event of a nuclear accident at the Guangdong Nuclear Power Station (GNPS) / Lingao Nuclear Power Station (LNPS) at Daya Bay, the Hong Kong Observatory (HKO), as one of the key departments in the Government's Daya Bay Contingency Plan (DBCP) (Security Bureau, 2002), would provide technical support to the Government's Emergency Monitoring and Support Centre (EMSC) in protecting the safety of people in Hong Kong. Within the DBCP framework, the HKO serves as:

(a) the first point of contact round the clock, for receiving nuclear emergency messages;
(b) the first department to make initial assessment of any potential nuclear consequences of the accident;
(c) a monitoring and assessment centre in respect of release of radioactive material from the nuclear power stations; and
(d) one of the advisers on countermeasures necessary for protecting the safety of the public.

The potential triggers to activate an emergency response may be:

(a) a notification by the Guangdong authority or by the nuclear investment company based in Hong Kong;
(b) a notification by the International Atomic Energy Agency (IAEA);
(c) unusual readings reported by HKO's radiation monitoring equipment; and
(d) report(s) of rumour.

Once it is established that a nuclear incident has occurred, the DBCP may be activated by the Government at any one of four levels according to the nature and seriousness of the nuclear power plant emergencies. The four levels are Observation Level, Ready Level, Partial Activation Level, and Full Activation Level.

## 1.2 The HKO departmental plan for the DBCP

The Monitoring and Assessment Centre (MAC) of the HKO is the focal point for the collection, collation and analysis of the emergency radiation data. The HKO

departmental plan defines the roles and responsibilities of the HKO under the DBCP and spells out the procedures to be followed by the emergency staff including those manning the MAC. The MAC Controller (MACC), with the assistance of the Incident Assessor (IA) and the Survey Co-ordinator (SC), carries out initial incident assessment, emergency radiation monitoring, accident consequence assessment and formulation of countermeasures in accordance with the departmental plan. They have to follow the established action plans and procedures depending on the triggering events and the DBCP activation levels, respond to the developing situation, and liaise with other emergency response parties accordingly.

### 1.3 The Workflow Management System at the MAC

It is highly desirable to have a tool to assist the team members of the MAC in taking appropriate actions in accordance with the departmental plan effectively. A Workflow Management System at the MAC ("the workflow system") was developed in 2005 to assist the MACC and other key posts in the execution of their duties. The system is capable of routing the tasks to appropriate responsible MAC key posts automatically in accordance with the different triggering scenarios and the evolution of events. It provides process control of the emergency procedures to ensure that they are completed in the correct order and on time. The workload, stress and chance of human error during emergency operation may be reduced with the implementation of the system.

This note documents the design and the functions of the workflow system and describes the workflow behind the routing of tasks.

## 2. SYSTEM DESIGN

2.1 The workflow system is composed of three modules, namely, Schedule Server, Client Workstations, and Server Database.

2.2 Schedule Server

The Schedule Server is responsible for the overall coordination of the workflow system. It runs repeated cycles of task assignments to the Client Workstations, receives update from them, checks the overall progress of the workflow and then assigns new tasks to the Client Workstations again.

The Schedule Server is developed by Java programming language. Java, being a cross-platform language, is suitable for implementing server programs and web-based clients. The Schedule Server communicates with the clients using the Java Remote Method Invocation (RMI) via the Internet communication protocol TCP/IP. The Schedule Server has a component called DBMonitor which is a server thread, making use of the Java Database Connectivity (JDBC) driver, to keep monitoring the Server Database for workflow coordination.

2.3 Client Workstations

The Client Workstations are configured to the individual MAC posts such as the MACC, the IA, and the SC etc. Each post performs the duties as driven by the workflow, which is coordinated by the Schedule Server.

The client module, which is implemented as a Java Applet, runs on a web browser such as Internet Explorer.

2.4 Server Database

The Server Database records the status information on procedures underway and the history of previously executed procedures in the workflow system.

2.5 The system structure of the workflow system is shown in Figure 1.

## 3 WORKFLOW HIERARCHY

3.1 A workflow is made up of many processes that define the emergency responses and procedures. These processes such as investigations, notifications, reminders, status tracking and reporting, are organized in a hierarchy.

3.2 The workflow hierarchy has three tiers i.e. scenario, event and action. A workflow is distinguished by a scenario, which depends on a triggered incident and operates according to the procedures in the departmental plan for the DBCP. In the course of the evolution of the scenario a number of events occupy the second tier. Examples are investigation, confirmation and notification of an emergency event, activation of emergency responses, and de-activation of emergency plan. Actions, occupying the hierarchy's third tier, are tasks in response to events. They are assigned to specific users in a batch under the same event. Examples are: collecting data, making telephone calls and writing up reports.

3.3 Six scenarios of workflows are drawn up from the potential triggers given in Section 1.1. They are

(i) Receipt of an emergency message from the Prevention and Emergency Administrative Commission Office of Guangdong Province for Nuclear Accident of Civil Nuclear Facility (PEACO, GD);
(ii) Receipt of a notification message from the China Light and Power Company Limited (CLP) in connection with faults at the GNPS;
(iii) Receipt of an emergency message from IAEA;
(iv) Alarm(s) of the Radiation Monitoring Network and/or Automatic Gamma Spectrometry System is (are) triggered;
(v) Alarm of the On-line Water Contamination Monitoring System; and
(vi) Miscellaneous reports of problems at the GNPS/LNPS from other sources.

The hierarchy diagram of the workflows is illustrated in Figure 2(a) and (b). Each workflow starts with a triggering scenario which consists of nine events in total describing the possible evolution of emergency responses. The actions arising from or associated with each event are indicated in the rectangular boxes. These actions comprising specific tasks are then assigned to the appropriate users in a batch for the same event.

3.4 A parent-child relationship of events in the hierarchy means that the parent node

must be executed before the child node. Actions with a sibling relationship in the hierarchy may be executed at the same time.

3.5 The workflows are represented by Extensible Markup Language (XML) documents which provide an easy way to structure data hierarchically. Moreover, the application programming interfaces (APIs) written in Java, such as Java-based Document Object Model API **(**JDOM API), are set up for parsing XML documents to make it easy to manipulate XML documents in the workflow system.

## 4 SYSTEM FUNCTIONS

4.1 The workflow system provides different working configurations for the login users according to their post titles. It directs the routing of tasks in the pre-defined workflows based on the DBCP triggering scenarios, the GNPS/LNPS emergency class, the accident event evolution and the information provided interactively by users. The MACC has the overall control of the workflow system and the authority to re-assign tasks to the other post holders or to bring forward the tasks in the schedule list. Example of the screen layout of the Client Workstation is shown in Figure 3.

4.2 Having been assigned a task by the workflow system, the user has to acknowledge the assignment by either selecting ‘Confirm’ when the task is completed or ‘Skip’ to skip the task. The targeted task completion time and a countdown clock are shown on the display of the Client Workstation, to alert users to complete the task in time. Those skipped tasks will be re-assigned to the user every 30 minutes until the tasks are confirmed. For those tasks which require decision-making, the workflow system will prompt the MACC to input ‘Yes’ or ‘No’ to control the direction of workflow.

4.3 When all actions in an event are processed, the workflow system carries out task assignment for the next event in the workflow according to users’ interactive information.

4.4 At the later stage of an emergency event when work is focused on the radiation monitoring and assessment, repetitive tasks will be assigned to the responsible users at regular intervals according to the schedule, until the DBCP is de-activated.

4.5 There are also functions for managing the task schedule such as viewing and printing of the task list, re-scheduling tasks and printing the log sheet of the task completion times for record purpose. The MACC can also change workflows for different triggering scenarios and emergency levels, in response to the evolution of the emergency event. The pre-defined flowcharts of tasks for different scenarios and emergency levels established in the workflow system may be printed upon request.

4.6 The MACC may at any time change or terminate the processing workflow. A log sheet of all task completion times is printed for record purpose at the end of a workflow process. An example of the workflow report is shown in Figure 4.

4.7 The workflow status is recorded by the workflow system regularly, such that the system could resume the status and the workflow process even if the system is shut down accidentally.

4.8 The workflow system can be readily employed as a training tool in an orientation exercise. For staff newly enlisted to the MAC, it serves to familiarize them with the DBCP emergency procedures. For serving staff, the system allows them to try out newly implemented procedures. Participants will be guided to execute the appropriate emergency responses for each scenario by navigating through the workflow system. Experience shows that this system when used as a training tool largely reduces the need for too many experienced staff in the MAC.

4.9 For the exercise planner, the system also serves as a useful tool which largely reduces the preparatory work for exercises and drills. It facilitates the preparation of a table-top exercise with choices of simulated emergency situations. After choosing a scenario, exercise participants will respond to a series of incidents and have to resolve problems in accordance with the DBCP. Depending on the objective of the exercise, the planner may choose to focus on a specific task such as notification of an emergency event or coordination among the emergency response parties. The workflow system provides guidance to the participants in proceeding with the pre-defined tasks or procedures in an effective way.

# 5 DISCUSSION

5.1 The MAC Workflow Management System was developed to assist the MACC in conducting the MAC business under the DBCP at a prescribed pace and to ensure the assignment of tasks to appropriate responsible officers in the correct order. The workflow system was tested in two departmental DBCP drills in 2005. Users generally considered the workflow system helpful and useful.

5.2 The benefits of the workflow system are:

(a) Better process control

The workflow system provides a secure and convenient platform for users. It provides users with an overview of tasks in the schedule, which helps them to plan their work and to focus effort on the assigned tasks. It enables the MACC to track, assess and re-organise the tasks of all emergency staff in the workflow process.

(b) Improved efficiency and quality

The automation of task assignment according to the pre-defined workflow ensures the right task is delivered to the right person at the right time, thus optimising the processes time and reducing the chance of human error. Tasks are defined and scheduled in XML documents. The workflow system implements the XML documents among users according to the specification and tasks will not be inadvertently left out. The countdown clock alerts users to the need to complete tasks before the due times. The workflow processes in XML documents can be easily updated to ensure optimal operation and to reflect changes in contingency plan. These facilities promote staff efficiency in responding to emergencies.

(c) A reference and training tool

The workflow system serves as a reminder to the experienced emergency staff and a valuable reference tool to the inexperienced staff in their execution of emergency duties. The workflow system also provides the simulation of emergency events in exercises and drills to maintain staff capability in emergency response.

5.3 The workflows for all six DBCP triggering scenarios and their associated tasks are prepared in the workflow system. As a backup of the system, printed copies of these workflows are incorporated into the modular colour plans of the departmental plan for the DBCP kept at the MAC.

5.4 The HKO has been using the Emergency Radiation Data Management System (ERDMS) to archive, process and display the radiation monitoring data and information for facilitating the decision making process at the MAC. The workflow system, if linked with the ERDMS in the future, would be able to automatically check for new emails or faxes in the ERDMS which indicate whether an assigned task has been completed. If this materializes, the user's acknowledgement would no longer be required, thus enabling the workflow to be streamlined further.

## REFERENCES


1. Security Bureau 2002 The Daya Bay Contingency Plan, Part I

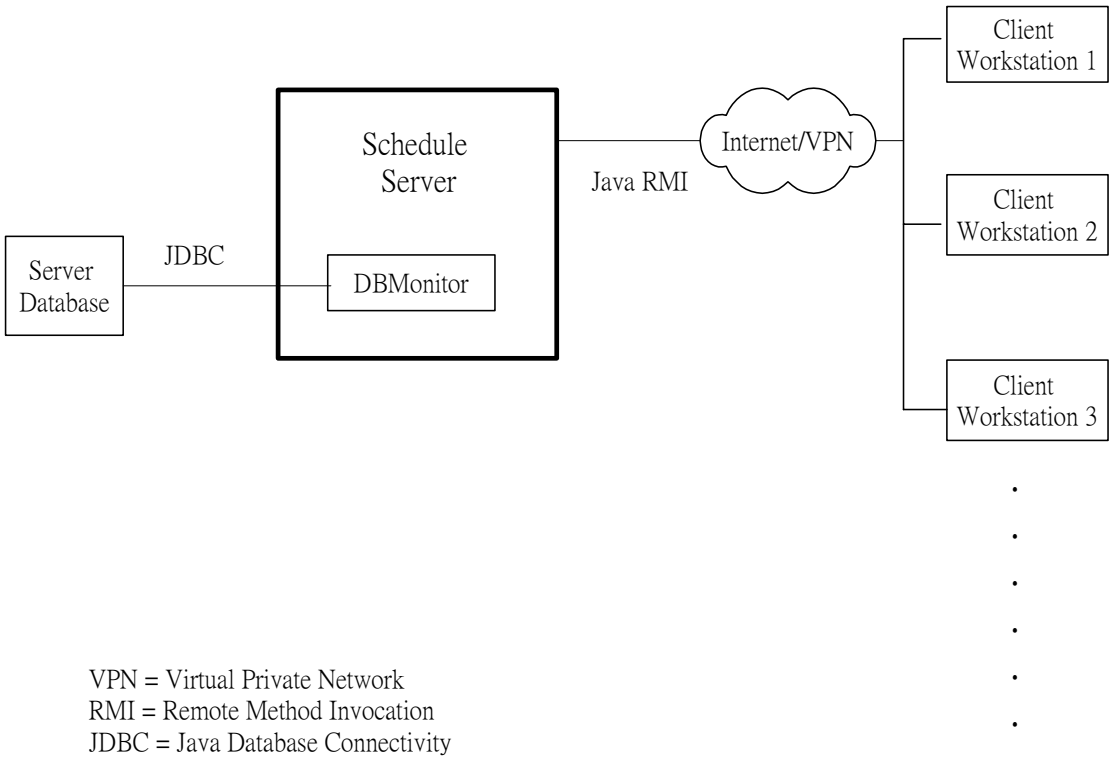



Figure 1 System Structure of the MAC Workflow Management System

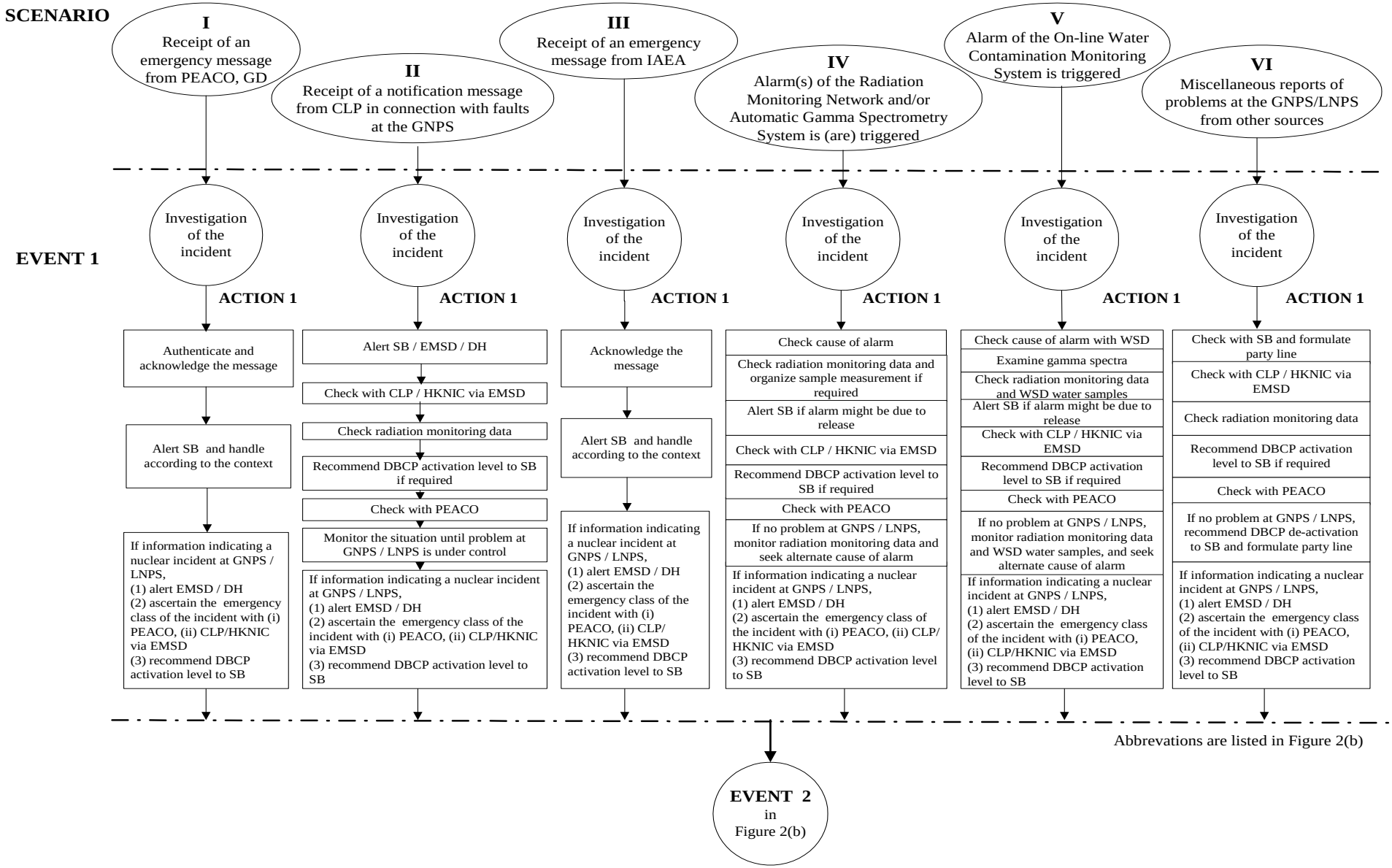
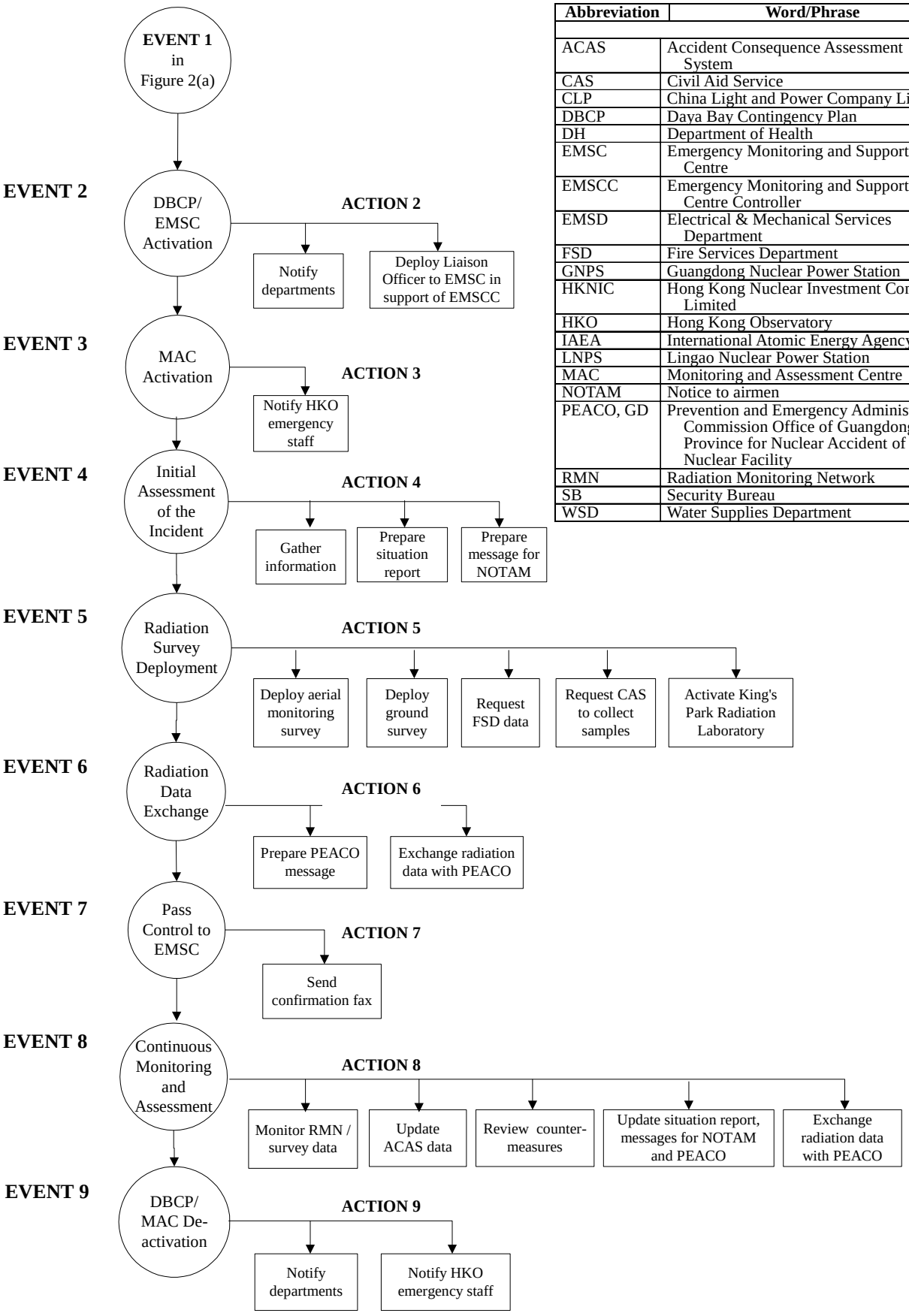



Figure 2(a) Hierarchy Diagram of Workflows of the Departmental DBCP Plan Showing the Six Triggering Scenarios and their First Batches of Event and Actions




| Abbreviation | Word/Phrase |
|---|---|
| | |
| ACAS | Accident Consequence Assessment System |
| CAS | Civil Aid Service |
| CLP | China Light and Power Company Limited |
| DBCP | Daya Bay Contingency Plan |
| DH | Department of Health |
| EMSC | Emergency Monitoring and Support Centre |
| EMSCC | Emergency Monitoring and Support Centre Controller |
| EMSD | Electrical & Mechanical Services Department |
| FSD | Fire Services Department |
| GNPS | Guangdong Nuclear Power Station |
| HKNIC | Hong Kong Nuclear Investment Company Limited |
| HKO | Hong Kong Observatory |
| IAEA | International Atomic Energy Agency |
| LNPS | Lingao Nuclear Power Station |
| MAC | Monitoring and Assessment Centre |
| NOTAM | Notice to airmen |
| PEACO, GD | Prevention and Emergency Administrative Commission Office of Guangdong Province for Nuclear Accident of Civil Nuclear Facility |
| RMN | Radiation Monitoring Network |
| SB | Security Bureau |
| WSD | Water Supplies Department |

Figure 2(b) Hierarchy Diagram of Workflows of the Departmental DBCP Plan Showing the Second to Ninth Batches of Events and Actions

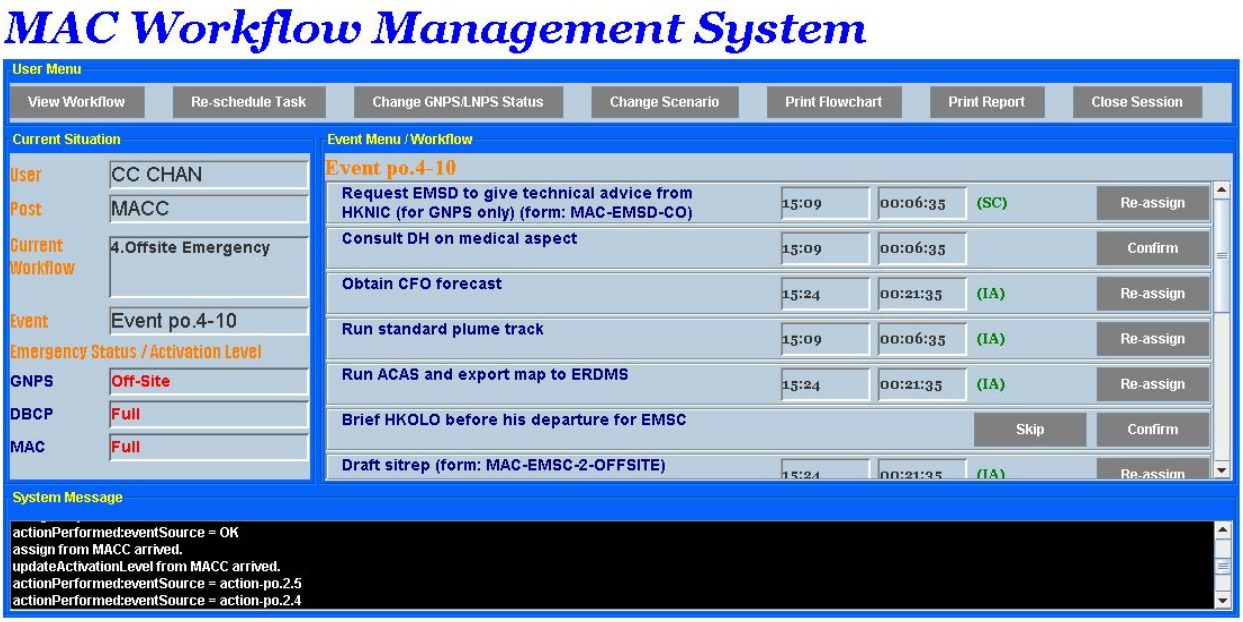



Figure 3 Screen Layout of the MAC Workflow Management System

| Event/ Action | Description | Post | User | Status | Completion Time |
|---|---|---|---|---|---|
| Event-2.1 | | | | | |
| Action-2.1.1 | Input the reception time of CLP Initial Notice | MACC | WL GINN | Done | 2005-10-20 15:23:52 |
| Event-2.2 | | | | | |
| Action-2.2.1 | Notify EMSD | MACC | WL GINN | Done | 2005-10-20 15:23:57 |
| Action-2.2.2 | Notify AD(R), DHKO | MACC | WL GINN | Done | 2005-10-20 15:23:58 |
| Action-2.2.3 | Notify SB | MACC | WL GINN | Done | 2005-10-20 15:23:59 |
| Event-2.3 | | | | | |
| Action-2.3.1 | PIR received? (Y/N) | MACC | WL GINN | Yes | 2005-10-20 15:24:03 |
| Event-2.7 | | | | | |
| Action-2.7.1 | Recommend DBCP Observation Level to SB upon Head/DHKO's approval | MACC | WL GINN | Sent | |
| Action-2.7.2 | Recommend MAC Partial Level to Head | MACC | WL GINN | Sent | |
| Action-2.7.3 | Instruct MACS to initiate cascade call to other departments | IA | LS LEE | Sent | |
| Action-2.7.4 | Send notification fax of DBCP Activation Level to SB and other departments | SC | YH KWOK | Sent | |
| Action-2.7.5 | Instruct MACS to initiate cascade call to HKO staff | IA | LS LEE | Sent | |

Figure 4 An Example of the Workflow Report