Data Collection Network Modernisation
What You Need to Know

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October 2018

Why "Data Collection Network Modernisation"?

Two continually recurring themes within CIMO and at associated conferences:

Planned modernisation of manual or automated network.

Sharing experiences of a recent network upgrade:
~40 papers at WMO International Conference on AWS [ICAWS-2017]
~16 papers at this TECO on user plans and experiences

This topic is significant in the community:

WMO IPET will be considered at CIMO subsequent to this conference [CIMO/MG-15/Doc. 2.2(6), 28.03.18]

Migration from Manual to Automatic Observations taking into account the whole involvement of the whole data chain from observations, data processing, data management to the information systems operated by the users of weather services.

This ideas in this paper are general and can be applied to...
new networks, or **modernisation of manual or automated** networks.

But let us first remind ourselves (and perhaps others) "why _measurements_ are so important"

Surface measurements are one significant part of the data set that describes the state of the Earth's complex and dynamic atmosphere at any particular moment.

Measurement networks at the **surface**, **through the atmosphere** and **satellites** are complementary and collaborate to: "fill in the gaps" that each can not see; perform cross confirmation or calibration.

The relative thickness of the Tropopause, where I live and play, on a **1m radius** sphere is **1.7mm**!
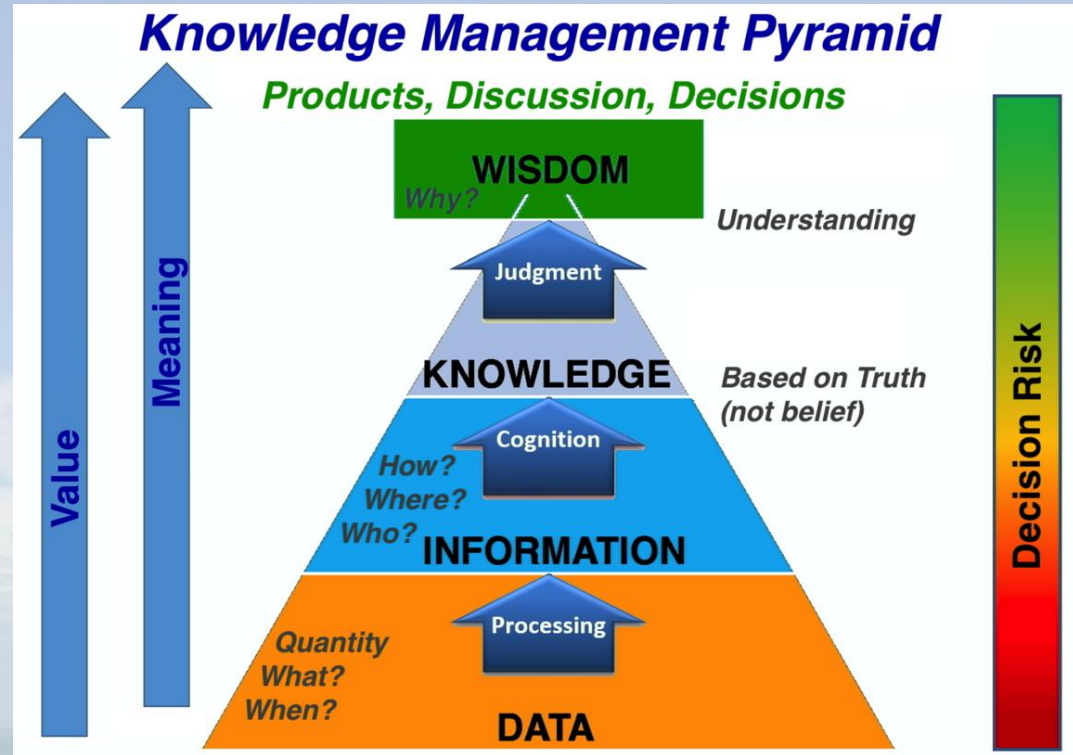
The same as the skin on an apple!
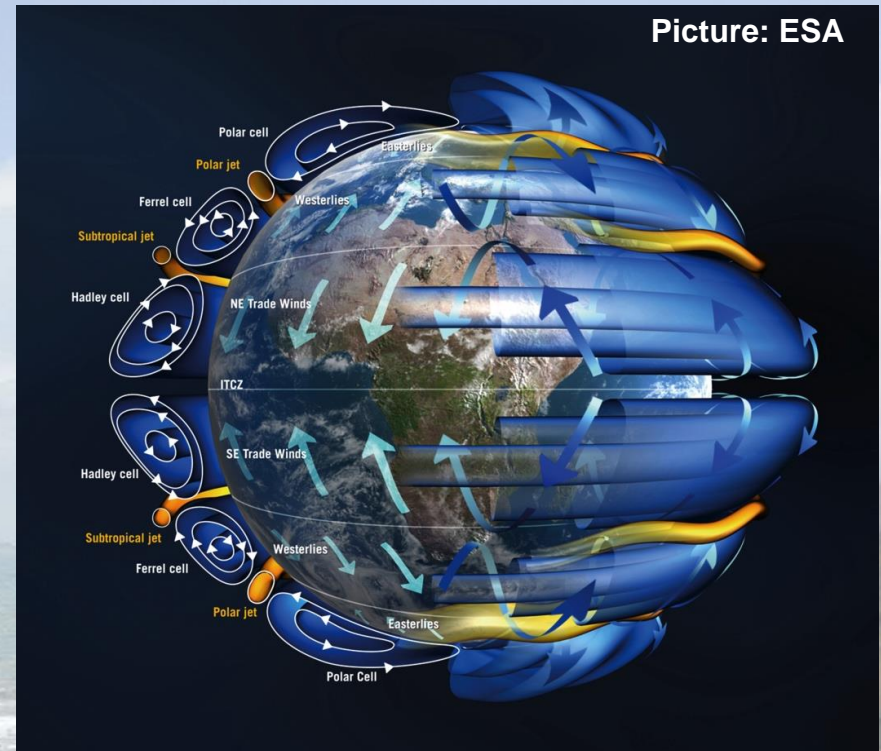
Picture: ESA

	Altitude in km	Scaled to 1m
Earth mean radius	6,371	1.0 m
Geostationary satellite	36,000	5.7 m
Polar orbiting satellite	850	13 cm
350g weather balloon bursts	30	4.7 mm
Tropopause (9 to 17 km)* Tops of thunderstorms* Commercial airliner (36,000 ft)	11	1.7 mm
Mount Everest	8.848	1.4 mm

* The Tropopause and thunderstorm tops vary by several km with latitude and season.

Why *data* is so important?

High quality measurements (data with information about that data) are the foundation for creating high value **weather intelligence** (knowledge and wisdom).

Knowledge Management Pyramid

Products, Discussion, Decisions

- WISDOM — *Why?* — Understanding
- Judgment
- KNOWLEDGE — Based on Truth (not belief)
- Cognition — *How? Where? Who?*
- INFORMATION
- Processing — *Quantity What? When?*
- DATA

Value | Meaning | Decision Risk

The intelligence then being used to make confident decisions to:

- ✓ minimise risk and protect public and property (safety, DRR, health)
- ✓ enhance life (commercial and economic systems, quality of life)
- ✓ future plan (medium to long term, improve natural resource resilience)

A measurement networks purpose is to quantify, with known quality, the **data and information** layers.

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What this paper is not about...

As there is already significant material available (some sources identified later) I have chosen not to cover in any detail the following...

- x   Specification preparation

- x   Tendering

- x   Purchasing

- x   Training

- x   Roll-out / Installation

- x   Commissioning

- x   Maintenance

- x   Calibration

What this paper is about...

I will focus on the following high level management and design processes which occur before any of the steps in the previous slide...

- ✓ When to start
- ✓ Preparation
- ✓ Project management (oversight)
- ✓ Consult (objectives & deliverables) stakeholders, operators, data users
- ✓ Rationale (technical design and a implementation plan)
- ✓ Transition planning - Identify associated impacts
- ✓ Collaboration with others
- ✓ System has supportable business processes
- ✓ Equipment design and construction is sustainable
- ✓ Data management and quality control
- ✓ Network Design
- ✓ Station Design
- ✓ Costs – Specification - Final steps   (briefly)

When to start...

The need to modernise a network will be triggered by some internal or external **change** that will likely become a major driver on how the project proceeds.

- ➤ Stakeholders – User prompted   (political, international, DRR, statutory, legal, commercial, incident)

- ➤ Budgets   (reduced or expanded)
- ➤ Human resources   (limited or reduced or expanded)
- ➤ Unsupportable systems   (no spares or too expensive or unsafe)
- ➤ Efficiency opportunities   (reduce costs and therefore expand)

Preparation (for the implementers)...

Knowledge about management and operation of measurement systems is essential.

❑ WMO Guide to Meteorological Instruments & Methods of Observation

❑ ICAWS-2017 conference

❑ TECO-2018 conference papers

❑ AWS specification for implementation & training [wmo-td862 Guidance on AWS]

❑ Relevant training (industry, WMO)

Project Management...

❑ Must be recognised as a **function in its own right**.

❑ If practicable the Project Manager should **not** be involved in technical design or implementation matters as this may create conflicts in work flow and priorities

❑ The project manager ideally has an **objective role** independent of all "User" groups, and implementation and operational staff

The project manager will look after at least the following:

➢ **Co-ordinate** and consolidate technical design and budget forecasts

➢ **Approvals** and **financial** requirements

➢ Maintain clear **responsibilities** and **demarcations** between groups

➢ **Monitor work flow** against objectives and planned time-lines

➢ **Monitoring of financials** (purchases and labour) against budgets

➢ Project level **record keeping**

➢ **Regular meetings** with implementation teams and "User" groups

➢ **Project variation** co-ordination and documentation

The need to consult ⇒ Objectives and Deliverables

"Userr" driven point of view and **not** "what do I need to measure?". Therefore...

- ✓ Meet as many user requirements as possible

- ✓ Identify critical requirements and ensure this are met

- ✓ Incorporate experience and insights i.e. previous lessons learned

Stakeholders (ToR: outcomes, budget, time-line)

- ✧ Company executives (and hired consultants)
- ✧ Local and Central government
- ✧ Donors providing funding
- ✧ International organisations (global or regional) e.g. WMO
- ✧ Industry leaders
- ✧ Partner organisations or countries
- ✧ Other network operators (with potential for information sharing)

Requirements can be financial, political, technical (regulations)

The need to consult ⇒ **Objectives and Deliverables**

Equipment operators (your people, partners, contractors)

- ✧ Stores and purchasing
- ✧ Calibration facility
- ✧ Systems engineering
- ✧ Field operations (site and equipment maintenance, manual observers)
- ✧ Land owner(s)
- ✧ Power and Telecommunications providers
- ✧ Cloud processing and storage
- ✧ Corporate data ingest, networking, architecture, storage
- ✧ Security (physical and data integrity)

Information users (care deeply about deliverable quality and timeliness)

- ✧ Agrometeorologists, Hydrologists, Climatologists
- ✧ Client data services (customers, Forensic services)
- ✧ Corporate communications and media
- ✧ Direct on-site delivery data users e.g. aviation, port, meteorological office
- ✧ Emergency services
- ✧ Forecast operations (public, aviation, marine, urban, commercial, warnings)
- ✧ Military
- ✧ Modeling
- ✧ Research
- ✧ WMO (also a stakeholder)

Rationale (technical design & implementation plan)...

Focus on the **Measurand** (data parameter, exposure, quality, processing, period, metadata) to meet "User" requirements, and **not on technology or instruments**.

Measurands => Define data parameter and installation requirements

Transition planning – Identify likely impacts...

When modernising an existing system, the **existing information chain** needs to be evaluated (measurement to delivered product) for **potential impacts** resulting from the proposed changes. Identified adverse impacts may require steps to be taken to **minimise disruptions** to existing information flows.
Refer to the paper for examples of process steps that should be reviewed.

Collaboration with others...

Increasing expectation that organisations and countries will collaborate to increase efficiencies and enhance data sets - spatial, temporal, local-to-global.

- ✓ Sharing infrastructure   (enclosure, towers, buildings, cables, power)
- ✓ Sharing communications   (though security is often a challenge)
- ✓ Sharing data & metadata   (but noting ownership and also sharing revenue)
- ✓ Measurements for others   (implement sensors at no cost or hosting)
- ✓ Providing aid   (technical expertise & equipment at cost or for free)

Supportable business processes...

✓Supplier and manufacturer are **technically capable** and **financially sound**

✓System is able to be **implemented** and **supported** by **your trained staff**

✓**Spares holding** is technically acceptable and spares these are included

✓**Maintenance schedules** to maintain operation are acceptable

✓**Support staff skill level** requirements are acceptable and training is included

✓System guaranteed **up-times** and **data availability** meet the project objectives

✓**MTBF** and **MTTR** are acceptable

✓Expected **Lifetime** and **lifetime cost** meets the project objectives

Equipment is environmentally friendly...

All manufacturing, installation and operating processes use materials that are:

❑ Sustainable

❑ Non-hazardous to life

❑ Non-deleterious to the environment

❑ Recyclable or bio-degradable

Data management and quality control...

The quality of knowledge and wisdom is only as strong only as the weakest link in the information quality chain. This chain must be identified and reviewed from a quality management perspective during transition planning.

Data processing quality algorithms
➢Tests, corrections, filters, alerts – more detail is available in the paper.

New data using complex analytics from existing infrastructure
➢Data is created from seemingly unrelated information streams, e.g. precipitation type and intensity from camera imagery, visibility from camera imagery.
➢Methods for traceability and quality control are being developed.

Database homogenisation (data and metadata)
➢A modernised system may have different requirements (review & adjustments).
➢Particularly significant to the climatological community (ECV).

Measurement homogenisation
➢Sensors exposed, calibrated and adjusted, and data processed, each in a particular way. Modernising a system may change these processes.
➢Overlap period required? Typically one or two years and either at all stations or representative ones depending on the measurand and data use case.
➢Particularly significant to the climatological community (ECV).

Network Design...

Current network performance is a baseline
Modernisation = potential benefits (temporal & spatial coverage, quality, cost, etc.).
Therefore current network performance must be documented as a **baseline for** checking **deliverables** (commissioning and testing), and project **objectives**.

Opportunity to review
➢How will the new system compliment others (satellite, upper air, AMDAR etc.)?
➢Existing systematic faults can be remedied?

Network technical requirements
➢Replace all system(s) – One unified solution, or
➢Replace all system(s) – Multiple solutions (e.g. hierarchical AWS?), or
➢Replace some   – Multiple solutions, retaining parts of existing network?

A unified solution may have infrastructure options but not performance options.
e.g. power supply: mains, solar, fuel cell, wind, third party, battery sizes.

Documenting the **network features** will form the basis for the **Station design(s)** which leads to the technical specification that will be required for purchasing.

A detailed list of technical network features is included in the paper.

Network Topology

The **Traditional AWS**, a logger/processor with sensors, local data processing and message coding, is coming to an end!

But not yet – NMHS will need new back-end systems, and IoT networks require low cost and low power communications networks that are not yet available at very remote locations.
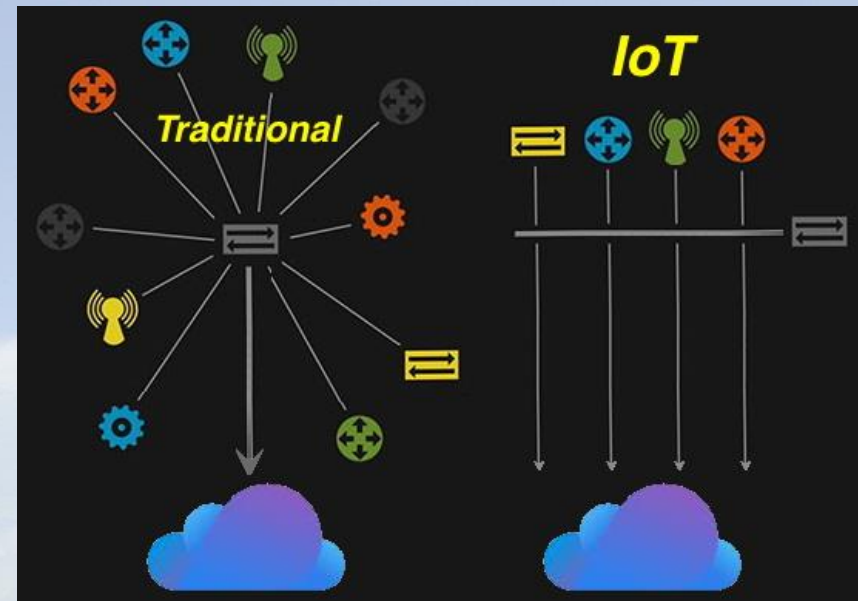
"IoT is a network that connects uniquely identifiable "Things" to the Internet.

The "Things" have sensing/actuation and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the "Thing" can be collected and the state of the 'Thing' can be changed from anywhere, anytime, by anything."   *Using any telecommunications method.*

➢**IoT topologies already exist** (suppliers and NMHS), data points => database.

➢For an IoT topology a significant **challenge** is the **database and API.**

➢**Traditional AWS** method can be implemented **on IoT**.

➢Early IoT was about **VOLUME (Big Data),** which does **not** mean **Big Value**. Smart central analytics are also needed.

IP network based solution...

Trend => AWS networks are becoming
IP based (Ethernet, WiFi or similar)

This allows ubiquitous IP based telecommunications networks to be used with
simple configuration changes to equipment (networking configuration).

> DSL, cellular, radio, LAN, WAN, satellite broadband

In the future all sensors will be IP networked bi-directionally to:

> The official database(s)

> Local data processor(s) – if required

> Local or distant (planet wide) maintenance/displays/customer systems

IP limitations   (industry is working on these)

x   Ethernet port power consumption is relatively high

x   May require a processor to control the communications (more power)

x   Information security while traversing public networks

x   Training of engineers about networking

AWS hierarchy...

In the past it was common to operate an entire network to one performance criteria, the highest one that would meet all user requirements (normally defined by WMO).

The new paradigm... "**Towards fit-for-purpose environmental measurements**"

Different User requirements can mean a hierarchy of AWS with different features:
- accuracy
- exposure
- temporal resolution (sampling, reporting)
- power
- reliability
- communications diversity & resiliency
- servicing
- cost
- other

Until now organisations have developed their own hierarchy of AWS.
WMO is leading standardisation => can exchange data with meaning and quality.
- ✓OSCAR database   [OSCAR]
- ✓Siting/exposure   [Siting Classification scheme]
- ✓Measurement quality   [**M**easurement **Q**uality **C**lassification scheme]

MQC scheme applies to **measurands...**
Class A: WMO required uncertainty, Annex 1.A   e.g. ECV or research
Class B: Has a wider uncertainty than class A   e.g. synoptic or aeronautical
Class C: Specifications more relaxed than B   e.g. well maintained public
Class D: Wider than class C or no information   e.g. crowd source, not maintained

Information Security...

IP communication often occurs over physically shared networks so security is imperative.
Must protect:
- ❑ System control and configuration
- ❑ Data integrity
- ❑ Data ownership

Security techniques to be considered are:
- ❖ **Physically secure** – access to computers and network ports is restricted
- ❖ **Logins** (secure usernames and passwords).
- ❖ **Virus protection** software on non-fixed configuration computers
- ❖ **Firewalls** or network rules (at BOTH ends of all insecure IP links).
- ❖ **Virtual Private Networks** (VPN) where packets are encrypted
- ❖ **Usage policies** (access groups, software lists, web browsing, email rules)

Connections between or through networks can be problematic because even if all the techniques above are employed there is still a risk of cross-network tampering.

If a connection between two networks is local and the messages are simple text, then using a serial connection (RS232, RS485 etc.) can mitigate this vulnerability.

Station Technical Design...

<u>Technical features</u> to be covered in the design and expanded in the specification:
- ◇ Equipment Configuration - see Network Topology
- ◇ Power supply methods - mains, solar, wind, fuel cell, battery backup
- ◇ Telecommunications methods - cellular, DSL, radio link, cable (serial), satellite
- ◇ Environmental operating conditions of the target installation(s)
- ◇ Equipment housing (materials, layout format) and configurations
- ◇ Required measurands and their uncertainty budget (end-to-end)
- ◇ Modularity & interoperability - connection, mounting, calibration, maintenance
- ◇ Algorithms - for quality control and derived data parameters
- ◇ Message codes and transfer protocols, error handling, backlogging
- ◇ Off site communications - IP based using TCP, UDP, Email, FTP, other
- ◇ On site communications - IP, serial cable, radio, WiFi, Bluetooth, Zigbee
- ◇ Enclosure layout and relevance - ECV, aviation, road transport, Synoptic
- ◇ Equipment Physical Security
- ◇ Health and safety of workers and the public
- ◇ EMI/RFI susceptibility and Transient protection schemes
- ◇ System preferred hardware and software platforms
- ◇ Software configurability and method – web browser independent
- ◇ Built in test systems
- ◇ Maintenance regime and techniques for sensors and AWS processor
- ◇ Equipment lifetimes - batteries, solar panels, plastics, metals, etc.

Station Technical Design...

Whether to retain technical control?

Traditionally NHMS purchase systems and spares, and have their staff fully trained to calibrate, install, configure, operate, repair and upgrade equipment.

This method enables NHMS to **retain high level of control** in **equipment choice** and **quality** (sensor and module choice, algorithms, message codes and protocols, communications methods, power supply methods, calibration), and to retain **flexibility, quality and data ownership**.

In recent time the number of suppliers is increasing that can offer various levels of capital and lease purchase...
- ❖ **Installation & operation** of a station network that sends data to NMHS servers
- ❖ The above – but with **data servers** (in the cloud) with data and metadata APIs
- ❖ The above – plus **product creation & delivery** to NMHS and NMHS customers

This method requires lower capital but higher operating costs, and less knowledge of the technology. The contract requirements are also different:
- ✧ Simpler technical specification
- ✧ Capital cost if required (contribution to setup costs)
- ✧ Guaranteed supply period, Network performance KPI
- ✧ Data storage longevity guarantee
- ✧ Data ownership and revenue sharing

Costs and budget review...

technical design => budgetary costs => review against ToR => refine budgets

The costs will need to be reviewed for at least:
➢Capital – funds and labour (installation, spares, calibration, support tools)
➢Operating maintenance – funds and labour (store, repairs, calibration, site)
➢Operating utilities – funds (telecommunications, power, lease)
➢Training – labour (installers, operators, repairs, systems, data users)
➢Dis-establishment at end of life – funds and labour (removal, site restoration)

Specification...

The Specification is necessary to ensure all the deliverables, budgets, resources, and timelines are documented for purchasing and implementation.

The specification is where Network Design and Station Design are translated into detailed deliverables to be part of the purchaser/supplier contract.
The specification will include details to confirm performance of the deliverables.

Documentation of this is covered else where [WMO-AWS Tender Specification]

Final steps...

From this point is after the scope of this paper, however as guidance - what's next?

➢ **Tendering.**

➢ **Equipment choice**, contract **negotiation** and **purchasing**.

➢ **Roll-out** (training, delivery, installation, commissioning).

➢ **Dis-establishment* of existing equipment** (labour, site restoration, packaging, transport, storage or disposal or sale, requirements for hazardous goods).

➢ **Dis-establishment* of a manual observation program**:

  o If contracted – Terms for existing contract termination need to be followed.

  o If employed – Re-training and redeployment if possible. Terms of employment termination. Staff wellbeing and assistance with transitioning.

➢ **Project review** at project completion to confirm deliverables against the original project, and identify "lessons learned" for future guidance.

➢ **Ongoing performance reviews** (data, metadata, costs) to assess if the network is continuing to operate as "fit for purpose".

*Dis-establishment can be a separate project one-two years later if overlap required.

Thank you

Questions...