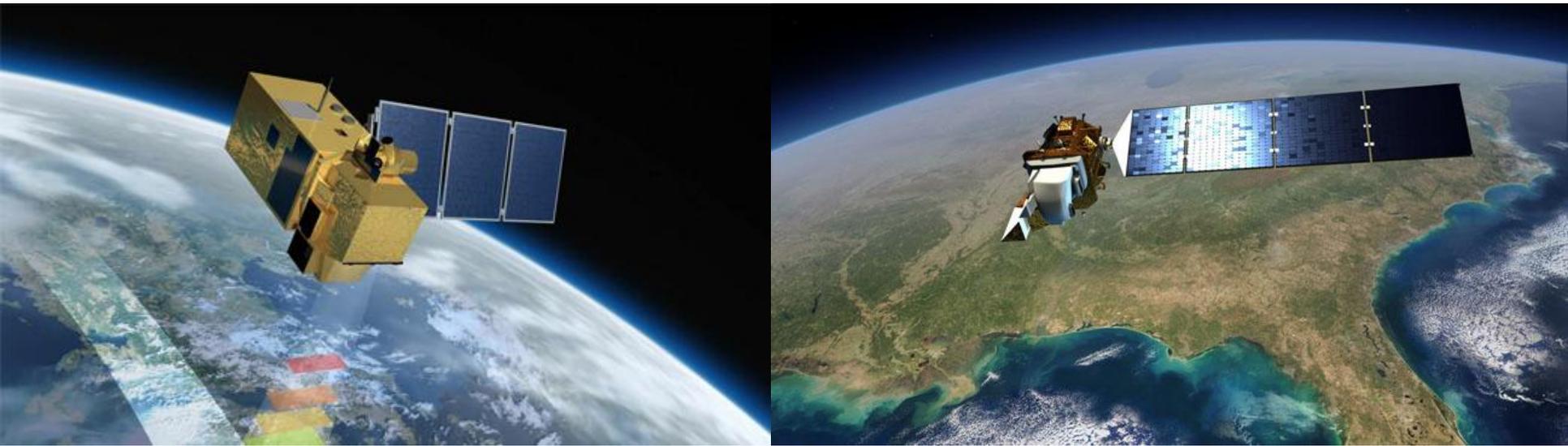


# NASA & USGS Preparations for Sentinel-2

Jeff Masek  
John Dwyer



July 22, 2014

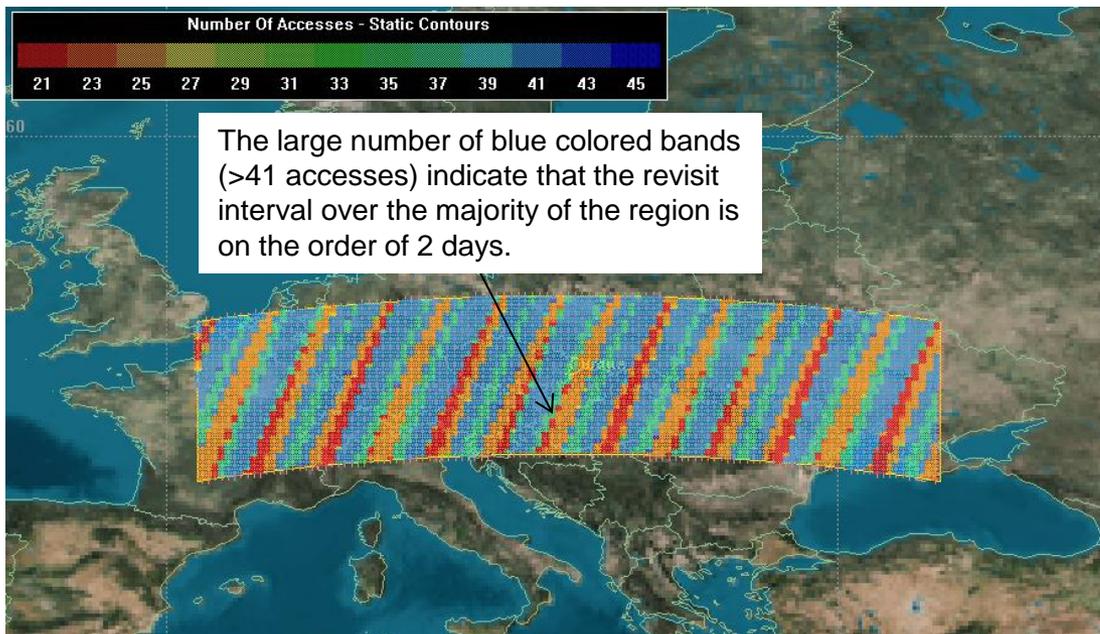
# Sentinel-2 and Landsat Synergy

Merging Sentinel-2 and Landsat data streams could provide 2-3 day coverage globally – transformational for land science

- *vegetation phenology at patch scale*
- *ecological change & land management*

Sentinel-2a launch currently planned for 2Q 2015

- *Sentinel-2b ~1 year later*
- *initial acquisitions restricted to Eurasia*



*Number of times Landsat-8 and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.*

- *21 accesses indicates a maximum revisit interval of ~3 days 19 hours*
- *46 accesses indicates a minimum revisit interval of ~1 day 18 hours*

*Courtesy Brian Killough, LARC*

# Programmatic Context

- USGS is the lead agency for discussions with ESA regarding Sentinel-2 data access
  - NASA has supporting role for S2, focused primarily on data products and analysis, and data characterization
- NASA is the lead agency for Sentinel-1 and Sentinel-3 discussions

# What's Needed to Make Full Use of Sentinel-2 Data within US?

- MSI Characterization & Cross-Cal with Landsat-8 OLI (USGS/NASA)
- Bulk access to Sentinel-2 L1C Data (USGS)
  - TOA, orthorectified reflectance
  - 100 x 100km UTM tiles
  - “Free and Open” policy ratified by EU, but individual users not associated with Copernicus Services will have lower priority
  - USGS pursuing a copy of the Sentinel-2 L1C archive at EROS
- Higher Level (“L2”) Products (NASA, USGS)
  - “Fundamental” Data Records
    - Sentinel-2 MSI & Landsat surface reflectance products
    - Merged & harmonized reflectance products
  - Higher-Level land science products (vegetation parameters, land cover, etc) based on Landsat/S2 fusion

# NASA Sentinel-2 Team (FY 2014)

PI

Proposed Investigation

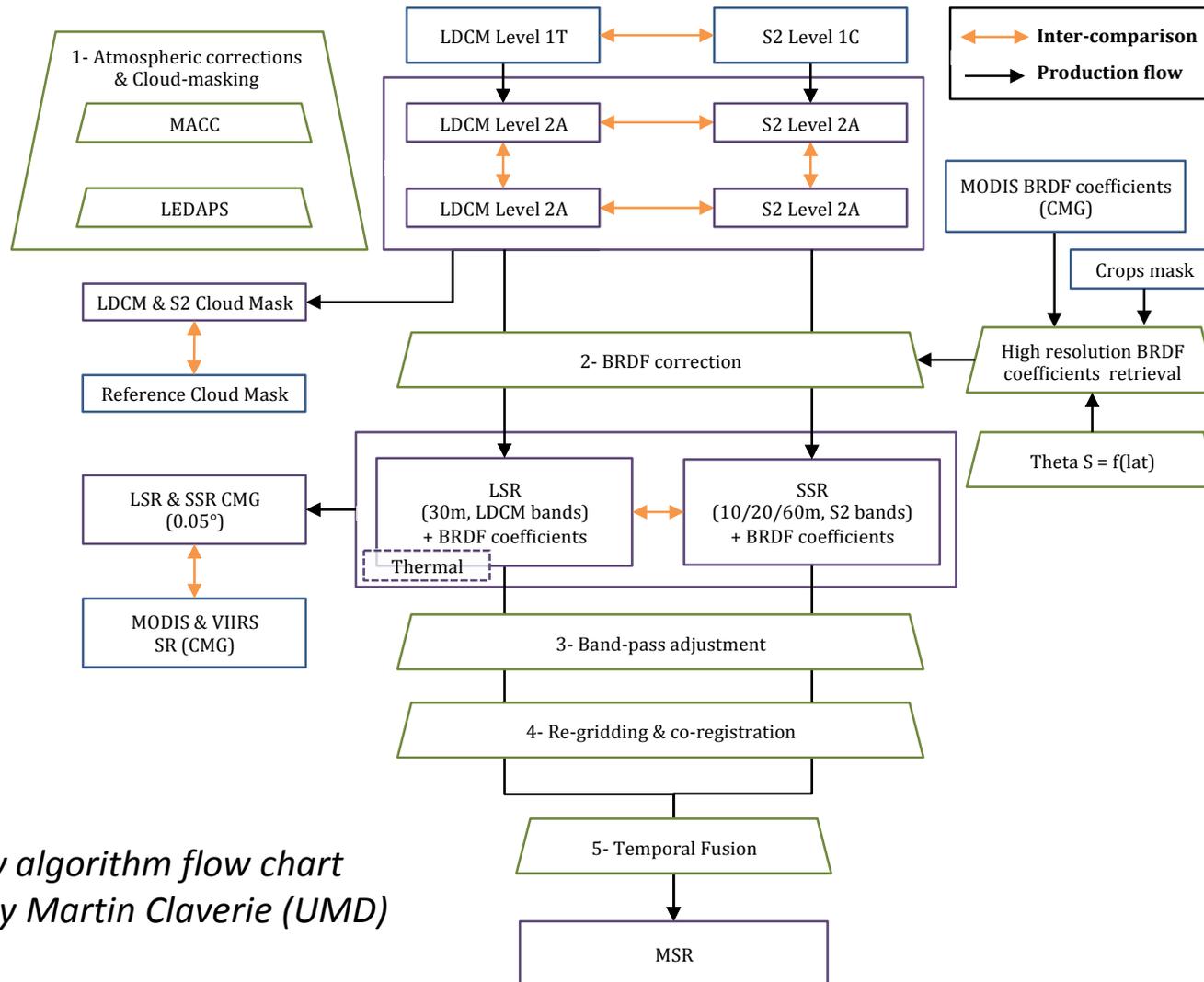
Helder, SDSU	Improved use of PICS sites including BRDF modeling & characterization; Improved use of vegetated calibration sites; Relative gain estimation via lifetime averaging
Czapla-Myers, U Arizona	BRDF measurements of US PICS/calibration sites; Analysis of Sentinel-2 prelaunch calibration data
Markham, NASA GSFC	Coordination of calibration / characterization team
Schott, RIT	DIRSIG simulations of Sentinel-2 + Landsat time series, including BRDF variability; testing BRDF corrections
Vermote/Claverie, NASA GSFC (w/ Hagolle/Dedieu/ CESBIO)	Atmospheric correction & BRDF approach for MSI and Landsat-8
Justice/Claverie, UMD	Prioritization of higher-level products for NASA Land Science
Schaaf, U Mass - Boston	BRDF corrections for MSI/Landsat
Woodcock, Boston U	Cloud cover algorithms; higher-level products
Roy, SDSU	Regridding/Projection approach for MSI & merged products; compositing approaches
Ganguly/Dungan, NASA ARC	Biophysical algorithm approaches for MSI; NEX programming & systems support

***NASA LCLUC solicitation for Land Imaging Science team in late 2014, with focus on Landsat/Sentinel integration***

# NASA FY14-15 Activities

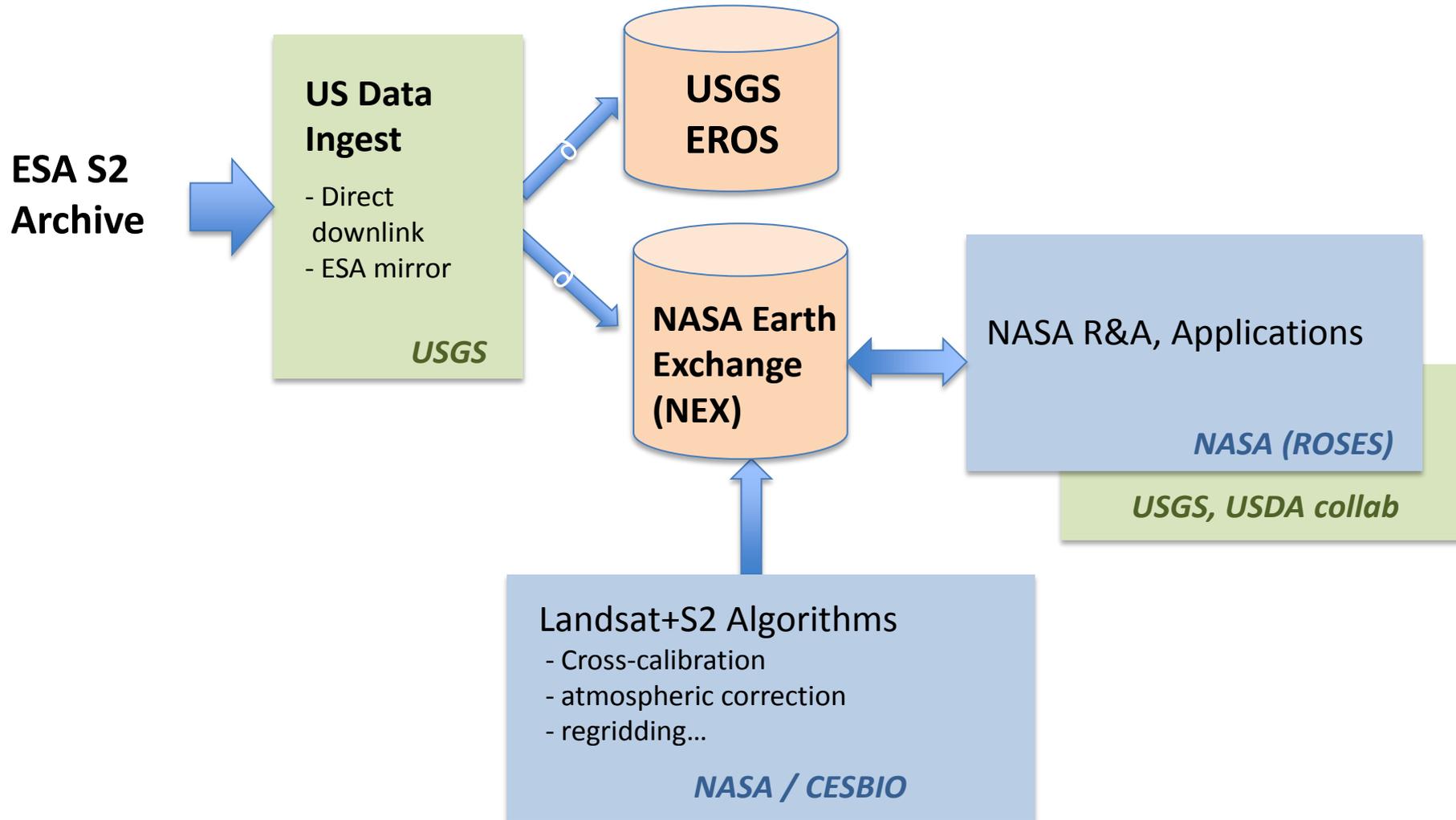
- Preparation for Sensor Characterization & Cross-Calibration (Markham, Czapla-Myers, Helder, Schott)
  - Continue pre-launch calibration activities (e.g. diffuser characterization, SADE)
  - DIRSIG simulations of MSI data
    - What variance will be introduced into an *uncorrected* time series by mixing Landsat and S2?
  - Improve BRDF characterization of US PICS sites
  - Post-launch planning (joint vicarious campaigns, PICS characterization, DIRSIG, etc)
- Prototype harmonized surface reflectance product from S2 and Landsat (Roy, Claverie, Schaaf, Vermote)
  - Algorithms & Data Flow
    - *Atmospheric correction*
    - *BRDF (solar, view angle) and band pass adjustments*
    - *Cloud/shadow screening & cirrus masking*
    - *Common gridding, compositing approach*
  - FY14 activities focusing on prototyping using S2 test data; initial implementation on NEX
- Higher-Level Land Cover and Biophysical products from merged moderate-resolution record (Woodcock, Justice, Ganguly)
  - Planning and prioritization of products (eg. GTOS ECV's)
  - QA & Validation components
- Research Solicitation through NASA LCLUC Program Fall 2014 to support Sentinel-Landsat product development
  - ~ \$2M per year available
  - Collaborative with ESA Scientific Exploitation of Earth Observation (SEOM) Program

# Prototype Merged Radiometric Record



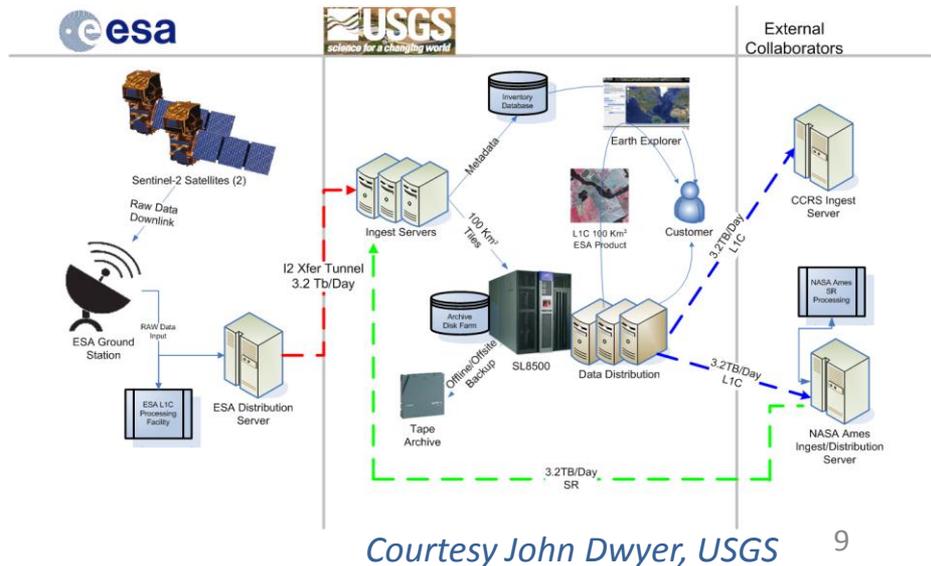
*Preliminary algorithm flow chart prepared by Martin Claverie (UMD)*

# Proposed Sentinel-2 / Landsat Architecture



# L1C Access: USGS Concept of Operations

- The Sentinel-2 MSI Level-1C (L1C) product is analogous to Landsat Level-1T (L1T). Approximately 800- 900GB of raw data to be downlinked per day will be processed to L1C by ESA.
- L1C products are orthorectified Top of Atmosphere (TOA) reflectance provided as 100x100km<sup>2</sup> tiles of 500MB each in UTM projection. L1C products are 16-bit with radiometric conversion coefficients and a QA band.
- USGS will pull L1C products from PACs for distribution to NASA Ames, Canada Center for Remote Sensing (CCRS), and the general public at no cost.
- NASA Ames to process L1C data to surface reflectance that will be pulled back to EROS for archive and distribution.
- USGS estimates for the data archive and distribution of Sentinel-2 L1C and surface reflectance (SR) products assume daily ingest volume of 1.6GB per satellite.
- Total data archive 6.4TB per day
  - L1C data archive of 3.2TB per day
  - SR data archive of 3.2TB per day
- Level-1C reprocessed data will be replaced – no concurrent versions



# USGS EROS Sentinel 2 Investigation Overview

- Objective:
  - Understand the options for acquiring and distributing Sentinel-2 MSI data along with Landsat data in a cost-effective way that best aligns with the priorities and strategies of USGS.
- Scope:
  - The scope of the Sentinel 2 Investigation is to study and understand the following:
    - Calibration & Validation
    - Networking, Data Ingest, Archive and Management
    - Data Discovery and Access
    - Data Interoperability
      - Radiometric, spectral, and geometric normalization of Level-1 and Level-2 products
    - Data Distribution Services
      - Formatting and packaging of Sentinel-2 data to ease usability with Landsat

# EROS Sentinel-2 IPT Members

- Project Sponsor – Jenn Lacey
- International Coordinator – Tom Cecere
- Project Lead - Kari Wulf
- Project Scientist - John Dwyer
- Engineer Lead – Chris Engebretson
- Cal/Val Lead - Dave Meyer
- SI Lead – Jim Nelson
- Storage & Archive
  - DAAC – Chris Doescher & Dave Meyer
  - LTA/SDW – Wayne Miller/Ryan Longhenry
- Networks – Mike Rechtenbaugh
- Data Analysis & Processing – Ron Morfitt, Tim Flahaven, Doug Hollaren
- Pre-Flight Calibration – Brian Markham, et. al
- Level-2 Processing – Jeff Masek
- *Other SMEs pulled in as needed*

# USGS Sentinel Requirements/Objectives

- Rather than defining requirements just yet, approach is to first assess what is possible and what value USGS could realize through various implementation strategies with Sentinel-2
- These are defined by minimum (threshold), breakthrough & target success criteria.
- Need to look at full breath of activities that would need to occur for each level of implementation and:
  - Understand science possibilities and viability
  - Understand technical possibilities and viability
  - Includes network connectivity and performance, archive management, data characterization, data access and discovery, distribution services, Level-2 processing, etc.
  - May include evaluating many alternative science and technical solutions to achieve stated objectives, including other gov't or commercial partners.
  - Involves working across projects at EROS and with Science Teams

# Implementation Tiers of Service

- Tier 1 – Threshold: the minimum requirement to be met to ensure that users can discover, access, and retrieve Sentinel-2 MSI data
  - Host a copy of Level-1c data, enable data discovery, distribute as is to general public, NASA Ames, and CCRS
  - Minimal amount of online cache (60-90 days), offline backup
- Tier 2 – Breakthrough: an intermediate requirement level between threshold and target which, if achieved, would result in substantial improvement in data accessibility and usability
  - Add a minimal amount of processing to increase data usability (reformatting, conversion of metadata to Landsat metadata model, pixel alignment, generate full resolution browse, enable coincident Landsat and Sentinel-2 data search and discovery)
- Tier 3 – Target: the value above which further development of products and services would provide only limited improvement in performance of services or data usability. The cost of improving the dataset or service beyond the target requirements would not be matched by a corresponding benefit.
  - Full radiometric and geometric processing of Level-1b to Level-1c



# Conclusions

- Combining Landsat and Sentinel-2 streams will provide a near-term path to improved temporal revisit
- Sentinel-2 to launch in mid-2015, with data available to US investigators by end-2015
  - Eurasia, Africa, cal sites during early mission
  - Global acquisitions in ~2016
- Both USGS and NASA are investing in activities to make available Sentinel-2 mission data & harmonize with the Landsat archive
  - USGS scoping system to provide copy of S2 data – funding yet to be committed
  - NASA supporting initial science group; Research Opportunity through LCLUC Program to follow in Fall 2014