Chapter 9

Development of a Concept of Operations

What Is in This Chapter?

In this final chapter, we explore the development of a Concept of Operations (ConOps) for a flash flood early warning system (EWS). Flash flood EWSs are complex systems, and so this chapter explains the purpose of a ConOps within the context of the "system engineering life cycle process". It then lists the main elements for any flash flood EWS ConOps. It concludes with some general guidance to avoid common mistakes in ConOps development and a checklist that links each of the earlier chapters to the process of developing a flash flood EWS ConOps.

Why Does a NMHS Need a Flash Flood EWS ConOps?

As indicated earlier in this Guide, contemporary EWSs are complex, dynamic systems. Indeed, the figure below, first introduced in the introductory chapter, shows that they are usually a "system of systems" integrating a large number of stakeholders and infrastructure in fairly sophisticated ways. By investing in the development of a ConOps, an NMHS can maximize the likelihood that its various EWS subsystems will effectively perform as an integrated,

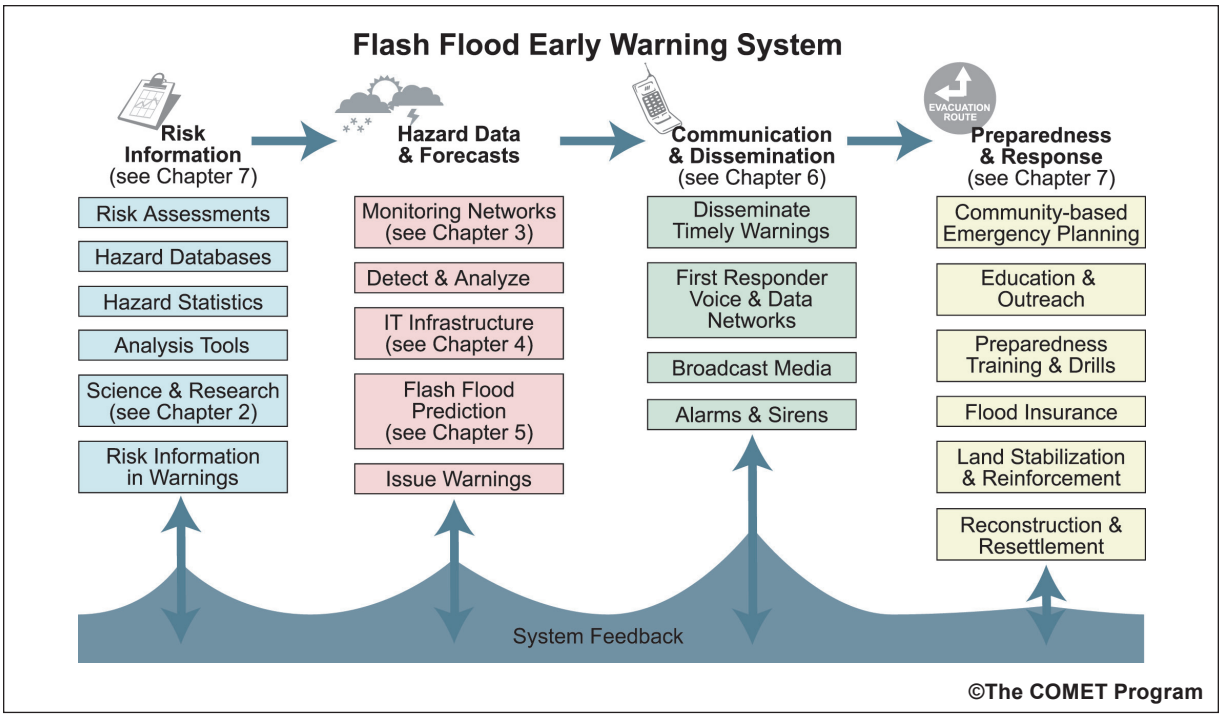

Figure 9.1 Components of a flash flood EWS

effective EWS, even if there are many stakeholders responsible for the various subsystems.

> **Tip**
>
> Proper investment in the development and maintenance of a ConOps is one of the most effective strategies for any group contemplating the implementation of flash flood EWS operations.

EWS design is an iterative process that requires an understanding of the "Systems Engineering Life Cycle process" (see Figure 9.2 below). The first step of that process is the development of the ConOps. Not only does the development of a ConOps facilitate the rest of the systems engineering process, it also provides a method for validating the success of that effort once the system is operational.[1] The risk of technical, political, and economic failure is much lower with a well-developed ConOps than if an NMHS attempts to implement a flash flood EWS without investing in conceptualizing that system's operations.

A 2005 study by the U.S. Government identified at least three benefits for having a well-prepared ConOps. They were:

1. **Stakeholder Consensus** – ensuring that every partner understands and supports the proposed system

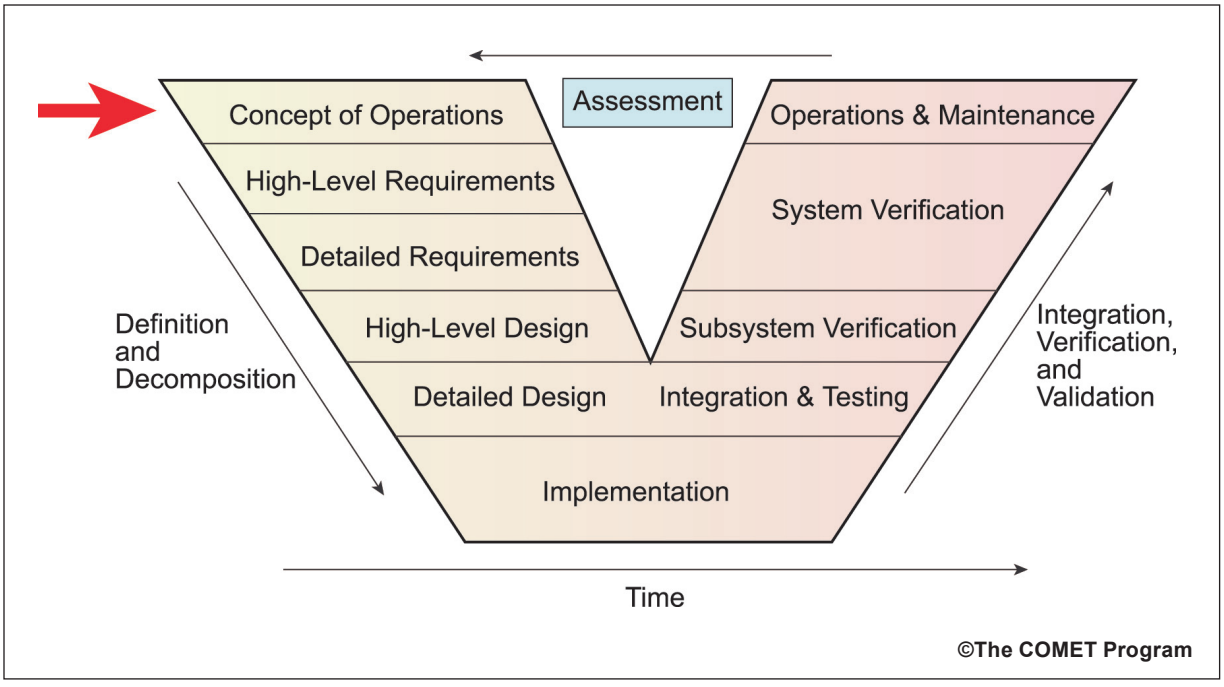

Figure 9.2 System engineering life cycle process

[1] There are several widely-recognized guidelines for concept of operations development that are helpful references from a technology perspective: (a) DI-IPSC-81430 – Operational Concept Description, December 1994 [MIL-STD-498], (b) ANSI/AIAA G-043-1992 Guide for the Preparation of Operational Concept Documents, January 1993, and (c) IEEE Std 1362-1998 Guide for Information Technology – System Definition – Concept of Operations Document.

2. **Risk Reduction** – forcing the sometimes painful but always beneficial process of predetermining every aspect of the system before it is procured or implemented
3. **Quality Improvement** – discovering every opportunity to leverage existing and new infrastructure to increase system performance.[2]

System Engineering Life Cycle Process[3]

An effective ConOps must consider all stakeholders of a proposed or actual system, no matter what their interest or role may be. And an effective ConOps should be as readable and relevant to high-level decision makers as it is to system operators.

ConOps development is the first step in the System Engineering Life Cycle process, which involves eight basic steps in total:

Step 1 **Concept of Operations** – The manner in which the system will be used.

Step 2 **Requirements** – The general and specific definition of what the system will do.

Step 3 **Design** – The general and specific definition of how the system will meet the requirements.

Step 4 **Implementation** – The construction and deployment of the system's components.

Step 5 **Integration and Testing** – As each component of the system is completed, it is integrated into the overall system and tested to ensure that the specifications are satisfied.

Step 6 **System Verification** – Also called acceptance testing, this step ensures that the overall system is consistent with the design and that it meets the requirements.

Step 7 **Operations & Maintenance** – This stage represents the ongoing process of using the system in the manner in which it was intended (and validating that it can be used in this way) and maintaining the system.

Step 8 **Assessment** – Regular verification that the ConOps reflects the optimal method of operations and that operations respect the method prescribed by the ConOps.

Figure 9.2 illustrates that ConOps development may be the first step in systems engineering, but even after system implementation, it is necessary to maintain that ConOps throughout the life of a system.

Systems engineering is a continuous, process-oriented method for implementing and then operating complex systems (such as a flash flood EWS) in a manner that (1) reduces risk, (2) controls cost and schedules, (3) improves quality, and (4) meets user needs. A ConOps system determines the success of every aspect of that process.

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[2] U.S. Department of Transportation, Federal Highways Administration, Developing and Using a Concept of Operations in Transportation Management Systems (FHWA-HOP-07-001), August 2005.

[3] Adapted from Dept of Transportation, ITS Standards for System Engineering Process (http://www.standards.its.dot.gov/learn_SysEng.asp)

What is a ConOps?

While there are a range of interpretations of the term "Concept of Operations", the following definition is especially relevant to organizations planning to implement a flash flood EWS:

> *"A Concept of Operations (ConOps)* describes the likely operation of a future or existing system in the terminology of its users, providing important information for the acquisition and/or development of that system.
>
> It may include identification and discussion of the following:
>
> 1. Why the system is needed and an overview of the system itself;
> 2. The full system life cycle from deployment through disposal;
> 3. Different aspects of system use including operations, maintenance, support and disposal;
> 4. The different classes of user, including operators, maintainers, supporters, and their different skills and limitations;
> 5. The environments in which the system is used and supported;
> 6. The boundaries of the system and its interfaces and relationships with other systems and its environments;
> 7. When the system will be used, and under what circumstances;
> 8. How and how well the needed capability is currently being met (typically by existing systems);
> 9. How the system will be used, including operations, maintenance and support; and
> 10. Scenarios illustrating specific operational activities involving the use of the system."[4]

In sum, a flash flood EWS ConOps needs to be a readable, comprehensive, and guiding document that enables all stakeholders – both strategic and operational – to understand the *who*, *when*, *where*, *why*, *what,* and *how* of the EWS.

Elements of a Flash Flood EWS Concept of Operations

The American National Standards Institute (ANSI) has published a Concept of Operations standard (ANSI/AIAA G-043-1992) that provides a helpful description of the elements that enable a Concept of Operations to describe any system characteristics from an operational perspective, and to answer the question, "what does the system look like?" from each stakeholder's point of view.

Figure 9.3 summarizes the major questions that any ConOps must answer.

[4] Andrew P Gabb, "Operational Concepts - Some Variations", from the Proceedings of the Systems Engineering, Test & Evaluation Conference, Sydney, Australia, October 30, 2002

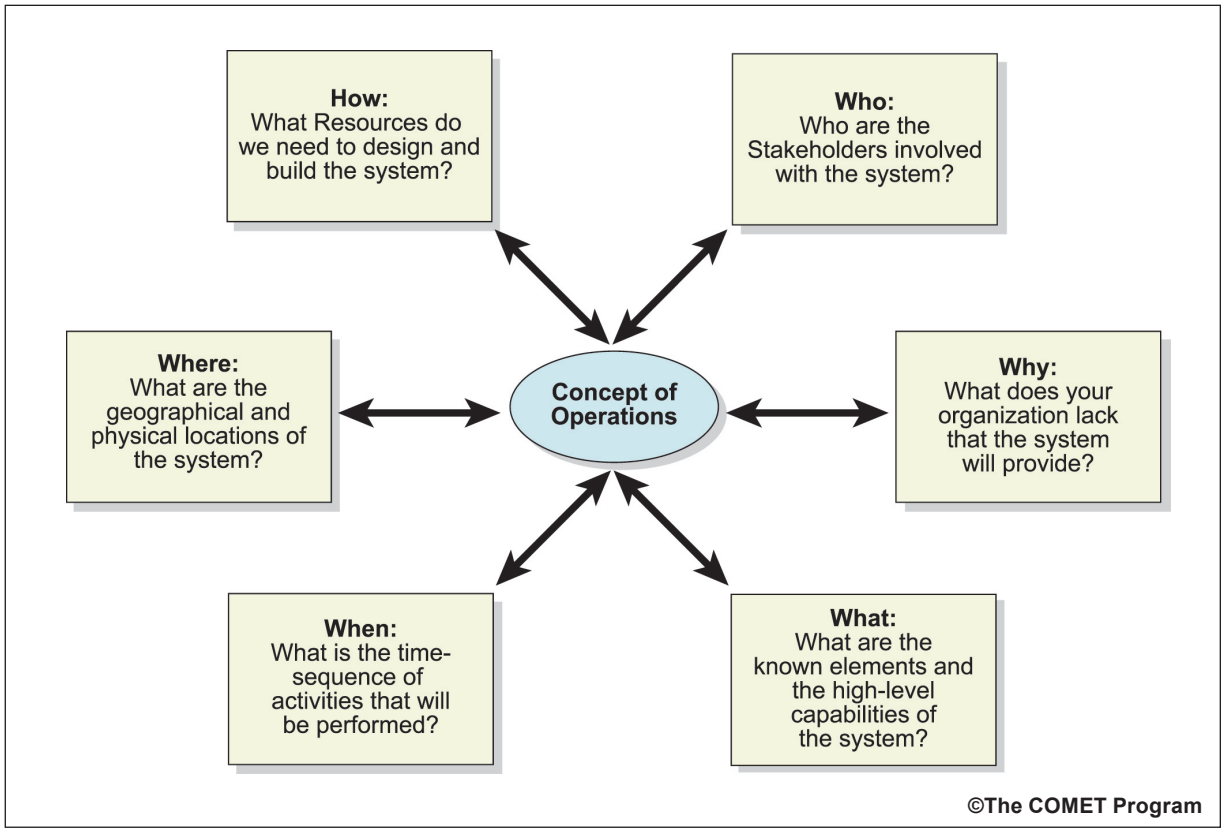

Figure 9.3 Questions that "drive" the development of a ConOps

Within the context of a typical flash flood EWS, the *who*, *when*, *where*, *why*, *what,* and *how* questions can be answered by ensuring that your ConOps addresses the following issues:

Scope – this provides the:

- Vision for the system
- Outline of the contents of the document
- Purpose for implementing the system
- Intended audience / beneficiaries
- Limitations of content covered

Knowledge References – this describes the experts and methods consulted through:

- Discussions with stakeholders, academics, and other experts
- Studies of systems from other countries around the world
- Analyses of mission requirements and operational needs
- Recommendations offered by vendors and product manuals

Operational Description –this describes the system from the users' perspective and includes a:

- Summary of each user's role and activities
- Clarification of the order of user operations
- Summary of the operational process procedures
- Description and flow diagrams associated with organizational decision making and management structures

System Overview – this is a "high-level" description of the mission requirements and interrelationships of key system components, and provides:

- Specific goals and objectives that are measureable and time-bound
- Interdependencies between subsystems
- Confirmation that the system's capabilities will satisfy its mission

Operational and Support Environments – describes the infrastructure associated with each subsystem's:

- Facilities
- Equipment
- Hardware
- Software
- Personnel
- Operational procedures
- Maintenance, training and support requirements

Operational Scenarios – describes the system "in action" using one or more representative flash flood scenarios to reflect:

- A range of stakeholder perspectives
- A range of stress/failure scenarios
- Both typical and extreme circumstances

Obviously there are many different ways to draft a ConOps, and the way you organize your ConOps should reflect the unique audience that it needs to serve. Each NMHS should consider the requirements of its stakeholders and then identify the most effective way to address the above issues in its flash flood EWS ConOps.

Tip

There are no shortcuts, and bypassing the full process of ConOps development will ultimately be self-defeating.

Not only does ConOps development take time, expertise and money, but it also requires leadership to ensure that every stakeholder has a voice in defining "success" once a system becomes operational. It is that difficult process of conducting extensive stakeholder consultation and technical research, and then conceptualizing a single system from a series of subsystems, that makes a ConOps so critical.

Common Mistakes to Avoid When Developing a ConOps

There are several mistakes that are commonly made by organizations that are inexperienced with, or less than fully committed to, the process of developing a ConOps. These include:

1. Expecting their system vendor(s), contractor(s), or other external partners to develop their ConOps for them as a part of their other deliverables. In order to be relevant and to ensure that there is deep ownership, an NMHS must ensure that strategic and operational program staff are responsible for the development of its ConOps.

2. Postponing ConOps development until after the system has been designed and delivered. A ConOps is a "living" document that must be drafted before a system design is finalized and then continuously kept up-to-date as system requirements change.

3. Allocating inadequate staff resources (time and money) for ConOps development. The process of conceptualizing the operation of a flash flood EWS is complex, tedious, and time consuming. It also requires research missions to learn about current practices in ConOps development from other leading EWS programs regionally and internationally.

4. Assigning unqualified staff for ConOps development. It is useless to create a ConOps team without ensuring adequate representation by personnel with experience in the organization's strategic, operational, technical, administrative, financial, and communications programs. Not only does the team need to conceptualize the operations of the EWS, it also needs to be able to document that vision effectively in the form of a written ConOps.

5. Cutting-and-pasting from another organization's ConOps. Borrowing another organization's plan in order to avoid the process of deliberating your own plan may seem like an efficient shortcut, but it is likely to ensure that the mistakes made by others will be made by you. Even worse, stakeholders (especially system operators) will have much weaker commitment to that "imported" ConOps than if they are given an opportunity to contribute to the development of their own ConOps.

6. Neglecting to update a ConOps while your new flash flood EWS is being implemented, and once it becomes operational. Unless your ConOps constantly reflects the actual system design, mission requirements, and operational vision, it will quickly become unreliable and useless. Make sure that as a part of your operational program, you systematically review and update the ConOps regularly to ensure that it stays relevant.

Requirements Checklist for a Flash Flood ConOps

The following checklist is not intended to be exhaustive or prescriptive, but only representative of good practices in flash flood ConOps development. It can be printed and used as a starting point for developing a flash flood EWS ConOps.

At a minimum, a flash flood EWS ConOps should include the following elements:

Documentation

- ☐ Distribution List – every person who must receive a copy of the ConOps
- ☐ Revision List – addenda and revised drafts that have been released since the original draft was released
- ☐ Associated Documentation – all manuals, guidelines, or policies that support the ConOps
- ☐ References and Sources – who and what was consulted in the preparation of the ConOps
- ☐ Method – how the ConOps was developed

Introduction

- ☐ Scope – the vision, purpose, and scale of the system
- ☐ Description – simple and understandable definition of the system
- ☐ Priorities – the priorities to be addressed by the system
- ☐ Method – the process used to develop the ConOps
- ☐ Contributors – names and affiliations of all those involved in developing the ConOps
- ☐ Glossary of Terms – the meaning of all key terms used within the ConOps
- ☐ List of Acronyms – the complete spelling of all terms abbreviated within the ConOps

Strategic Framework

- ☐ Mission Statement – clear, succinct articulation of the ultimate deliverables of the system
- ☐ Policy Mandate – basis for the NMHS to deliver the mission requirements
- ☐ Goals & Objectives – specific, measurable, attainable, realistic, and time bound
- ☐ System Definition – the system's description, in simple and understandable prose

Operational Framework

- ☐ Facilities – identification of all existing and new infrastructure required for the system to become "operational"
- ☐ Roles & Responsibilities – description of each subsystem operator's contribution at an operational level
- ☐ Staffing – listing of all staff required to operate the system successfully, in both the short and long-term
- ☐ Skills Development – description of the training, exercises, and drill regime necessary to ensure long-term system sustainability
- ☐ Communications – description of the primary and redundant channels through which information will flow between and beyond each subsystem (see Chapters 3 and 4)
- ☐ Data – inventory of the information requirements of each subsystem, including the need for historical data for model calibration as well as real-time data for flash flood forecasting (see Chapter 3)
- ☐ Models – description of hydrometeorological models used to generate flash flood forecasts (see Chapter 4)
- ☐ Products and Services – definition of the various outputs generated by the system (see Chapter 6 and Appendix E)
- ☐ Hardware – description of the system's technological infrastructure and hydrometeorological sensors, including gauge, radar, and satellite networks (see Chapter 4)
- ☐ Software – description of the application and operating packages used by each subsystem (see Chapter 4)
- ☐ Maintenance and Replacement – prediction of the maintenance requirements and longevity of each subsystem (see Chapter 4)
- ☐ Research & Development – provision of the framework for involving system operators and other partners in applications development (see Chapter 6)
- ☐ Outreach & Public Education – identification of the strategy for ensuring strong community-level participation in the success of the flash flood EWS (see Chapter 7)
- ☐ Operational Scenarios – depiction of several representative flash flood scenarios that describe how the system will perform during normal and extreme conditions (see Chapter 8)

Evaluation & Performance Indicators

- ☐ Overall System Performance Measures – definition of the minimum lead time for evacuation of vulnerable populations, maximum rate of "false positives"/erroneous flash flood warnings, community-level perception of value and reliability, etc.
- ☐ Subsystem Performance Measures – definition of the minimum percentage of time that weather radar subsystem needs to be functional, maximum allowable annual maintenance expenses for gauge networks, etc.

Appendices

- ☐ Overall System and Subsystem Diagrams
- ☐ Operational, Maintenance and Replacement Budget Plans

Important Points to Remember about ConOps Development

- Development of a Concept of Operations (ConOps) is the first step in the flash flood early warning system engineering life cycle.
- Every ConOps is a unique and "living" document that requires input from all stakeholders and regular maintenance.
- A ConOps attempts to answer, using relatively simple language, a system's who, what, why, where, when, and how.
- Don't take short cuts with developing a ConOps – it requires serious, devoted attention by strategic and operational personnel in order to be effective.

References

U.S. Department of Transportation, Federal Highways Administration, 2005. Developing and Using a Concept of Operations in Transportation Management Systems (FHWA-HOP-07-001), August 2005, p. 43