Tuesday , 14 October, 14:15 – 15:00 PM

Session 2

Introduction to Systems Approach and Backwards Planning

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CTA Meteorology, Climate Monitoring and Forecasting

Caveat and Disclaimer

Caveat: While a few specific examples of observing systems and networks will be given, most of this talk is by necessity fairly high level/non-specific as the details of a particular network is almost always situation-dependent.

Disclaimer: While some items of equipment will be shown, display of them here is not an endorsement. Each item has its pluses and minuses, which need to be considered when considering it for adoption to meet a particular need

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There will opportunities throughout the workshop to discuss the details of your networks: coffee breaks, lunches, and/or the clinic that follows the close of the meetings on Thursday. Note: need to reserve a time during the clinic

Taking a **systems approach** and using **backwards planning** ensures that an observing network, whether new or an extension/upgrade of an existing network, produces the desired outcomes

> **Systems approach** → identifying not only the components of a system, but also understanding how those components work together to provide the desired result
>
> **Backwards planning** → a design begins with the application and works backward to the required observations . ***"Start at the end, and finish at the beginning"***

In this talk, I emphasize the practical and the pragmatic in observing network design. It lays the ground work for the talks that follow.

The focus in this talk: **surface observing networks**

Why this seemingly narrow focus?

- Data from such networks are foundational for all meteorological and climatological products and services
- Especially the case for products and services at the meso-/micro-scales ("farm", watershed, urban scales)
- Basic ideas presented here can be used to plan upper air networks, radar/satellite observations, aircraft systems, buoy systems, ...

And there is plenty to talk about with just surface networks

Systems

Observing system → the collection of observing equipment at one station; can be only one sensor, but usually consists of several (micro view)

System can also refer to the **end-to-end system**, the distributed assemblage of hardware, software, and humans that connects measurements in the field to decisions by users (macro view)

Observing Network → a number of observing systems deployed across the landscape to supply data within an end-to-end system supporting a particular application

Relevant WMO guidelines and related materials …

- Provide excellent guidance on making good surface observations, particularly on synoptic and sub-synoptic scales (time and space) for submission to the Global Telecommunication System

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Drafts WIGOS Regulatory Material for Review by WMO Members	
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WIGOS Projects	ICG-WIGOS Task Teams
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Top

NEWS
- WIGOS Regulatory Material (WRM) **10 October**

Cross-cutting
- Global Observing System (GOS)
- Global Atmospheric Watch (GAW)
- Hydrology and Water Resources Programme (HWRP)
- Global Cryosphere Watch
- AMDAR
- Instruments and Methods of Observation Programme (IMOP)
- Marine Meteorology and Oceanography Programme (MMOP)
- WMO Space Programme (WSP)
- WMO Information System (WIS)
- WMO Quality Management Framework

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- Are not as helpful with observations made on smaller time and space scales, for very local, very applied purposes, but with its **WMO Integrated Global Observing System (WIGOS)** initiative, WMO is moving toward policies and procedures for dealing with other than the traditional synoptic observations. **It is these local observations that we are most interested in here.**

Examples of the **meteorological uses** of local surface observations

- Development of local MOS
- Monitoring onset, following evolution of HIW weather → nowcasting
- "Ground truth" → using point measure to calibrate area measures (radar/satellite)
- Assimilation into initialization for numerical models
- Local (meso- and micro-scale) climatologies → the foundation for monitoring the evolving microclimates were people live and work

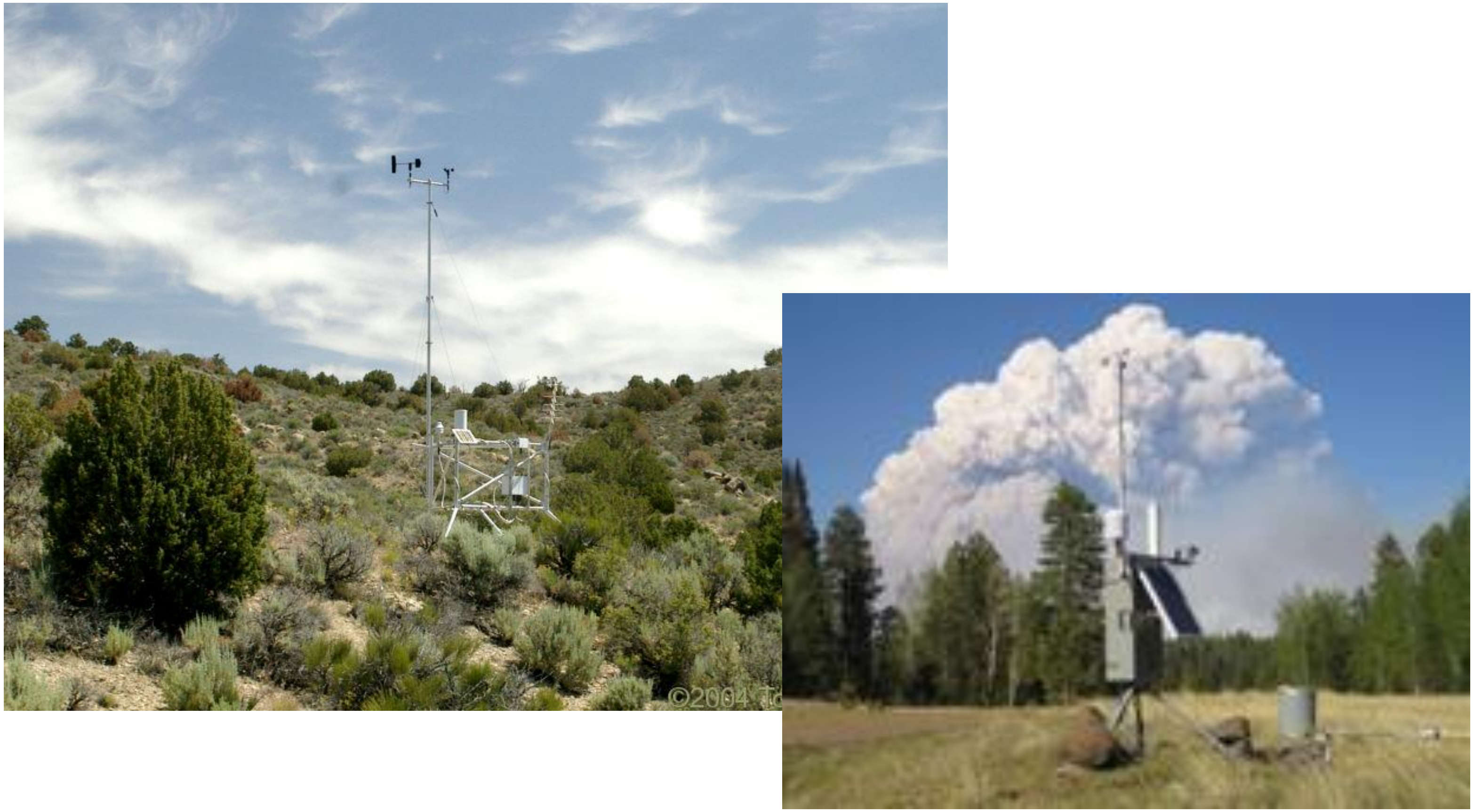
These and other **meteorological uses** produce the **decision support information** needed by users (e.g., index-based crop insurance)

Types of networks of interest here:

- agro-meteorology
- hydro-met monitoring (water management, including irrigation and hydroelectric) (flash flood monitoring)
- road/rail/airport/seaport hazard monitoring
- renewable energy (solar, wind)
- wind-wave monitoring
- air/water quality
- fire danger, controlled burns, and wild fire response

While each use could lead to a different observing network, we try to make our observing systems and networks as multipurpose as possible. In practice, we usually wind up with at least a few specialized networks deployed across a region

An traditionalobserving system with individual instruments in a agricultural meteorology observing network



Two observing systems in a fire weather/wild fire meteorological observing network. The above-left image shows Incident Remote Automated Weather Station (IRAWS) deployed near a large wild fire. The image to the lower-right shows a permanently located RAWS station.

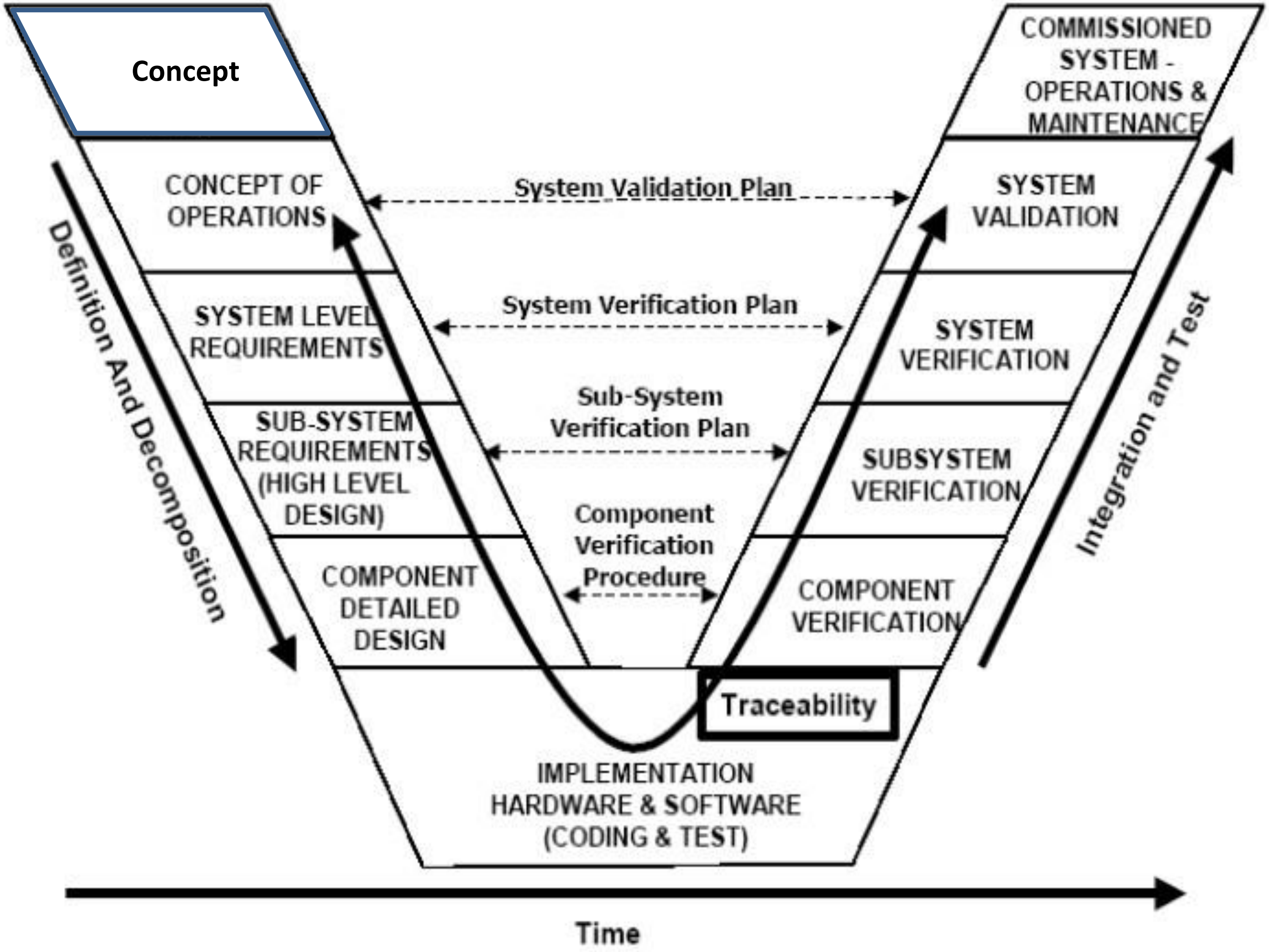
Note that although the WMO standard for surface wind measurements is 10 m above ground level, RAWS sites record winds at 6 m or roughly 20 ft.

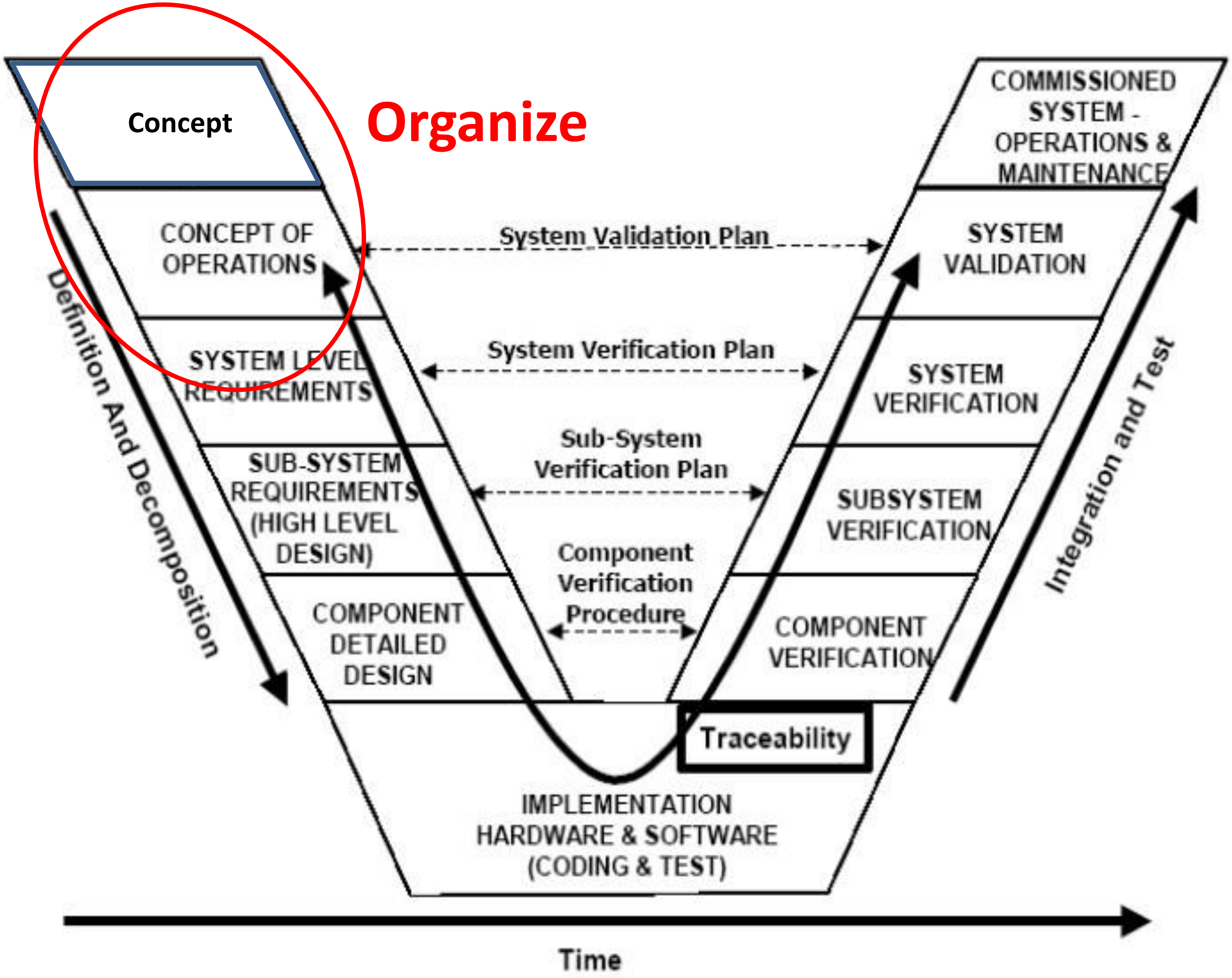
Designing and deploying observing networks is but one element of a larger meteorological engineering design challenge: the intentional design of an **end-to-end system** to produce specific meteorological products and services to support decisions by a particular group of decision makers

A design process …

- Begins with understanding the supported customer's decision making process
- Takes a minimalist, cost effective approach: focus on meeting the most critical needs first → Prioritization
    - In the real world, funds are always finite usually too few; what can be done with the funds available?; what is the best use of those funds? (if I spend on this, what is my lost opportunity?)
- Considers the full range of possible users - primary, secondary, tertiary – to maximize multi-purpose applications

Follows a **systematic planning methodology** to ensure all essential elements are covered – here we will consider the **Vee Model** as an example methodology. It can be applied to the end-to-end system, the observing network, and observing system, the last two as part of the process of creating the first.


Concept
CONCEPT OF OPERATIONS
SYSTEM LEVEL REQUIREMENTS
SUB-SYSTEM REQUIREMENTS (HIGH LEVEL DESIGN)
COMPONENT DETAILED DESIGN
IMPLEMENTATION HARDWARE & SOFTWARE (CODING & TEST)
COMMISSIONED SYSTEM - OPERATIONS & MAINTENANCE
SYSTEM VALIDATION
SYSTEM VERIFICATION
SUBSYSTEM VERIFICATION
COMPONENT VERIFICATION
System Validation Plan
System Verification Plan
Sub-System Verification Plan
Component Verification Procedure
Traceability
Definition And Decomposition
Integration and Test
Time



Organize

Frame the Concept and Develop the Concept of Operations → the most important steps: addresses the questions

What is to be done? How is it to be done? and by who?

Concept of Operations

Concept of operations (CONOPS): an easily understood, user-oriented description of the quantitative and qualitative characteristics of a proposed end-to-end system and lays out how a set of capabilities to be employed to achieve desired objectives. It evolves via iteration with stakeholders , who ultimately make commitments toward the realization of the system and sign off on the CONOPS.

A CONOP helps an organization document in plain language what is required and what should be built for effective end-to-end system. It should address any/all of the following items:

The system's purpose

The system’s function in the organization

The stakeholders themselves, who could be users of the system, people developing the system, or anyone who depends on the system

For the CONOP to be effective, information on the following is needed:

How the system will be used

Recorded goals

System requirements

A project plan leading to creation of the system

Stakeholder buy-in and support is required for the project to move forward as planned

Stakeholders should be involved throughout the project to ensure that the system is being built according to plan and will meet the recorded and expected goals.

Backwards Planning → Framing the Concept And Developing the Concept of Operations

End-to-end system

User makes decision (requirement for training)

↓

User decision-support system/process

↓

Dissemination/transmission of decision support information

↓

Production and delivery of observation and forecast products and services
(meteorological information becomes decision support information)

↓

Other data (e.g., model output) → **Data assimilation and analysis** (meteorological data becomes meteorological information for use by forecasters)

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QA/QC of data → **Archive**

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Collection/transmission of data

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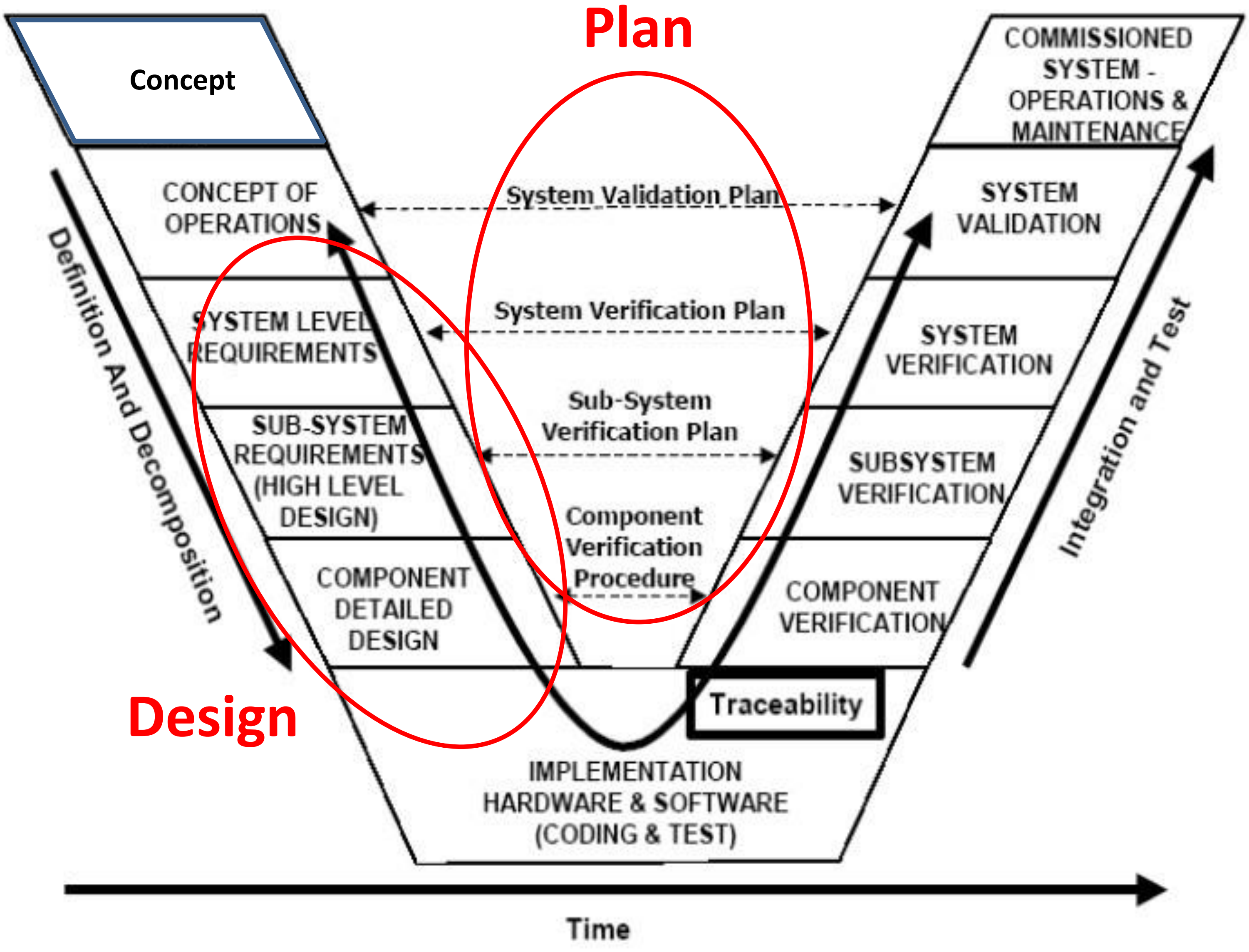
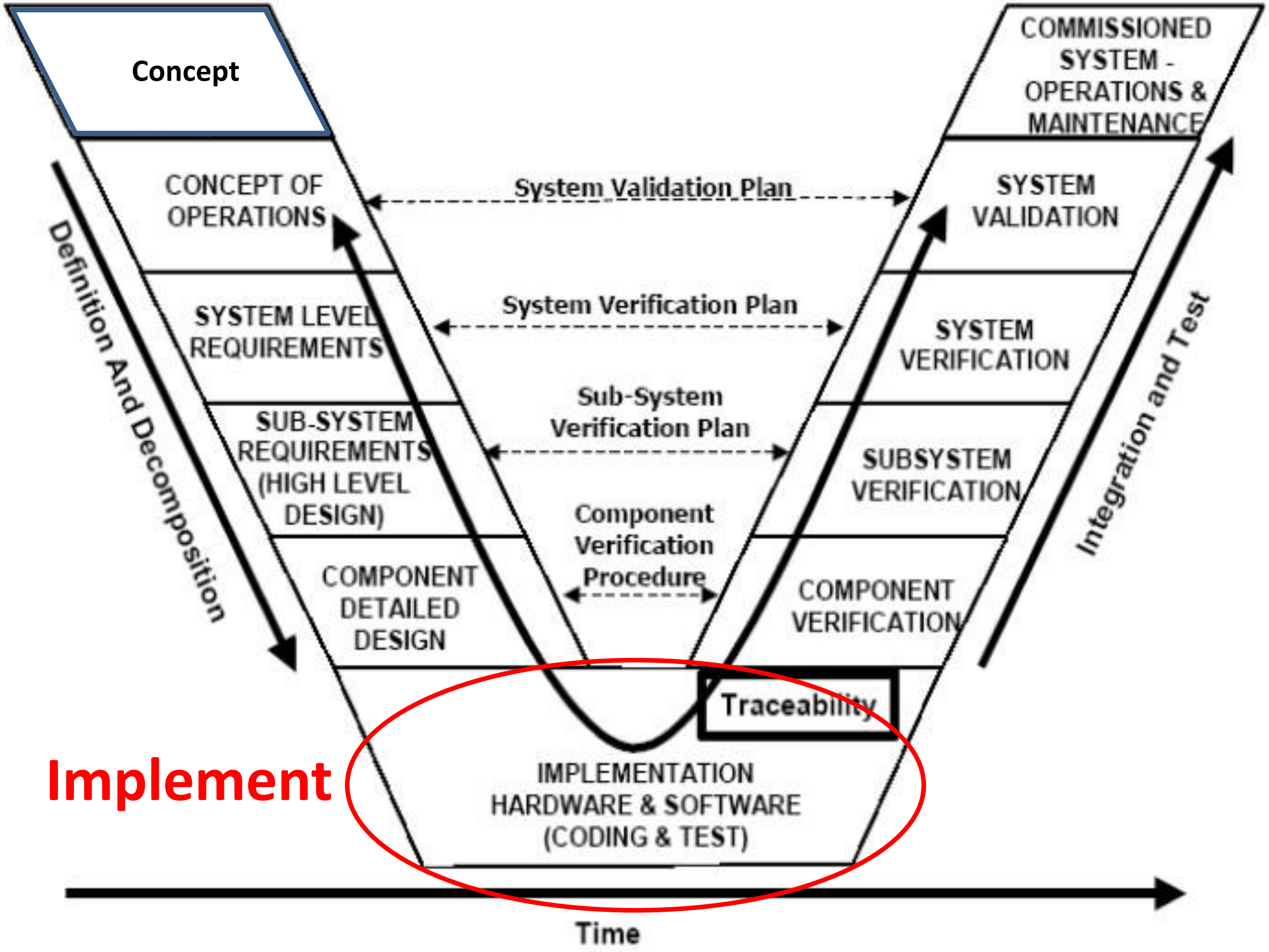
Observing systems & **observing network** (production of data)

Arrows indicate sequence of consideration



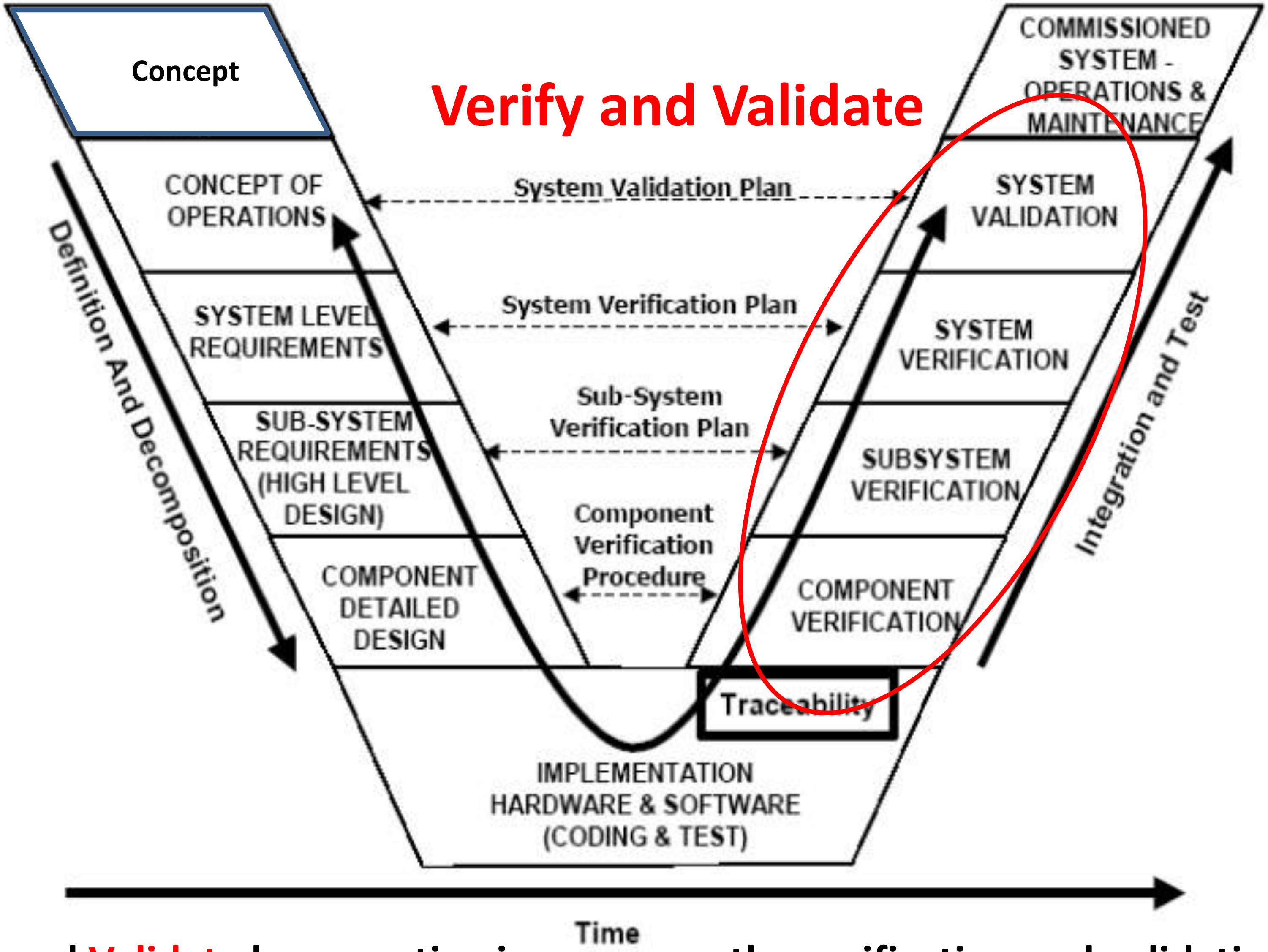
Design the system to carry out the concept of operation by specifying requirements. Identify required staff skills and training needs. Simultaneously, **Plan** for the validation and verification of the completed system.



Implement

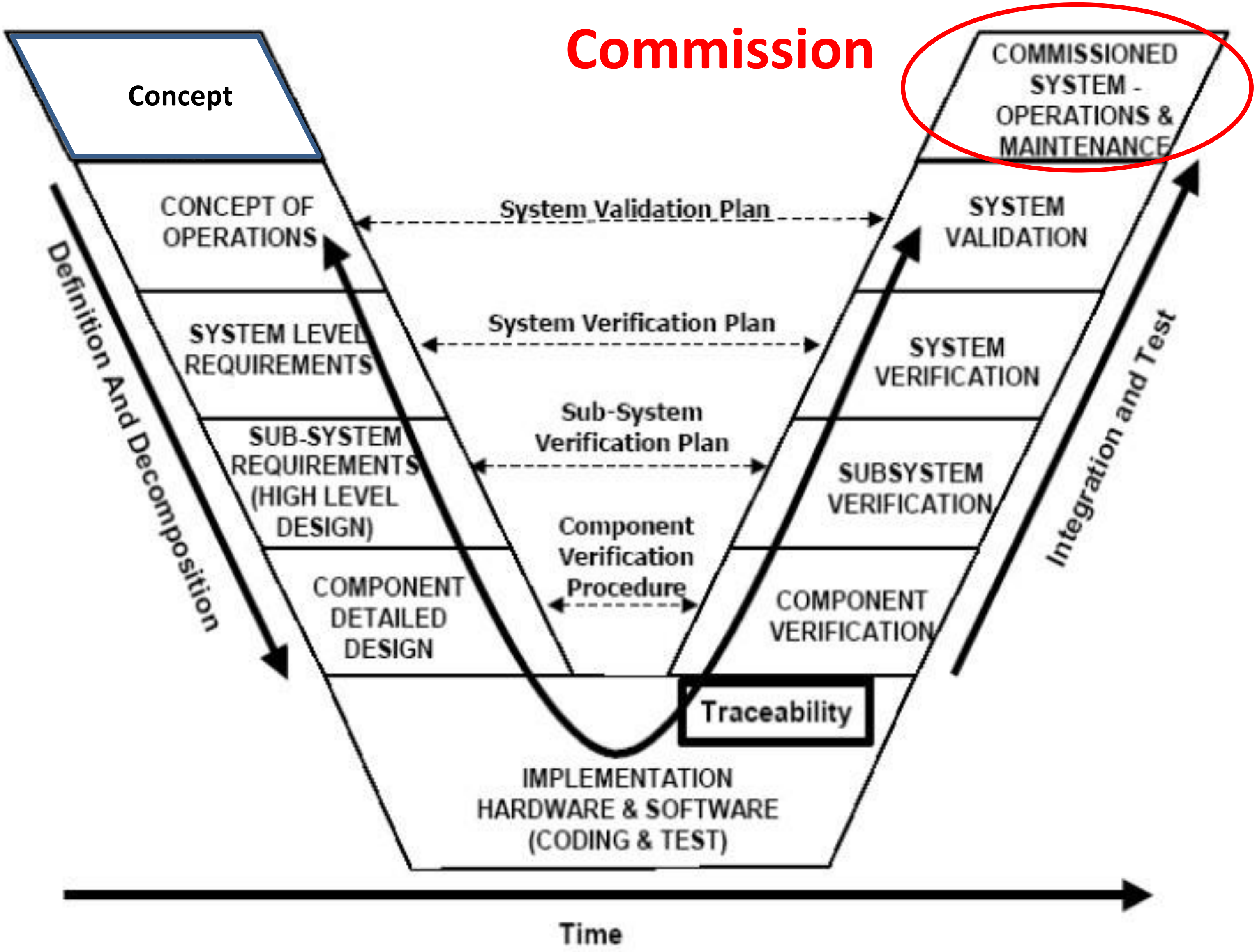
Implement via procurement, local fabrication, and installation ; includes training

Verify and Validate



Verify and Validate by executing in sequence the verification and validation plans developed during Design to ensure the components, sub-systems, and whole system are made, integrated, and installed properly (verification) and the system as a whole performs as desired (validation)

Commission



Upon successful Validation, formally Commission the system and begin routine operations and maintenance

Sustainability

Sustainability is in part related to good design of hardware, software, human factors

A key element of sustainability is maintainability of the hardware and software. Examples of relevant design issues:

- **Minimize or eliminate moving parts** in anemometers and rain gauges
- **Open code** or at least accessible software
- **Simplify and standardize** hardware/software to extent possible → minimizes training, maintenance, forward compatibility issues
- **Calibration** using only simple techniques, minimal special tools or instruments

Another key element of sustainability is the necessary funding stream to operate and maintain the system, including continued training of staff. This needs to be an integral portion of the **CONOPS**, **Design**, and **Implementation** of the system. More in due course on how to do this via Public-Private Partnerships.

Human Factors and Capacity Building

The human factor - an integral part of the design process → perhaps more difficult than hardware/software. If individuals will be reassigned, have duties changed, eliminated, or otherwise feel threatened, special measures may be warranted to gain their support or ensure they do not impede the work.

Steps to enhance the technical and professional capacities of staff should be part of the design process and integral part of Implementation. Traditional techniques still work well, perhaps augmented by on line delivery of certain topics, if supported with time to study and necessary financial support:

- Technical training
- Professional development
- On-the-job training (OJT) is effective if a strong professional mentor is available

Local fabrication and self-installation of as much of a new system as possible is an excellent way to build technical capacity

In Closing, a Few Guiding Principles

- ***"… le mieux est l'ennemi du bien"*** *(… the best is the enemy of the good)* Voltaire, in the opening of his moral poem *La Bégueule*
  - There is never a perfect solution
- **Avoid "build it and they will come" thinking**
- **System life time** is determined in large part by the availability of spares. Buy a reserve to use only when the manufacturer drops support; until that happens, buy routinely. When the manufacturer drops support, seek a new system.
- **A system has a lifecycle and user needs change.** Plan for periodic upgrades and enhancements, and ultimately for replacement
- **Provide local access** to data from nearby site → builds local ownership
- **Provide free and open access** of data to citizens → builds entrepreneurs
- **Less is more**: it is better to deploy fewer but long term sustainable observing systems that a larger number of systems that soon prove unreliable/unsustainable

Questions? Comments?

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