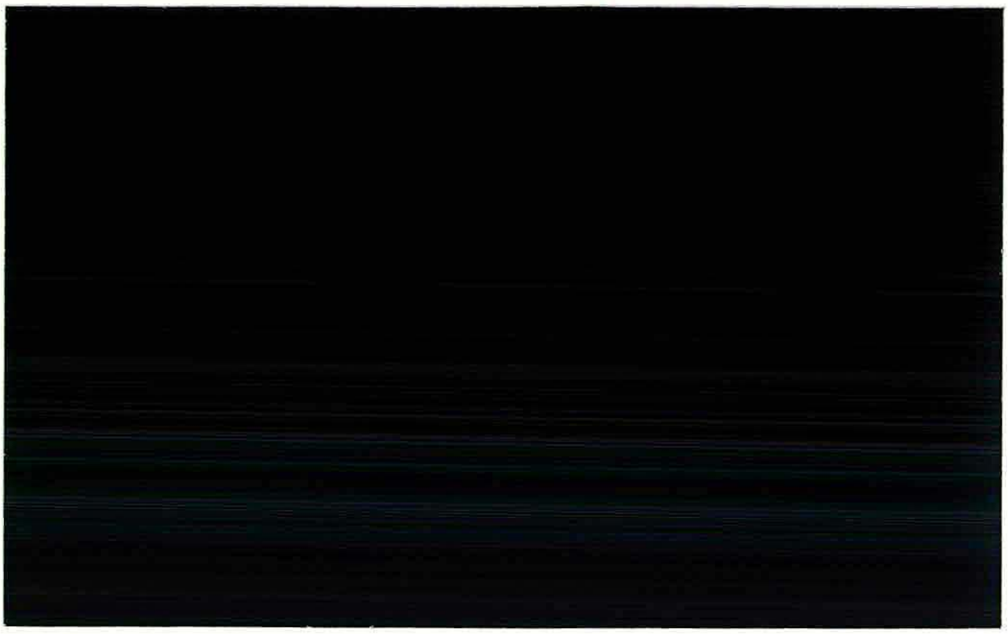
Institute of Hydrology



Natural Environment Research Council

National Rivers Authority
River Flow Forecasting System

IH Technical Note No. 7

Forecast Subsystem Functional Specification

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Version 2.0

November 1990

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1. Introduction

The role of the Forecasting Subsystem within the River Flow Forecasting System (RFFS) is to provide the means by which forecasts are generated of river level, flow and other quantities for sites within a river network. Important considerations in the design of this subsystem are:

(1) Flexibility. It should be possible to make changes to the specified set of sites and quantities for which forecasts are required without having to start again from scratch. It should also be possible to modify existing rules, or introduce new rules, for the calculation of forecasts. In meeting these requirements, it is clear that the system to be developed will not be restricted in potential application to only the Yorkshire river system.

(2) Resilience. The system must be capable of generating forecasts even when portions of data which would normally be used are not available. It is implicit that good use should be made of the data which are available.

(3) Utility. The system must be able to respond to demands for information typically met in a flood situation within a reasonable amount of elapsed time. Examples of such demands are: generation of forecasts for a selected subset of points of immediate interest; exploration of forecasts based on imposed assumptions about future rainfall or river-control decisions.

Overall, the Forecasting Subsystem provides three sets of facilities:

(1) Operational facilites. These generate the forecasts required for real-time use and for post-event investigations.

(2) Structure specification. These allow specification of the way in which all the forecasts required within a region will be generated.

(3) Calibration facilities. These are used to define values for the model-parameters of modelling routines used for particular catchments or river-channels: they can be used to study and improve the accuracy of forecasts as more experience is accumulated.

The calculation of forecasts on a region-wide basis within the Forecast Subsystem consists of two intermeshed parts:

(1) Modelling routines. These are calculation rules or algorithms which represent models of catchment and river-channel behaviour and which are used to specify how forecasts are to be constructed. They include rules for how "updating" is to be acheived, as well as simple tasks such as calculation of averages across raingauges. Because of the nature of these models it is generally true that essentially the same modelling rules can be used for many different catchments or river-channels, with only a few values (model-parameters) changing to reflect the specific catchment or channel. A number of model-algorithms are included within the RFFS as supplied and further algorithms may readily be incorporated.

(2) Information Control Algorithm (ICA). This provides the interface between

the modelling routines and the databases holding observed and forecast values. It coordinates requests for the observed data required by the modelling routines, executes the modelling routines, coordinates transfer of information between them, and returns completed forecasts to the forecast database. It also manages the data required for model-initialisation (model-state values) which are transferred from previous forecast-runs. The ICA provides a structure which specifies the order in which modelling routines are to be executed, what data are supplied to them and what to do with data generated by them.

An outline of the overall approach adopted for forecast generation is given in Section 2: this describes the way in which the forecasting problem is subdivided and indicates the tasks performed by the ICA. Section 3 describes the specification of the set of forecast requirements for the Forecast Subsystem and discusses the steps necessary to set up a new network configuration or to modify an existing one. An outline functional description of the major subsystems within the Forecast Subsystem is provided in Section 4.

2. Approach to forecasting

The approach taken within the RFFS to the generation of forecasts on a basin-wide scale is to subdivide the problem into a large number of more manageable ones. The solution of a subproblem corresponds to use of a modelling routine, while the combination of the results of the sub-problems is in the hands of the Information Control Algorithm.

A typical sub-problem represents an individual catchment or a separate reach of river-channel. The sub-problem is the question of how to calculate forecasts for the downstream point of the channel or catchment. Specifically, observations may be partially available for values at the downstream point and these should be used in reaching the target of the sub-problem. The target is a complete series consisting of observed, infilled and forecasted values for the downstream point. It can be assumed that any other series of data required for solution of the sub-problem will contain no missing data. The term "model-component" is used to describe one of these sub-problems and its solution. General sub-problems (model-components) may be rather more complex than this case, but it includes the essential point that a model-component need only concern itself with missing-values (past or future) within the data-series for which it is to construct forecasts. A sequence of executions of model-components, each performing the task of constructing complete series of data-values which may be required for later model-components, ultimately leads to complete series for all data-series in the overall problem. There will usually be a separate model-component for each catchment and each river-channel reach represented within the overall model for the region.

The solution to a sub-problem defined by a model-component may require a combination of modelling routines: for example a combination of a simulation-mode channel-flow routing model with an error-prediction model. Each modelling routine exists within the RFFS as a section of FORTRAN 77 code accessible in subroutine form. Such a section of code is termed a model-algorithm. A single model-algorithm will in general be used by many individual model-components, but each model-component will require different model-parameter values to be used. The numbers of such model-parameters will typically vary from model-component to model-component even though they use the same model-algorithm.

Because the modelling routines reflect the behaviour of actual catchments and channel-reaches, it is inevitable that the time taken for these routines to warm-up will reflect the response-durations of such systems. This may mean a matter of 1-2 days for tidal channel-reaches or 6-12 months for catchments. In order to avoid having to execute model-components over such long periods, when the required forecast period may be only 8-12 hours, the Forecast Subsystem takes the approach of initialising model-components with sets of data-values remembered from previous runs. Such sets of data-values are called model-states. There may be a separate set of model-states for each model-component. A set of model-states contains enough information to start a model-component running from a given time point in such a way as to exactly duplicate the results which would have been obtained from that point on had the model-component been started in the far past. Thus the model-states provide a summary of the data supplied to a model-component up to a given time-point: this summary contains all the details relevant to that model-component.

Besides the model-states which represent summaries of past-data, each model-component makes use of a number of series of data-values which represent current data. These series represent:

(a) observations of, and the forecasts generated for, those quantities the model-component is constructed to forecast;

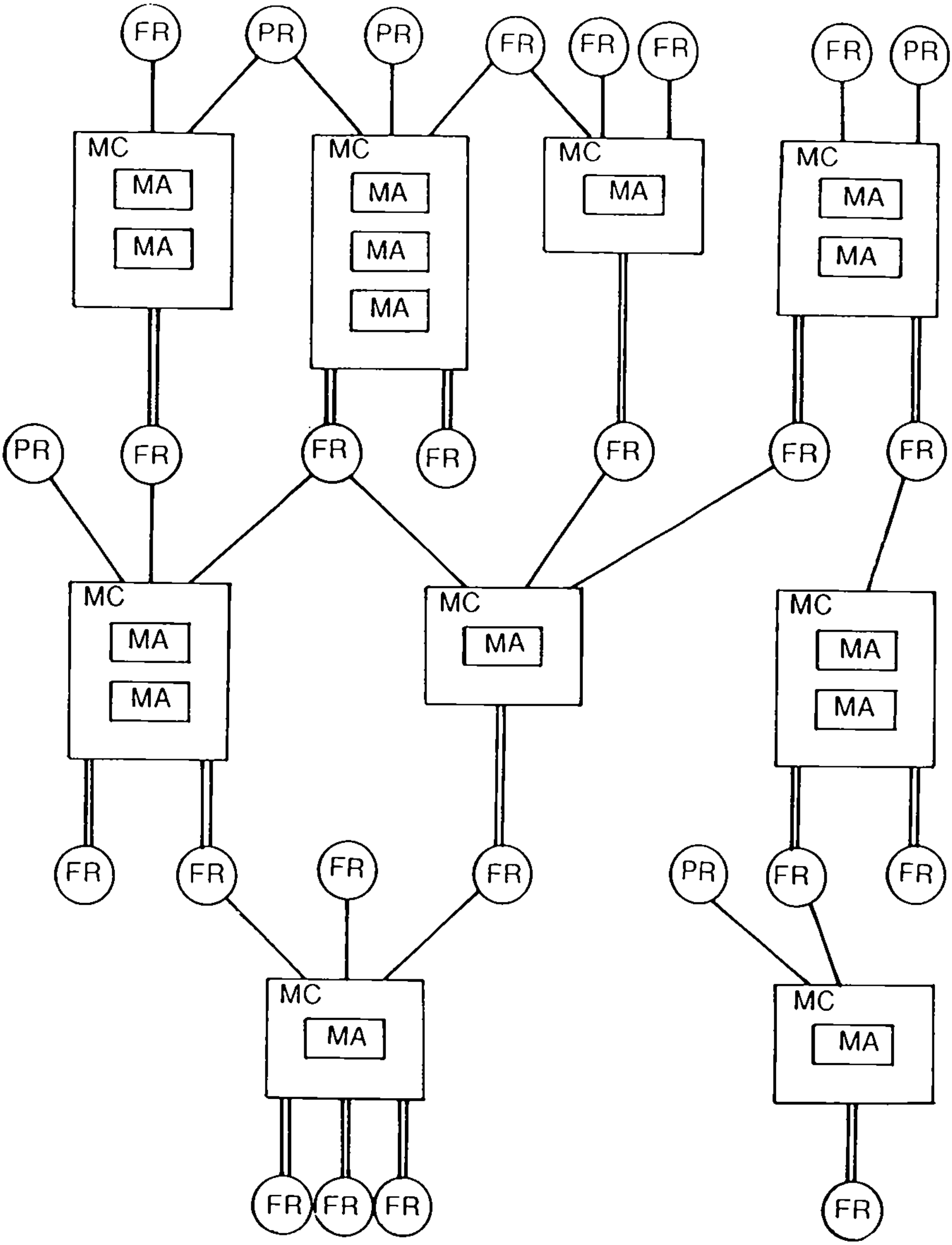
(b) observations, and values infilled and forecasted by another model-component, of other data required by the model-component.

Such series are called forecast-requirements. Often, they will correspond to a requirement for the RFFS to generate and store a forecast of a particular quantity (e.g. river level) at a particular site . However, they may also be used as a convenient intermediate point for transfer of information between model-components. Thus the term "forecast-requirement" is used to designate time-series which are used to pass data into or out of model-components. The term "profile-requirement" is used for certain special types of forecast-requirement: these are concerned with the handling of certain types of data which need to be treated in special ways either within the Forecast Subsystem or in the way that data are accessed from other subsystems. Profile-requirements always have the role of supplying data-values for model-components and they never occur as series for which forecasts are to be generated by the Forecast Subsystem.

An essential ingredient of the approach to forecasting within the Forecast Subsystem is that, for any given forecast-requirement, there can be at most one model-component which is responsible for infilling and forecasting of the corresponding time-series of data-values. Figure 2.1 shows a schematic representation of the inter-relationship between the various model-elements for a possible configuration.

The term "model-network" is used to denote the entire collection of model-components, model-algorithms, forecast-requirements and profile-requirements involved in solving the forecasting problem for a given river-basin or set of river basins. Usually, the inter-connections of the model-network will correspond in a broad sense with the actual river channel network. The Forecasting System provides the option of generating forecasts for only a subset of forecast-requirements by allowing the definition of subsets (subnetworks) of a model-network.

Figure 2.2 provides a schematic representation of the inter-relationship between forecasting runs. The emphasis here is on the sets of model-states, the values of which are saved for an intermediate time-point during a run period. Typically the model-states will be saved for a time-point somewhat earlier than the actual time at which the run is generated: this is to allow for the later arrival of telemetry data and for user-edits of the observation data held on the data-base. Note that, for such data to be included in later runs, the run-initialisation time must be chosen to be strictly before the time-points affected. The use of an early model-states saving time is chosen so that most operational forecasting runs can be started from the latest set of model-states



FR - Forecast Requirement   MA - Model Algorithm   — data used

PR - Profile Requirement   MC - Model Component   = data constructed

Figure 2.1 A possible set of model-network elements

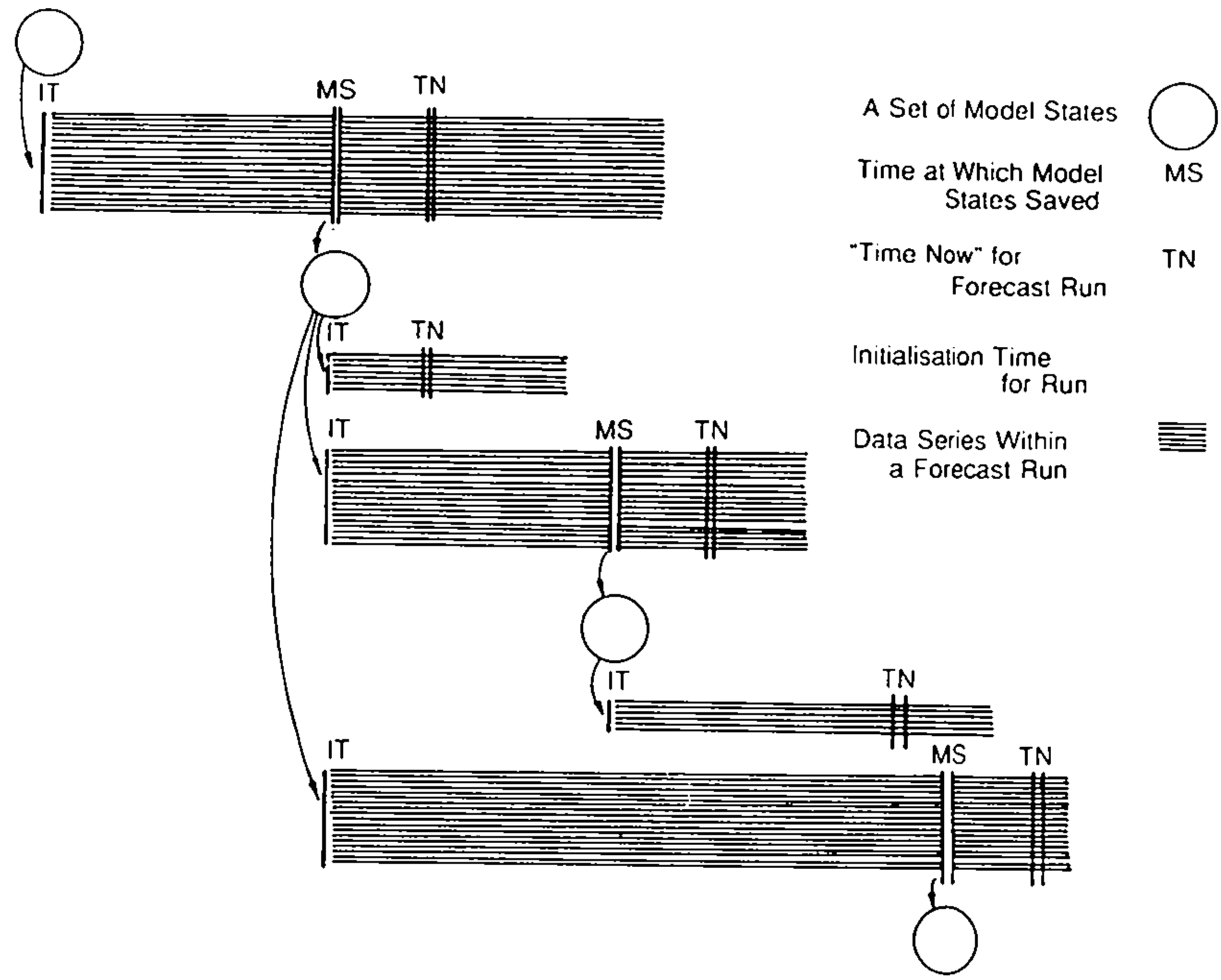


Figure 2.2 Schematic showing transfer of model-states values between forecasting runs

available. However, a number of earlier sets of states will usually be held and this allows for cases in which data for earlier time-points arrive or are modified by the user. A further aspect of model-states saving is that the Forecast Subsystem will not try to create an updated set of states if this would be for a time-point for which little or no time had passed since the model-initialisation time. The two parts of a forecasting run, before and after the saving of model-states, do not differ in any essentials. Although the part after the model-states have been saved corresponds to the "future" in a broad sense, missing data may occur within observation series at any point and, furthermore, the last available observation in a data-series may be at any point before or after the model-states saving time and even possibly after the "time-now" point for certain applications.

The actual execution of a run to generate forecasts will involve the following steps:

(1) Selection of model-network (or subnetwork);

(2) Selection of a time-point for which model-states have been saved previously;

(3) Selection of a lead-time from the current time out to which forecasts will be generated;

(4) Selection of an intermediate time-point at which to save values of the model-states for use in further runs;

(5) Retrieval of the values of the model-states for initialisation;

(6) Acquistion of all available observation data for the time-period for all the forecast-requirements in the network;

(7) Acquistion of all data for the time-period for all the profile-requirements in the network;

(8) Saving of all the above information about the run to allow regeneration of the forecasts during post-event investigations;

(9) Execution of a series of model-components, for each of which the model-states are copied at the intermediate time-point;

(10) Saving of the completed time-series for all those forecast-requirements designated to be stored on the RFFS forecast database;

(11) Saving of the set of values for model-states at the intermediate time-point.

3. System configuration for forecasting

In order to implement the approach to forecasting outlined above, the Forecast Subsystem must hold complete information about the model-network to be used. It holds this information in the form of "configuration detail" files. These configuration detail files are created and updated by the Forecast Subsystem. The process of creating the configuration detail files for a new or revised model-network is a one-off task: the information contained in the files is used to allow forecast-generation runs to proceed efficiently.

The configuration detail files are created by extracting and combining information from a user-maintained set of "model-component detail" files which effectively provide a piecemeal specification of the overall forecasting problem. Checks on the consistency of this piecemeal information are made by the Forecast Subsystem.

The set of model-component detail files consists of a separate file for each individual element in the model-network and each file contains information about that element and about its relationship to other directly connected elements. Within the overall set there are four types of files, one for each type of element:

(1) forecast-requirement description files;
(2) profile-requirement description files;
(3) model-component description files;
(4) model-algorithm description files.

Each type of file contains a range of information some of which is necessary for the operation of the Forecast Subsystem, some which is useful as a guide to the user about the inter-relationships within the network and some which is a provision for future extension of the facilities provided by the RFFS. A summary of the most important items of information contained within the files follows.

Forecast-requirement description files

Name of site and quantity represented;
Identifier for accessing observed data from system database;
Flag for whether forecasts are to be stored on forecast database;
Identifier for model-component which constructs forecast.

Profile-requirement description files

Type of data represented;
Flags for whether to include or exclude this data-series from forecasts according to run-time options;
Flags for special data construction procedures.

Model-component description files

Identifiers of forecast- and profile- requirements providing data;
Identifiers of forecast-requirements for which this component constructs forecasts;
Identifiers, and order of execution, of model algorithms used;
Identifiers for data to be passed to model-algorithms, including data-series created and used only within the model-component;
Model-parameter values for the model-algorithms;
Numbers of values in the model-states for each model-algorithm.

Model-algorithm description files

Identification for specific FORTRAN subroutine to be used;
Numbers of data-series used (possibly designated as variable);
Numbers of model-parameters used (possibly designated as variable);
Numbers of model-states used (possibly designated as variable);
Names for model-parameters;
Names for model-states.

In order to implement a minor change to an existing model-network it should be necessary to modify only a few of the description files or to create a few new ones. This can be done by using a standard editor since each model-component detail file is an ordinary text file, albeit one having a fixed format. Once these modifications have been made, the model-network is configured by using the Forecast Subsystem to read and check the above files and to use them in creating the configuration-detail files.

The procedures for setting up a new network and of modifying and extending an existing network are relatively straightforward provided that the required model-algorithms are already provided within the existing system. If a new model-algorithm is to be introduced, it is clear that parts at least of the RFFS package of programs will need to be re-linked in order to incorporate the new code. The system as supplied will provide a limited number of dummy algorithms which may be replaced with the code required for new algorithms. This would allow new algorithms to be introduced without access to or modification of the source code of the supplied RFFS routines. However, it has the disadvantages of requiring specific types of argument lists for the subroutines to be introduced and of putting a limit on the number of algorithms that can be introduced. Modifications to the RFFS source code allowing more general access to subroutines would be fairly simple to implement. Typically both types of modification would be available to users privileged to make any changes at this level.

In the course of using the Forecast Subsystem to generate forecasts, parts of the configuration detail information are updated. These parts relate to the definition of subnetworks within the main model-network, and to the time-points at which sets of model-states are available for each network or subnetwork.

4. Description of Subsystems

4.1 SUBSYSTEM 3: FORECAST SUBSYSTEM

4.1.1 Overview

The Forecast Subsystem is responsible for the generation of forecasts of flows, river levels and all other related quantities. This subsystem includes facilities by which the network of model components necessary to create forecasts for the whole of a river-network is defined. Subnetworks can also be defined. The forecast generated to meet any single forecast requirement within a network is, in general, constructed by a model-component from observed data, acquired from the operational data-base, and from forecast-data generated for other forecast-requirements within the network. Execution of model components is carried out in an order which ensures that the requisite data-values will be available as they are needed. A data flow diagram for the Forecast Subsystem is presented as Figure 4.1.

4.1.2 Subsystem 3.1: Model-network Configuration

This subsystem allows a model-network to be defined. Included are facilities to aid in the editing and cross-checking of the details about individual model-components, forecast-requirements and model-algorithms.

4.1.3 Subsystem 3.2: Operational Forecast Subsystem

This subsystem controls the generation of forecasts within a river-network system or subnetwork. Forecasts are stored for access by other subsystems of the RFFS. A range of interactive facilities are provided to allow forecast-runs to be tailored to suit requirements.

4.1.4 Subsystem 3.3: Calibration

This subsystem consists of a number of individual facilities which allow calibration of the parameters of the model-components which are used to generate forecasts for any given forecast-requirement. The description-file for each model-component contains space for a brief calibration history of the component, as well as containing the parameter-values to be used for operational forecasts.

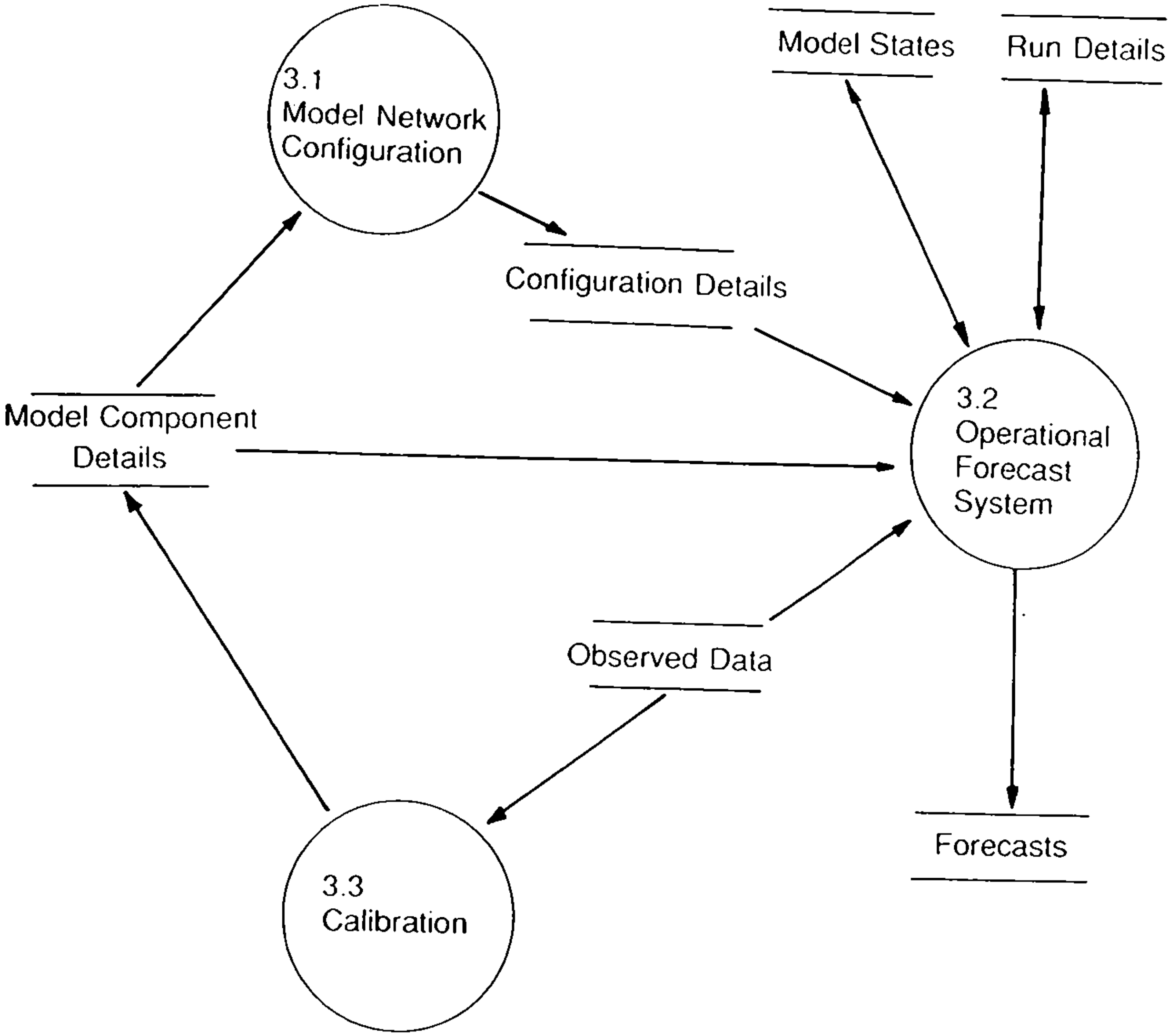


Figure 4.1 Subsystem 3: Forecast Subsystem

4.2 SUBSYSTEM 3.1: MODEL-NETWORK CONFIGURATION

4.2.1 Overview

This subsystem allows model-networks to be defined. A complete model-network description consists of a set of inter-linked lists which defines the use of data and model-algorithms to construct forecasts for all forecast-requirements within a river-network or set of river-networks. The process of model-network definition starts from a set of network-description files. These are individual descriptions of each forecast-requirement, each model-component and each model-algorithm: they contain first-order linking information which is used to construct a fully defined model-network. Among the information contained within the model-network description are :

(1) the order in which individual model components are to be executed so that data for later model-components are available as required;

(2) pointers to the locations where data will be stored when the Forecast Generation Subsystem (3.2.4) is executing - these include:
(a) observed data;
(b) constructed intermediate values being passed between model components;
(c) forecast values to be passed to the forecast data-base.

Facilities are included to aid in the editing and cross-checking of the details about individual model-components, forecast-requirements and model-algorithms. These details are held as text-files which can be created or edited using ordinary file-editors : however some corrections to these files may be made by the cross-checking programs. A data flow diagram of the Model-Network Configuration Subsystem is presented as Figure 4.2.

4.2.2 Subsystem 3.1.1: Simple Tests of File Structures

This subsystem provides a simple test of whether an individual network description file can be read. It also provides a facility whereby blank versions of each file type can be created to act as a template when setting-up new files. An alternative to this would be to copy and edit an existing file of similar structure.

4.2.3 Subsystem 3.1.2: Cross-checking of File Structures

This subsystem provides facilities for ensuring that the information contained in an individual network description file is consistent with that in all other immediately associated description files. Among the information generated by this subsystem are:

(1) Anotated listings of the description files which may aid in interpretation;

(2) Listings of parameter-values accompanied by parameter names extracted

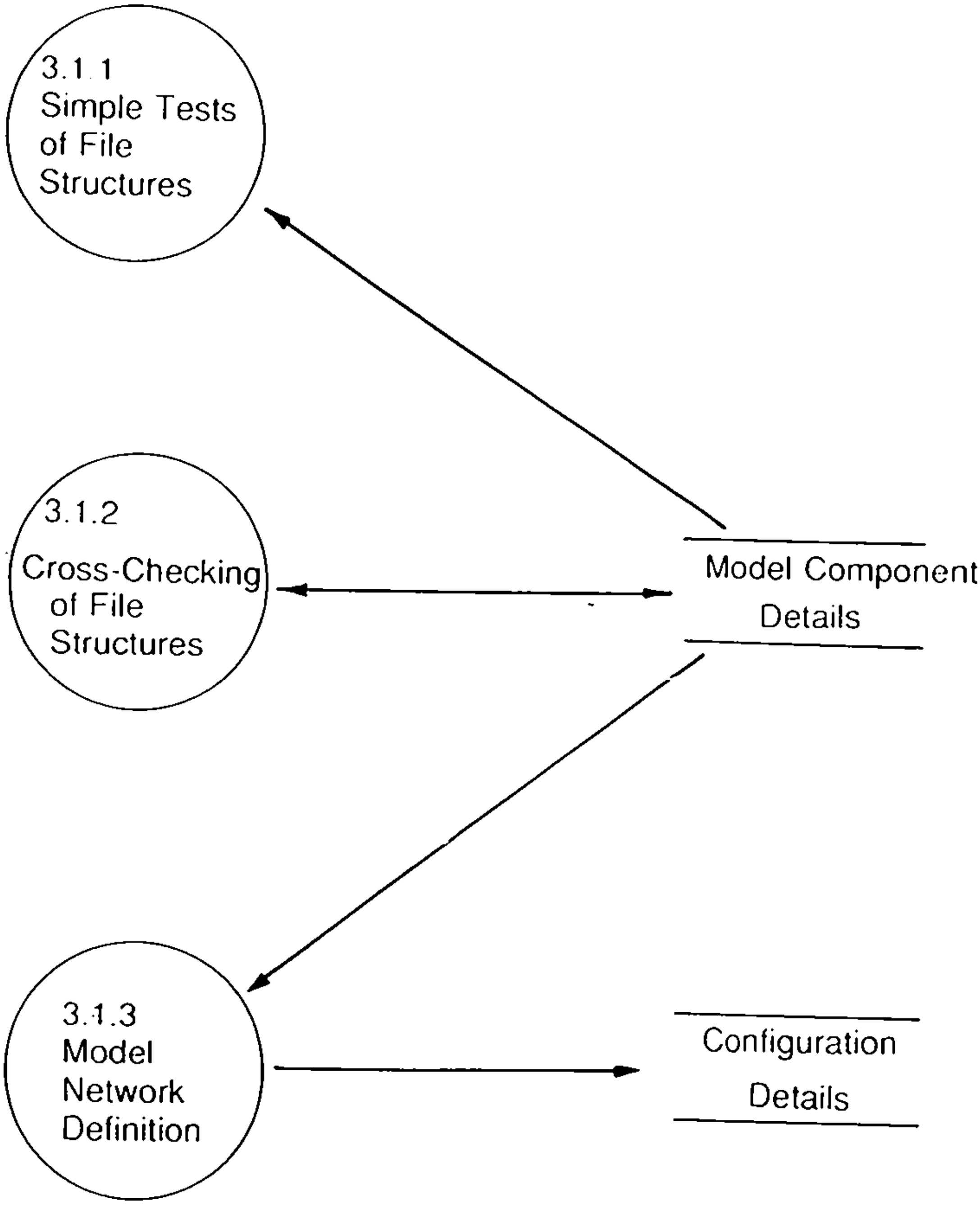


Figure 4.2 Subsystem 3.1: Model-Network Configuration

from associated description files;

(3) Listings of the names of model-state values associated with each model component.

4.2.4 Subsystem 3.1.3: Model-Network Definition

This subsystem is responsible for creating and defining a model-network. That is, it assembles all the information from individual network description files that is required to fully define the task of creating all the forecasts required on one or more river networks. A number of facilities are available which provide summaries of the order of calculation within the Forecast Generation Subsystem and of the data-values used and created at each stage.

4.3 SUBSYSTEM 3.2: OPERATIONAL FORECAST SUBSYSTEM

4.3.1 Overview

The Operational Forecast Subsystem is responsible for the generation of forecasts within a river-network system or subnetwork. Forecasts are stored for access by other subsystems. This subsystem allows subnetworks of an existing network to be defined and it manages the details of these. It also manages the sets of model-states associated with each subnetwork. Each run generating a set of forecasts for a subnetwork is defined by an individual run-detail file, created within this subsystem, which is available for later reconstruction of forecasts, subject to optional modification of a limited number of details. A data flow diagram for the Operational Forecast Subsystem is presented as Figure 4.3.

4.3.2 Subsystem 3.2.1: Manual Run Facility

This subsystem provides an interactive facility for the initiation of forecast runs. It allows, among other options :

definition of subnetworks ;
examination of model-states ;
selection of the time-point for the initial states of a run ;
selection of lead-time of forecasts ;
control of use or non-use of certain external data-sources ;
choice of on-line or batch mode for forecast generation.

4.3.3 Subsystem 3.2.2: Automatic Run Initiation

This subsystem provides for the non-interactive initiation of "overnight" runs. It sets up certain default values for the options available within subsystem

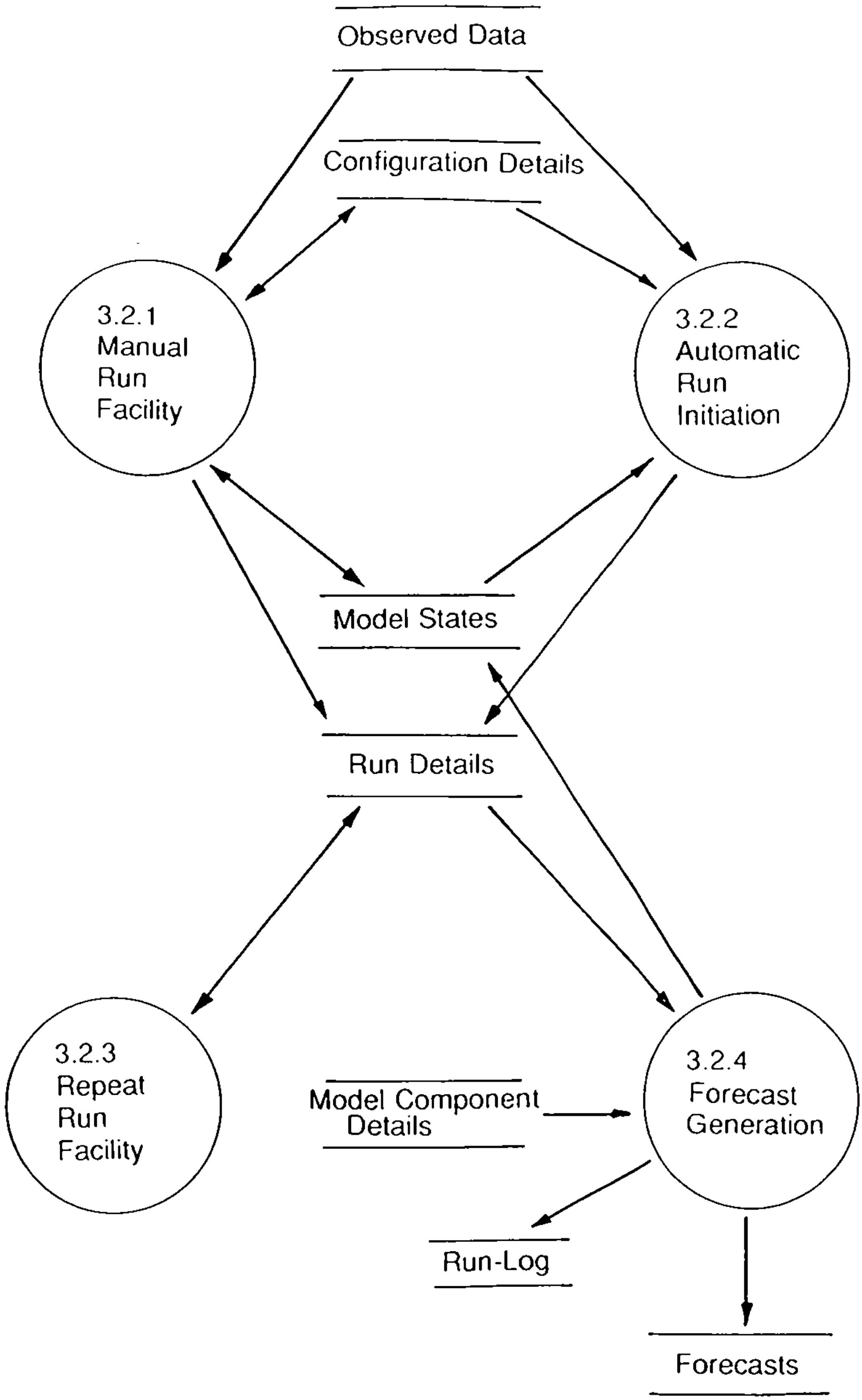


Figure 4.3 Subsystem 3.2: Operational Forecast Subsystem

3.2.1 and it is available as the basis of routine "overnight" runs.

4.3.4 Subsystem 3.2.3: Repeat Run Facility

This subsystem allows the re-creation of the forecasts generated by a forecast-run for which the run-detail file has been kept. There are two purposes for this subsystem :

(1) As a tool for flood-event inquests.

(2) To allow minor changes to details of a previous forecast run while ensuring that gross details remain identical.

4.3.5 Subsystem 3.2.4: Forecast Generation

This subsystem controls the generation of the forecasts required to meet the specifications set up in one of subsystems 3.2.1 , 3.2.2 or 3.2.3. It also manages the storing of updated values for the model-states.

4.4 SUBSYSTEM 3.2.1: MANUAL RUN FACILITY

4.4.1 Overview

This subsystem provides an interactive facility for general purpose control of forecast runs. It provides for the creation and management of subnetworks of forecast-requirements, together with management of the sets of states associated with the subnetworks. A forecast-run may be initiated for any of the subnetworks presently defined. Such a run (executed by subsystem 3.2.4) may result in the creation of an updated set of model-states which are then available for initiating subsequent forecast-runs. A number of sets of model-states applicable to different base-times are maintained for each subnetwork and any of these may be chosen as the initial states for a forecast-run. The data flow diagram for the Manual Run Facility Subsystem is presented as Figure 4.4.

4.4.2 Subsystem 3.2.1.1: Summarise Network Information

This subsystem provides a facility to summarise the information currently held for the main network and for each subnetwork. This summary consists of :

(1) the subnetwork name and number;

(2) the number of sets of model-states held;

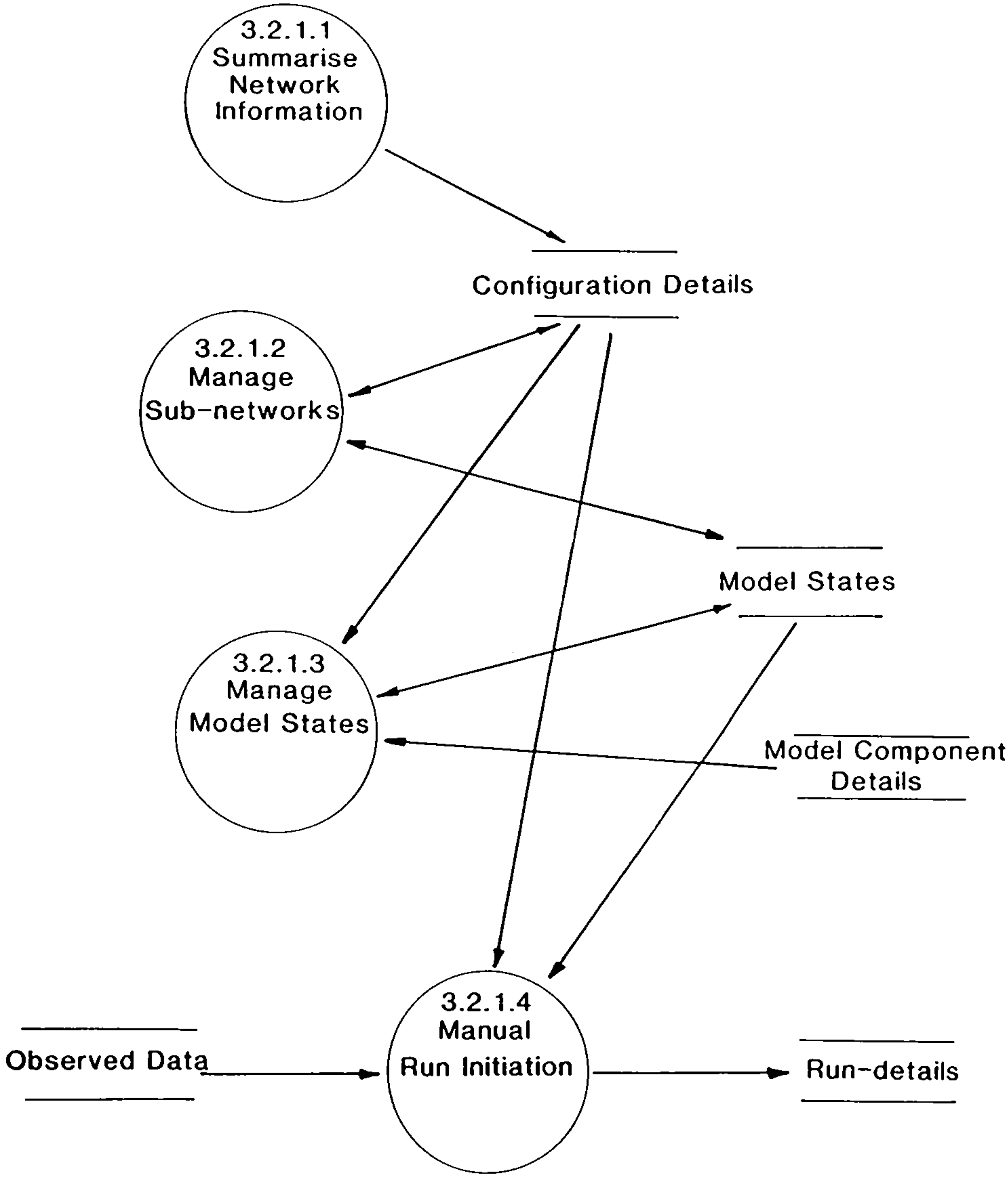


Figure 4.4 Subsystem 3.2.1: Manual Run Facility

(3) the time-point for the latest set of model-states.

4.4.3 Subsystem 3.2.1.2: Manage Subnetworks

This subsystem provides for the creation and deletion of subnetworks. On creation of a subnetwork from the main network or from an existing subnetwork, the relevant subset of a selected set of model-states may be copied in order to provide an initial-states set for the new subnetwork. On deletion of a subnetwork the subsystem manages the deletion of all the sets of model-states held for that subnetwork. The main network may not be deleted.

4.4.4 Subsystem 3.2.1.3: Manage Model-States

This subsystem provides a facility for examining the values held within a particular set of model-states. The values of the model-states for a selected model-component are displayed together with the associated names for the model-states. This subsystem also allows the deletion of a selected set of model-states. Note that the process of saving an updated set of states within the Forecast Generation Subsystem (3.2.4) contains an automatic procedure for limiting the number of sets of model-states held and for selecting and deleting superfluous sets. Thus this deletion facility is not required for routine use but is available for those cases where particular sets are identified as erroneous.

4.4.5 Subsystem 3.2.1.4: Manual Run Initiation

This subsystem provides an interactive facility whereby the specific details of a forecast-run can be set up and the run initiated. The run may be specified for either on-line or batch execution: in either case execution of the run is in the control of the Forecast Generation Subsystem (3.2.4). Following an on-line run, control is returned following this execution to the Manual Run Facility (3.2.1). In the case of a batch run, control is returned to the same point immediately that the batch run is submitted.

A number of options are available when setting up a forecast-run. These include the following choices:

(1) subnetwork for which forecasts are to be generated;

(2) time-point of model-states for model initialisation;

(3) lead-time of forecasts;

(4) treatment for Met. Office and other types of rainfall forecast (include or exclude, multiplication by a factor);

(5) treatment of rainfalls derived from radar (include or exclude);

(6) default series for rainfall, to be used if usual forecasts are not available or are excluded.

This subsystem also provides a "test-mode" option which can be used to run the RFFS for any time-period for which data are stored in the database. Normally, the Manual Run Initiation subsystem uses the actual time at which a run is set up as the basis for :

(1) the default set of states for model-initialisation;

(2) the time-point for which updated states will be stored;

(3) the notional time-origin of the forecasts in the run.

Note that in real-time mode this subsystem retrieves from the data-base any relevant data held, and that this includes "future" observations, if any. (This is the result of using a uniform data-acquistion procedure and of the need to allow inclusion of firm decisions about future control actions.) In the test-mode, the time-origin of the forecast run can be reset and only data at or before this time are retrieved from the database.

4.5 SUBSYSTEM 3.3: CALIBRATION

4.5.1 Overview

This subsystem consists of a number of individual facilities which allow the calibration of the parameters of model-components. The description-file for each model-component contains space for a brief calibration history of the component, as well as containing the parameter-values to be used for operational forecasts: these will we manually updated following calibration using tools within this subsystem. Also within this subsystem are facilities for model-structure exploration.

A small number of different types of model component are supplied with the RFFS. Separate model-calibration programs are available for each of these types. Apart from the facilities for Hydraulic Routing, which are of a special form, these programs are essentially similar in structure and are based on the same approach to calibration via a two-stage procedure of first minimising "simulation mode" errors and then minimising the errors associated with use in "updating mode". The same search procedure is used in each case for minimising a model-performance criterion for which a number of options are provided. The search procedure provided is a modified form of Simplex (or polytope) function minimisation procedure.

One purpose of the model-structure exploration tools is to help in assessing appropriate time-delays for use in some of the model components. However they also provide access to certain special types of model-structure which are potentially useful. Thus they provide a way of calibrating:

(1) a linear transfer function noise model for use as a model component in its own right.

(2) an error-prediction model for use in association with a model for which an "updating" facility is not provided.

These tools implicitly contain calibration procedures taking special advantage of the particular associated model-structures and are thus entirely separate from the other calibration facilities. A data flow diagram for the Calibration Subsystem is presented in Figure 4.5.

4.5.2 Subsystem 3.3.1: PDM Calibration

This subsystem allows calibration of a particular but reasonably general form of rainfall-runoff model. The model may include either a state-updating approach or an error-prediction approach to forecasting while making use of latest observations of the series to be forecast. The rainfall-runoff model is an extended and revised version of the Probability-Distributed Model (PDM). It is essentially a conceptual model for catchment response to rainfall, in which linear and non-linear storages are used to represent water held in the soil, in aquifers or in channels: a wide range of options are provided for the rules governing transfer of water between the model elements.

4.5.3 Subsystem 3.3.2: Hydrological Routing Calibration

This subsystem allows calibration of a simple model for channel-flow routing which is suited to free-flowing rivers and which allows the speed of travel of flood waves to be modelled as varying with the flow conditions. Extensions to the basic form of model are incorporated to represent off-channel storage effects and also to allow the simultaneous fitting of a stage-discharge relationship for cases where there is no established relation. This facility includes the fitting of an error-prediction model to provide an updating mode for real-time use.

4.5.4 Subsystem 3.3.3: Hydraulic Routing Calibration

This subsystem provides access to a numerical hydraulic model. Such models typically involve many hundreds of parameters representing channel geometry etc. and also are comparatively slow in execution. Although not all of the model-parameters would be candidates for calibration, these features mean that it is not sensible to adopt an automatic search procedure for calibrating hydraulic models. The facilities provided allow visual comparisons to be made between observed and modelled river-levels and model-parameters can be varied between individual runs. An "updating-mode" for the hydraulic model is available using the linear-model calibration tools (Subsystem 3.3.5) to construct an error-prediction model.

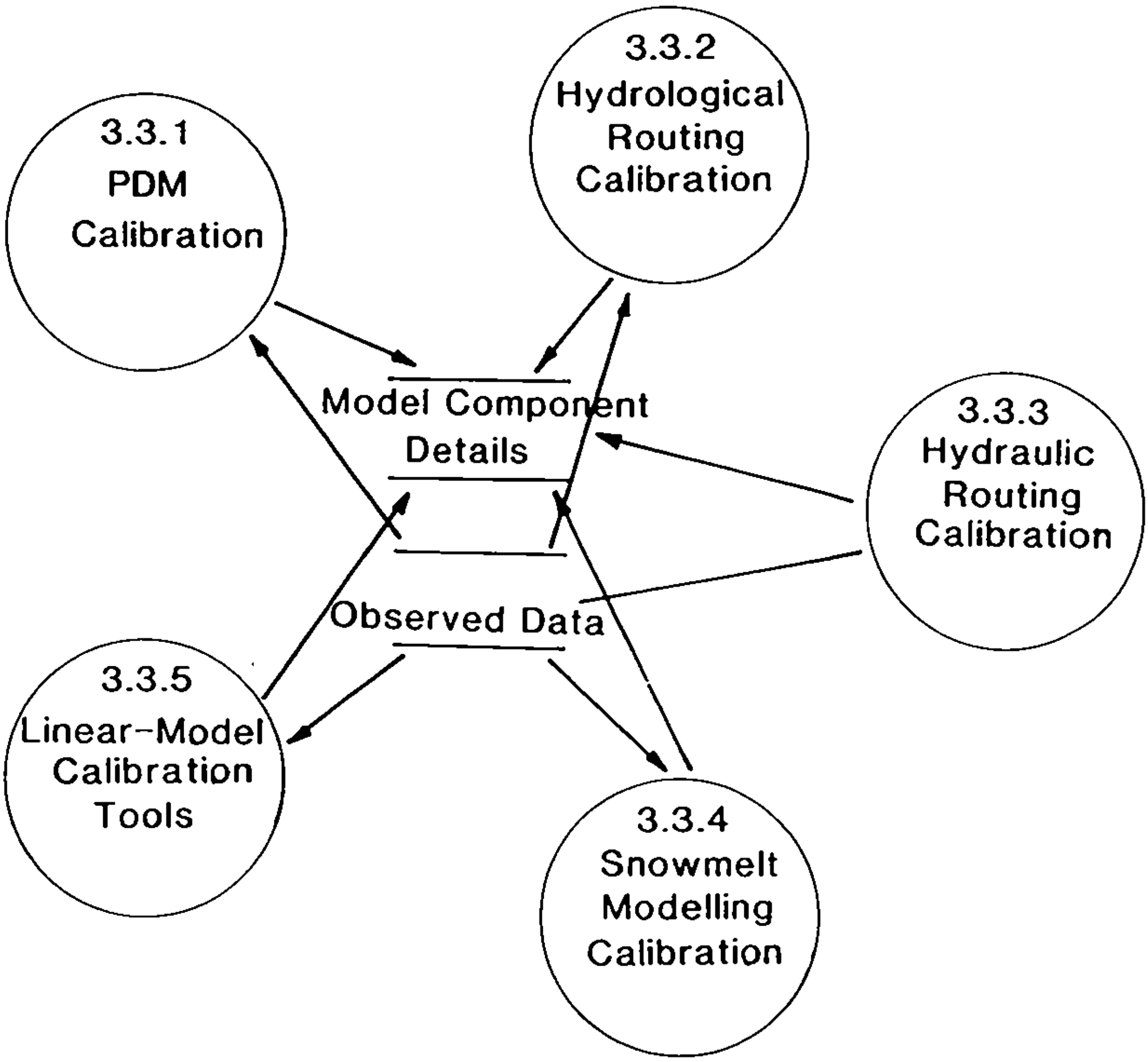


Figure 4.5 Subsystem 3.3: Calibration

4.5.5 Subsystem 3.3.4: Snowmelt Modelling Calibration

This subsystem allows calibration of a model for snowmelt. A combination of a temperature-based snowmelt equation and a conceptual snowpack store form the basis of the simple model. Calibration facilities are tailored to make use of daily snow water-equivalent values obtained from snow-surveys: such values can also be used for state-updating.

4.5.6 Subsystem 3.3.5: Linear-model Calibration Tools

This subsystem allows linear transfer-function and noise models to be constructed. As part of this suite of utilities, data-exploration tools such as autocorrelations, cross-correlations and estimated impulse-response functions can be calculated and displayed. These have a role in deciding the numbers of parameters to fit within the linear models available but they are also useful in other contexts, notably in assessing time-delays between associated series.