NATIONAL ECOLOGICAL OBSERVATORY NETWORK

THE ROLE OF OBSERVATORIES AND EXPERIMENTS IN LARGE SCALE ECOLOGICAL FORECASTING

Russ Lea | National Ecological Observatory Network (NEON)

Outline

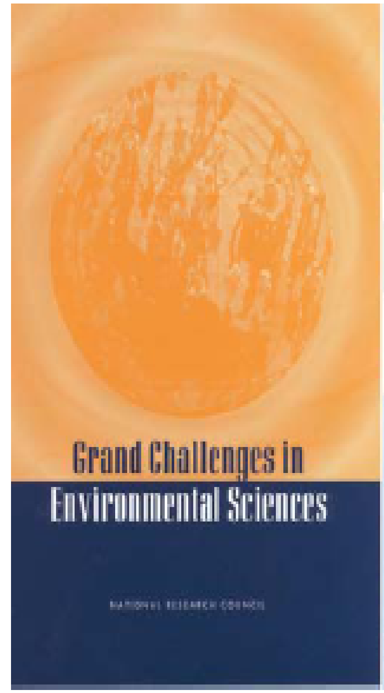
Rationale and Overview Design of NEON

Ecological Forecasting

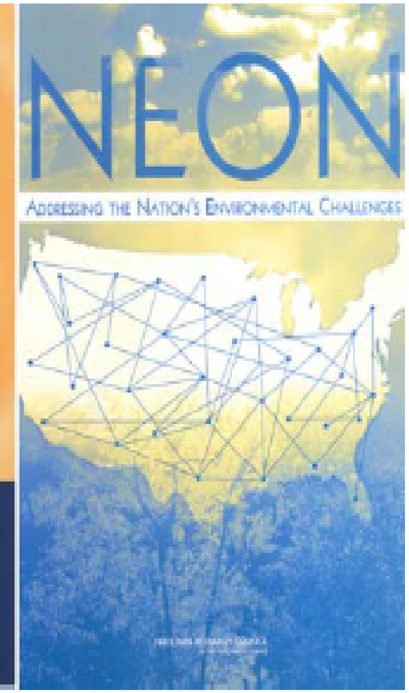
Role of Ecologists and System Engineering Approach

Grand Challenge Areas

1. Biodiversity
2. Biogeochemical cycles
3. Climate change
4. Ecohydrology
5. Infectious disease
6. Invasive species
7. Land use



NRC (National Research Council). 2001. Grand Challenges in Environmental Sciences. Washington DC: National Academies Press.



NRC (National Research Council). 2003. NEON: Addressing the Nation's Environmental Challenges. Washington DC: National Academies Press.

Grand Challenge Areas

The goal of NEON is to *enable understanding* and *forecasting* of the *impacts* of ***climate change***, ***land use change*** and ***invasive species*** on *continental-scale* ***ecology*** by providing infrastructure to support research, education and environmental management in these areas.

CAUSES OF CHANGE

Climate Change: Understanding and predicting climate variability, including directional climate change and its impacts on natural and human systems

Land Use: Understanding and predicting changes in land use and land cover that are critical to biogeochemical cycling, ecosystem functioning and services, and human welfare.

Invasive Species: Understanding and forecasting the distribution of biological invasions and their impacts on ecological processes and ecosystem services.

← ***Interactions and Feedbacks*** →

RESPONSES TO CHANGE

Biogeochemistry: Understanding and predicting the impacts of human activities on the Earth's major biogeochemical cycles.

Biodiversity: Understanding the regulation of biological diversity and its functional consequences for ecosystems.

Ecohydrology: Understanding and predicting changes in freshwater resources and the environment.

Infectious Diseases: Understanding and predicting the ecological and evolutionary aspects of infectious diseases and of the interactions among pathogens, hosts/receptors, and ecosystems.

NEON Site Design

NEON Site Design

Agriculture Systems

Climate Change or Atmospheric Transport

Forest Management

Invasion Biology

Urban Ecosystems

Aquatic

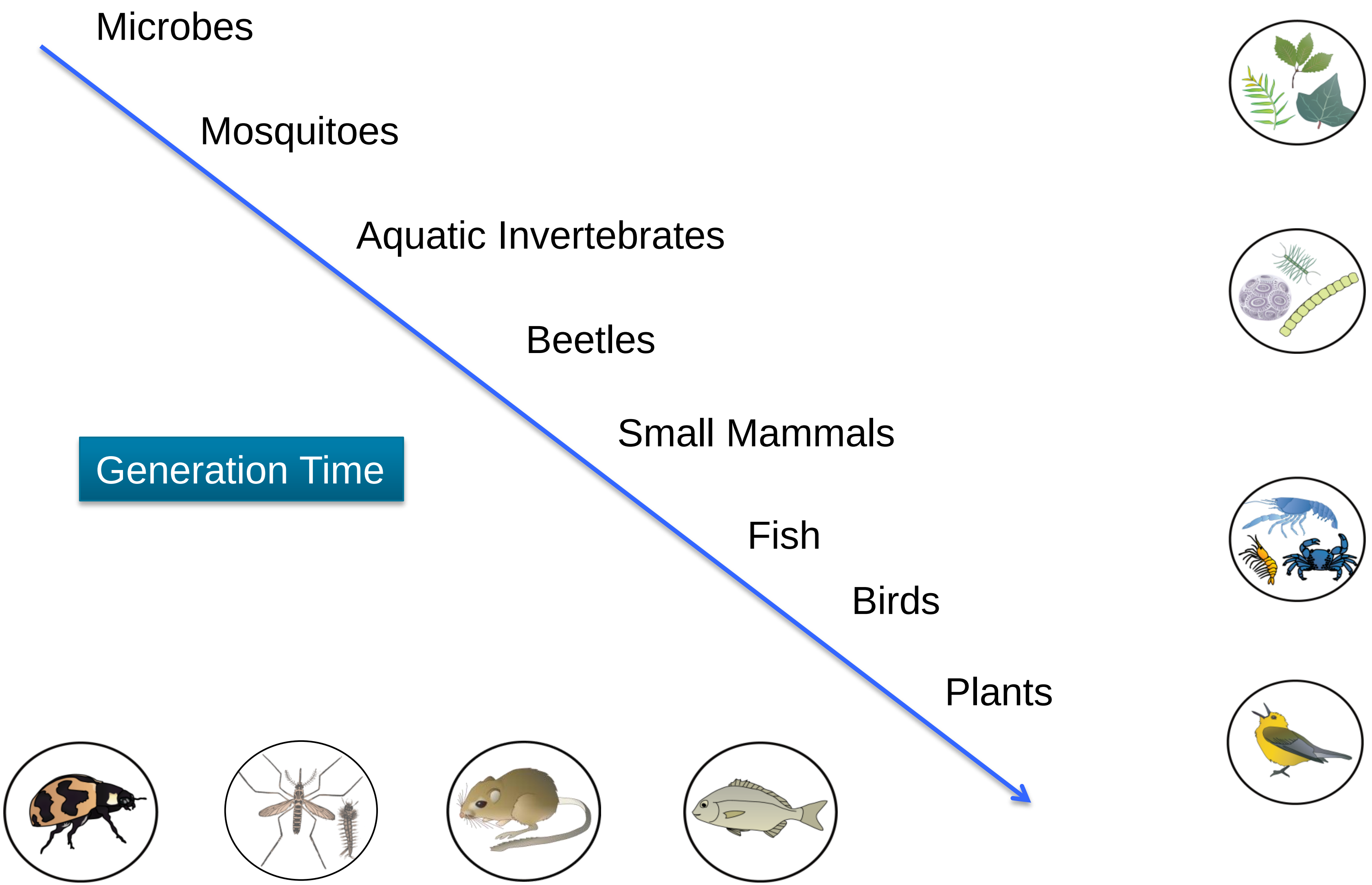
NEON Science Sub Systems (alphabet soup)

FSU	Fundamental Sentinel Unit	Human Obs. Bioarchive
FIU	Fundamental Instrument Unit	Automated Instrumentation
AOP	Airborne Observation Package	Aircraft Remote Sensing
AQU	Aquatic/STREON	Human Obs/automated instrumentation
LUAP	Land Use Analysis Package	Satellite Remote Sensing +

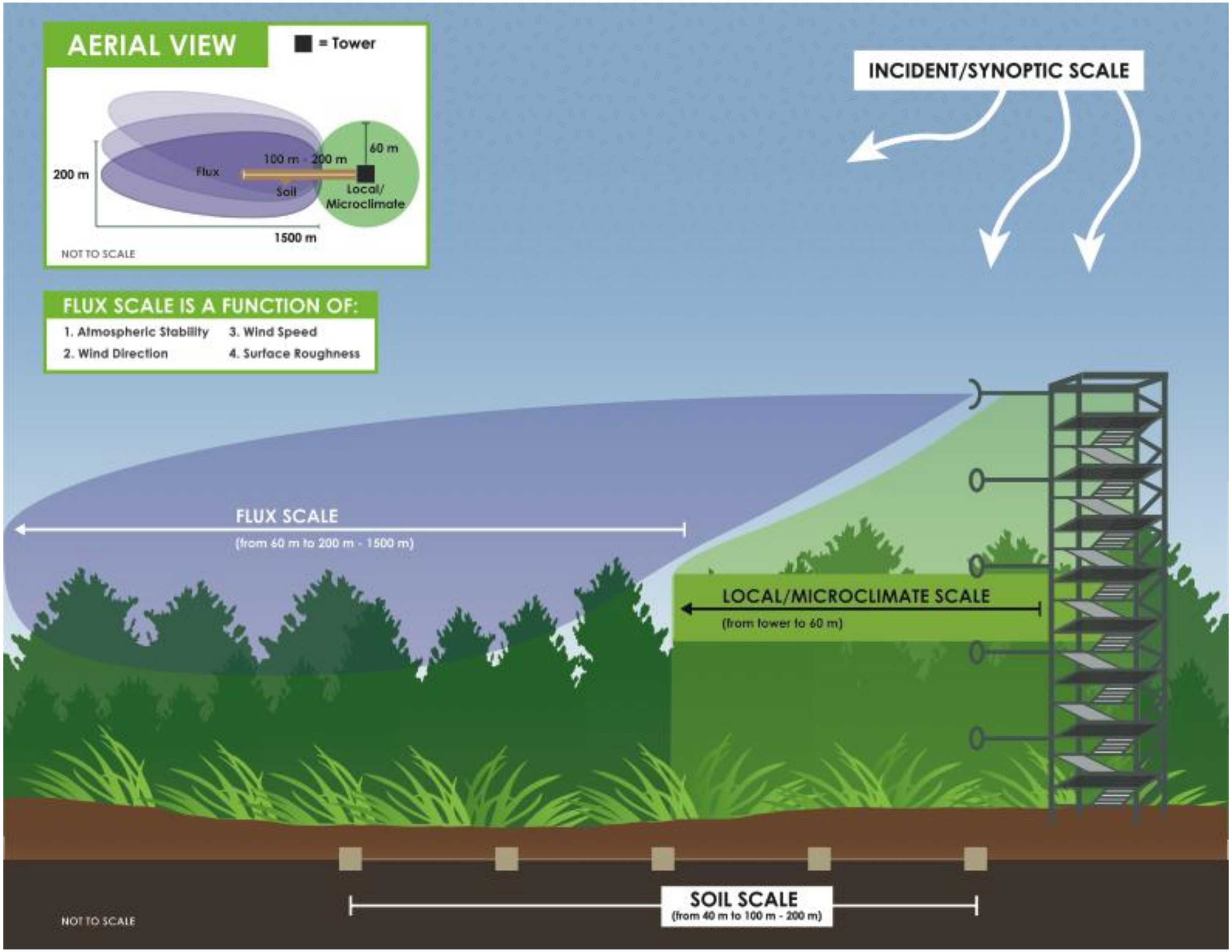
Fundamental Sentinel Unit

- Biodiversity
- Population Dynamics
- Productivity
- Phenology
- Infectious Disease
- Biogeochemistry
- Microbial Diversity and Function
- Ecohydrology

Fundamental Sentinel Unit

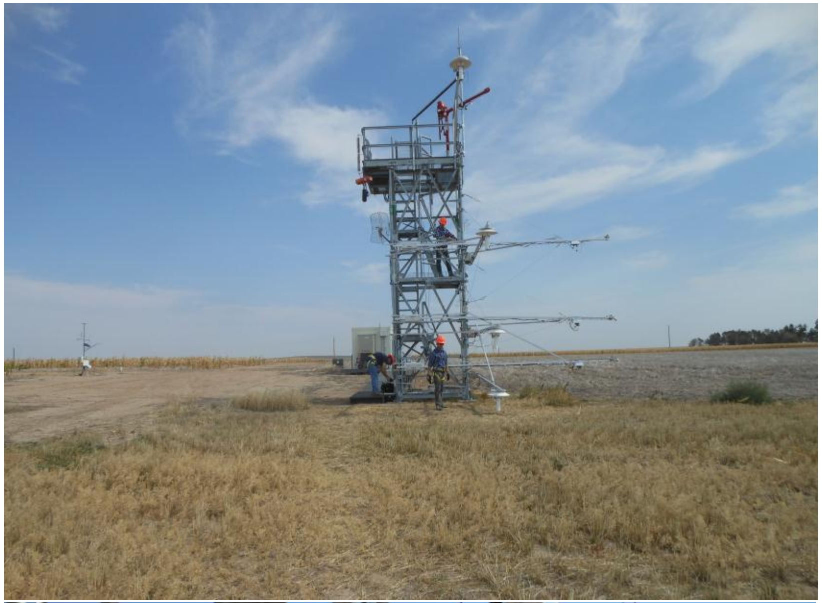


Fundamental Instrument Unit



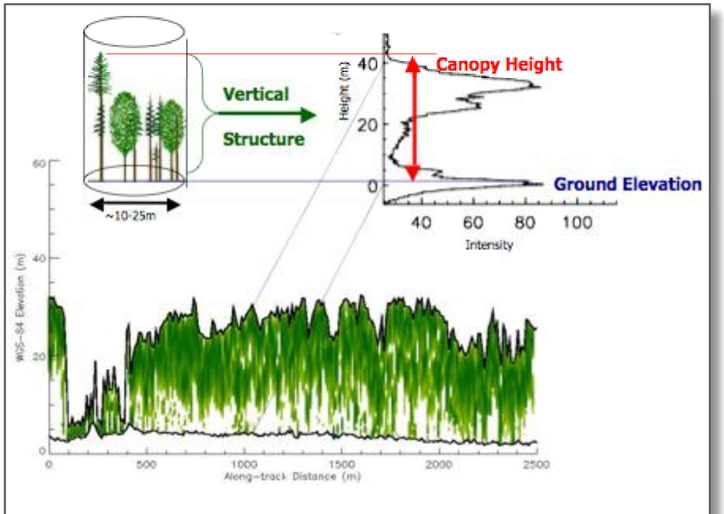
Fundamental Instrument Unit

- Physical and chemical climate forcing
- Ecosystem responses
- Stand/plot level sampling
- Automated instrumentation
- Micrometeorological scalars and fluxes
- Soil array
- Over 2000 measurements per core site at frequencies of
- Daily, and ~0.1 to 20 Hz
- Total 50 Tb y-1



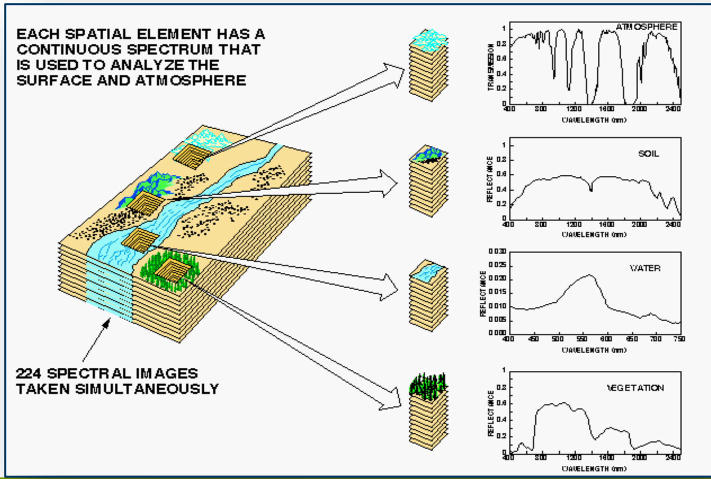
Airborne Observing Platform

Waveform Light Detection and Ranging



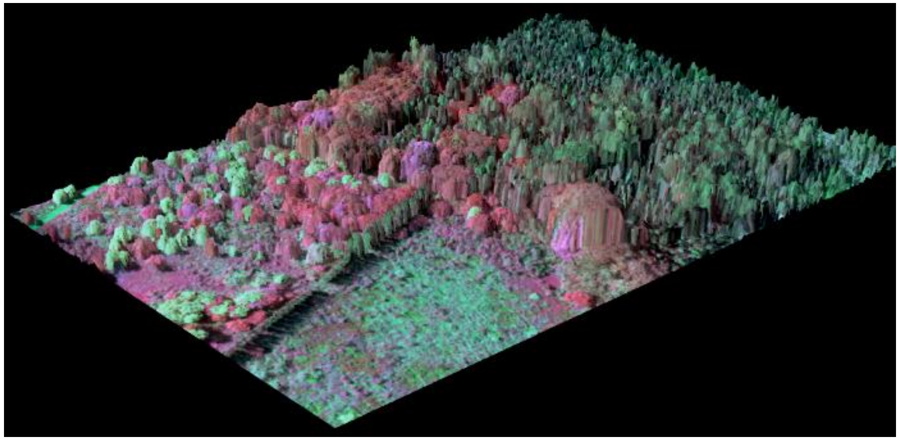
+

High-fidelity Imaging Spectroscopy



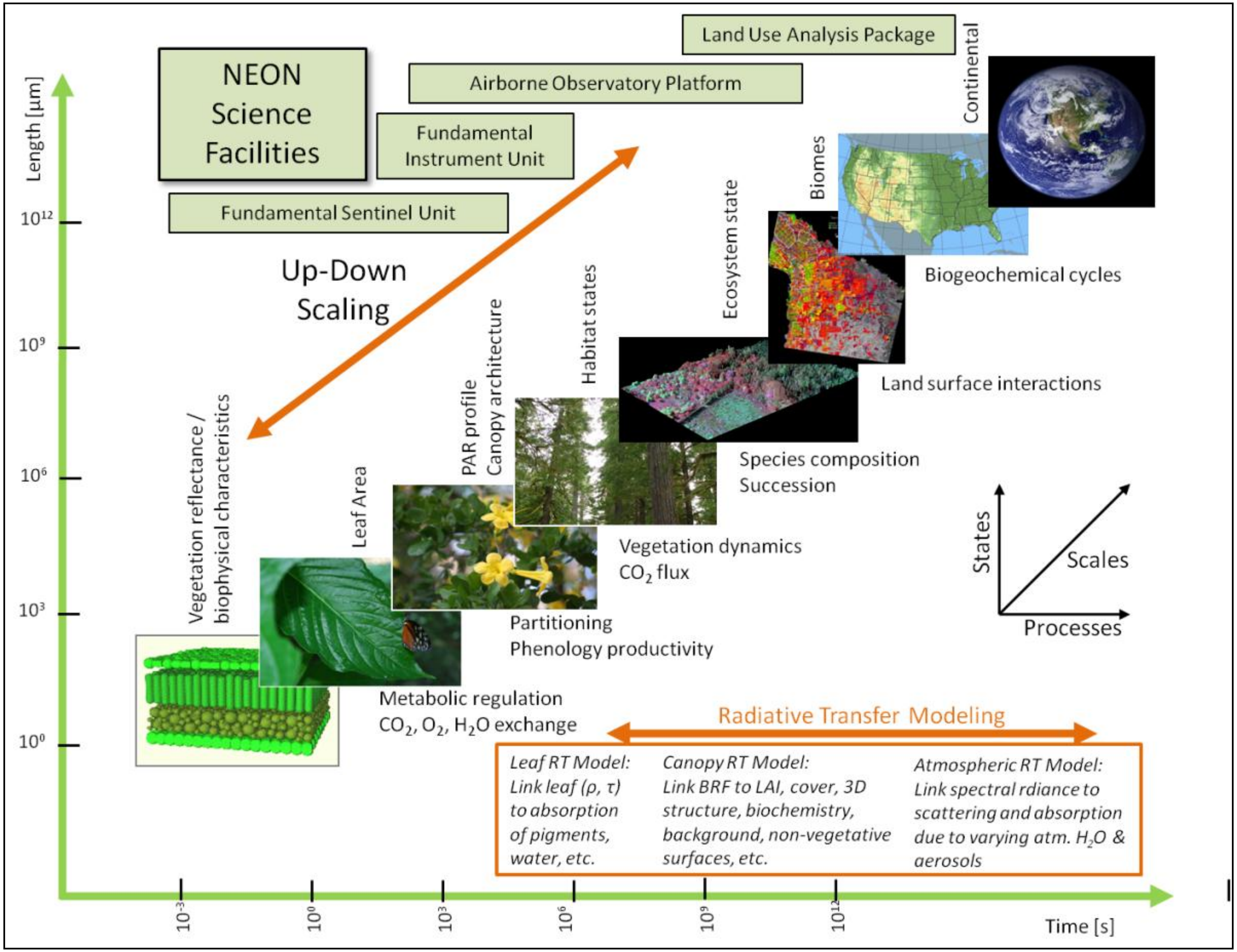
What are we after?

- Detailed chemical, structural and taxonomic information on ecosystems at fine spatial resolution

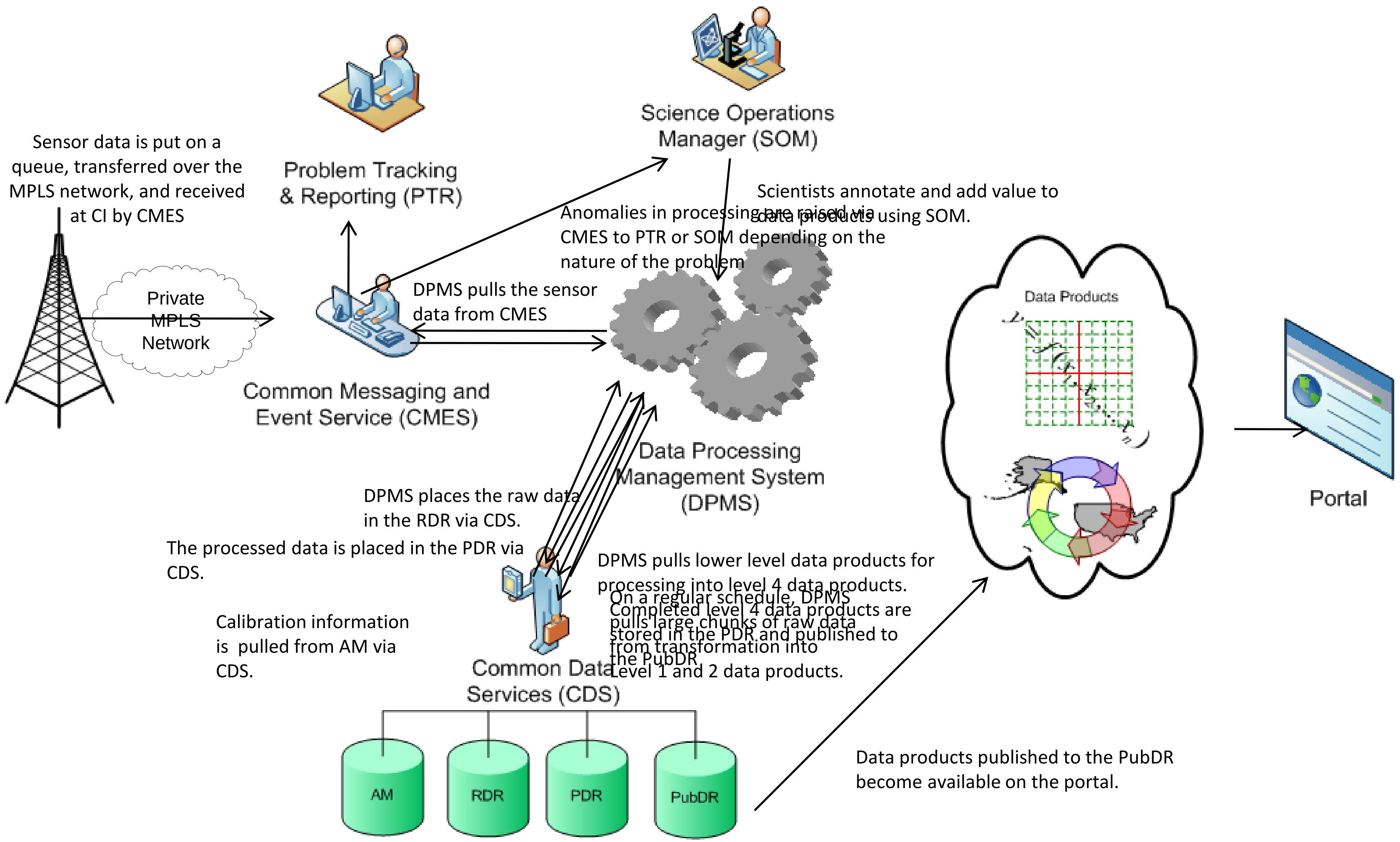


- Sampling at the scale of individual organisms (~1m) over 100's of sq. meters around NEON sites
- Bridge the scales from organisms (i.e., trees or shrubs) as captured by plot sampling, to stand scale observations as measured from flux towers, to the scale of satellite based remote sensing

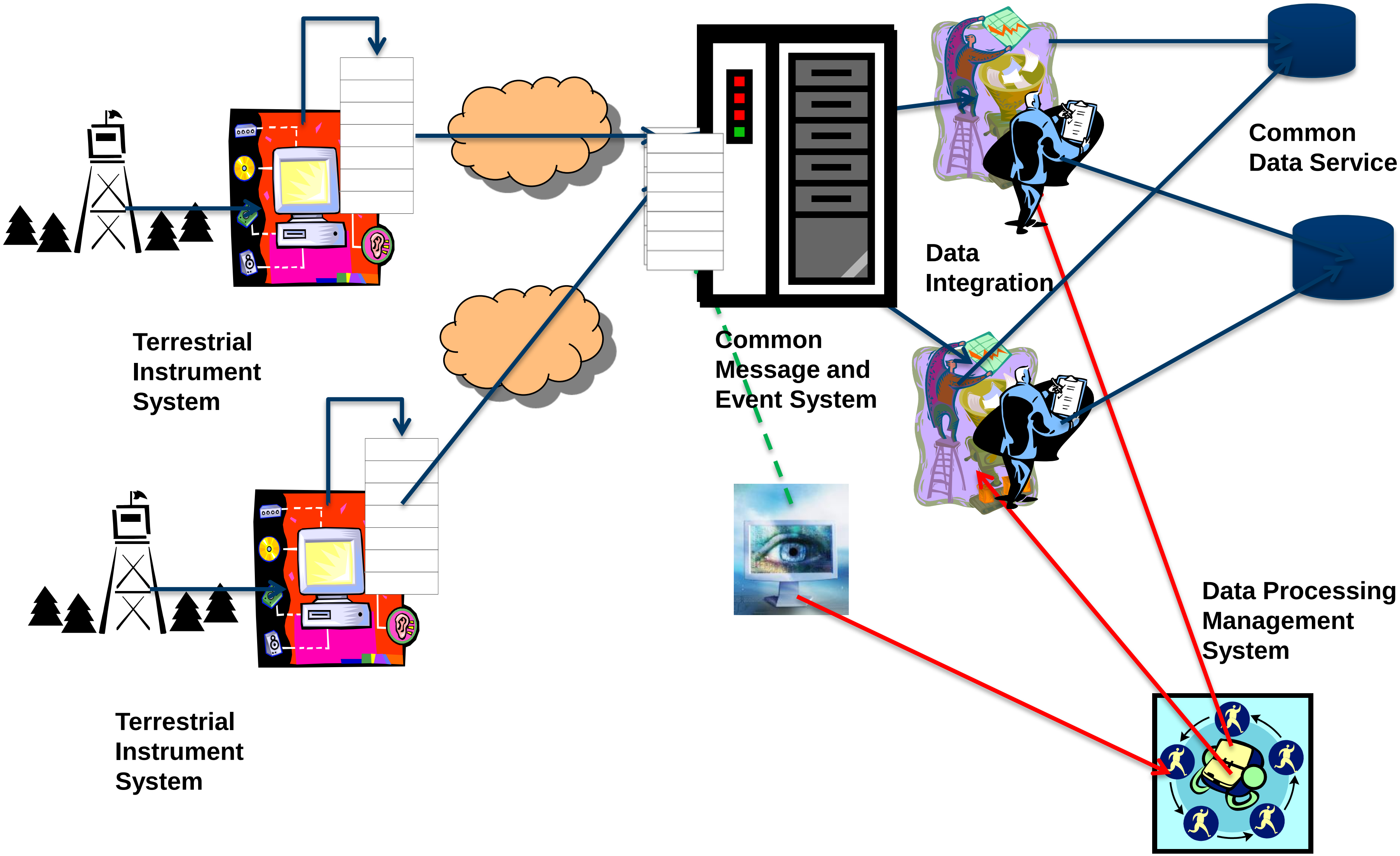
Scaling Strategy



Data Flow 24/7/365



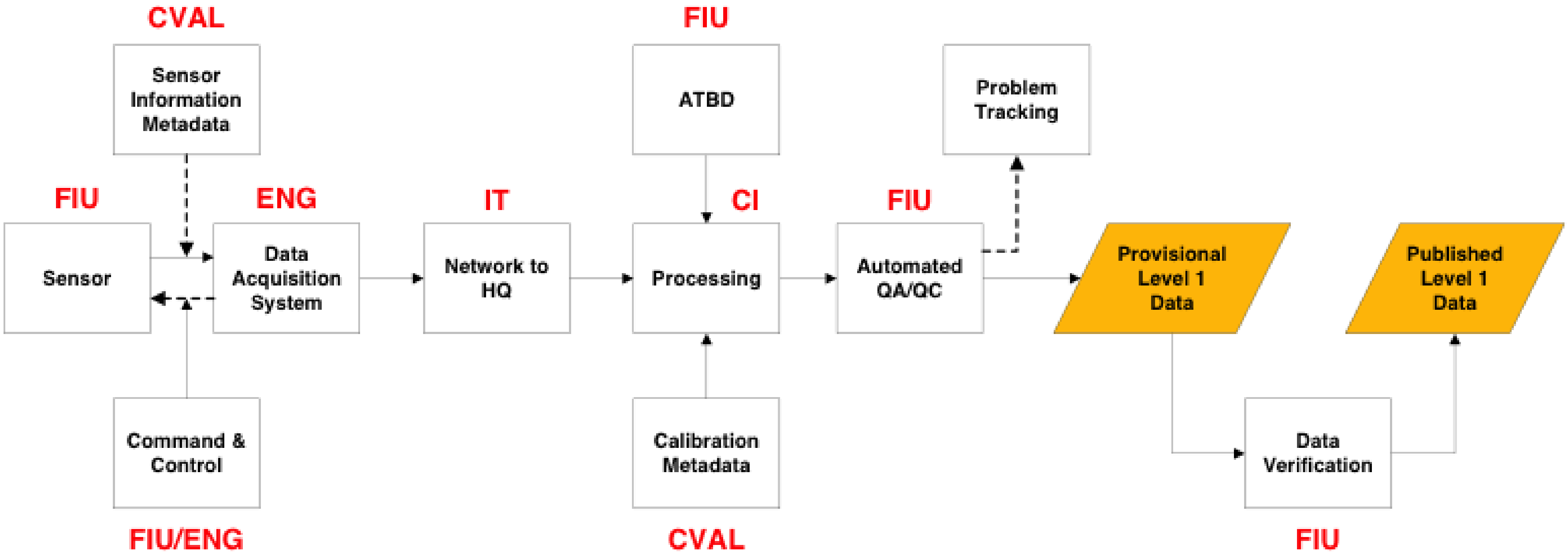
TIS Data Handling



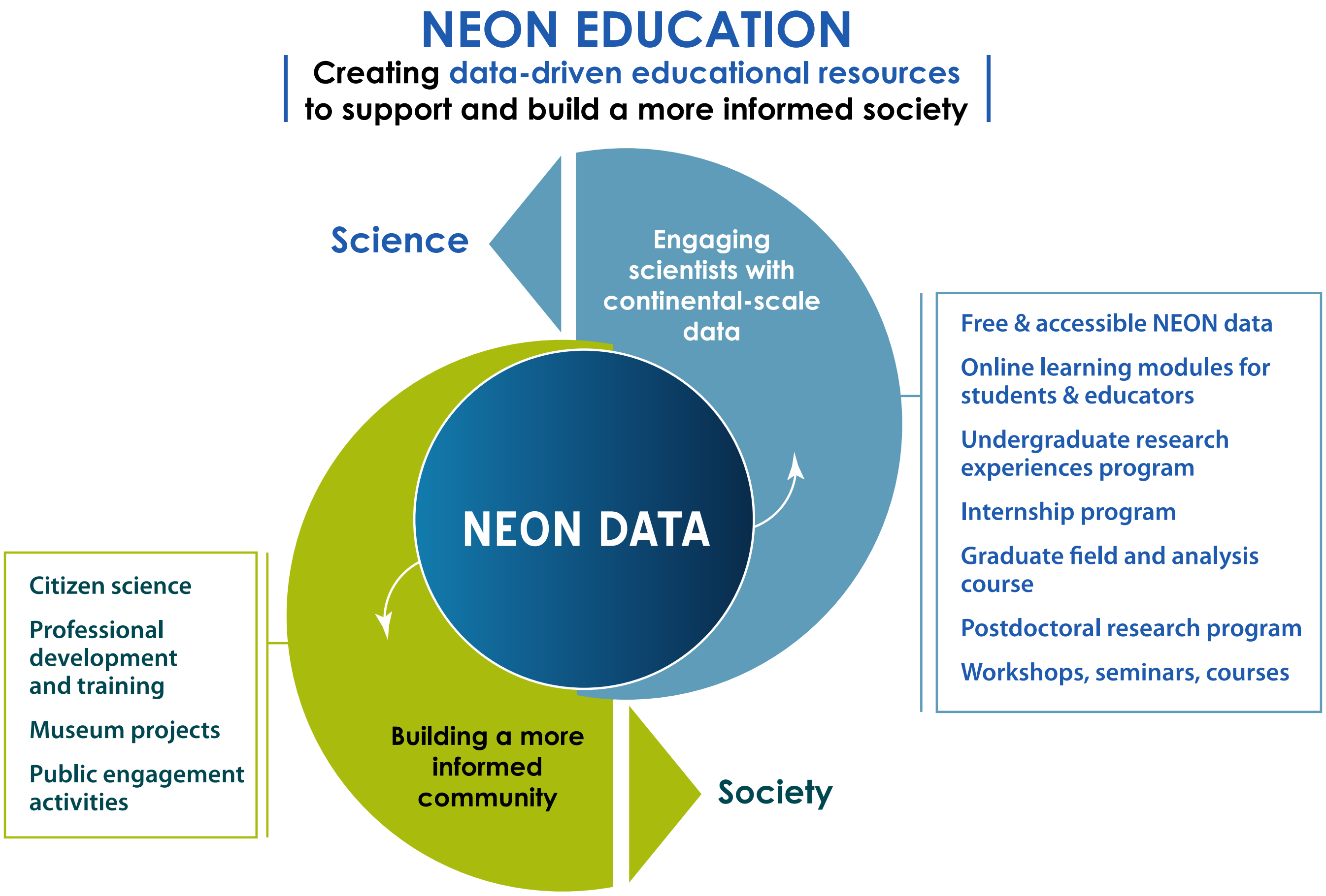
Data Flow

➢ **Integrated the Data Flow Designs**

- Command, Control, and Configuration (C^3) documentation
- Advanced QA/QC approaches
  - Plausibility tests which will be used for Site Acceptance Testing
- Algorithm Theoretical Basis Documents, L0 to L1 DPs
- Data Verification Algorithms



NEON Education



NEON's data-driven educational resources support a scientifically-literate society by engaging scientists, students, educators, citizen scientists, and decision makers in exploring continental-scale ecological questions and contributing to new scientific discoveries.

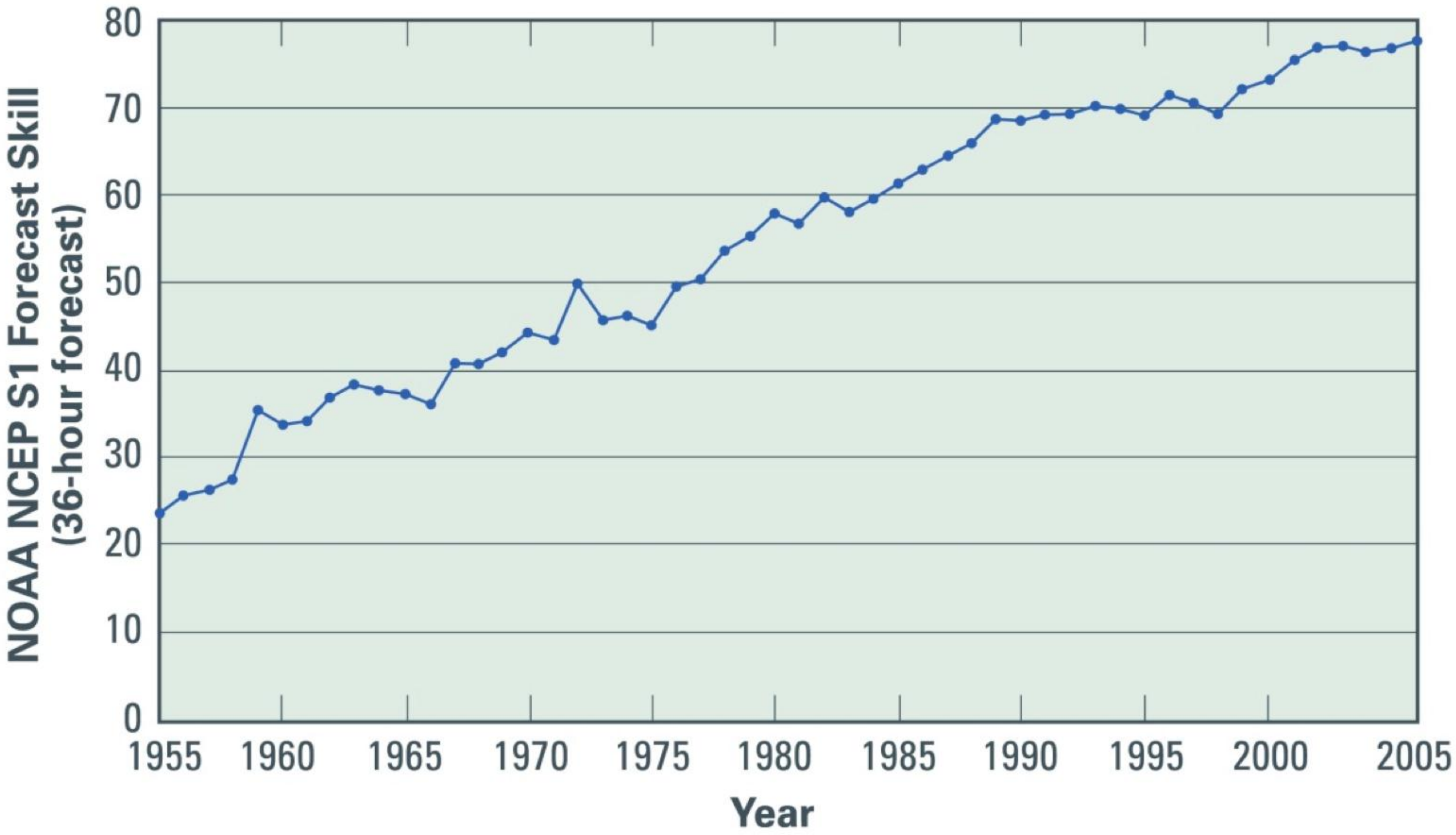
Ecological Forecasting

- Directly aligned with establishing a baseline understanding **now**

- Casts the cause and effect paradigm of NEON into understanding present and future states of ecosystems:
  - What is the most likely future state of an ecological system
  - Provides an applied context of 'what-if' given a decision made today

- Provides a conceptual framework that can be applied to all elements in managing carbon science: theory, exp design, experiments, implementation, infrastructure, data products

Ecological Forecasting



Improvements in forecasts come from repeated comparison between data and forecasts

How are ecological forecasting, experiments, and observations related?

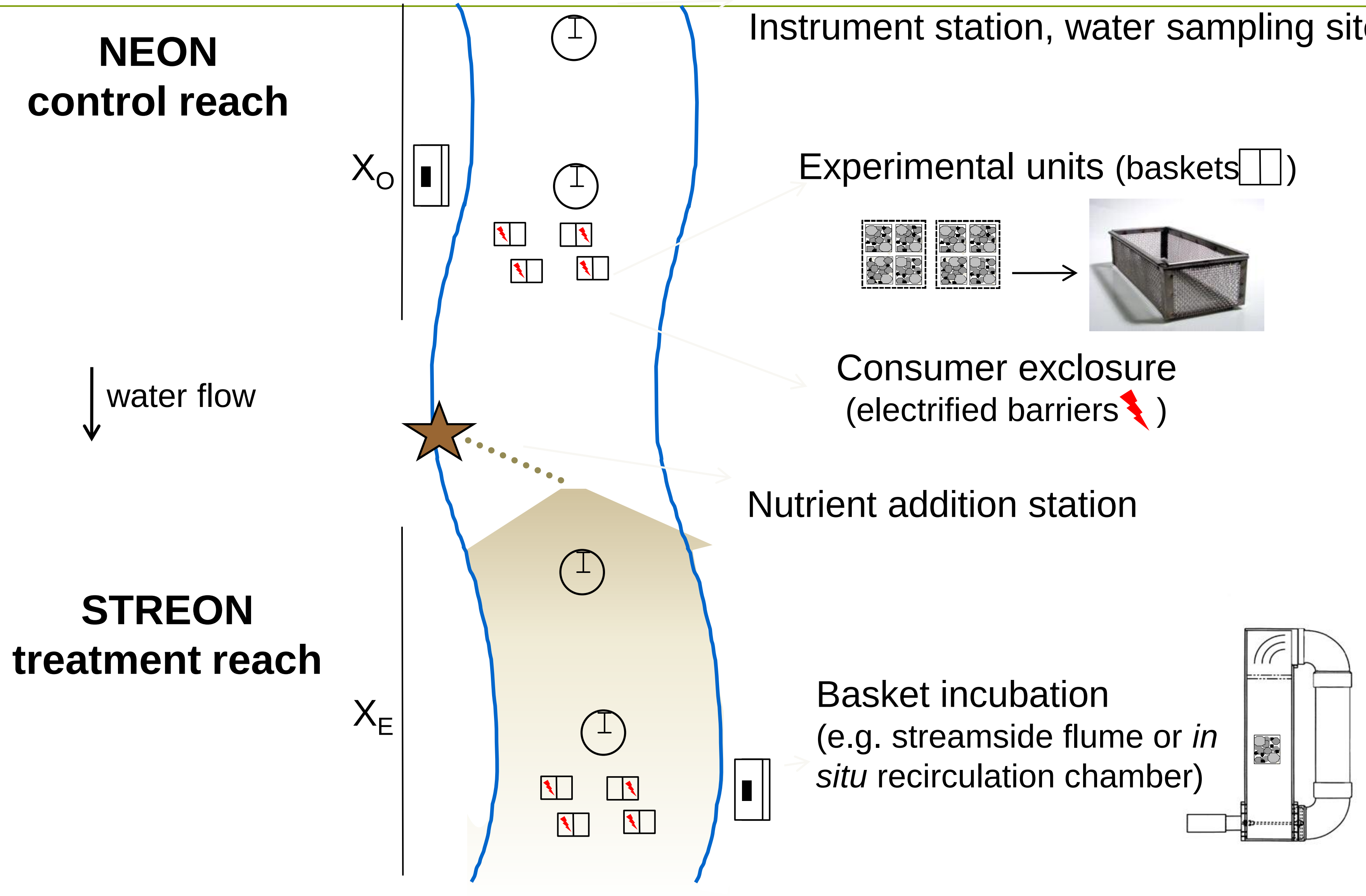
The need for observations of the starting point (now)

The need for quantitative information about specific processes (temperature sensitivity, susceptibility to drought, tipping points…)

- Estimates of system state
- Information on process parameters
- Experiments/process studies to elucidate unknown processes and non-linear responses
- Observations collected systematically over time and space to challenge iterative forecasts

A paradigm for ecological research?

STREON Experiment



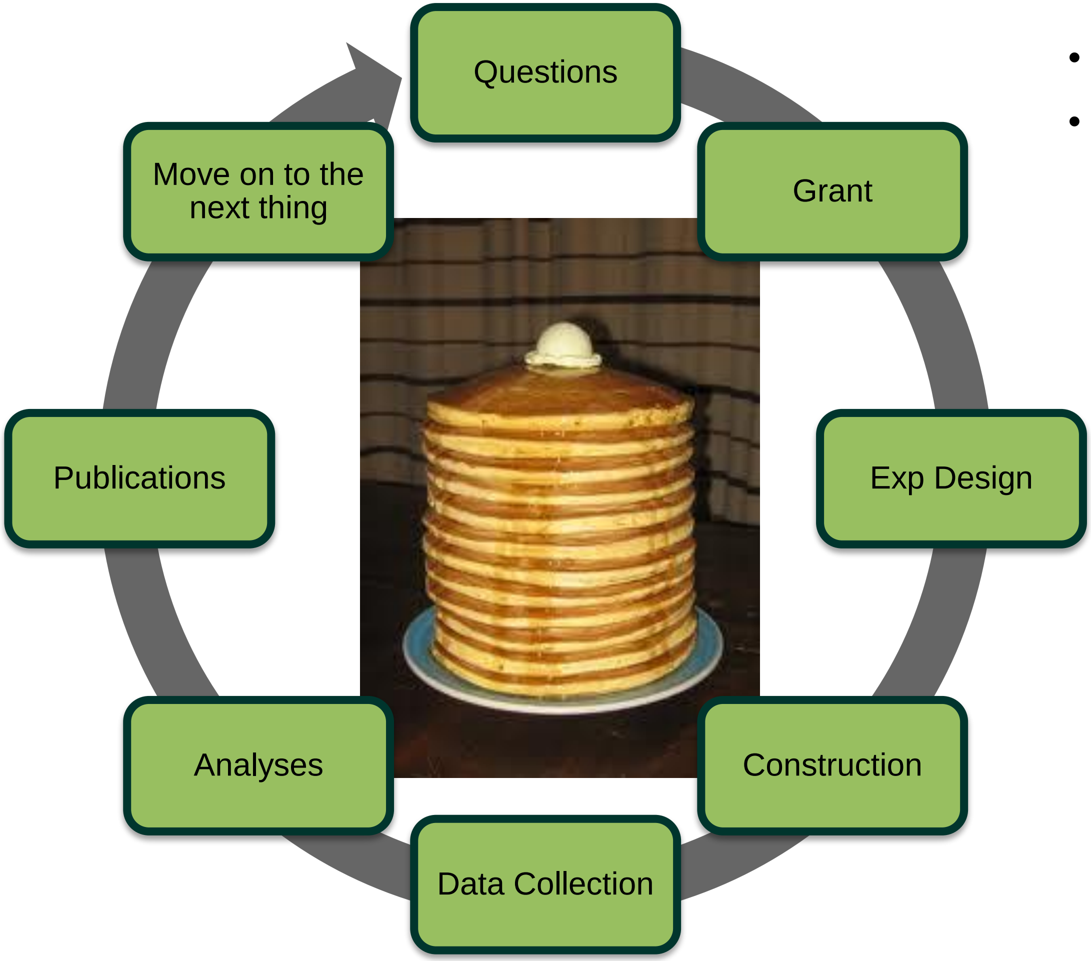
Advancing Ecology

- Means to address the 'Grand Challenges'
  - Cause and effect paradigm
  - Scale in time and space
- New large tools – Observatories
  - Other disciplines have Observatories
    - Particle Accelerators > high energy physicists
    - Telescopes > astronomers
    - Research Vessels > oceanographers
  - 'New' type of $

What are the roles of scientists in developing an Observatory?

Balancing Scientific Creativity with Baseline measurements

Scientist’s Approach to Project Science

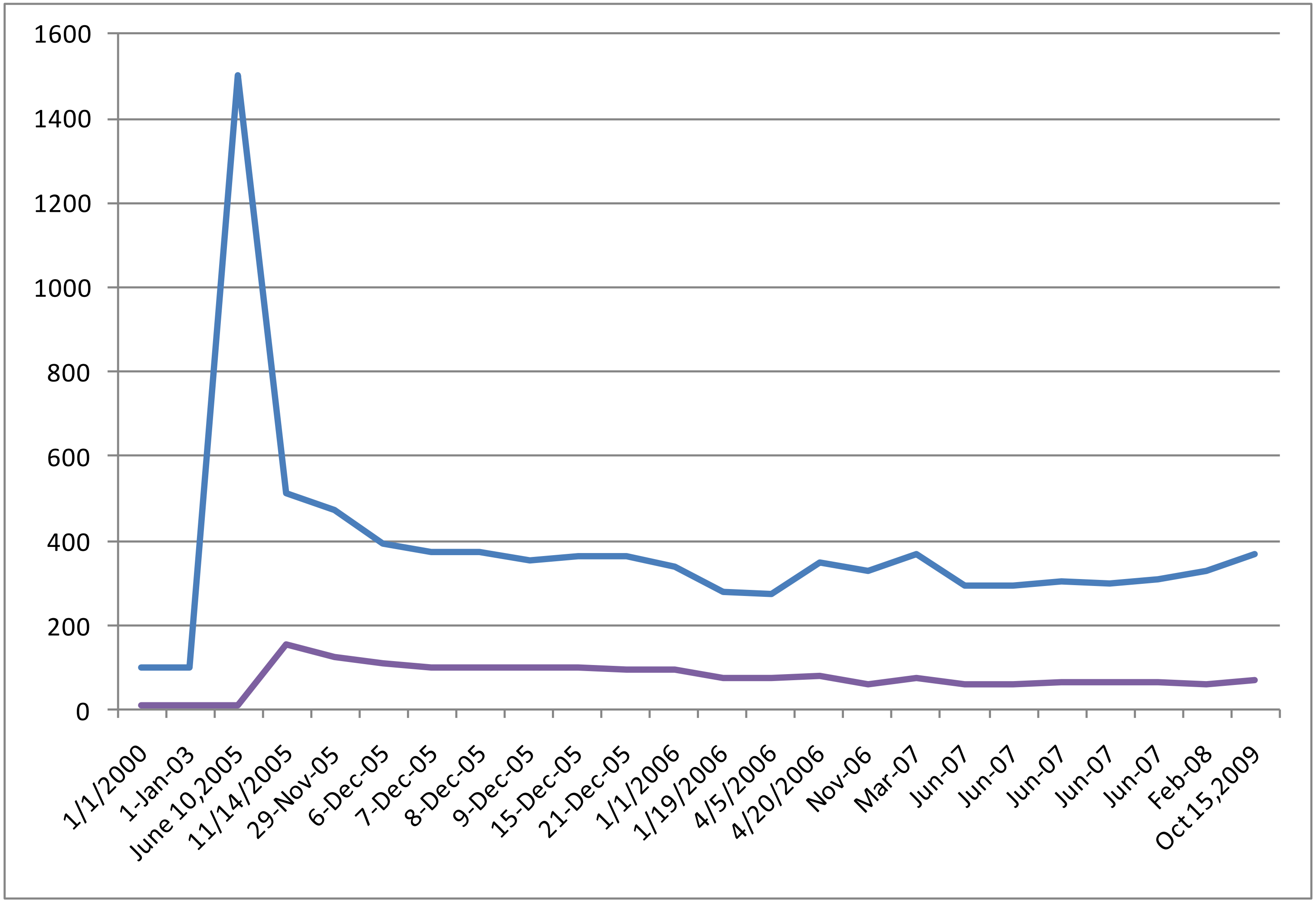


- Hypotheses testing: ‘what can we do?’
- Rationale for long term observations
- Capabilities-based (network development)
- Additional organizational complexity is often layered

Pro	Con	
✔		Scientific creativity
✔	✕	Comfort-level for scientists and bottom-up approaches
	✕	Complexity becomes open-ended problem
	✕	Governance is often difficult, and not extensible
	✕	Difficult planning for Program Officers/Sponsors
	✕	Problematic for long term sustainability

NEON's Near Death Experience

NEON Construction/Cost Estimate

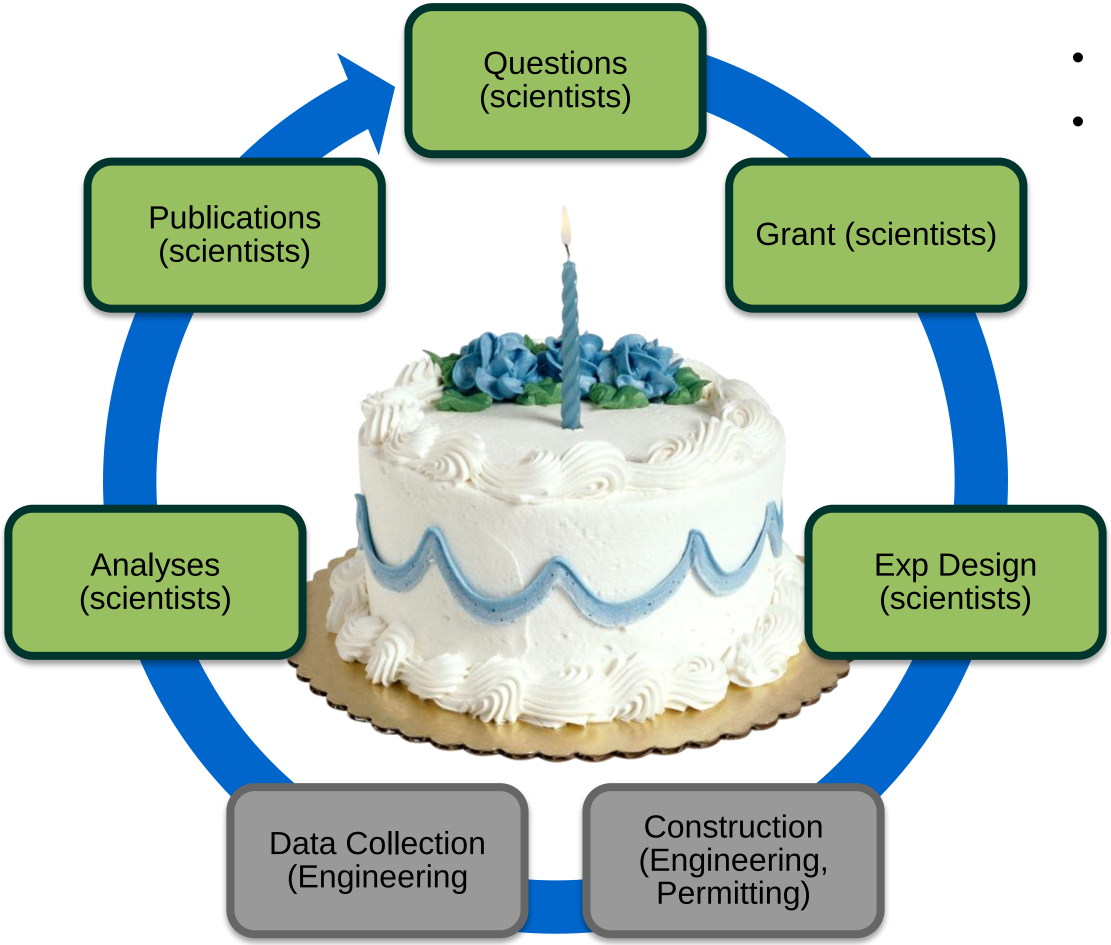


NEON's Near Death Experience

- Late 90's…...Concept of standardized ecological observatory.
- 2000-2005….Community workshops, establish boundary conditions. Shopping list/Christmas tree approach (diag).
- (~2005)……..NSF began to push in key directions. Replaced mgt.
- 2006………..Integrated Science and Education Plan (ISEP).
- 2007………..PDR1: NEON needs further D&D, Mgt.
- 2008………..New D&D phase: flowdown & deliverables, site design contract underway, project office ramp-up (6-50 staff).
- 2009………..PDR/FDR, (+65 staff), successfully completed FDR.
- 2010………..Prototyping and business operations (+135 staff).
- 2011………..Began construction.

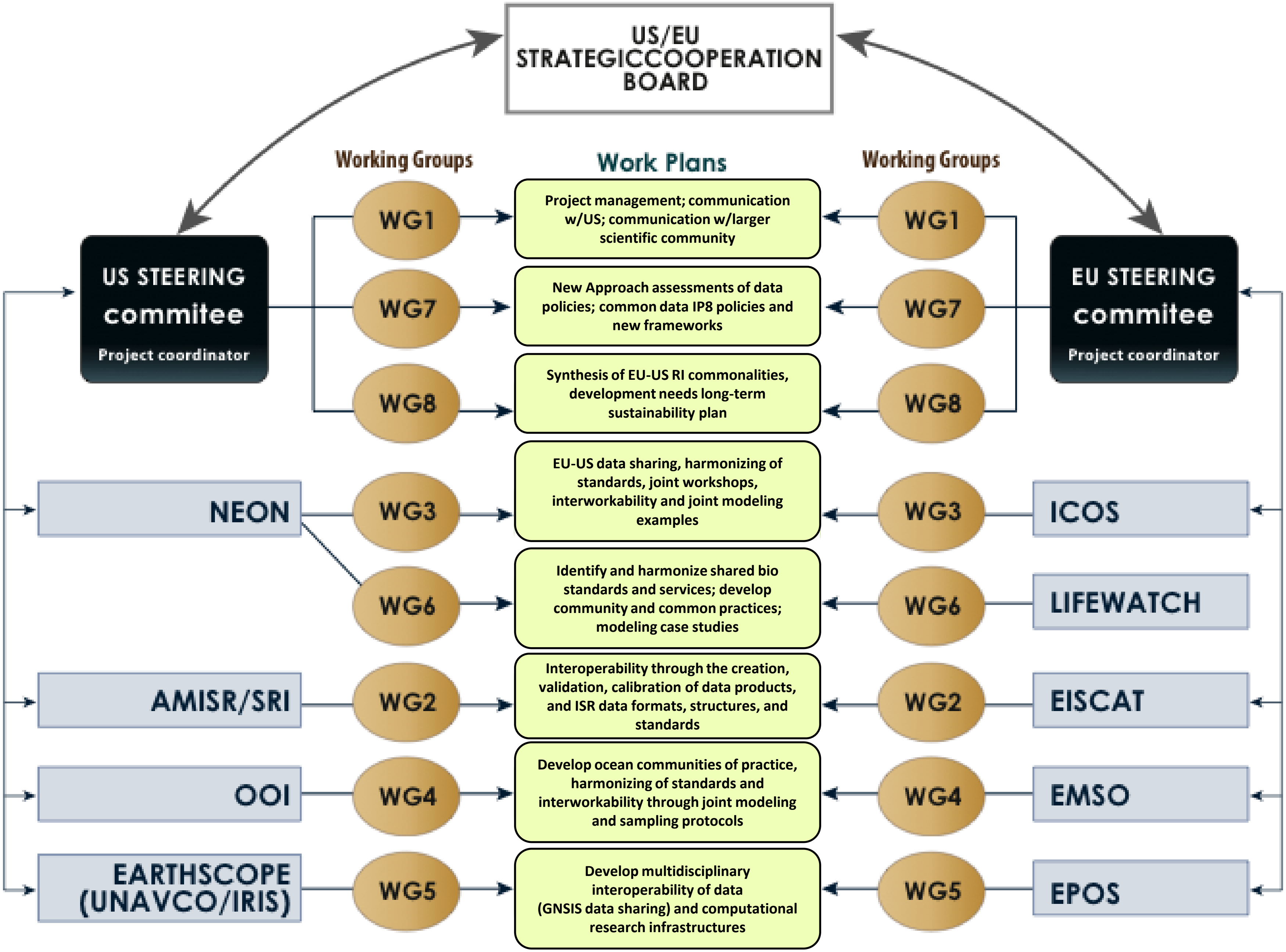
Balancing Scientific Creativity with Baseline measurements

Systems Engineering Approach



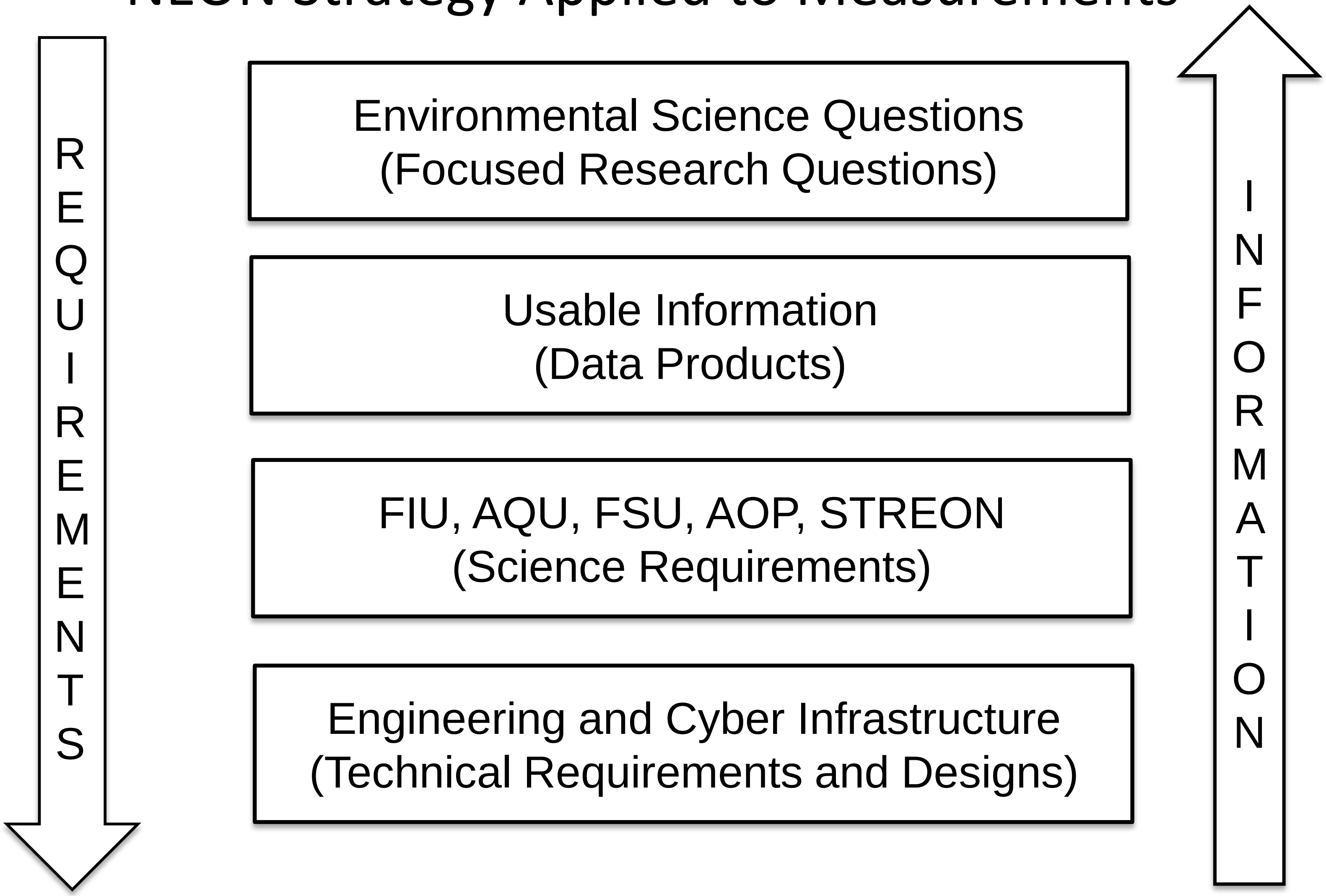
- Formalized hierarchical requirements
- Asks ‘what must be done?’
- Measurements are considered baseline
- Steps are parsed out (see diagram)

Pro	Con	
✔		New roles for scientists, both internally and externally
✔		**Clearly defines scope, budget, schedule, risks**
✔		Complexity is inherently planned for
✔		Develops planning horizons for Program Officers/Sponsors
✔		Fosters long term sustainability
✔	✕	Requirement approach does not necessarily impose a single unique solution


US/EU
STRATEGICCOOPERATION
BOARD
Working Groups
Work Plans
Working Groups
US STEERING
commitee
Project coordinator
EU STEERING
commitee
Project coordinator
WG1
Project management; communication w/US; communication w/larger scientific community
WG1
WG7
New Approach assessments of data policies; common data IP8 policies and new frameworks
WG7
WG8
Synthesis of EU-US RI commonalities, development needs long-term sustainability plan
WG8
NEON
WG3
EU-US data sharing, harmonizing of standards, joint workshops, interworkability and joint modeling examples
WG3
ICOS
WG6
Identify and harmonize shared bio standards and services; develop community and common practices; modeling case studies
WG6
LIFEWATCH
AMISR/SRI
WG2
Interoperability through the creation, validation, calibration of data products, and ISR data formats, structures, and standards
WG2
EISCAT
OOI
WG4
Develop ocean communities of practice, harmonizing of standards and interworkability through joint modeling and sampling protocols
WG4
EMSO
EARTHSCOPE
(UNAVCO/IRIS)
WG5
Develop multidisciplinary interoperability of data
(GNSIS data sharing) and computational research infrastructures
WG5
EPOS

NEON's Scientific Approach

NEON Strategy Applied to Measurements



Scientist Roles

<u>Capabilities based</u>
(networks)

- "What can we do?"
- PI driven – grant structure
- Strong scientific creativity
- Deliverable 'themes'
- Discovery/experiments
- Open ended

<u>Examples</u>

- LTER
- AmeriFlux - Fluxnet
- GLEON
- BASIN
- CZO

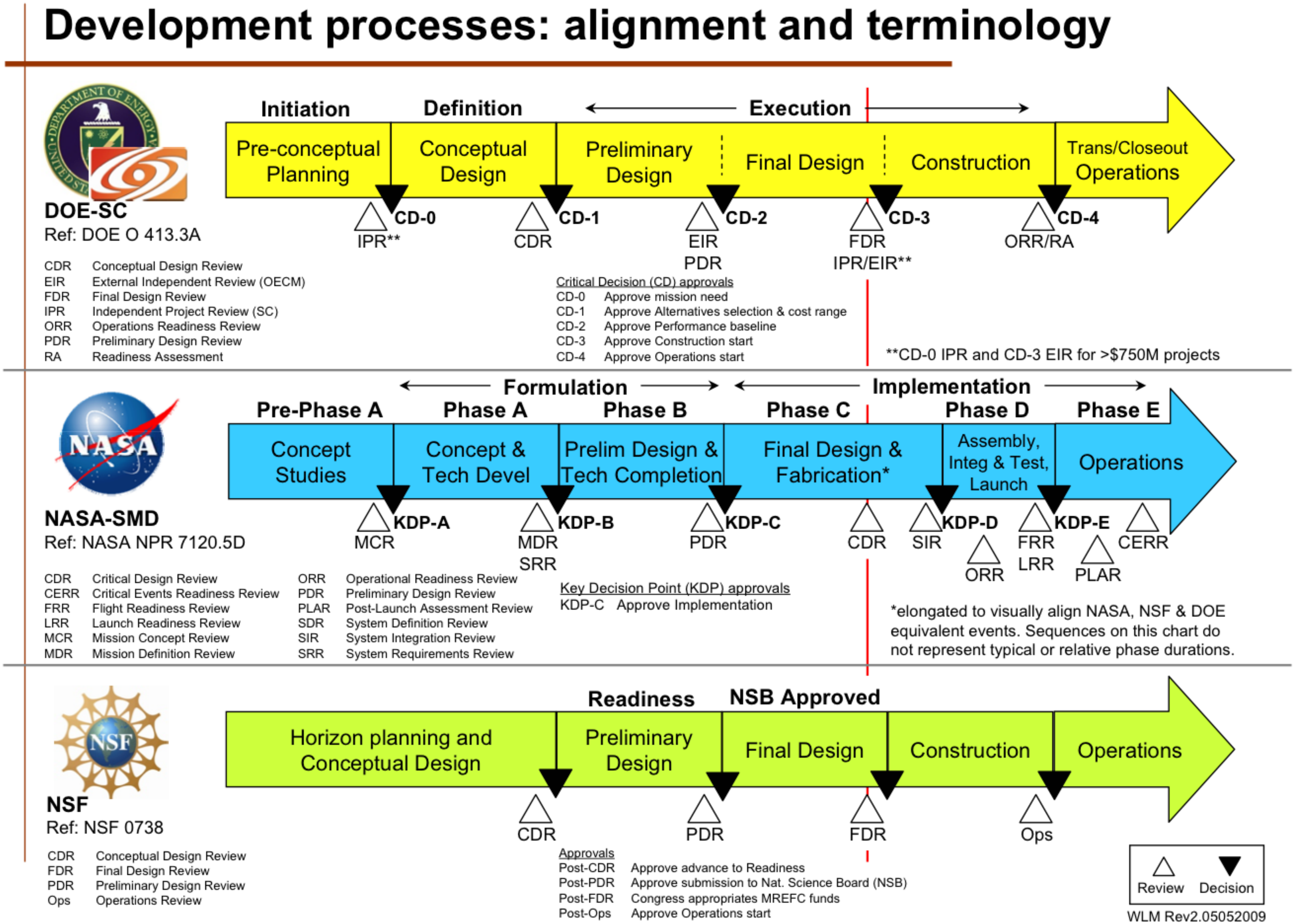
<u>Requirements based</u>
(infrastructure)

- What must be done?"
- Community engagement
- Mature baseline science
- Well defined deliverables
- Science sustainment
- Manage costs/risk/scope

<u>Examples</u>

- NSF Observatories
- DOE ARM
- NOAA US CRN
- OK Mesonet
- NASA Satellites

Development of Large Project Science



Thanks

Many respondents appeared to desire more specific details and expressed an interest in data communicated that can be readily used in their work.

The National Ecological Observatory Network is a project sponsored by the National Science Foundation and managed under cooperative agreement by NEON Inc.

Organization

<u>NEON – National Ecological Observatory Network - US</u>

"…to *enable understanding* and *forecasting* of the *impacts* of ***climate change, land use change*** and ***invasive species*** on *continental-scale* ***ecology*** by providing infrastructure to support research, education and environmental management in these areas."

single supporting agency – National Science Foundation

175 staff HQ in Boulder CO – and growing (currently ^45 staff)

Russ Lea	CEO
Krista Laursen	Project Manager
Dave Tazik	Project Scientist
Hank Loescher	Assistant Director of BioMeteorology
Andrea Thorne	Assistant Director of Terrestrial Ecology
Tom Kampe	Assistant Director of Remote Sensing
Steve Berukoff	Assistant Director of Data Products
Heather Powell	Assistant Director of Aquatic Sciences
Bob Tawa	Director of CyberInfrstructure

Other NEON Deets

$433 mil in MREFC,
Five year construction schedule, we are in the first year in construction
~ 70 mil y-1 operations budget, planning for a 30-y life span

Primary Participation WP 3 and 6 w/ partners ICOS and Lifewatch

Activity Participate in WP 1, 7, and 8

Coordinate the funding support from NSF to the other Observatories

30 - 40 day data latency
Open data policy
All data at HQ

Constructing the data formats and data portals
ISO protocols
Partners in 15 international organizations
Ingest 75 national datasets from other agencies