SoSECIE Webinar

Welcome to the
2021 System of Systems Engineering Collaborators
Information Exchange (SoSECIE)

NDIA National Defense Industrial Association

MITRE

We will start at 11AM Eastern Time

You can download today's presentation from the SoSECIE Website:

https://mitre.tahoe.appsembler.com/blog

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NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
  Mr. Rick Poel, Boeing
  Ms. Jennie Horne, Raytheon
OSD Liaison:
  Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- I have muted all participant lines for this introduction and the briefing.
- If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.
- Download the presentation so you can follow along on your own
- We will hold all questions until the end:
  - I will start with questions submitted online via the CHAT window in Teams.
  - I will then take questions via telephone; State your name, organization, and question clearly.
- If a question requires more discussion, the speaker(s) contact info is in the brief.

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2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars

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March 23, 2021
Fuzzy Architecture Description for Handling Uncertainty in IoT Systems-of-Systems
Flavio Oquendo

April 6, 2021
Holistic architecture description for a future Global Health Assurance Systems of Systems
Adrián Unger

April 20, 2021
Leveraging Set-Based Practices to Enable Efficient Concurrency in Large Systems and Systems-of-Systems Engineering
Brian Kennedy

May 4, 2021
OUSD R&E: USD(R&E) Mission Engineering (ME) State of Practice
Elmer L. Roman

May 18, 2021
Application of Probabilistic Graph Models to Kill Chain and Multi-Domain Kill Web Analysis Problems
Jason Baker and Valerie Sitterle

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars

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June 1, 2021
Applying an MBSE Approach for Evaluating Shipyard Operations
David Jurkiewicz

June 15, 2021
Implementing a Digital Engineering Environment for Mission Engineering
Jason Anderson and Jeffrey Boulware

June 29, 2021
Digital Engineering: From Toolchain to Platform
Dr. Aleksandra Markina-Khusid

July 13, 2021
Developing Meta Systems Architectures for Leading Innovation with Complex Societal and Technical Challenges
Dr. Cihan Dagli

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

Distributed Architecture for Monitoring Urban Air Quality: A Systems Engineering Approach

System of Systems Engineering
Collaborators Information Exchange (SoSECIE)

March 9th, 2021
11:00 a.m. to Noon Eastern Time

Speaker: Adrián Unger
adrianunger@gmail.com
www.linkedin.com/in/adrian-unger-systemsengineer

Georgia Institute of Technology
Professional Master's in Applied Systems Engineering (2019)

Agenda

- Motivation
- Project goals
- Context
- Development process
- Conclusions
- Acknowledgements

Motivation

- Capstone Project
- Sponsor: Georgia Tech’s PMASE program
- Co-sponsor: NASA’s Earth Science & Technology Office
- Support to New Observing Strategies (NOS) project

Project Goals

- Urban air quality domain
- Use of SE methods & tools
- Needs, use cases & high-level requirements
- Distributed monitoring architecture
- Focus on Research // Early Adopters // 3 Rs (reproducibility, replicability & reliability)

Why Urban Air Quality?

UN environment programme

Air pollution, which kills an estimated 7 million people every year, is the biggest environmental health risk of our time.

unenvironment.org/explore-topics/air/about-air

*The **short-lived climate pollutants** black carbon, methane, tropospheric ozone, and hydrofluorocarbons are the most important contributors to the man-made global greenhouse effect after carbon dioxide, **responsible for up to 45% of current global warming**.* (IGSD, 2013)

SUSTAINABLE DEVELOPMENT GOALS

3 GOOD HEALTH AND WELL-BEING

7 AFFORDABLE AND CLEAN ENERGY

11 SUSTAINABLE CITIES AND COMMUNITIES

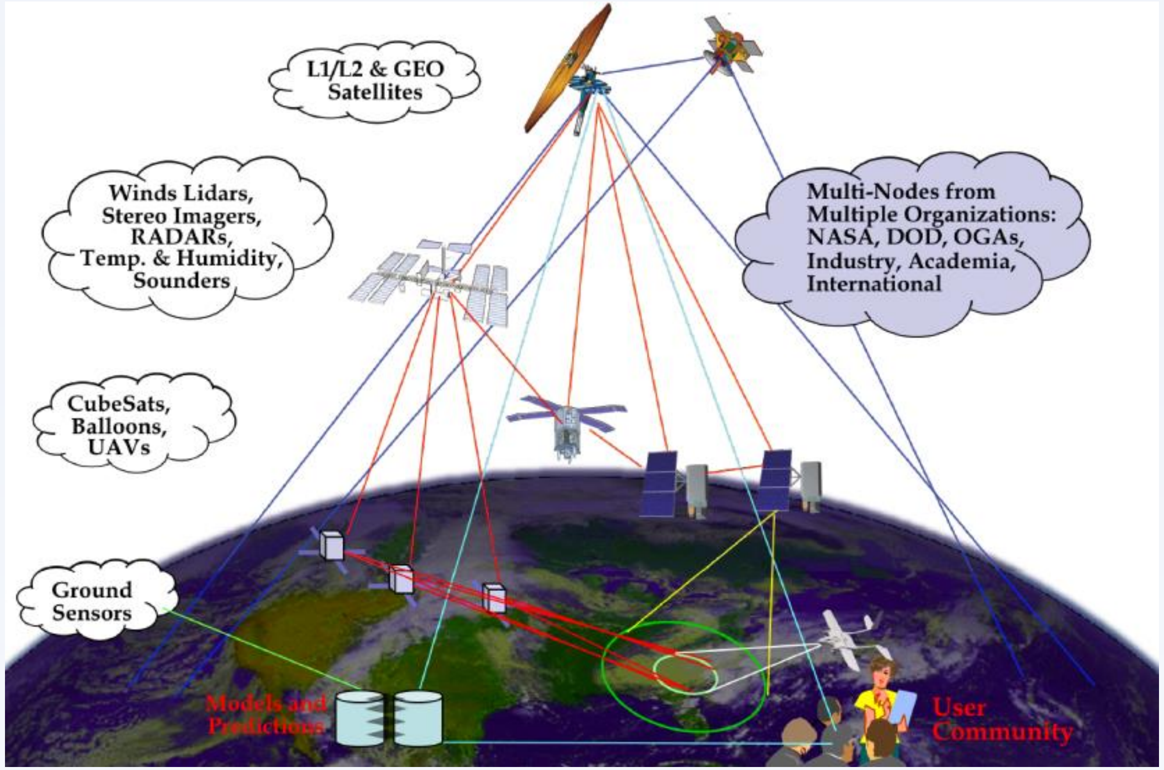
12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

17 PARTNERSHIPS FOR THE GOALS

Why a Distributed Monitoring System?

- Multiple sources, users & technologies
  - Satellites to indoor monitoring
  - Public, Private, Research, etc.
- System of Systems
  - Multiple purposes and level of stakeholders
  - Multiple lifecycles
  - Multiple owners (& governance)
- Allow data sharing and processing
- Georeferenced decision-making



ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190028350.pdf

Development Process

Mission Analysis

Use Case Analysis

Sociotechnical Analysis

Requirements Analysis

System Architecture

Development Process

- Mission Analysis
- Use Case Analysis
- Sociotechnical Analysis
- Requirements Analysis
- System Architecture

Mission Analysis

Monitoring

- Access by nodes
- Raw & processed data
- Data validation (reliability)

Action

- Action from nodes
- Current situation triggers
- Enhanced monitoring or mitigation

Predictive

- Action from nodes
- Predictive model triggers
- Avoid or reduce consequences

Mission Analysis

Stakeholder & Use Case Analysis

Sociotechnical Analysis

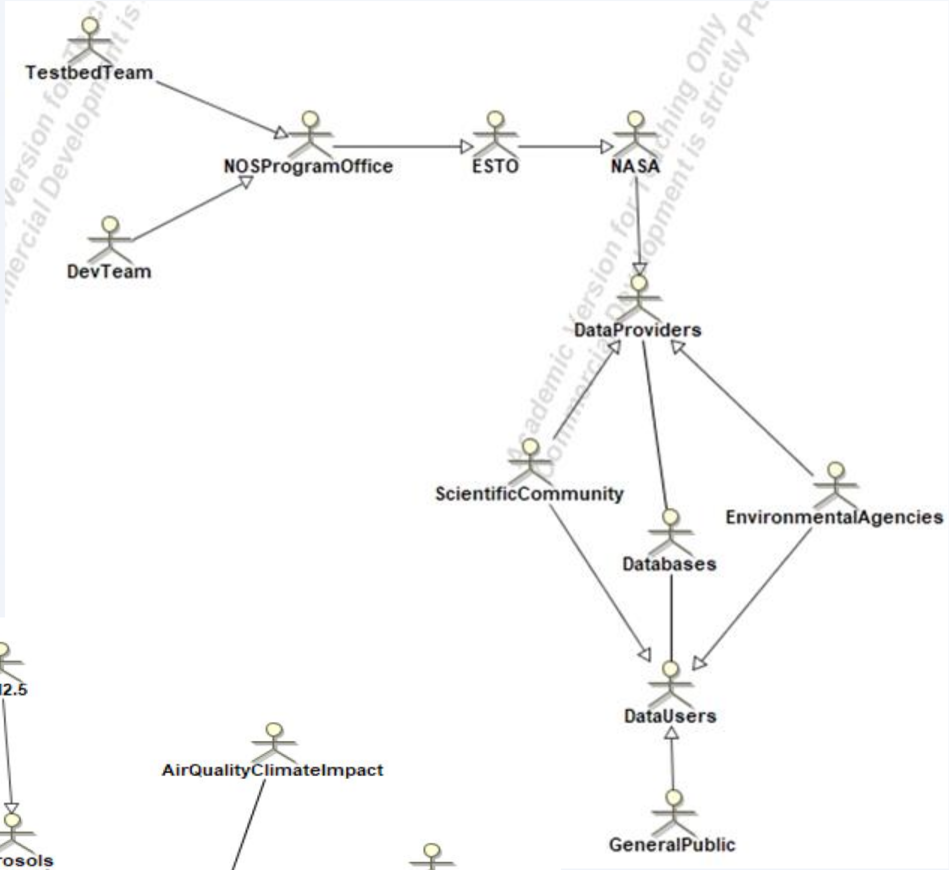
Requirements Analysis

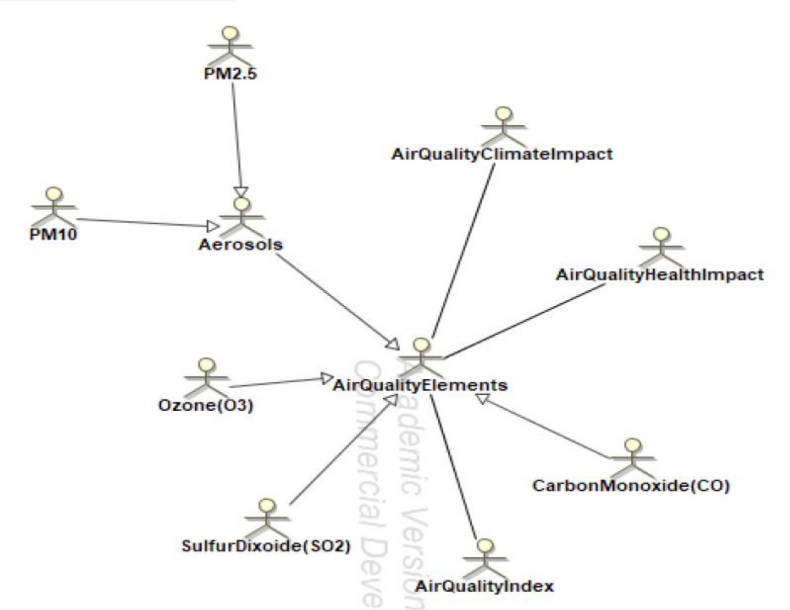
System Architecture

Stakeholder & Use Case Analysis

- Actor identification
- Multi-level use cases

- Primary Stakeholders: **Data Providers** and **Data Users**
- NASA Earth Science Technology Office establishes infrastructure for NOS project.
- Data providers and data users interact with and utilize infrastructure to receive data product.
- Scientific community and environmental agencies are primarily both a data provider and a data users. Concerned with precision and accuracy of data (fundamentally rooted in calibration of instruments and sensors… big challenge!)
- Non-personnel actors are air quality elements being sensed and correlated with research data



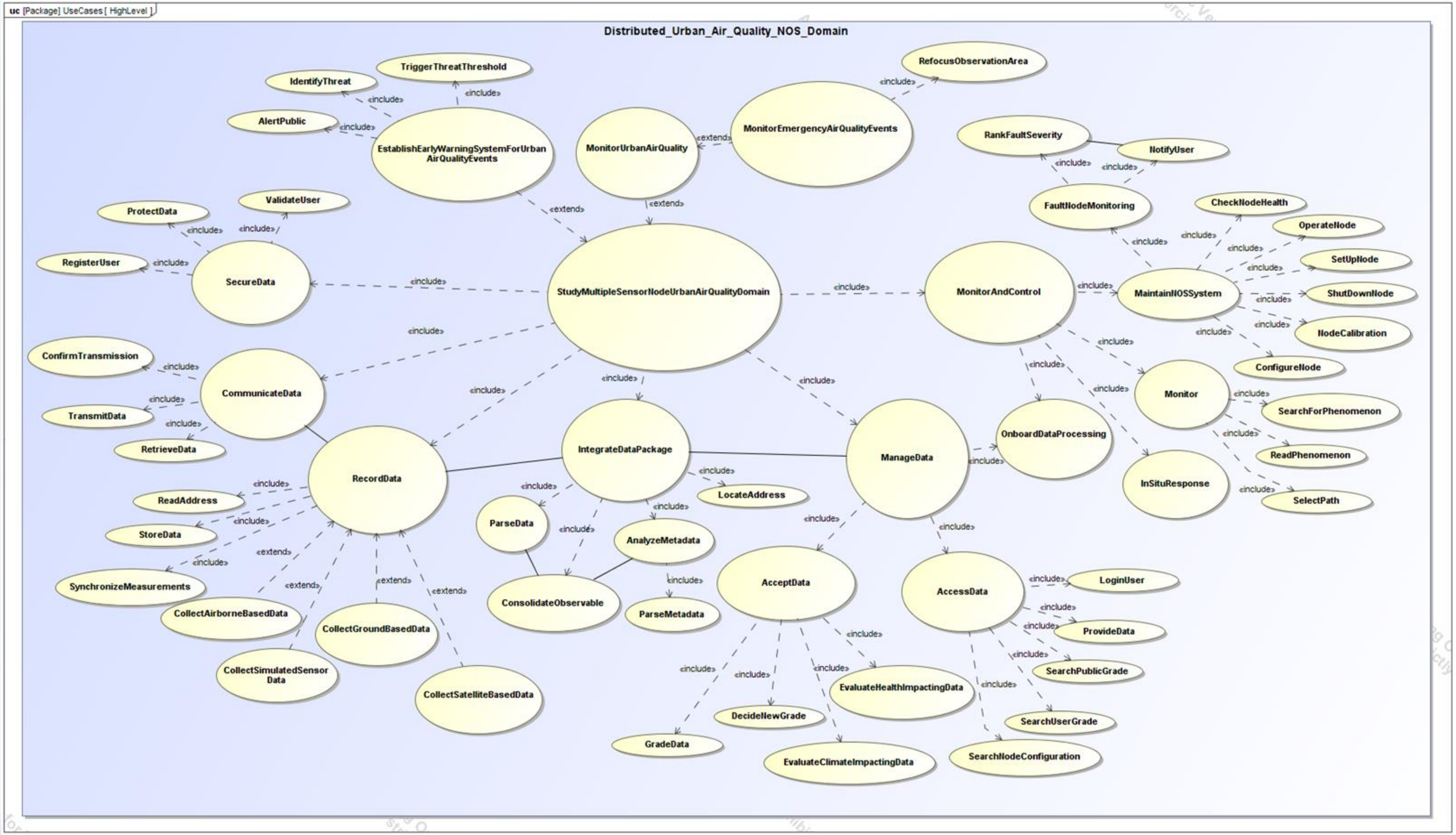


Primary Urban Air Quality NOS Use Cases:

- Data collection (Recording Data)
- Data Integration
- Data Management
- Data Communication
- Data Security
- Node Network Monitoring and Control

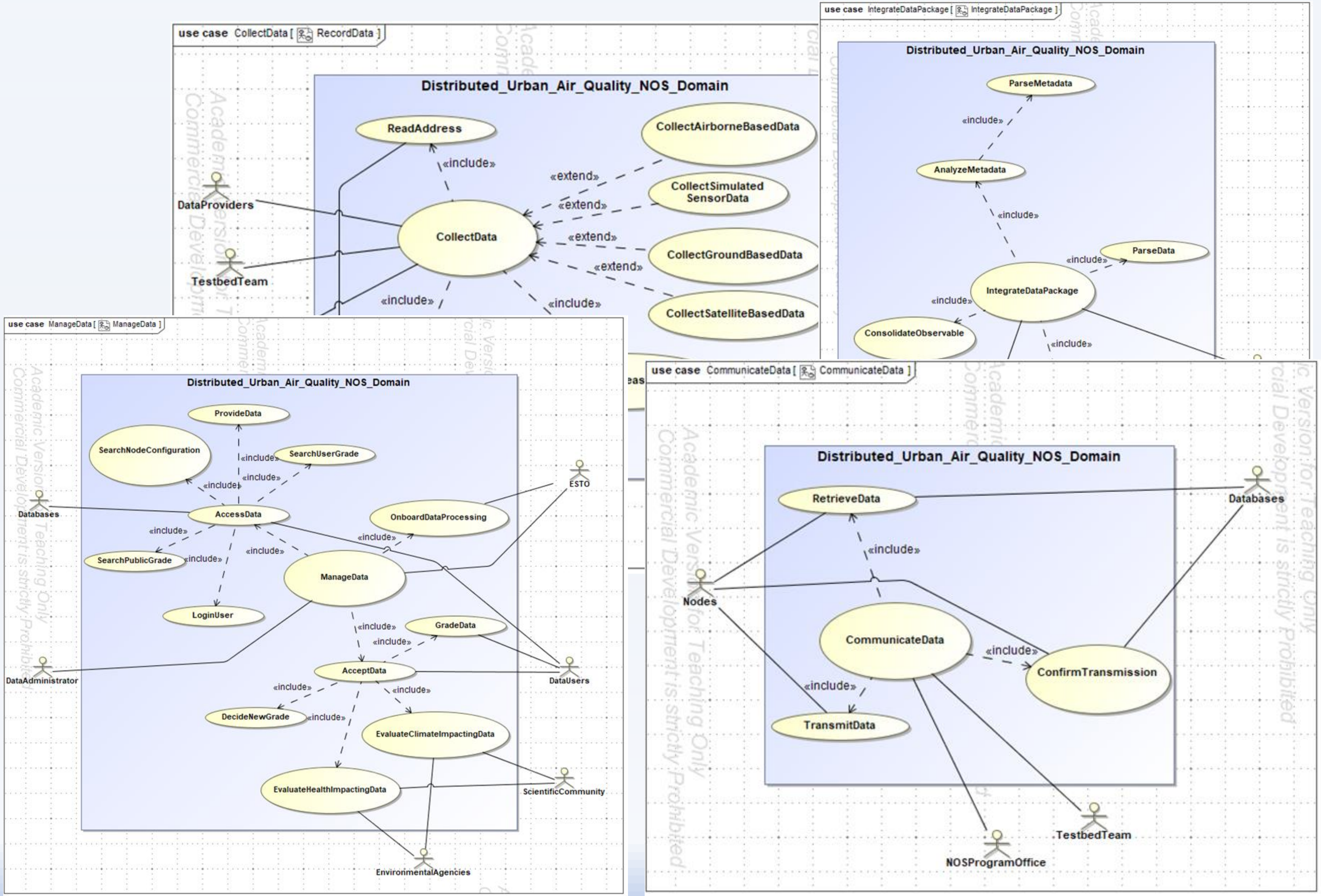
Use Case Extensions *(use all included elements of primary use case):*

- Monitoring Mode (Normal Operation)
- Emergency Mode "Refocusing"
- Early Warning (Predictive)



Use Cases

- Collect Data
- Integrate Data
- Manage Data
- Communicate Data
- Secure Data
- Monitor & Control



Mission Analysis

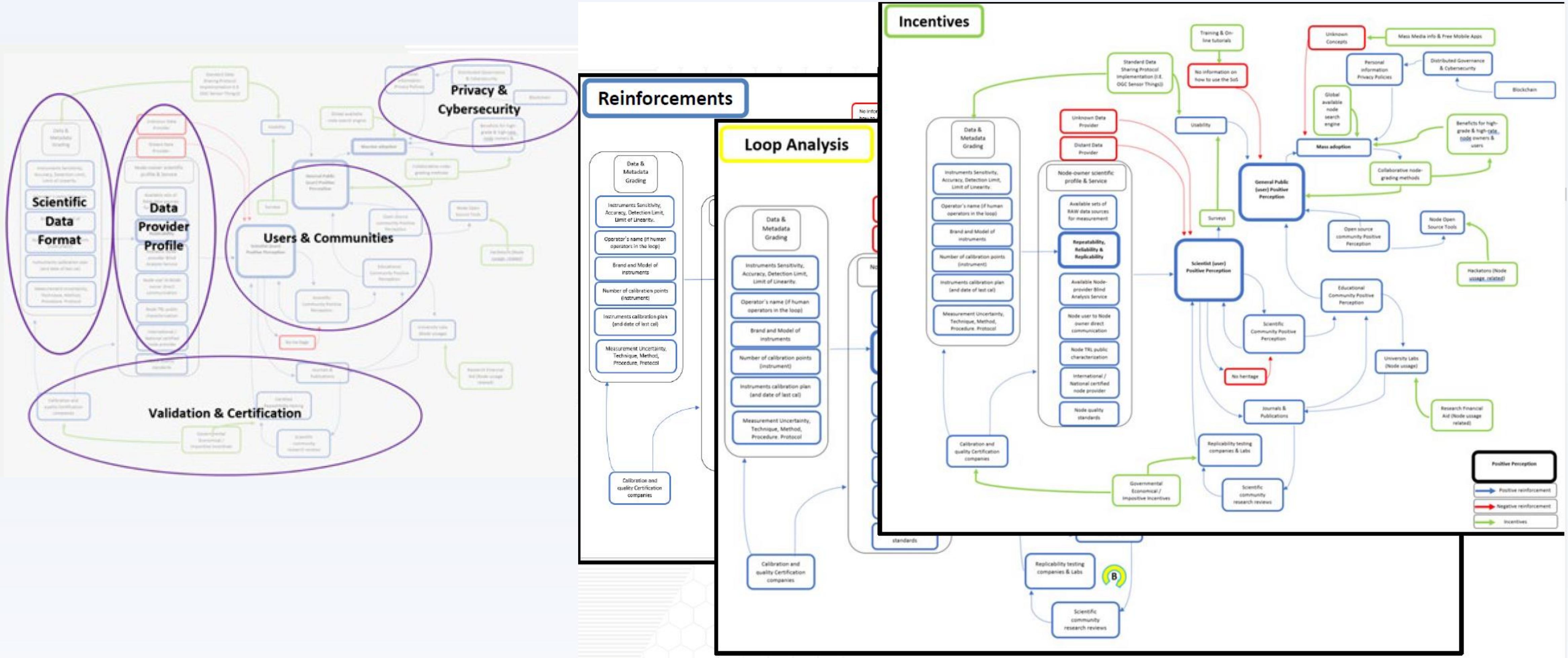
Use Case Analysis

Sociotechnical Analysis

Requirements Analysis

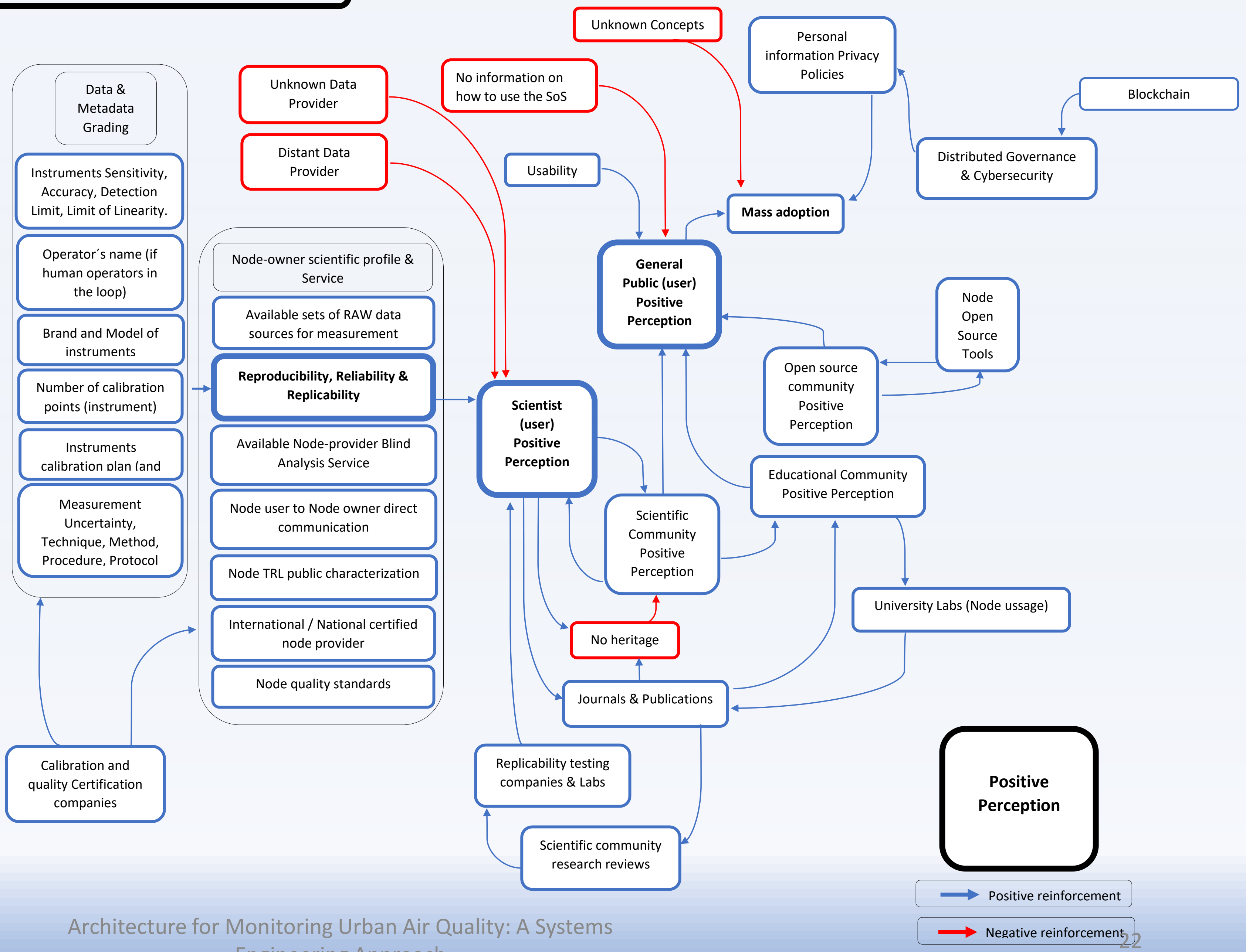
System Architecture

Sociotechnical Analysis



Interactions & Perceptions

- High-level mapping
- Support to requirement analysis
- Perception & confidence
- Required & desired
- Key aspects of influence
- (reproducibility, replicability & reliability)



Mission Analysis

Use Case Analysis

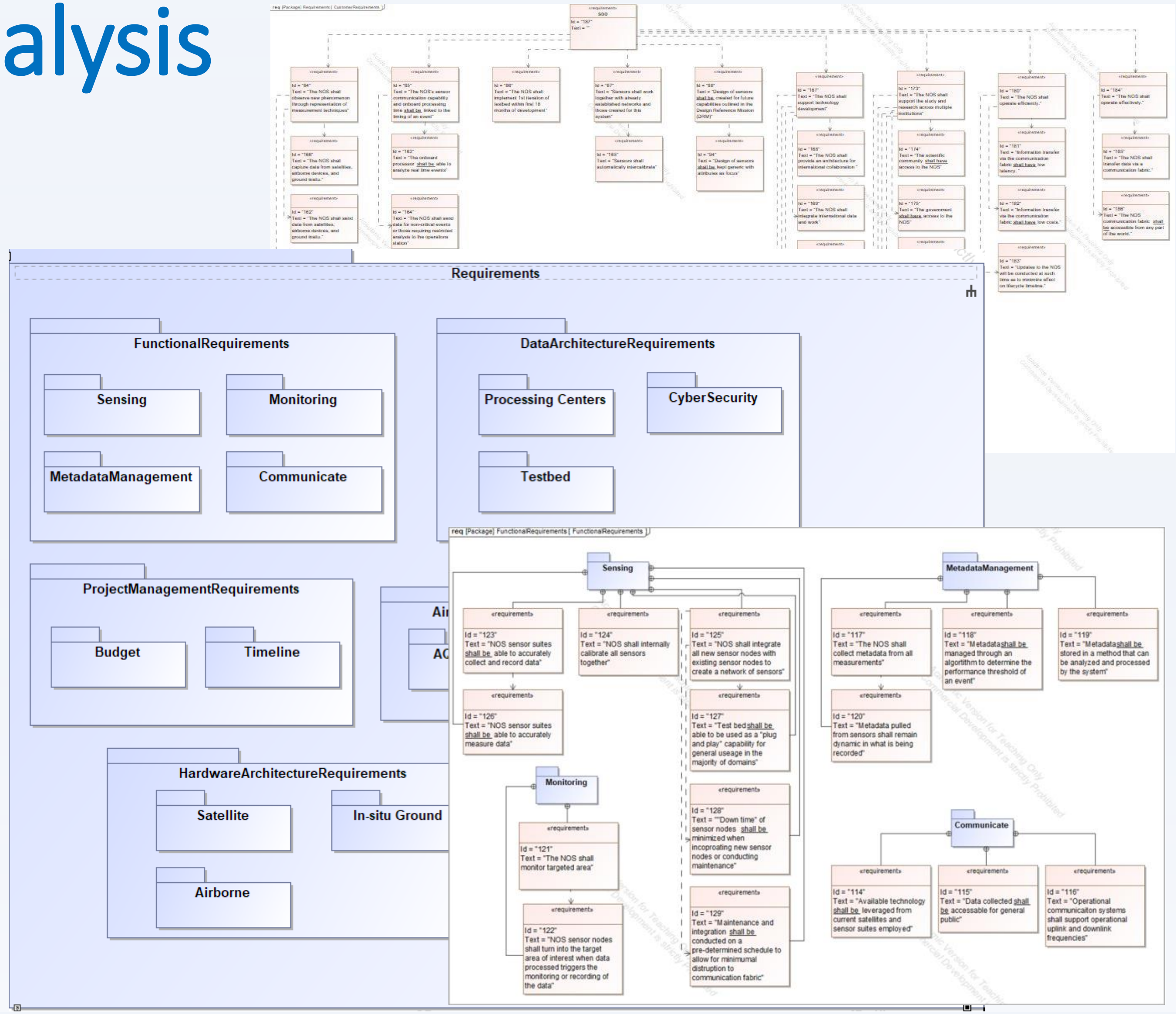
Sociotechnical Analysis

Requirements Analysis

System Architecture

Requirements Analysis

- Functional
- Data architecture
- Hardware architecture
- Sociotechnical
- Project management
- Air quality
- Human systems integration



Mission Analysis

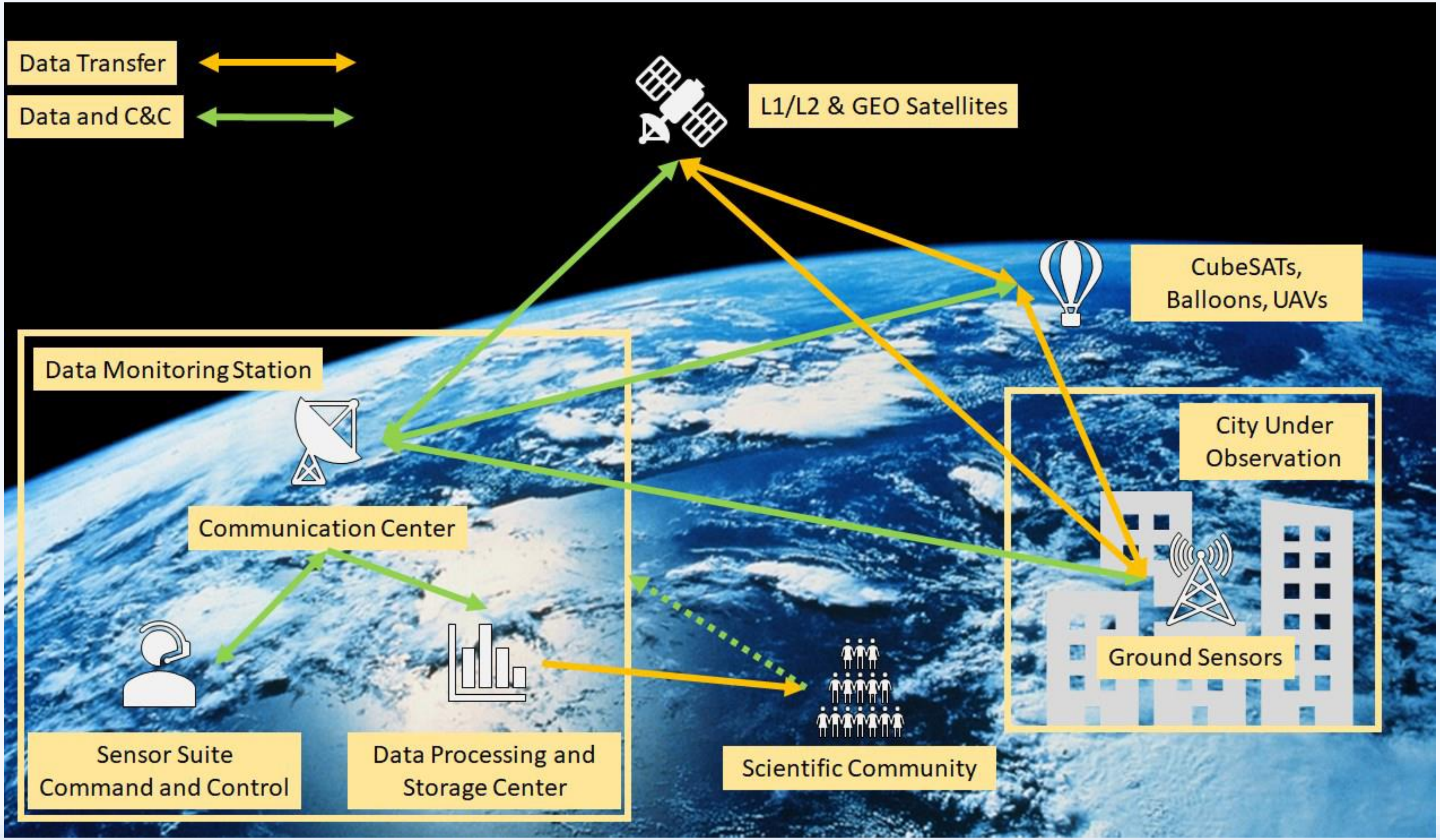
Use Case Analysis

Sociotechnical Analysis

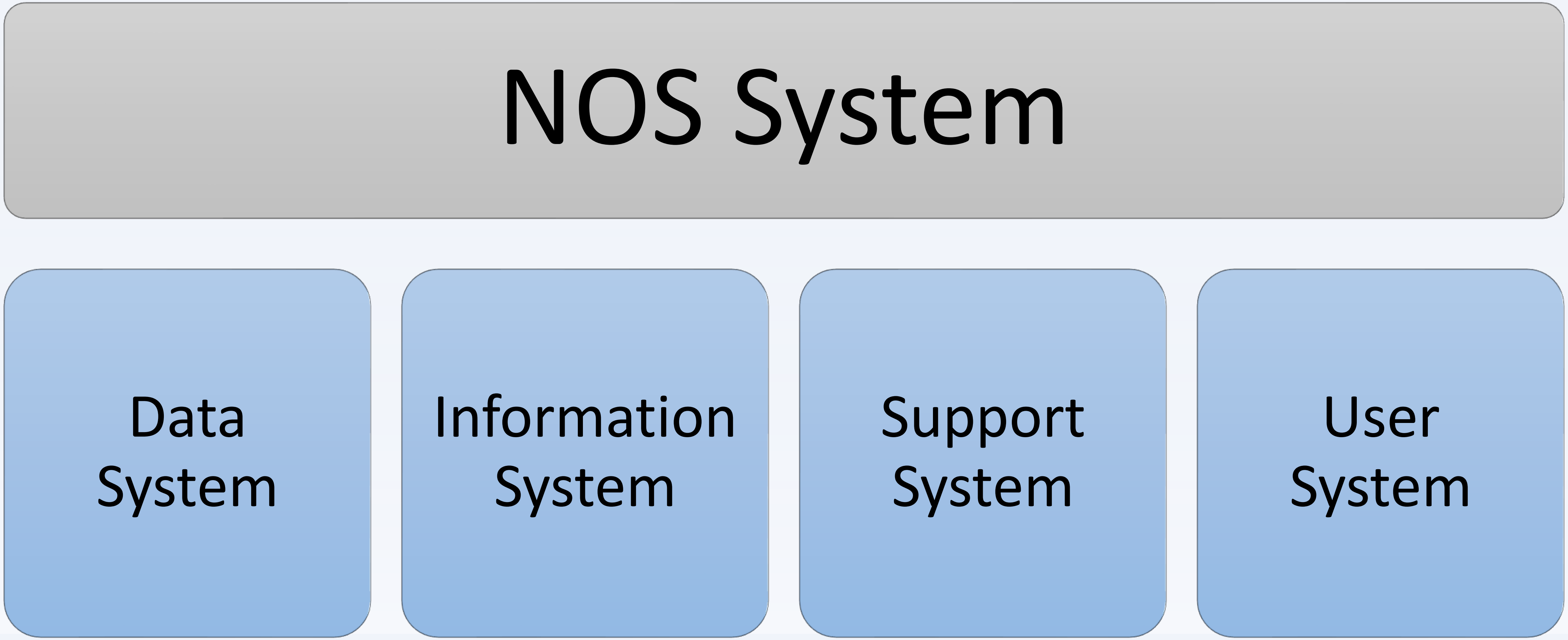
Requirements Analysis

System Architecture

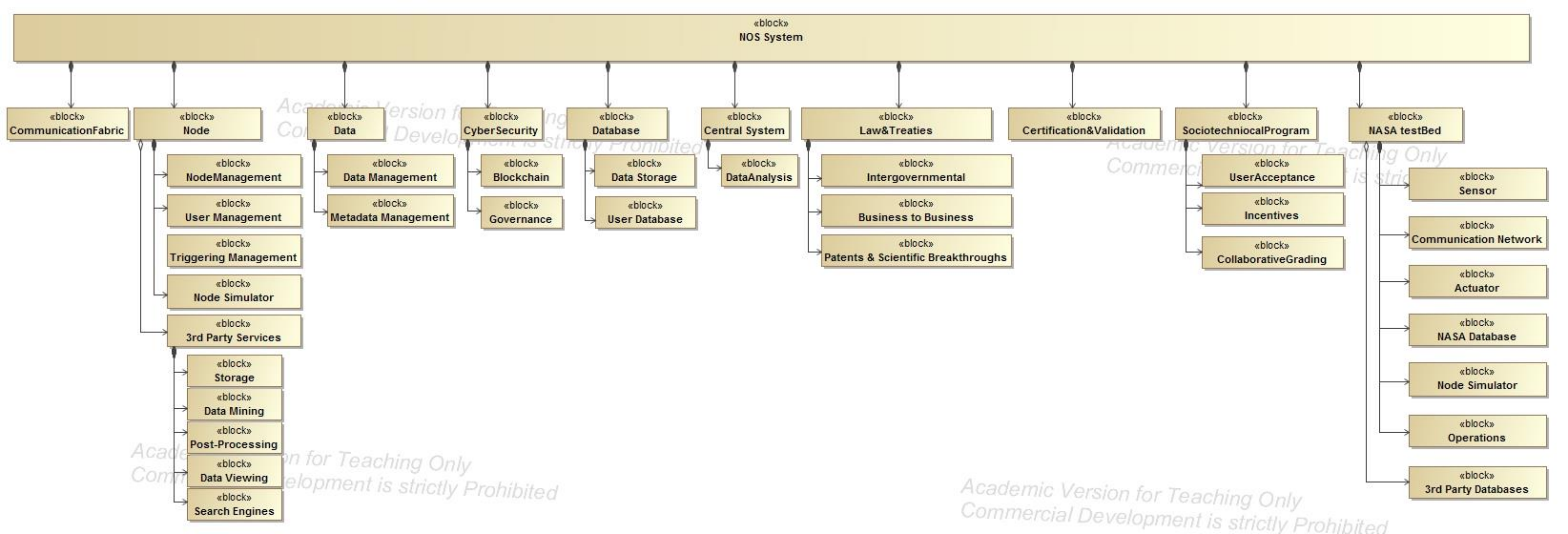
System Architecture



System Architecture



Proposed System (BDD)



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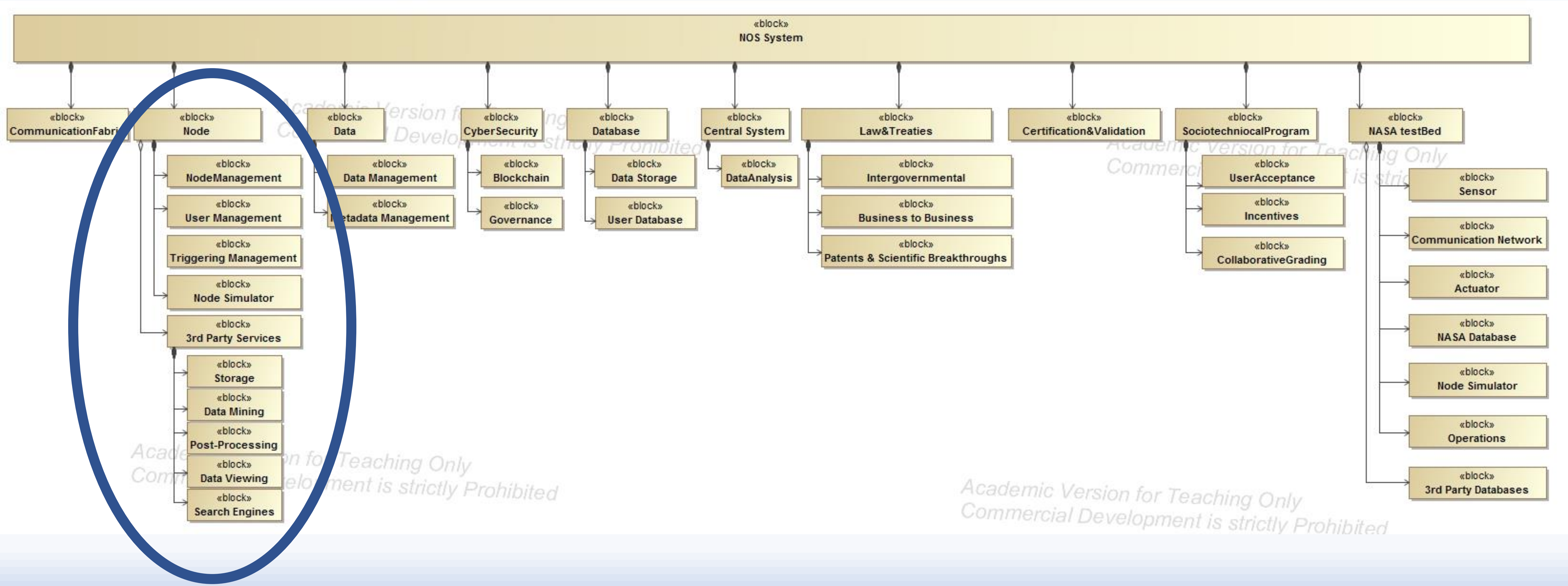
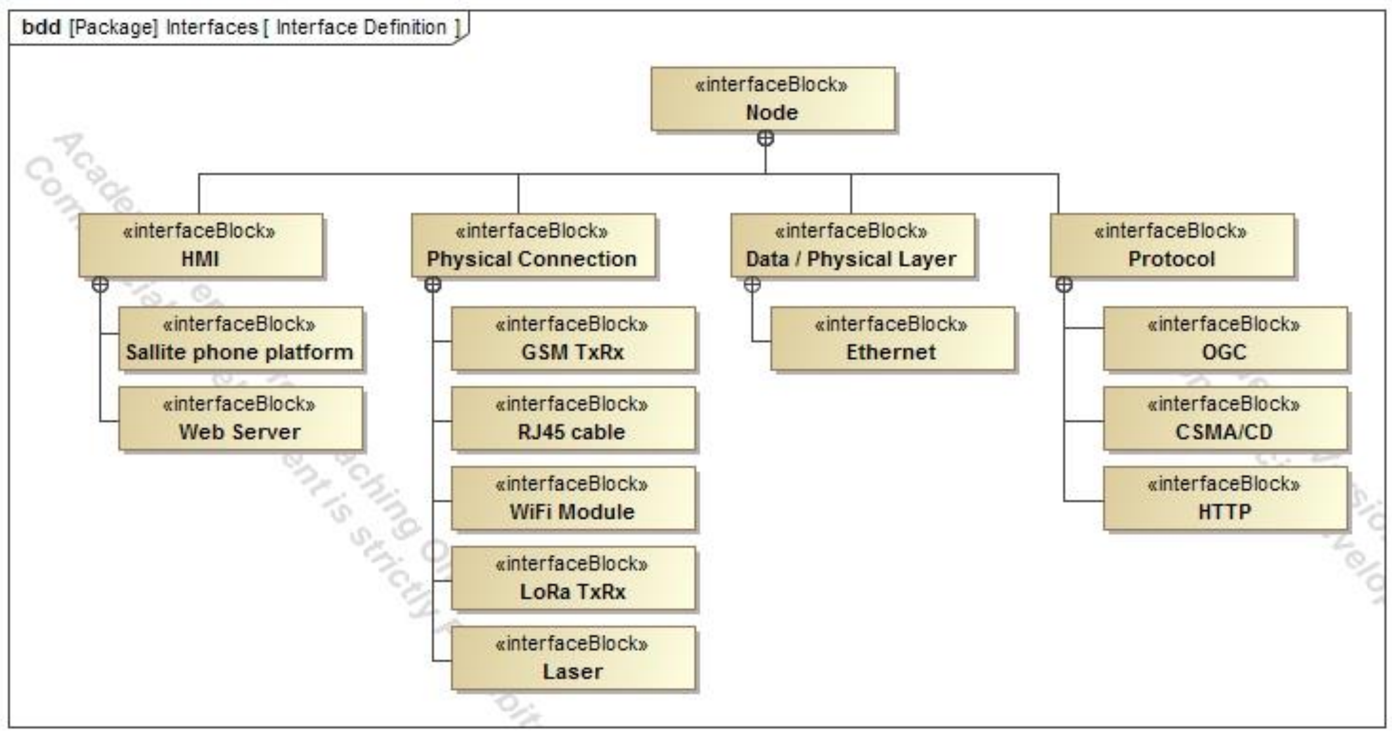
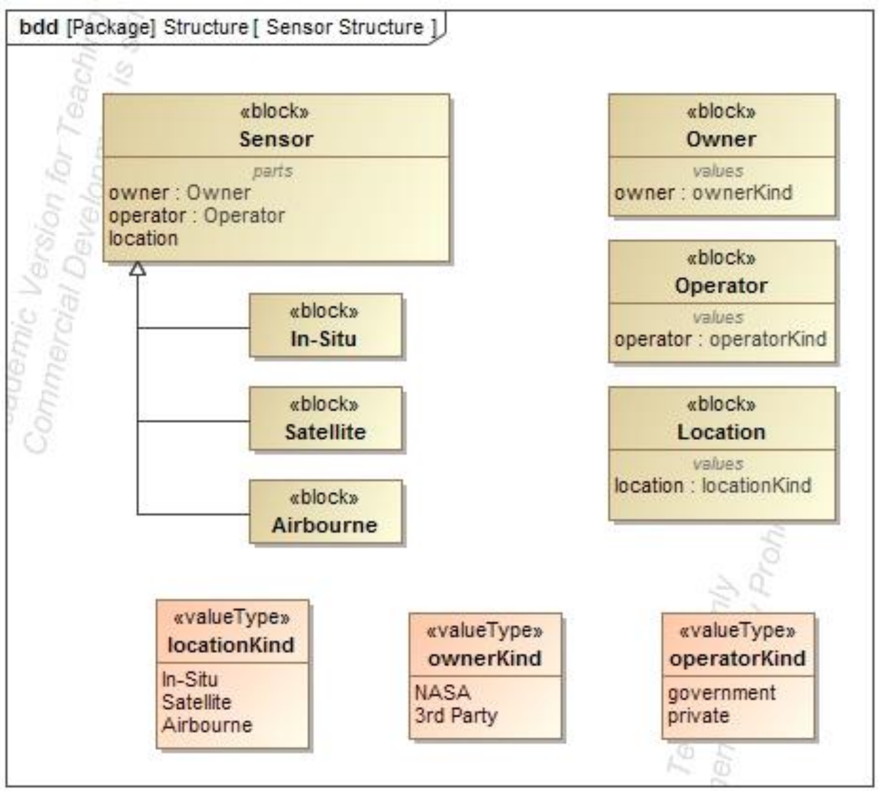
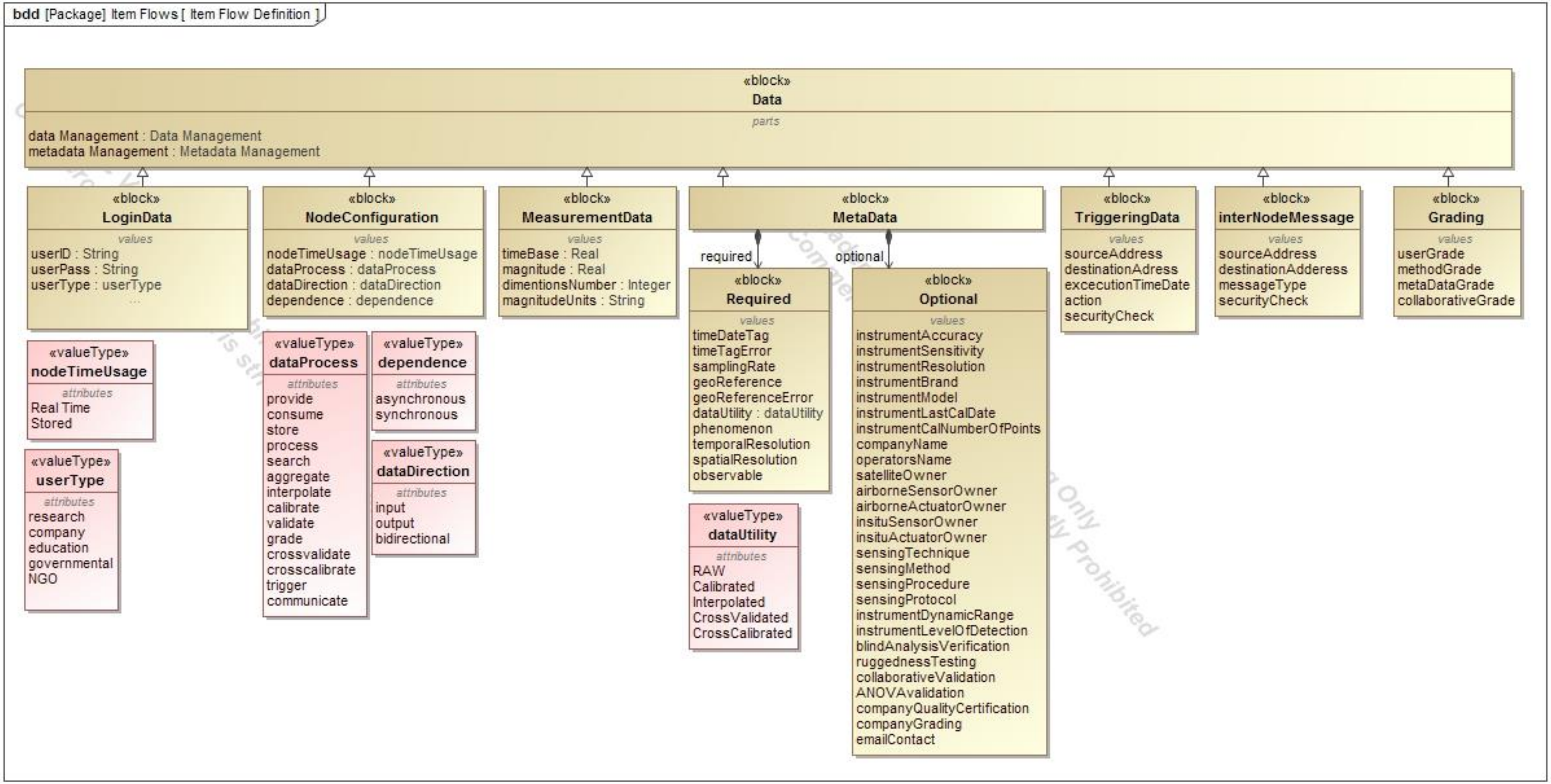


Node // Sensor





The concept of "Node" is critical and should be discussed in future work for deriving requirements (and establishing boundaries)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«block»
Data
parts
data Management : Data Management
metadata Management : Metadata Management
«block»
LoginData
values
userID : String
userPass : String
userType : userType
...
«block»
NodeConfiguration
values
nodeTimeUsage : nodeTimeUsage
dataProcess : dataProcess
dataDirection : dataDirection
dependence : dependence
«block»
MeasurementData
values
timeBase : Real
magnitude : Real
dimentionsNumber : Integer
magnitudeUnits : String
«block»
MetaData
required
optional
«block»
Required
values
timeDateTag
timeTagError
samplingRate
geoReference
geoReferenceError
dataUtility : dataUtility
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spatialResolution
observable
«block»
Optional
values
instrumentAccuracy
instrumentSensitivity
instrumentResolution
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instrumentModel
instrumentLastCalDate
instrumentCalNumberOfPoints
companyName
operatorsName
satelliteOwner
airborneSensorOwner
airborneActuatorOwner
insituSensorOwner
insituActuatorOwner
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sensingMethod
sensingProcedure
sensingProtocol
instrumentDynamicRange
instrumentLevelOfDetection
blindAnalysisVerification
ruggednessTesting
collaborativeValidation
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companyQualityCertification
companyGrading
emailContact
«block»
TriggeringData
values
sourceAddress
destinationAdress
excecutionTimeDate
action
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interNodeMessage
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sourceAddress
destinationAdderess
messageType
securityCheck
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Grading
values
userGrade
methodGrade
metaDataGrade
collaborativeGrade
«valueType»
nodeTimeUsage
attributes
Real Time
Stored
«valueType»
userType
attributes
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company
education
governmental
NGO
«valueType»
dataProcess
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consume
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interpolate
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crosscalibrate
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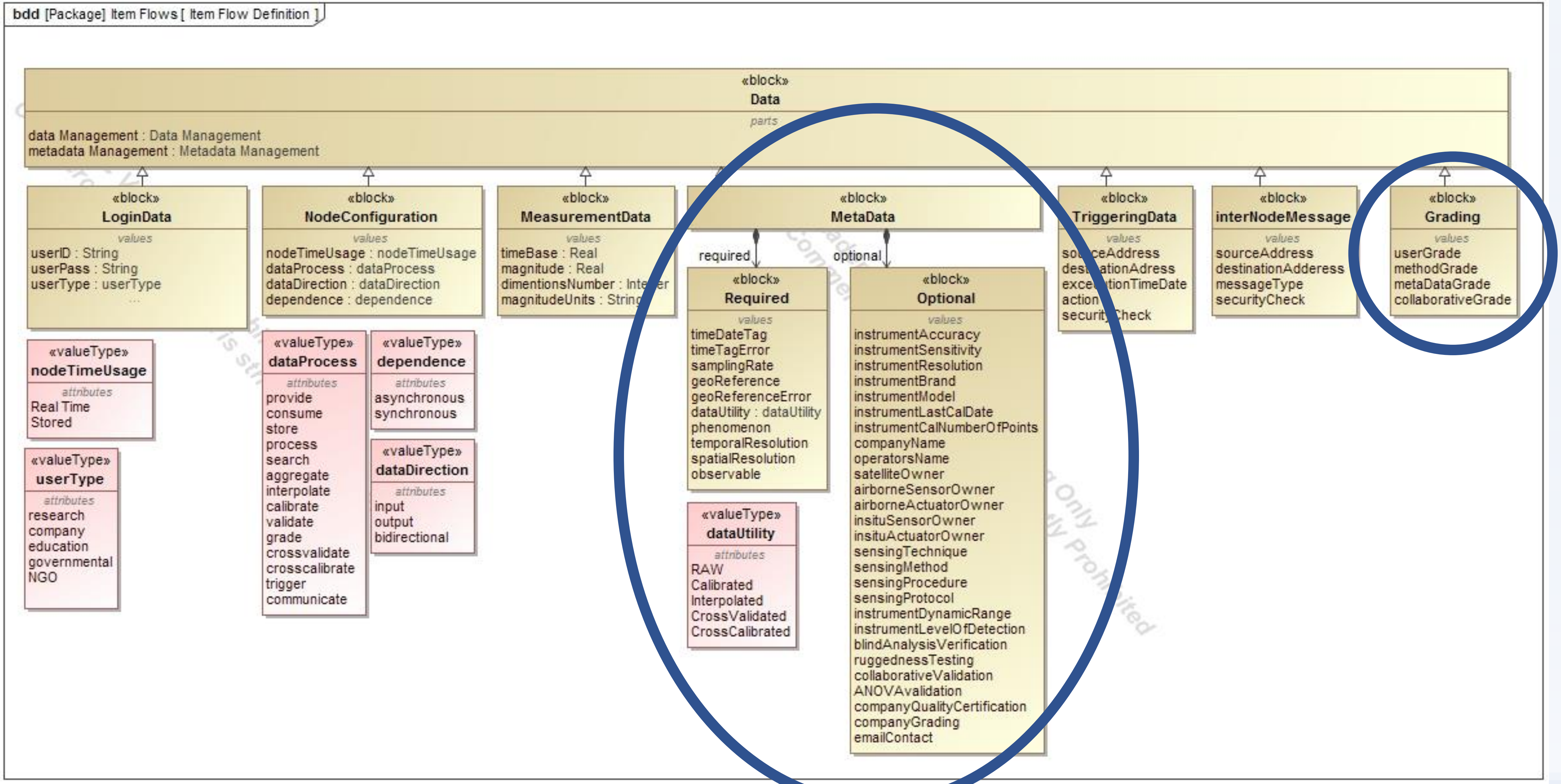
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ruggednessTesting
collaborativeValidation
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companyGrading
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destinationAdress
exceptionTimeDate
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securityCheck
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destinationAdderess
messageType
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userGrade
methodGrade
metaDataGrade
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«valueType»
nodeTimeUsage
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Real Time
Stored
«valueType»
userType
attributes
research
company
education
governmental
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consume
store
process
search
aggregate
interpolate
calibrate
validate
grade
crossvalidate
crosscalibrate
trigger
communicate
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dataDirection
attributes
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Air Quality Data Fusion: STATE OF THE ART

Massive amounts of historical data available, but in different formats

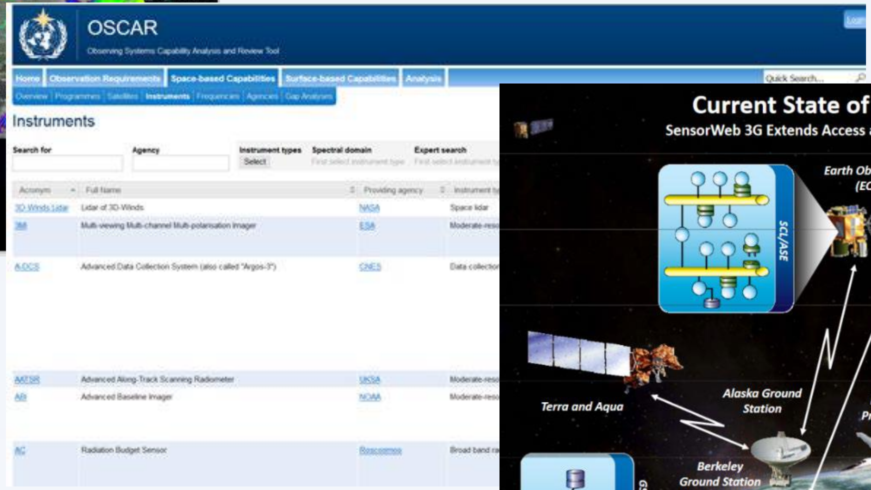
•For cross validation: not only Data fusión through analysis, but also through Machine Learning
•Two samples a day from satellite information for Air Quality (MODISTerra, Aqua, etc.)
•For cross calibration and aerosol Dynamic models simulation: Supercomputers
•Data Fusion methods need ground information: satellites measure vertical aerosol optical depth, ground sensors and air borne integrate horizontally
•Data sharing has started: “operational data” does not imply“ research data”
•Street level triggering with hundreds of meters of resolution need “low signal correlations”: ground sensor nets and interpolation.

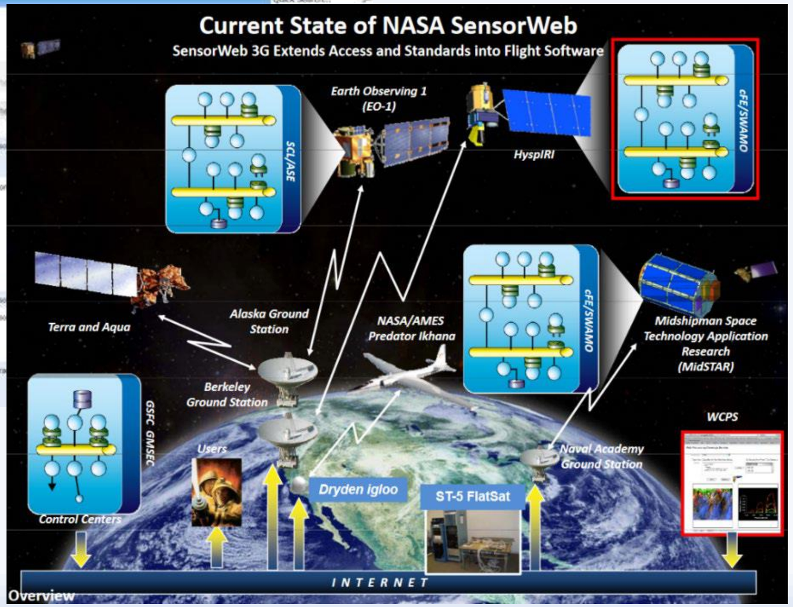
False positive & false negative events in Air Quality Observable detection may have expensive consequences.
•In the present, Automatic Triggering for Air Quality phenomena may need humans in the loop

Source: Dr. Mariel Friberg interviews & “Improving regional air quality modelling using machine learning to fuse surface and satellite information”, M.D. Friberg, R.A. Kahn, NASA GSGC, USRA.

Global Sharing: STATE OF THE ART

OGC®
Making location count.





- •Open Geospatial Consortium
- •OSCAR
- •Sensor Web

For further work

- How to quantify:
  - the relative importance of heterogeneous latency contributors
  - the total End-to-End latency (in all the existing use cases)
- Does OGC standards admit partial implementations of Blockchain? (for example: Blockchain only for MetaData)
- Without knowing the approximate data size to be requested from Servers, clients can be easily overwhelmed by very large responses from servers.
- Likewise, servers can also be overwhelmed by an unreasonable number of requests.
- How would these Standards manage triggering actions around the globe without being enabled by a Human in the Loop? (hypothesis: an actuator from one system is triggered by another system (from different owners)

Conclusions

- Flexible network node interface increase acceptance
- User perception and confidence is important
  - 3 “Rs”: Repeatability, Reliability & Reproducibility // Metadata
- Data validation and security as building blocks
- Commercial partners would enhance capabilities
- International standards may speed up definitions (i.e. OGC)
- This is a starting point. Much further work still required.

Acknowledgements

- Georgia Tech Professional Education
- NASA's Earth Science Technology Office
- Interviewed Scientists
- PMASE instructors & class of 2019

PMASE Capstone Team NASA

- Adrian Unger
- Dylan Shean
- Fabio G da Silva
- Jennifer Nguyen
- Laura B Beebe
- Philip Dewire
- Stephen Grzelak
- Tom McDermott (Mentor)

Thank you for your time

Now, Q&A

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