Science For A Better Life

Case Study in Geospatial Analytics: Building a Global Platform for Agro-Environmental Analysis

OGC Agriculture Domain Working Group 2016

09-22-2016 / Kris Matson / Version 2

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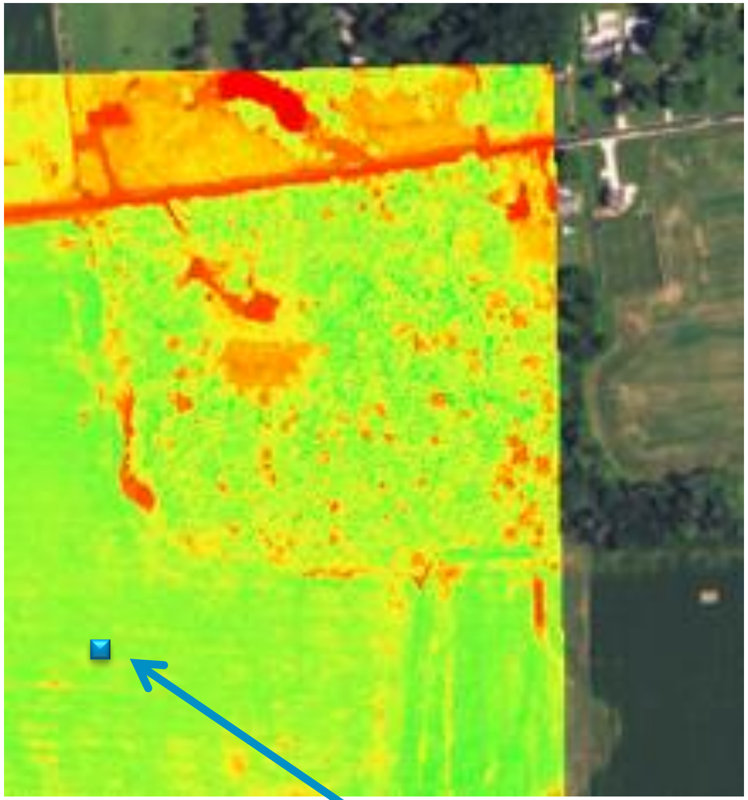
Bayer CropScience On-Farm Trials

Studying Real-World Product Response



30ft x 30ft research trial plot

Must understand crop protection product effects in real-world situations

- Efficacy trials on 30 X 30 foot plots do not easily translate to ½ mile X ½ mile fields
  - Not enough variability in the small plot
  - Large fields are not homogeneous
  - Practical conditions differ from R&D

Why answer questions on product response in the real world?

- Help growers to be more profitable – and grow more crops
- Help growers to be more sustainable – limit off-target effects

Helping growers to be more profitable and sustainable

Bayer CropScience On-Farm Trials

Challenges in trial data collection and management

Communicating and Managing Trial Protocols

- Originally communicated only at season start
- Insufficient data collection guidance
- Lack of visibility into protocol workflow & issues

Timely Collection of Protocol Data

- Bulk data egress at end-of-season → #epicfail

Missing Metadata

- Metadata is required for on-field activitiesas well as geospatial data

High-Variety & High-Volume Data

- Equipment, sensors, & FMIS software format all aggregate data differently

Result: Analysis and Modeling At-Scale is Difficult or Even Impossible

- **For analytics at-scale, standards are not optional**

> - End of year 1 - complete data from only 50% of trials.
> - Question: How to scale from 30 to 200 fields?
> - Answer: **STANDARDS**

USB is a standard…
but what about the files?!

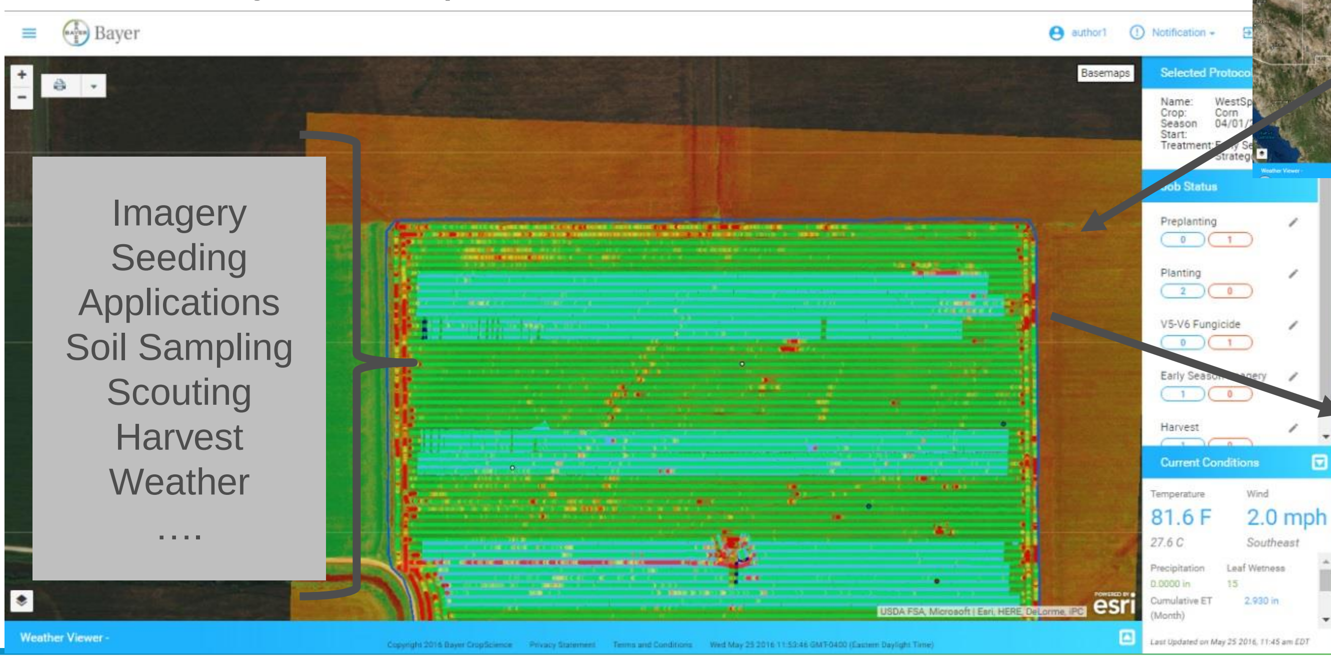
What We Are Building

A Field Trial Protocol Management System → FTPro

Software platform for the systematic collection, processing and analysis of trial data from commercial farm operations

Provides standardized data to visualization and analytic tools:

- To understand product performance and ROI
- Analyze multiple fields and seasons



Inspiration for this Presentation

Vision for Geospatial Analytics via Open Standards

OGC Future of Geo-Analytics

Lack of interoperability is a serious technical debt

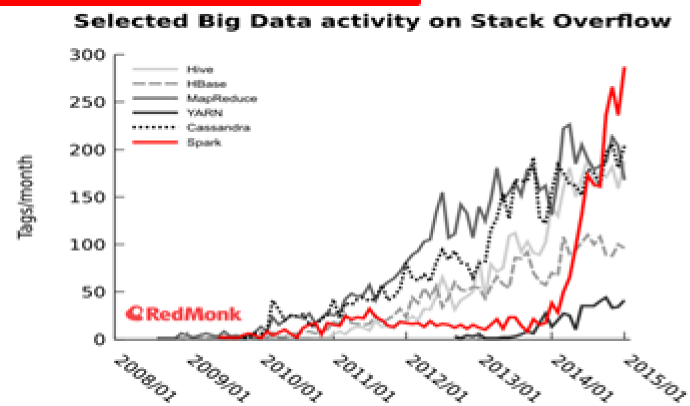
Lessons from the success of Apache Spark…

interchange is necessary for the ecosystem

major use cases tend to build their own ML libraries – despite a case where a majority of committers tend to support a common vision and encourage use of a canonical library (MLLib with DataFrames)

when a successful business grows over time, challenges arise by definition: managing separated teams, mergers and acquisitions, increased audits, regulations, etc.

therefore, lack of interchange for analytics represents a serious technical debt and potential liability

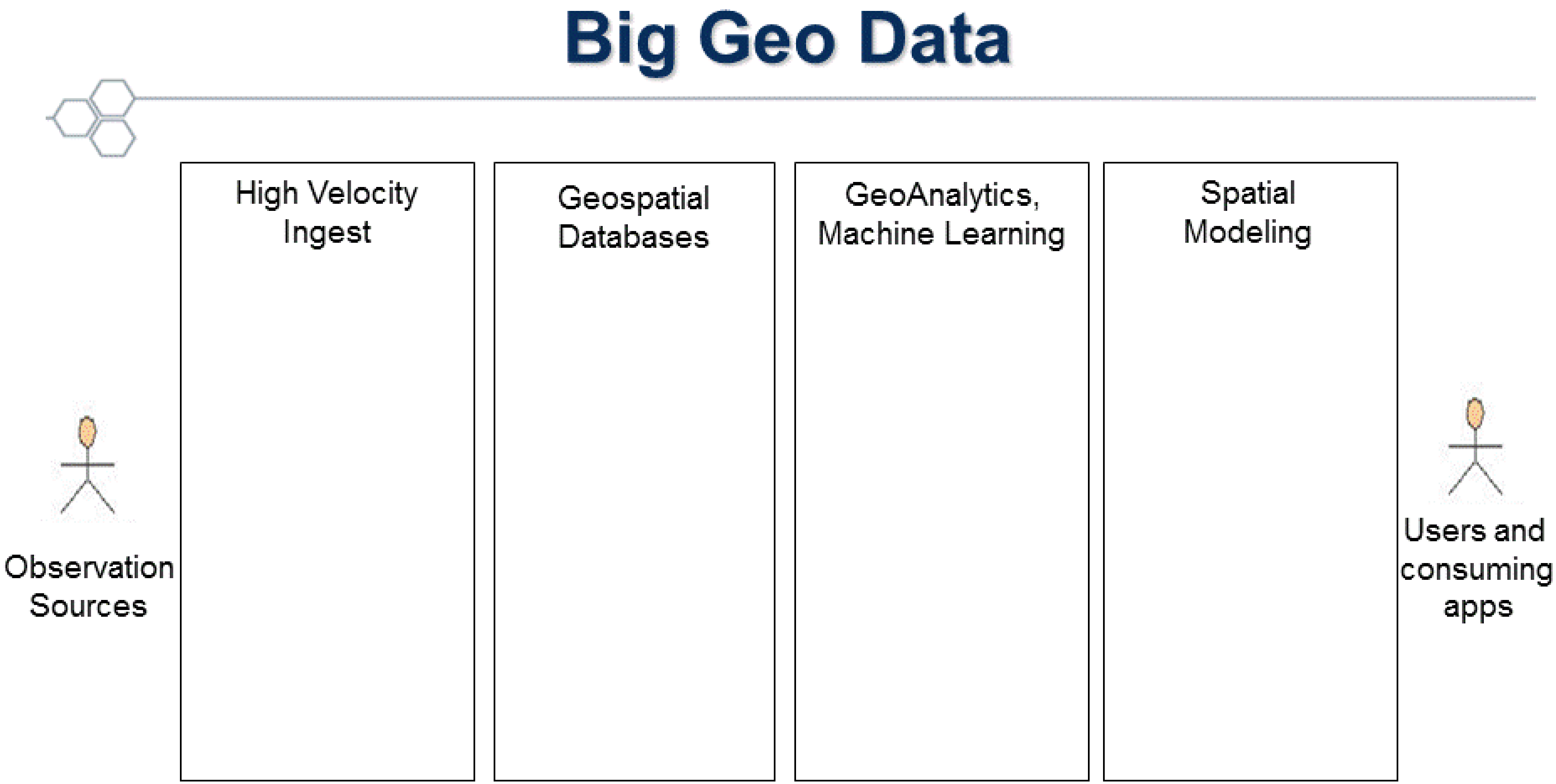


Spark

Source: "Use of standards and related issues in predictive analytics" KDD 2016, SF 2016-08-16 Paco Nathan, O'Reilly Media

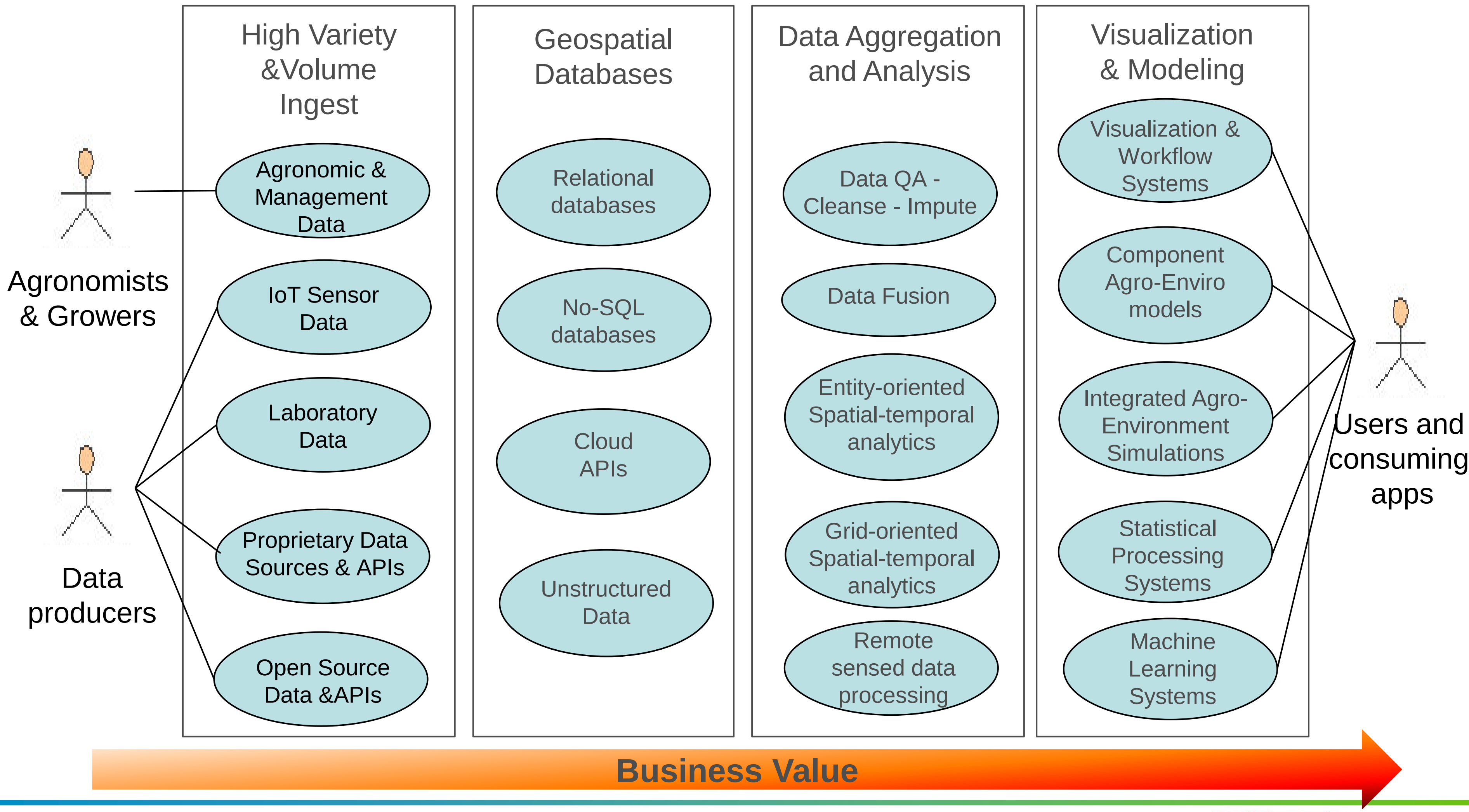
OGC Big Geo Data Analysis Use Case

Presented at ENVI Advanced Analytics Symposium



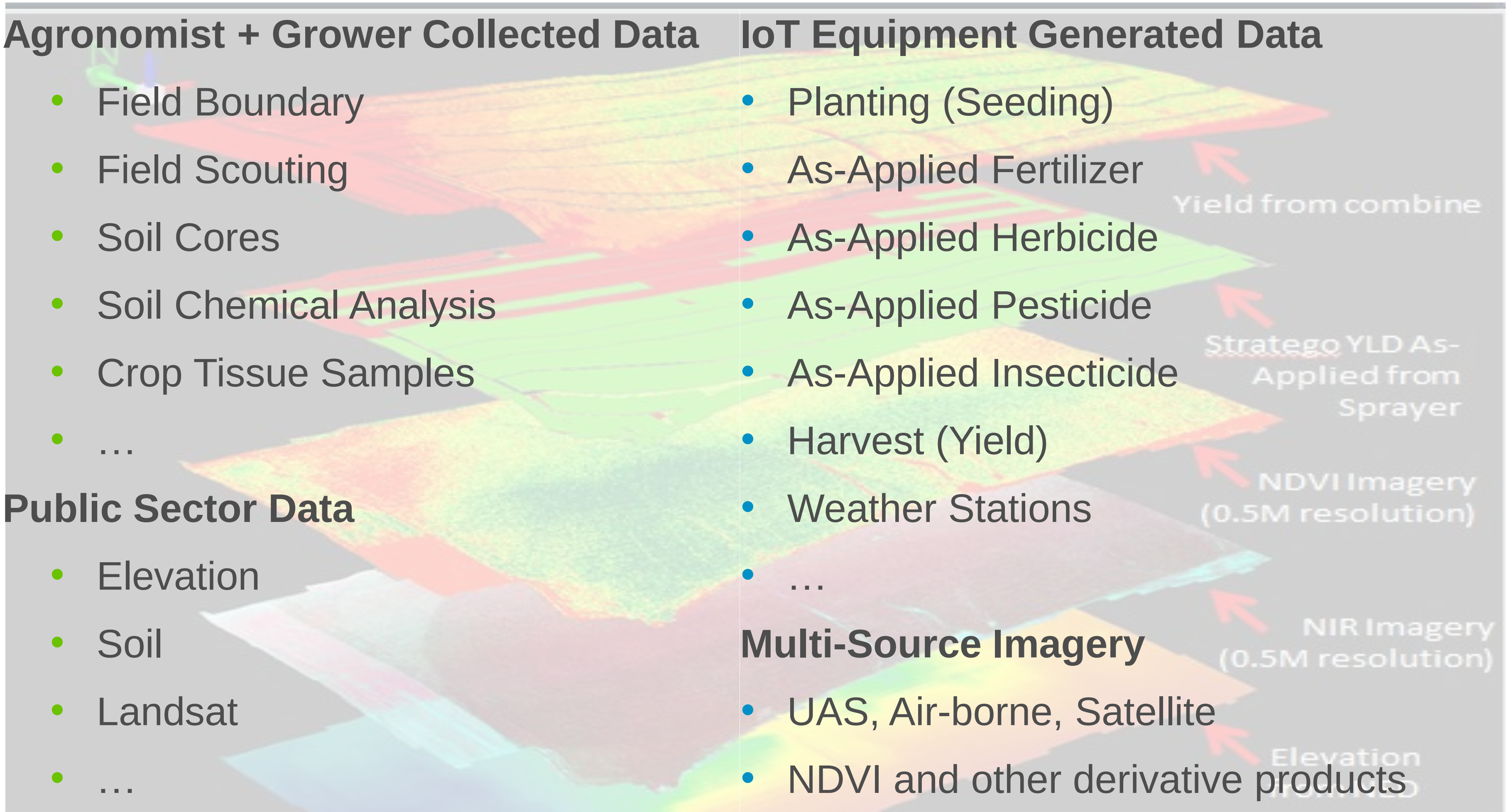
Big Data Use Case for Ag R&D Trials

High-Variety & High-Volume Analytic Pipeline



Typical Field Data Sources

Agronomic, Management, and Spatial data



Agronomist + Grower Collected Data

- Field Boundary
- Field Scouting
- Soil Cores
- Soil Chemical Analysis
- Crop Tissue Samples
- …

Public Sector Data

- Elevation
- Soil
- Landsat
- …

IoT Equipment Generated Data

- Planting (Seeding)
- As-Applied Fertilizer
- As-Applied Herbicide
- As-Applied Pesticide
- As-Applied Insecticide
- Harvest (Yield)
- Weather Stations
- …

Multi-Source Imagery

- UAS, Air-borne, Satellite
- NDVI and other derivative products

Agriculture IoT Data

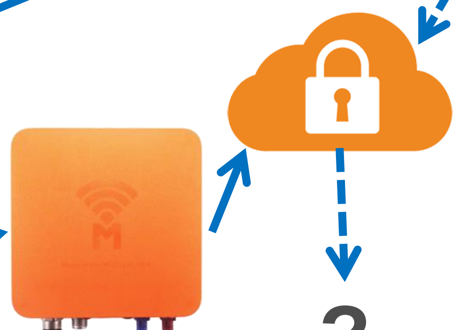
Equipment data capture and aggregation

Planting

Spraying

Data Logging

Harvest



?

Typical Ag equipment data issues:

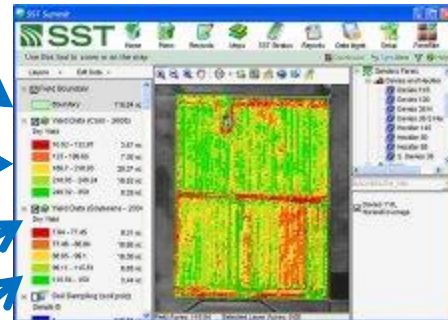
- Was the seed variety entered into the Planter?
- Was the applied product entered?
- Was an applicator nozzle clogged?
- Was the harvester calibrated?
- **Data egress in cloud or as files?**

Agronomist & Grower Collected Data

Varying sources, structure, aggregation and standards

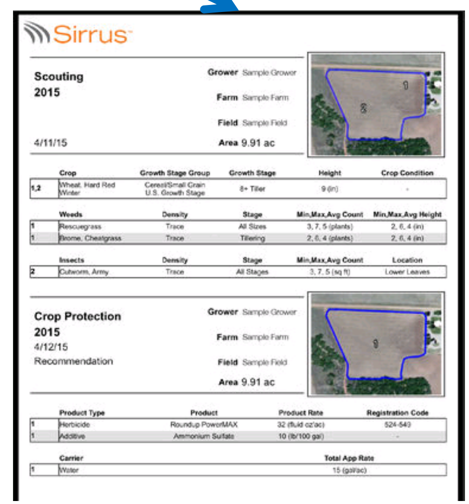
Field scouting

Farm management information system



Cloud

shp, csv, …



Sirrus

Scouting 2015

4/11/15

Grower Sample Grower
Farm Sample Farm
Field Sample Field
Area 9.91 ac

	Crop	Growth Stage Group	Growth Stage	Height	Crop Condition
1,2	Wheat, Hard Red Winter	Cereal/Small Grain U.S. Growth Stage	8+ Tiller	9 (in)	-

	Weeds	Density	Stage	Min,Max,Avg Count	Min,Max,Avg Height
1	Rescuegrass	Trace	All Sizes	3, 7, 5 (plants)	2, 6, 4 (in)
1	Brome, Cheatgrass	Trace	Tillering	2, 6, 4 (plants)	2, 6, 4 (in)

	Insects	Density	Stage	Min,Max,Avg Count	Location
2	Cutworm, Army	Trace	All Stages	3, 7, 5 (sq ft)	Lower Leaves

Crop Protection 2015

4/12/15

Recommendation

Grower Sample Grower
Farm Sample Farm
Field Sample Field
Area 9.91 ac

	Product Type	Product	Product Rate	Registration Code
1	Herbicide	Roundup PowerMAX	32 (fluid oz/ac)	524-549
1	Additive	Ammonium Sulfate	10 (lb/100 gal)	-

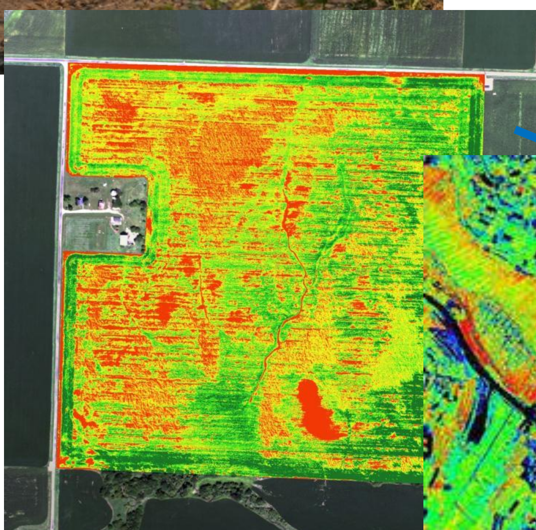
	Carrier	Total App Rate
1	Water	15 (gal/ac)

Field digitizing　　Management recommendations　　Report documents

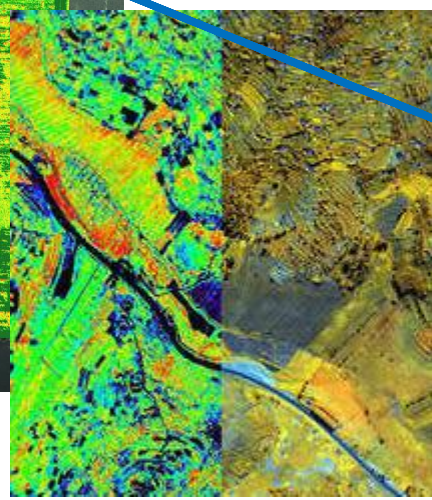
Sensors and Multi-Source Imagery

Covariate data capture and aggregation

Unmanned Air Systems



Airborne imagery



Satellite imagery

Vendor APIs

Bayer CS Aggregation Services

Weather and Moisture

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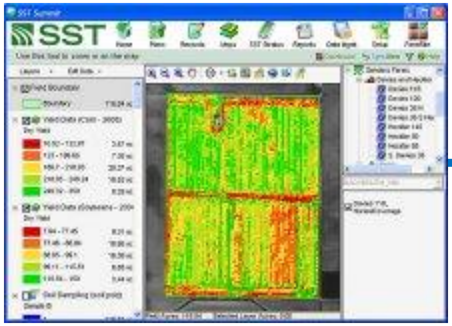
SST agX Cloud

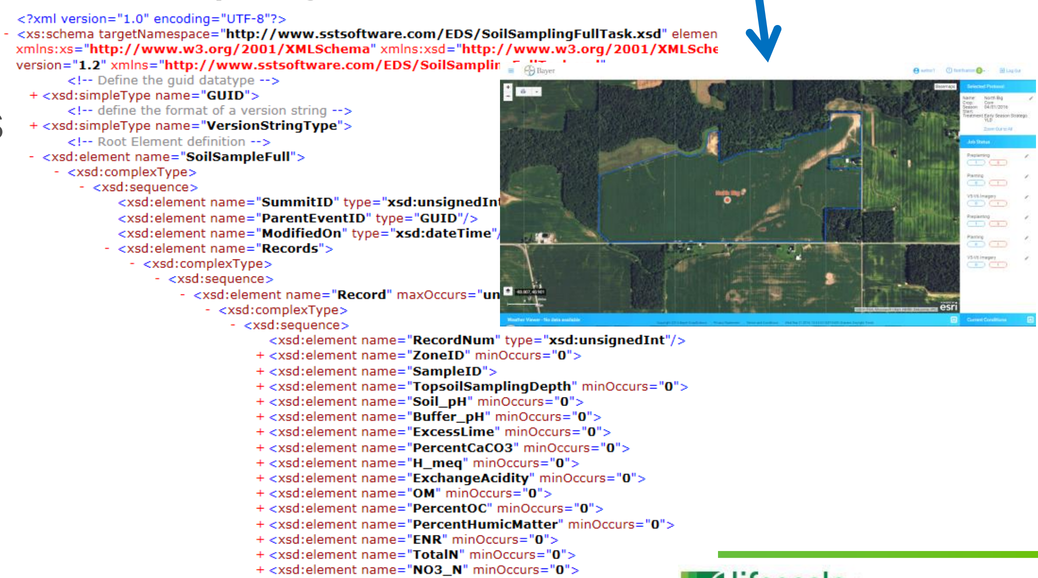
Standards and AWS interface for field data

- **Standardized cloud interface for agriculture operations data**
  - Field-specific data payloads
    - Management data
    - Spatial data
- **XML encoding**
  - Robust schemas XSD encoded
  - WKT shape types for geometries
  - GeoTIFF for imagery
- **Practical standard supporting:**
  - Farm operations
  - System interoperability

Farm management information system



Soil sampling XSD



Soil Sampling Task v 2.0

Bayer to evaluate this next quarter – global objective


```
 <?xml version="1.0" encoding="UTF-8"?>
- <SoilSample xmlns="http://www.sstsoftware.com/EDS/SoilSamplingTask.xsd" SchemaVersion="2.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
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    <ParentEventID>dcf0831c-aa91-41bb-9a77-6ae2367e2e71</ParentEventID>
    <ModifiedOn>2016-07-14T16:19:33.248Z</ModifiedOn>
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    - <Record>
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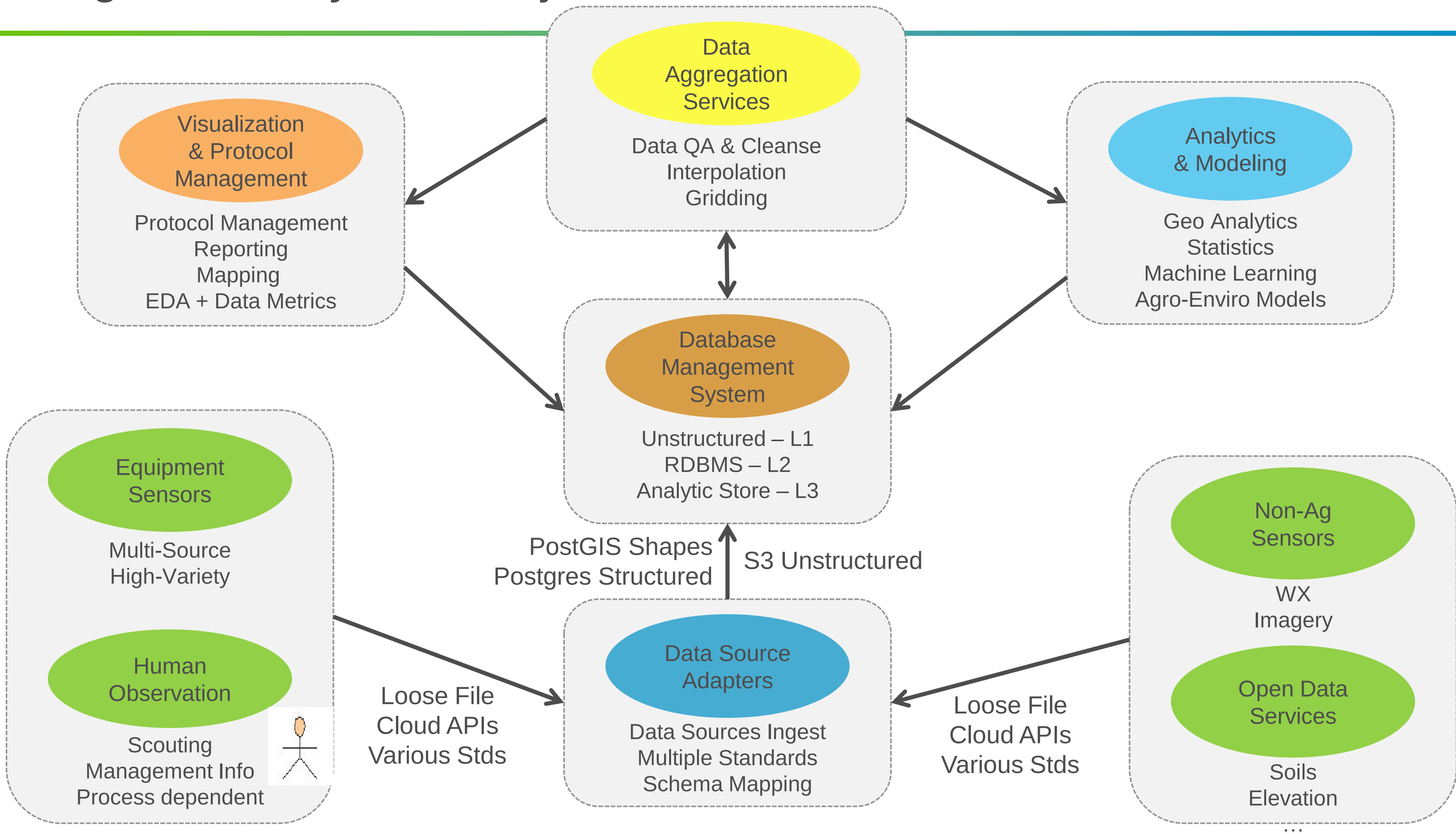
FTPro Architecture

High-Level System Object Model



Principles of our Approach

Iterations on a Minimum Viable Product

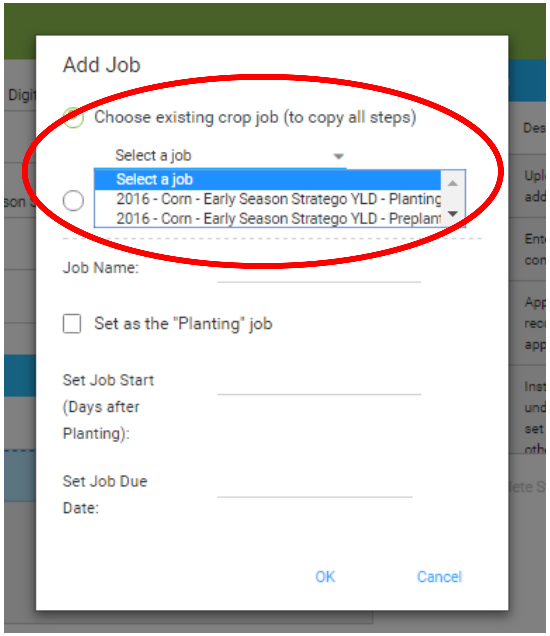
- **Standardize the workflow UI and UX in software first**
  - Maximizes Product Owner participation at the start
  - *Then* iteratively re-engineer the back-end and interfaces as demanded by user stories
- **Maximize use of Open Systems and Open Standards in early platform development phases**
  - Core back-end systems are the hardest to change
  - Use COTS proprietary systems for fast build-out where expedient
- **Maximize use of loosely coupled web services for platform interfaces**
  - It is easier to use other's interfaces than design and build your own
  - De-couple interfaces later where proprietary interfaces or tight-coupling was used in early iterations, guided by technical debt and/or user stories
- **Be highly aware of accumulating technical debt**
  - Keep track in the product backlog
  - Standards are practical and essential but require thinking beyond the next 2 sprints

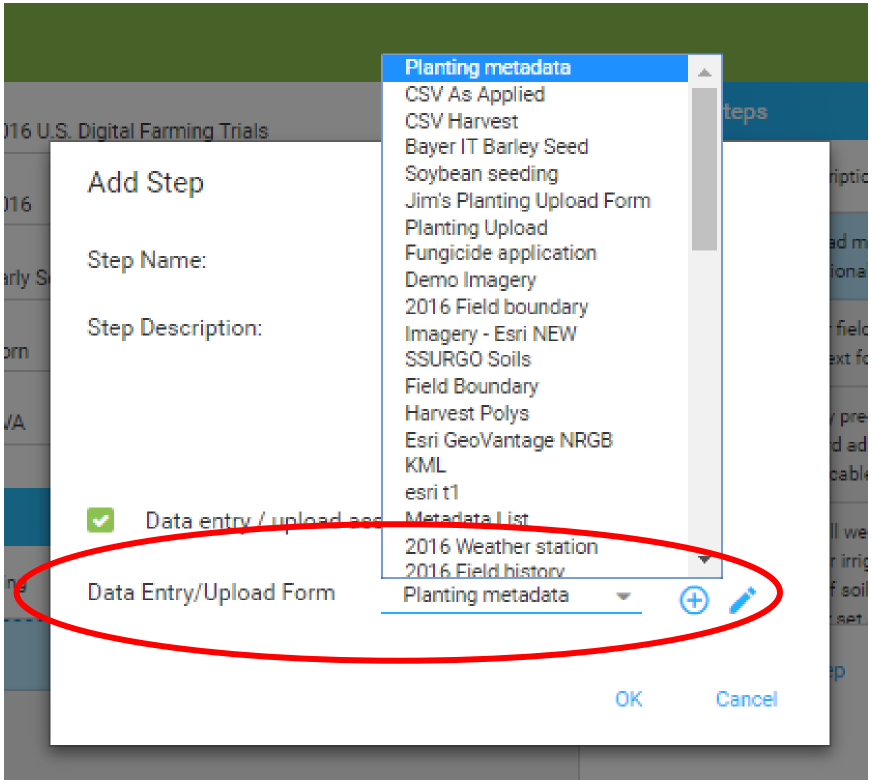
Standardizing the Protocol Contract

Template the protocol and its component parts

Each protocol and sub-elements are configurable templates

- The Job is a template
- The Job Step is a template

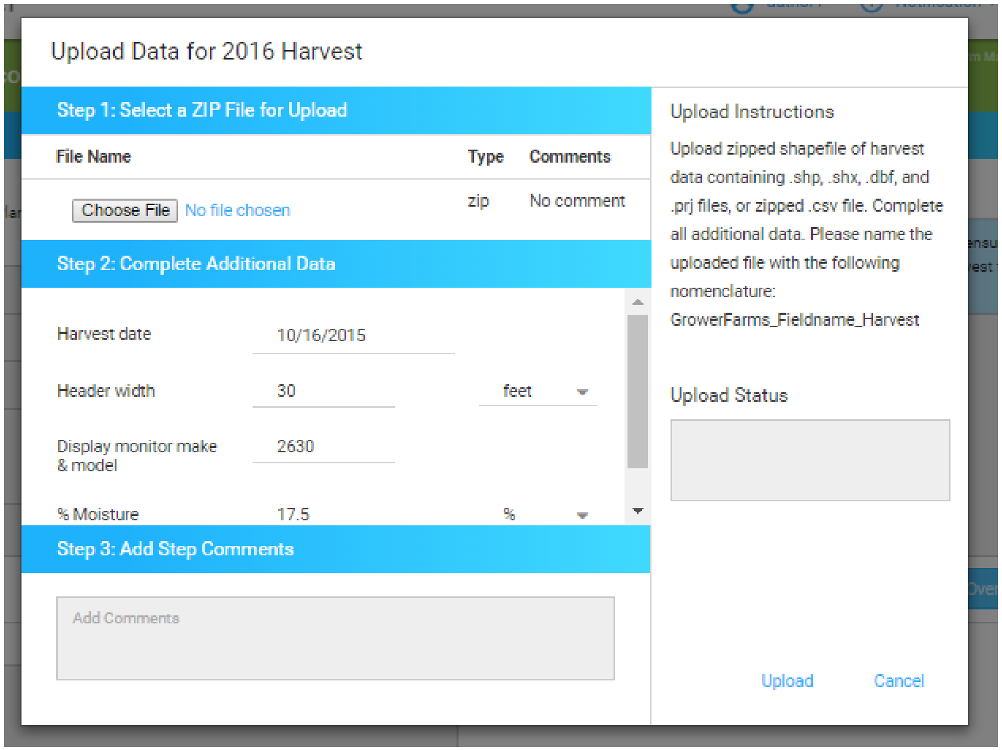




Allows flexibility for each experiment while governing inputs

Standardizing the Protocol Workflow

Adding Context – Geospatial Data is not Enough



Metadata Capture Form

Contextual data varies depending on the job step

- Provides a flexible way to collect field and protocol management data without making changes to the data model
- The seed variety may be very important for understanding the harvest
- Equipment manufacturer will be important for application, but not for soil sampling

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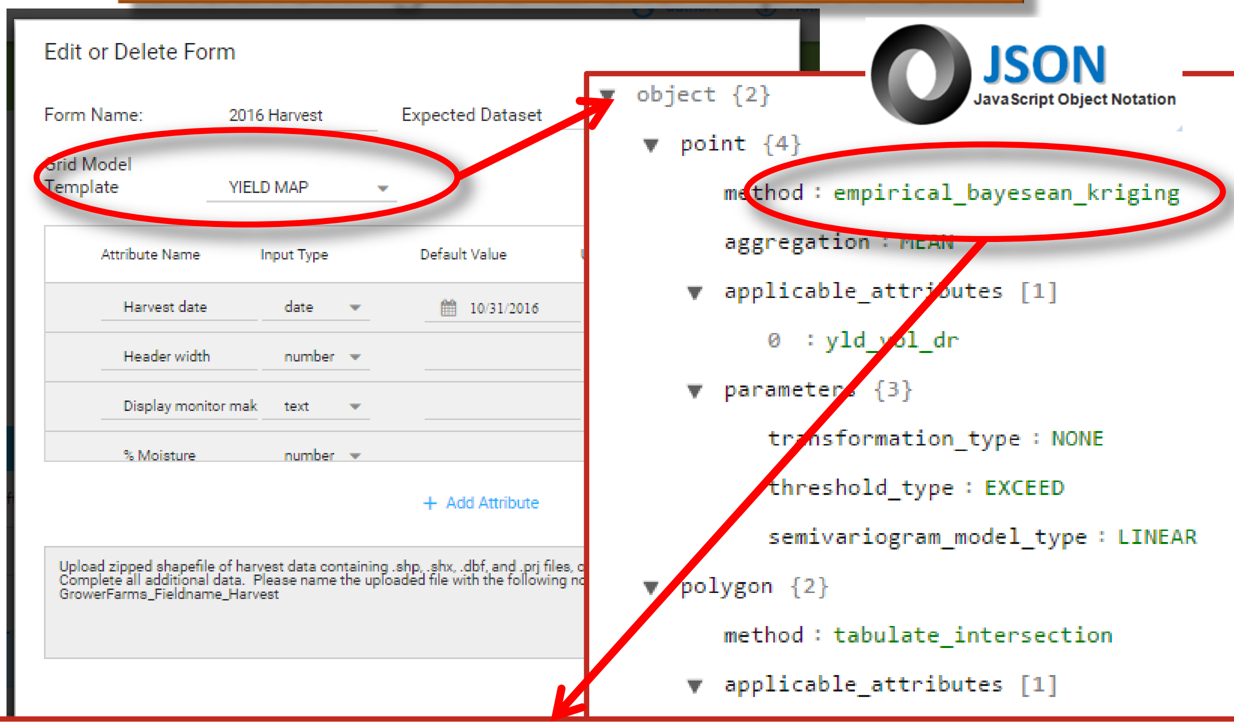
Standardizing the Analytic Pipeline

JSON Templates for Analytics

Each data set type has unique spatial processing sequences

- Spatial processing templates areeasily configured and stored as JSON objects
- Gives users the ability to tailor analytics to the research objectives and source of data collection

Authoring the Data Input Form



Syntax

EmpiricalBayesianKriging_ga (in_features, z_field, {out_ga_layer}, {out_raster}, {cell_size}, {transformation_type}, {max_local_points}, {overlap_factor}, {number_semivariograms}, {search_neighborhood}, {output_type}, {quantile_value}, {threshold_type}, {probability_threshold}, {semivariogram_model_type})

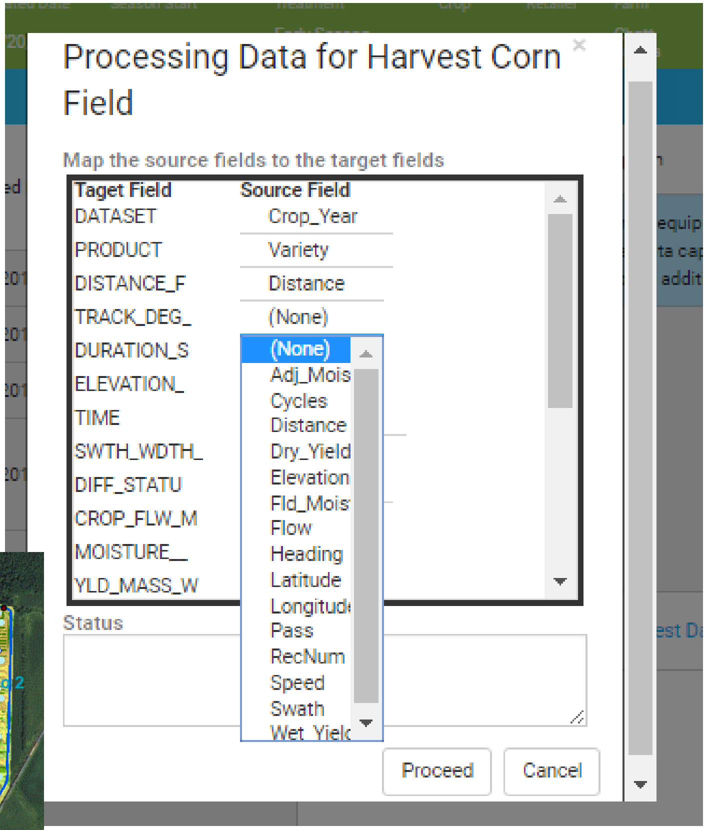
Standardizing the Ingest

Templates for Schema Mapping and Visualization

Each internal geospatial data type has a standard schema

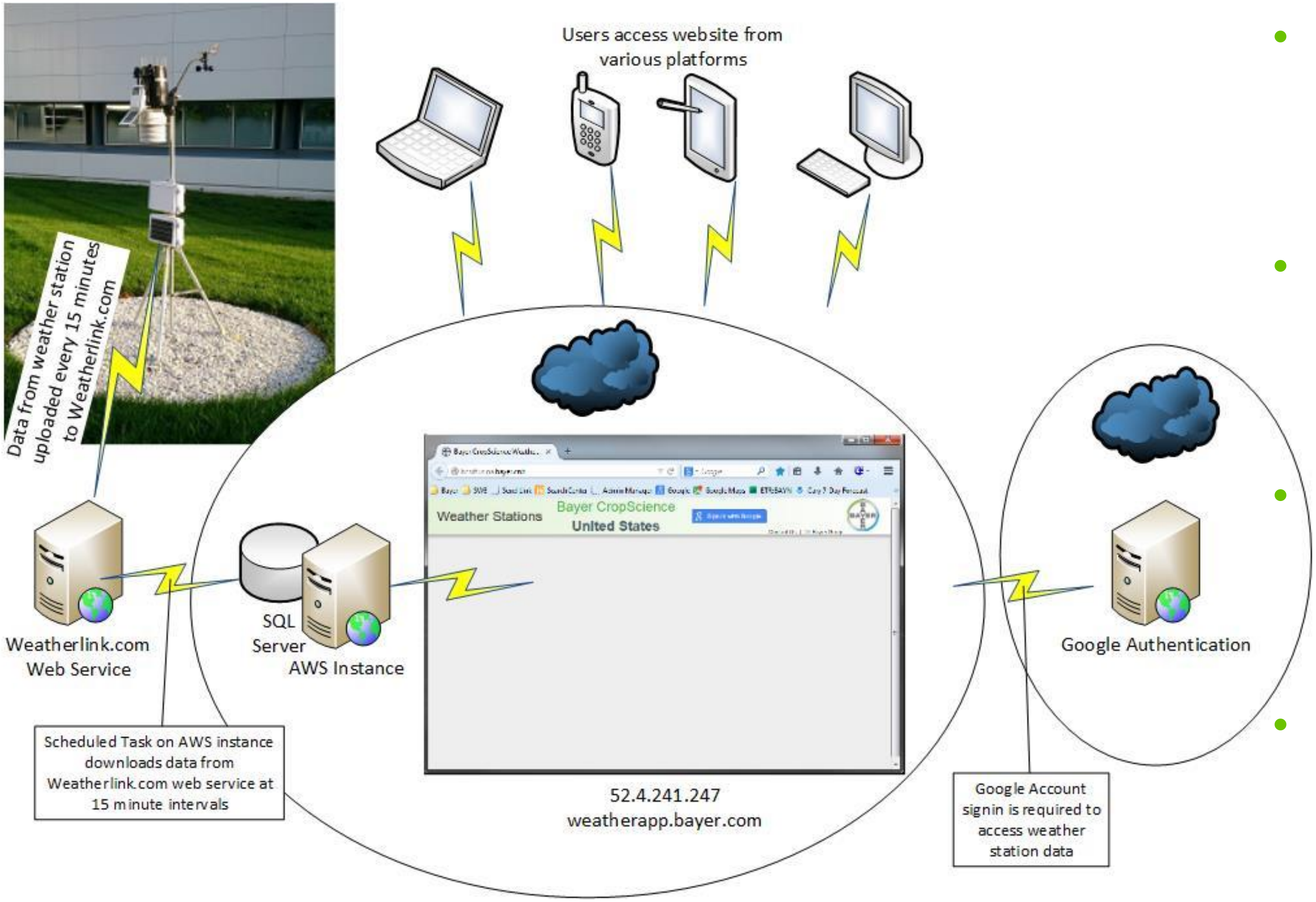
- Interactive schema mapping transforms data from any source to a common Level 2 data model for visualization, plus first-order analytics and modeling
- Deeper analytics go to the Level 1 data store
- Visualization symbology is also a user-modifiable template

Schema mapping



Weather Service for On-Field Stations

Private weather station aggregation architecture v.1



- Each station xmits raw to Davis weatherlink cloud, 15 min intervals
- Weatherlink aggregates, publishes JSON messages
- BCS AWS service subscribes and aggregates JSON in RDBMS
- BCS publishes REST interfaces for consuming apps

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Thank you!

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