Alabama Remote Sensing Consortium

Annual Meeting | February 28, 2017

Auburn University Huntsville Research Center

Welcome/Introductions

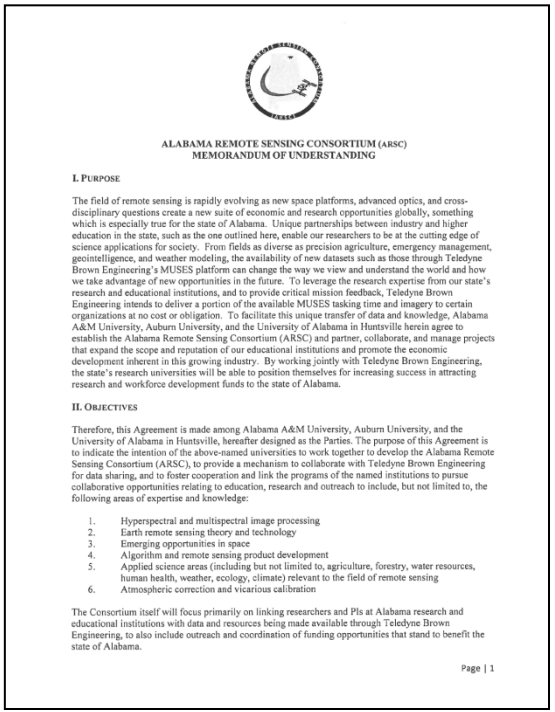
- **Safety**
- **Restrooms**
- **Wi-Fi - Version 291LVW Password: 4a19c739**
- **Ground Rules**
- **Notes / Actions**
- **Introductions**

Agenda

11:30-12:00	Arrive/Coffee	All	
12:00 PM	Welcome / Introductions	M. Ogles	
12:05 PM	ARSC Activities Past Year	R. Griffin	
12:15 PM	TBE Status Updates (Launch, Data Delivery, Cal/Val)	R. Perkins	
12:45 PM	ARSC New Business	W. Tadesse	
12:55 PM	Wrap Up/Adjourn	M. Ogles	
1:00-2:00	Follow-on Discussions	All	

**minutes will be taken by M. Ogles and posted onto the ARSC website (nsstc.uah.edu/arsc)*

MOU



ALABAMA REMOTE SENSING CONSORTIUM (ARSC)
MEMORANDUM OF UNDERSTANDING

I. PURPOSE

The field of remote sensing is rapidly evolving as new space platforms, advanced optics, and cross-disciplinary questions create a new suite of economic and research opportunities globally, something which is especially true for the state of Alabama. Unique partnerships between industry and higher education in the state, such as the one outlined here, enable our researchers to be at the cutting edge of science applications for society. From fields as diverse as precision agriculture, emergency management, geointelligence, and weather modeling, the availability of new datasets such as those through Teledyne Brown Engineering's MUSES platform can change the way we view and understand the world and how we take advantage of new opportunities in the future. To leverage the research expertise from our state's research and educational institutions, and to provide critical mission feedback, Teledyne Brown Engineering intends to deliver a portion of the available MUSES tasking time and imagery to certain organizations at no cost or obligation. To facilitate this unique transfer of data and knowledge, Alabama A&M University, Auburn University, and the University of Alabama in Huntsville herein agree to establish the Alabama Remote Sensing Consortium (ARSC) and partner, collaborate, and manage projects that expand the scope and reputation of our educational institutions and promote the economic development inherent in this growing industry. By working jointly with Teledyne Brown Engineering, the state's research universities will be able to position themselves for increasing success in attracting research and workforce development funds to the state of Alabama.

II. OBJECTIVES

Therefore, this Agreement is made among Alabama A&M University, Auburn University, and the University of Alabama in Huntsville, hereafter designed as the Parties. The purpose of this Agreement is to indicate the intention of the above-named universities to work together to develop the Alabama Remote Sensing Consortium (ARSC), to provide a mechanism to collaborate with Teledyne Brown Engineering for data sharing, and to foster cooperation and link the programs of the named institutions to pursue collaborative opportunities relating to education, research and outreach to include, but not limited to, the following areas of expertise and knowledge:

1. Hyperspectral and multispectral image processing
2. Earth remote sensing theory and technology
3. Emerging opportunities in space
4. Algorithm and remote sensing product development
5. Applied science areas (including but not limited to, agriculture, forestry, water resources, human health, weather, ecology, climate) relevant to the field of remote sensing
6. Atmospheric correction and vicarious calibration

The Consortium itself will focus primarily on linking researchers and PIs at Alabama research and educational institutions with data and resources being made available through Teledyne Brown Engineering, to also include outreach and coordination of funding opportunities that stand to benefit the state of Alabama.

Page | 1

- Purpose & Objectives
- Data Agreement
- Membership
- Intellectual Property & Data Usage

**executed February 17, 2016 for a duration of 5 years*

Organization & Governance

(1) Reach out to institutional contacts or executive committee for information/questions and timeline
(2) Submit data request via TBE web portal *(more to come on this)*
(3) Submit proposal form to ARSC

(1) Quarterly evaluation of proposals
(2) Coordination of overlapping proposals and provide advice vis-a-vis vicarious cal/val activities
(3) Approval of data requests via TBE web portal
(4) Organizing letters of support and data sharing

(1) Schedule approved requests
(2) Deliver acquired data to distribution node *(more to come on this)*

Letters of Support

- Dr. Karen McNeal (Auburn), NSF

NRT-INFEWS: Addressing the Food-Energy-Water Nexus in the SouthEastern US through Resiliency (FEW-SEUS), January 29, 2017

- Dr. David Pan (UAH), NSF

Improving Predictive Lossless Compression of Large Image Datasets Using Data-Driven Learning, November 7, 2016

- Dr. Mike Fogle (Auburn), NASA

Sustainable Land Imaging-Technology TRL Advancement, March 26, 2016

***we will execute requested letters of support at any time, but do give us a little notice*

Presentations

- *Teledyne's Multi-User System for Earth Sensing (MUSES)*, JACIE, April 14 2016. R. Perkins, D. Krutz, R. Mueller, E. Carmona, R. Griffin, L. Graham, R. Miller
- *Imaging Spectroscopy Applications Using the DESIS Hyperspectral Instrument on MUSES*, JACIE, April 14 2016, R. Perkins, E. Carmona, R. Griffin
- *Alabama Remote Sensing Consortium (ARSC),* GISA Annual Meeting, April 20 2016, M. Ogles, R. Griffin, W. Tadesse, R. Perkins
- *Alabama Remote Sensing Consortium (ARSC): An industry-higher education consortium and a unique resource for the state of Alabama.* GEOHuntsville Annual Summit, May 4 2016, R. Griffin, M. Ogles, W. Tadesse, R. Perkins

Outreach Activities

- R. Griffin Auburn Presentation (Geosciences), GEO Huntsville BoD Outreach
- M. Ogles Presentations and Faculty Meetings
- W. Tadesse activities
- R. Perkins Presentations

TBE Update
Ray Perkins, Chief Engineer

Data (What, When, How Much)

- Data acquired from TBE's MUSES platform. As of mid-late 2017 (projected) that will include DLR's DESIS-30 instrument.
- ARSC's agreement with TBE guarantees 450,000 km2 of data to be used by ARSC member PIs over 5 years (2016-2021) - for perspective, about 3.5 times the state of Alabama.
- Requested data can be global but must be in regions covered by the ISS (51.6deg).
- Researchers can request any amount of data they want, with several caveats
  - An understanding that multiple researchers will likely be requesting data in any given year and ARSC will attempt to accommodate as many highly-rated requests as possible per year (see the proposal preparation tips below)
  - ARSC will try to spread out data tasking usage to guarantee data availability over the course of the 5-yr period, so roughly-speaking 100km2 of data might be tasked under this agreement per year of the MOU
  - Requesters must be from ARSC member institutions
  - Any ARSC member will have free access to any data previously tasked and acquired for another ARSC member
- The ARSC committee can sign NDA's upon request
- Data distribution from TBE to ARSC members is currently being worked out.

Data Tasking Requests

Submit DATA REQUEST via TBE online system.

Submit PROPOSAL FORM via email to ARSC. This is a one page overview of your proposed project, the amount of data requested, contact information, and addressing the scoring criteria (to the right).

Scoring Criteria:

(1) Plans to leverage the data for funding and likelihood to result in follow-on research

(2) Number of other institutions/PIs involved

(3) Amount and location of data requested and time span for which data requested

(4) Coordination with classes and number and type of students involved

(5) Data used for vicarious calibration/validation activities

Data Request Tips

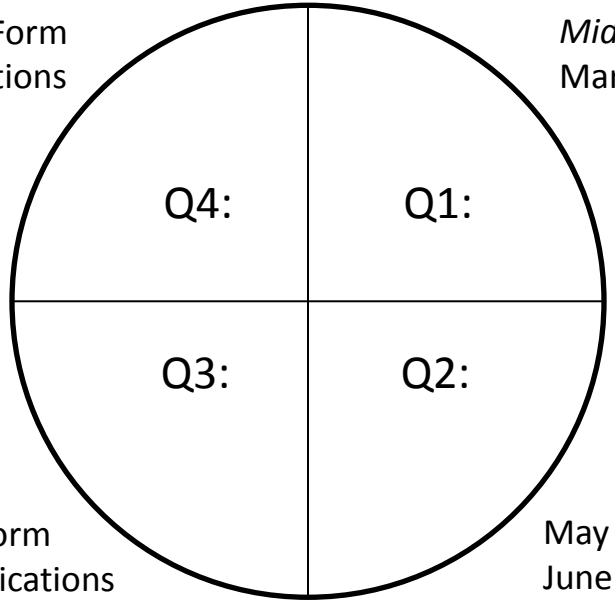
Items to consider:

1) Any data acquired or tasked for vicarious calibration activities in which ARSC members are involved does ***not*** count toward the MOU data limit but does still go through the ARSC process (…so choose wisely)
2) There is a direct relationship between the amount of data requested and the relative scoring value of having multiple institutions/PIs involved
3) The consortium can provide both a means to support your research through the provision of data and ***letters of support*** as well as a means to identify collaborators and compete for larger proposals (more to come on this later)
4) Application areas of high value to TBE may be good avenues to pursue additional ***teaming agreements*** with TBE to acquire additional data and handle subsequent IP

Data Requests: Deadlines

November 1: Project Proposal Form
December 1: Approval Notifications

February 1: Project Proposal Form
Mid-February: Annual Meeting
March 1: Approval Notifications



***bear dates in mind when submitting proposals if you intend to leverage these data.**

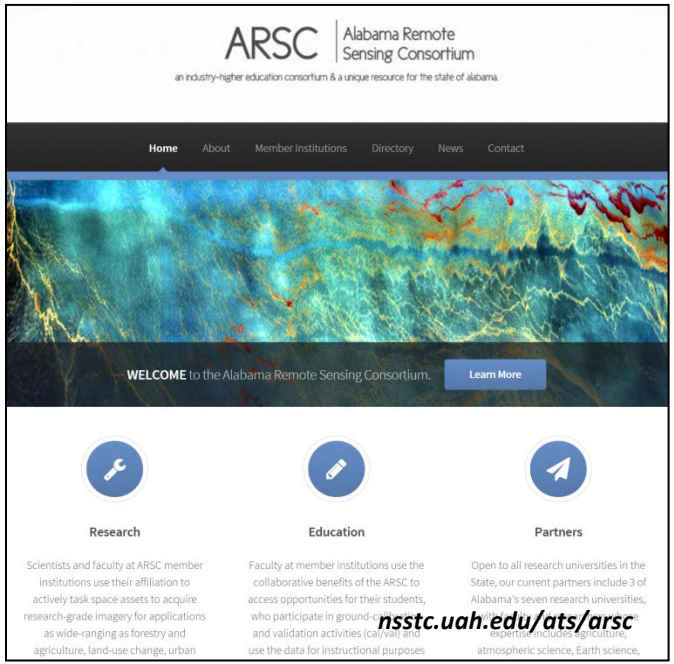
August 1: Project Proposal Form
September 1: Approval Notifications

May 1: Project Proposal Form
June 1: Approval Notifications

Upcoming Activities

- How to get involved
- Conferences & Outreach
- Proposals (joint and individual)
- Resources
- Data requests and proposal Letters of Support
- Calibration/Validation activities and coursework

Institutional Contacts



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Mr. Mike Ogles, Auburn
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256.998.1423

Dr. Wubishet Tadesse, Alabama A&M
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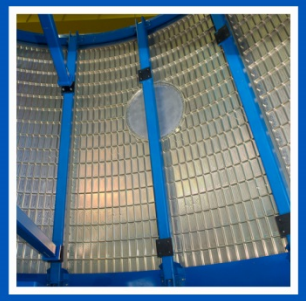





Current MUSES & DESIS Status

For the Alabama Remote Sensing Consortium (ARSC)

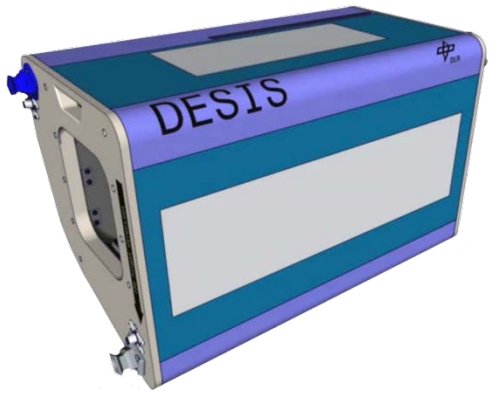
February 28, 2017

Ray Perkins

TELEDYNE TECHNOLOGIES
Everywhereyoulook™

Teledyne and DLR Partnership

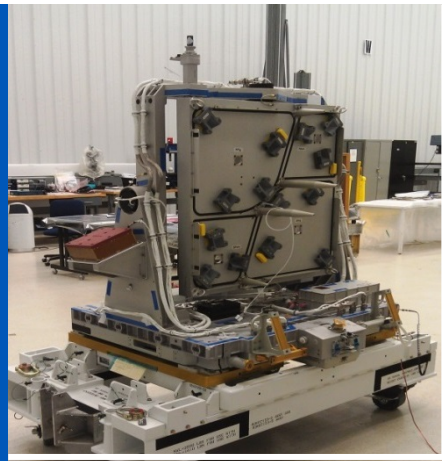
- **Teledyne & DLR, the German Space Centre, have partnered for the DLR Earth Sensing Imaging Spectrometer (DESIS) to be hosted on Teledyne's Multi-User System for Earth Sensing (MUSES) mounted on the International Space Station (ISS)**
- **MUSES is an Earth-imaging platform designed, built, owned and operated by Teledyne**
  - A commercialization project for the ISS
  - Hosts up to 4 robotically installed & removed instruments
  - Provides precision pointing for earth observing instruments
  - Provides all EO mission planning, control, and data downlink
  - MUSES is licensed by NOAA for commercial remote sensing
- **DESIS is a Visible to Near-InfraRed (VNIR) Imaging Spectrometer**
  - Designed and built by DLR
  - Operated by Teledyne
  - DLR uses DESIS for scientific research and humanitarian purposes
  - Teledyne uses DESIS for commercial purposes



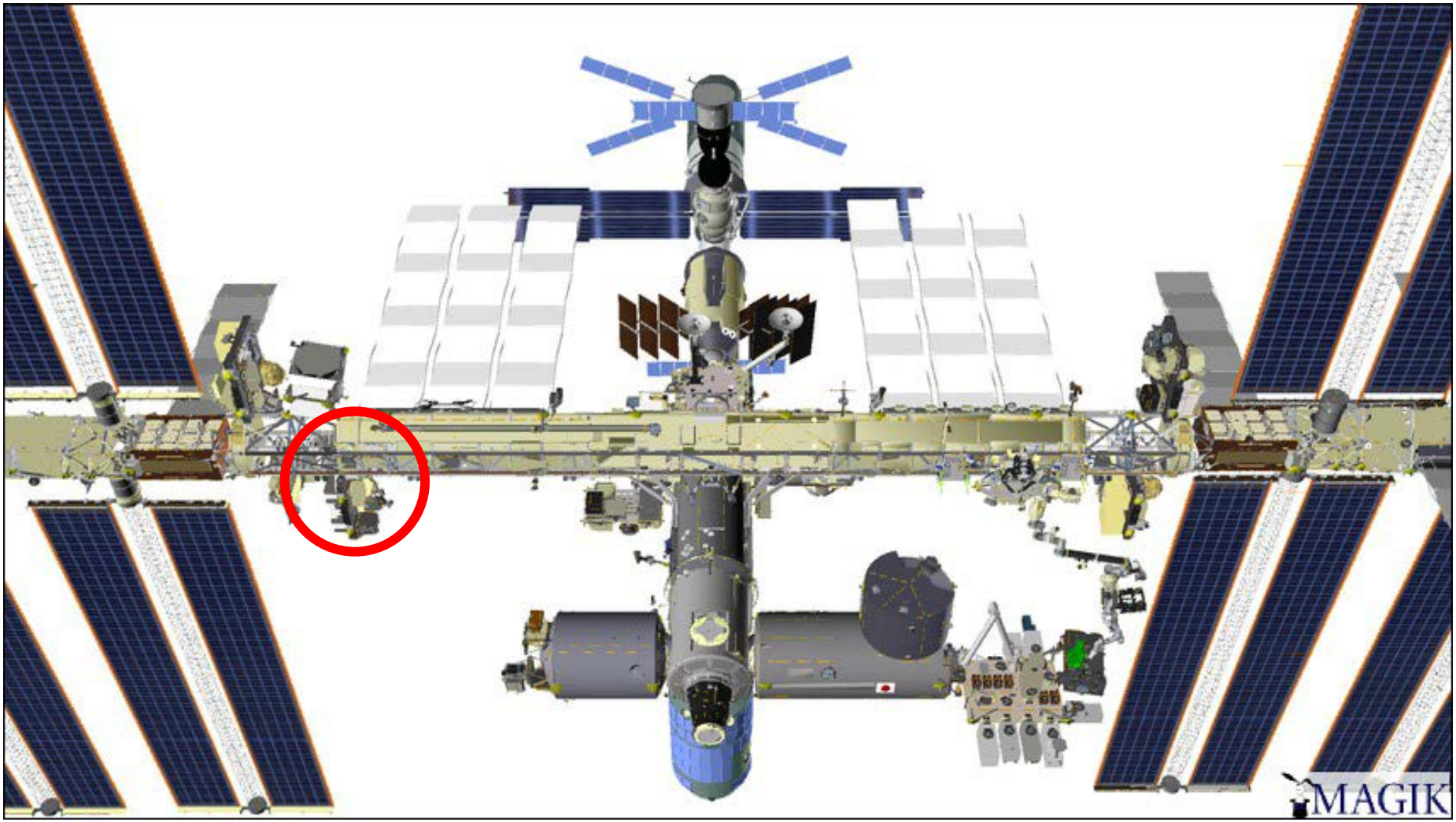
DLR

Multi-User System for Earth Sensing (MUSES)

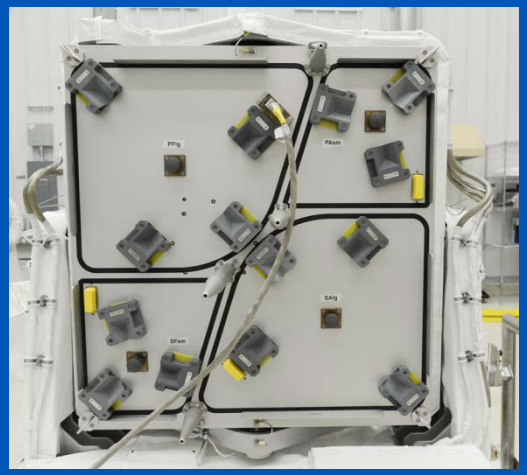
- MUSES Platform
- Located on ELC 4-2
- Inertially stabilized
- Precise pointing and Earth surface target tracking
- Up to 4 robotically installed instruments
- Total data downlink ~225 GB/day
- Teledyne owns the platform, determines pointing schedules, and retains data rights in cooperation with partners
- Instruments launched in “soft stowage”



MUSES Location on ELC-4



Platform Capabilities

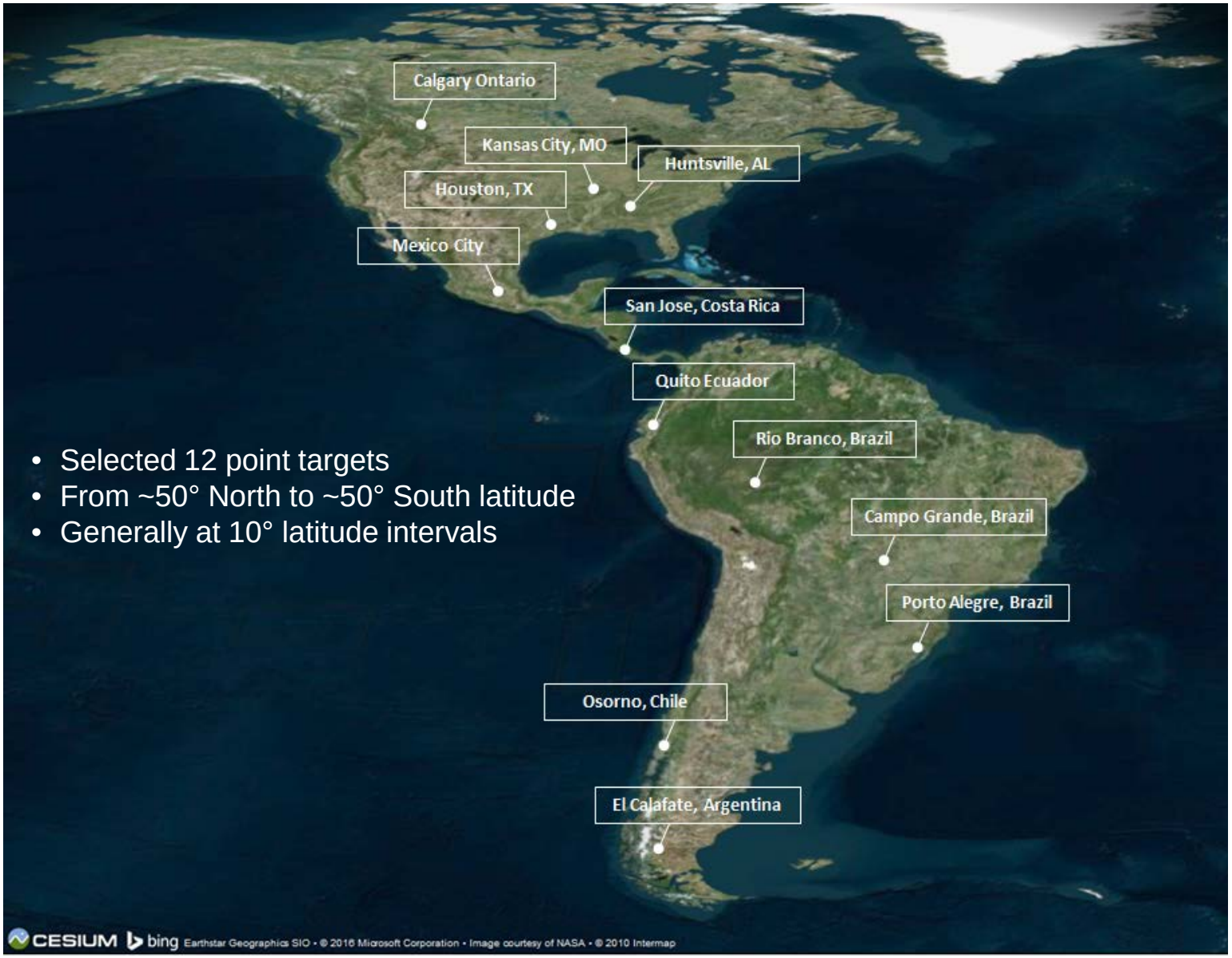


Pointing Knowledge	≤ 30 arc seconds (~ 60 m on ground from 400 km altitude)
Field of Regard	5° outboard cross-track 45° inboard cross-track +/- 25° along- track
Star Tracker	Sodern SED26
Inertial Measurement Unit	Honeywell Miniature Inertial Measurement Unit (MIMU)
Precision Time	Sourced from the ISS GPS, ± 250 usec to MUSES instruments
Location knowledge	Sourced from the ISS GPS, ± 50 meters, RMS
Orbit	51.6° Inclination, 400 km altitude ± 5% (nominal)
Data Processing	Linux Server on-board ISS with redundant 8 TB storage
Daily Downlink Capacity	225 GB

Earth Observation From the ISS – Why It Works

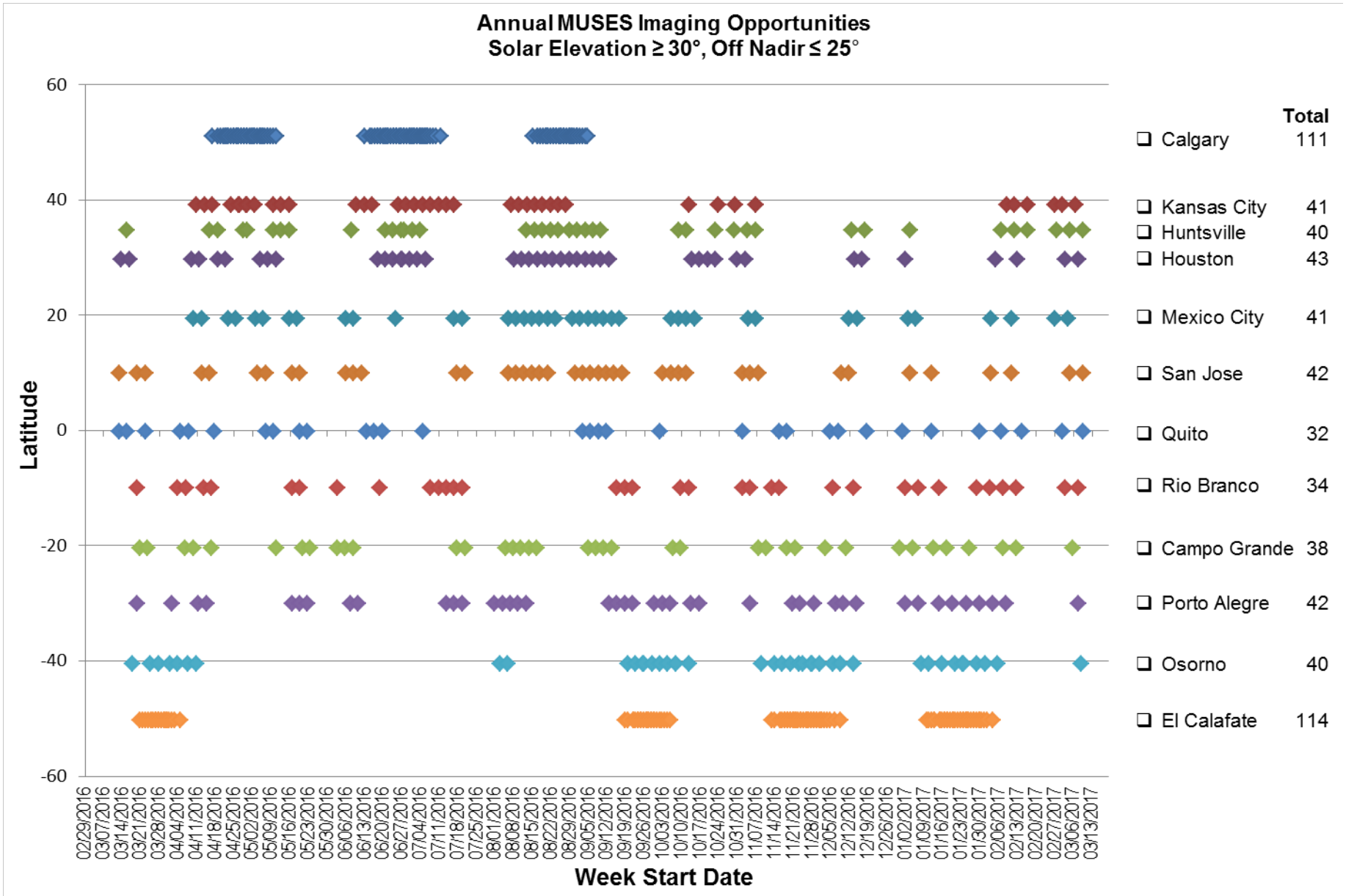
- Coverage of ~90% of populated Earth
- Coverage of ~100% of ocean shipping lanes and major navigational ports
- Coverage of 100% of tropics and equatorial region
- Sophisticated spacecraft bus with required resources
- Upgrade and exchange of instruments as technology and/or markets evolve
- Traditional barriers to entry minimized

MUSES Imaging Opportunity Analysis



- Selected 12 point targets
- From ~50° North to ~50° South latitude
- Generally at 10° latitude intervals

MUSES Imaging Opportunities



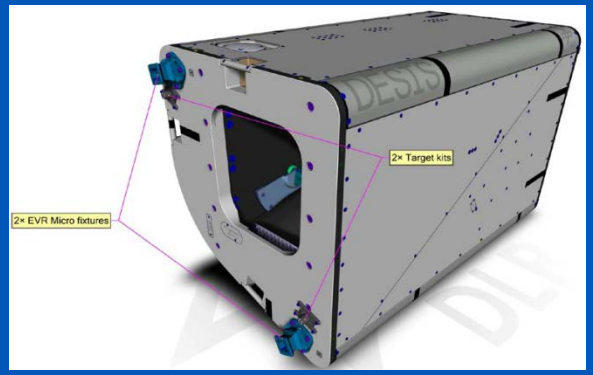
DLR Earth Sensing Imaging Spectrometer

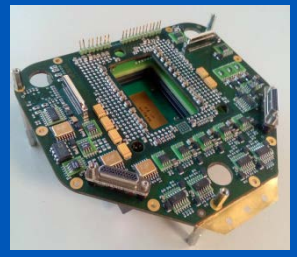
- Teledyne and DLR have partnered to build and operate the DLR Earth Sensing Imaging Spectrometer (DESIS) from the Teledyne-owned MUSES Platform on the ISS
- Teledyne retains rights for commercial use
- DLR retains rights for scientific use
- Launch planned for Q4, 2017
- The DESIS Instrument will be used to
  - Enable scientific RESEARCH
  - Expand HUMANITARIAN response
  - Provide COMMERCIAL value

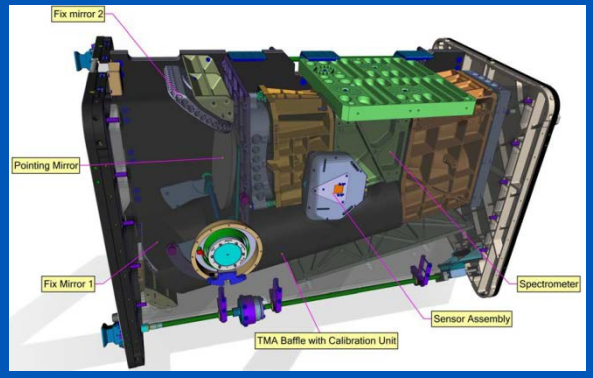
DLR

DLR Earth Sensing Imaging Spectrometer (DESIS)

Characteristic	DESIS Features
Ground Sampling Distance	30 m @ 400 km altitude
Ground Swath	30 km @ 400 km altitude
Spectral Range	400 nm – 1000 nm
Spectral Bins	Measured: 235 @ 2.55 nm Programmable binning on-orbit
Quantization	12 bits + 1 gain bit
Signal to Noise Ratio @ 550 nm	205:1 sampled at 2.55 nm 406:1 binned to 10.2 nm
On-board calibration	Dark Field for DSNU LED Array for PRNU
Independent Pointing	Pointing Unit ±15° Along Track
Independent Time and Location	On-board GPS

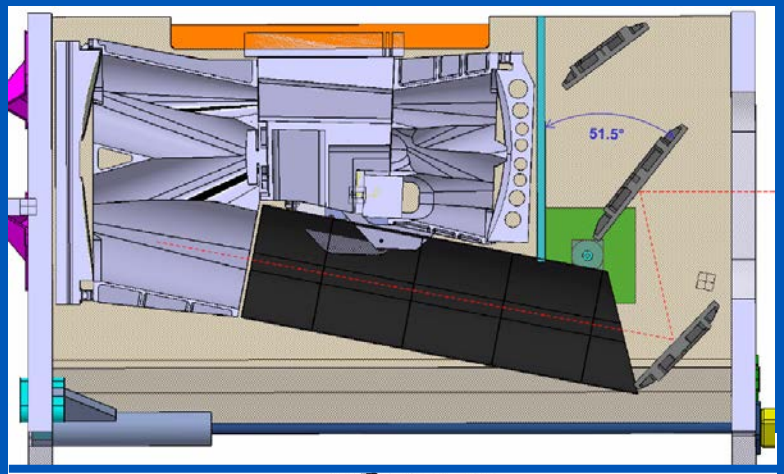


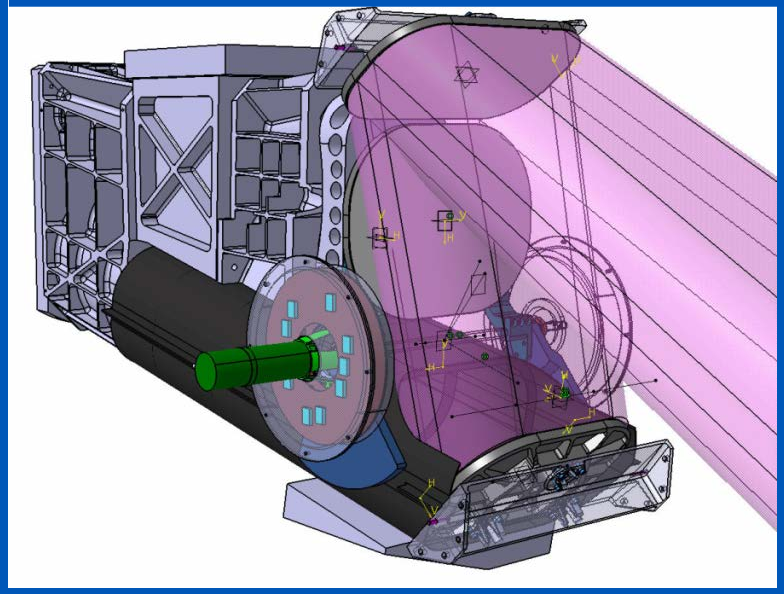




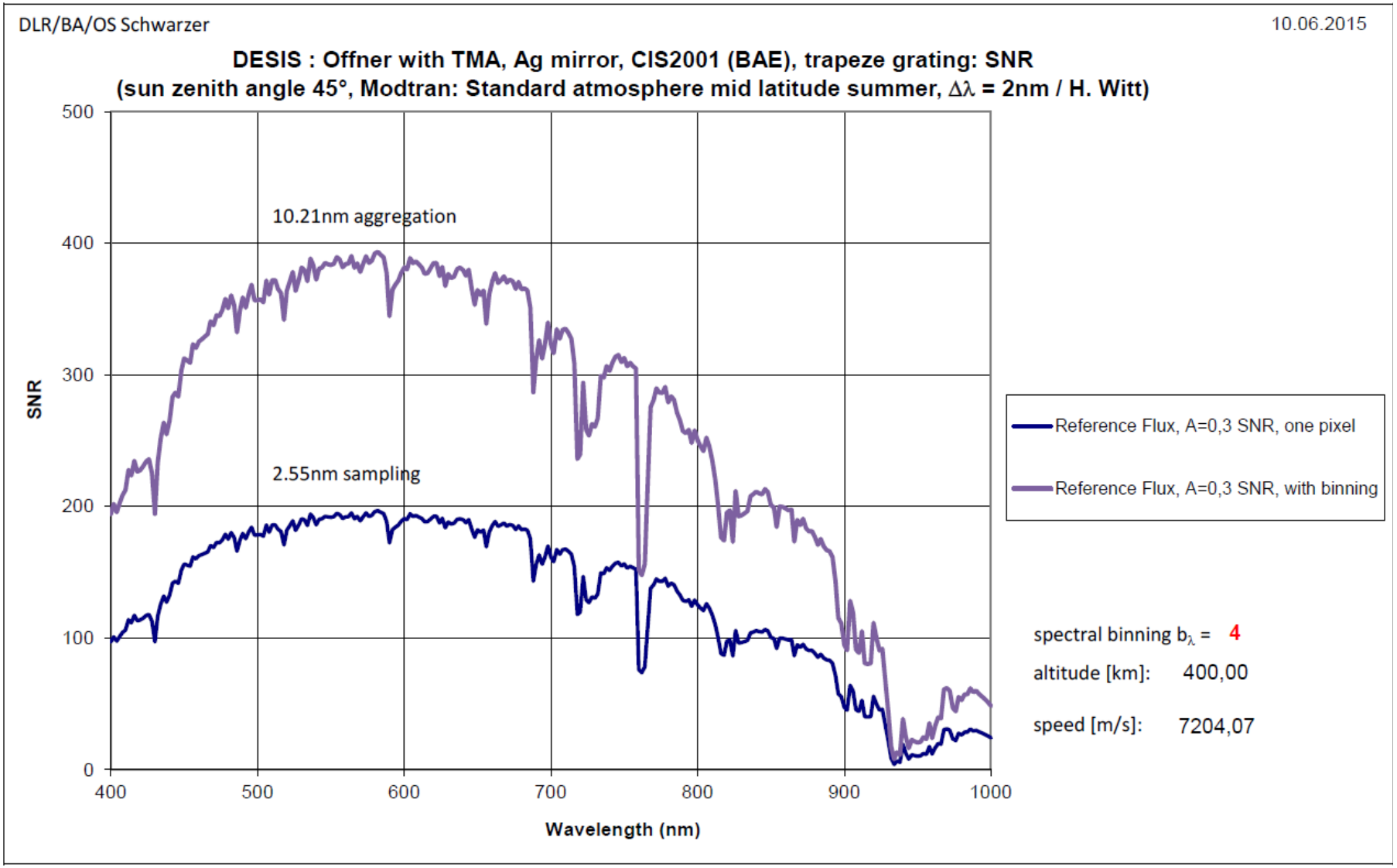
DESIS Pointing Unit

- **Changes sight ±15° in the along-track direction**
- **Earth Sensing Mode**
  - 11 measurement positions ±15° (every 3°)
  - Repeatability / accuracy 20 arc minutes
  - Target replacement time ≤ 0.5 seconds
- **Stereo Mode**
  - Collection of up 3 image tiles at different angles
  - Used for BRDF & altitude extraction
- **Forward Motion Compensation Mode** (experimental)
  - Used to increase SNR for specific targets
  - Speed 0.6 deg/sec and 1.5 deg/sec
  - Accuracy 0.06 degrees (1/10 GSD)
  - Range of rotation ±15°





DESIS Signal to Noise (SNR)



SNR for 2.55 nm sampling distance and spectral binning by factor 4

Partnership: DLR and TBE Data Processing

TBE GS

Image Data & Telemetry

Tasking

Teledyne Tele-Science Center

Image Data & Telemetry

Teledyne Earth Sensor Portal

Tasking

Catalog
DESIS Archive + Auxiliary Data

Order Management

L1A – Transcription

L1B – ToA Correction

L1C - Orthorectification

L2A – Atm. Correction

Processing

DESIS data + Auxiliary data

Share Calibration
Share Validation

Products

Data Request

TBE Customers

DLR GS

Data Request

DLR Requestor

DLR DESIS Data Management System

L1A – Transcription

Data Storage DESIS Data + Auxiliary Data

L1B – ToA Correction

L1C - Orthorectification

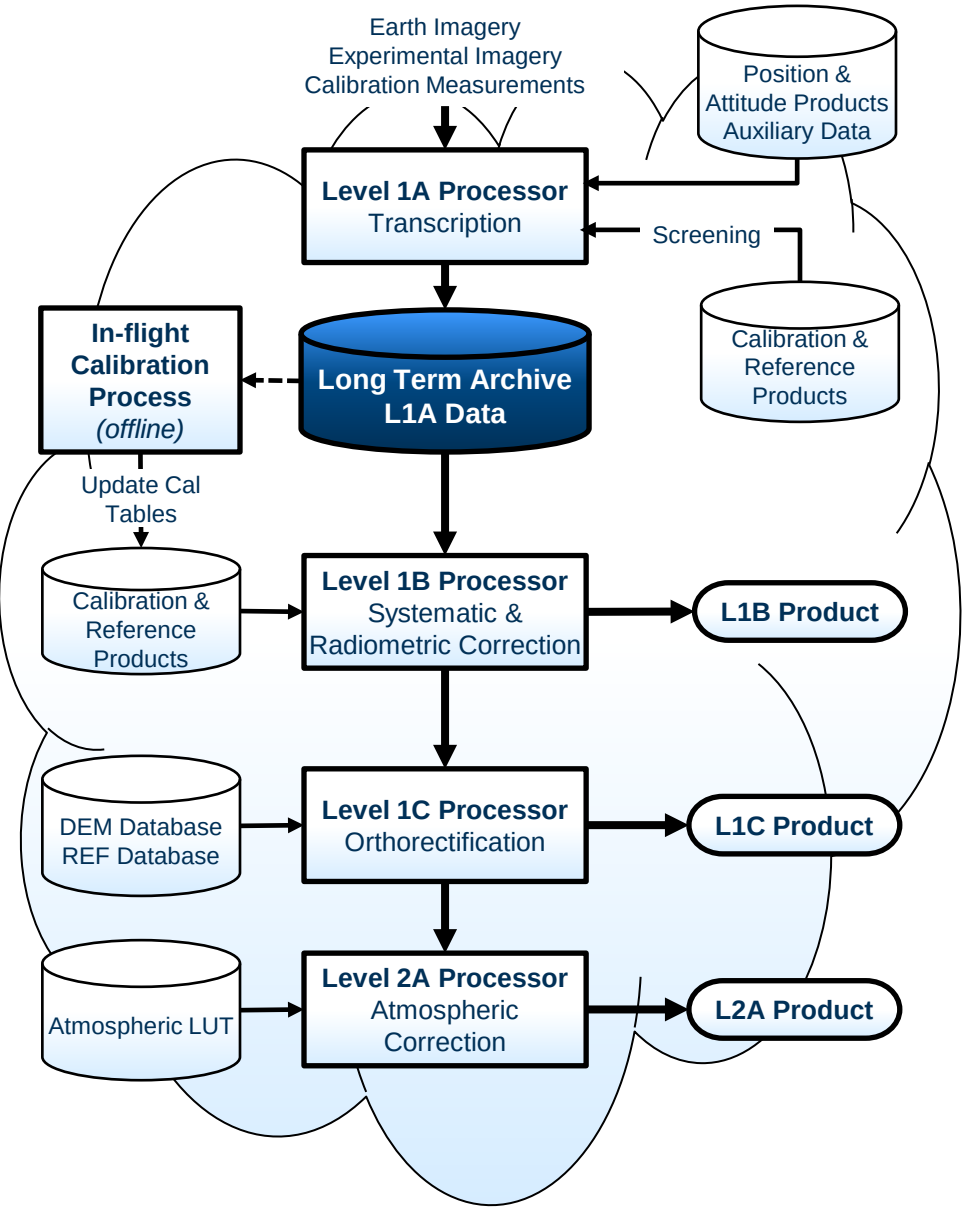
L2A – Atm. Correction

Products

DLR Research Partners

DLR

Processing Chain



L1A

- Extract & evaluate dark current data
- Tiling & reformatting of raw HSI
- Processing of Calibration Data
- Screen raw data
- Derive dead/suspicious pixel mask
- Generate quicklook image
- Metadata generation

L1B

- Input L1A HSI tiles + dark current data
- Apply systematic and radiometric corrections (housekeeping and AOCS data appended).
- Extract quality indicators
- Top of Atmosphere radiance.

L1C

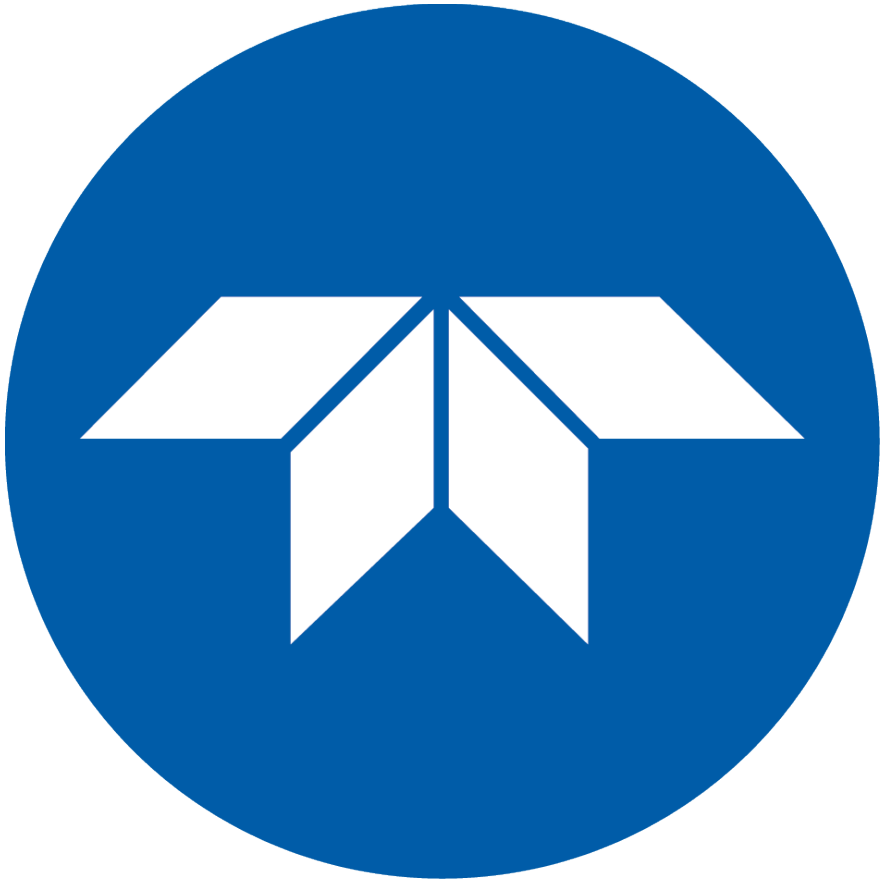
- L1B data is orthorectified and resampled
- Direct georeferencing using DEM
- Map projection.

L2A

- Atmospheric corrections using ATCOR
- At Surface reflectance

Current MUSES and DESIS Status

- **MUSES**
  - Delivered to KSC on Feb 6
  - Completed Payload Rack Checkout Unit Testing @ KSC
  - Completed end-to-end TSC to MUSES testing @ KSC
  - Handover to launch vehicle integrator on March 13, 2017
  - Manifested on SpaceX-11, scheduled for May, 2017
  - MUSES commissioning during Q2/Q3, 2017
- **DESIS**
  - Critical Design Review completed June 2016
  - MUSES-DESIS integration tests completed Jan 2017 (EM)
  - Conducting subsystem integration & test (FM)
  - Planned launch on SpaceX-13, Q4, 2017
  - DESIS commissioning during Q1/Q2, 2018



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