SOUTH AFRICAN NATIONAL SPACE AGENCY

Defining South Africa's next EO mission

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Historical background and EO heritage in South Africa

- Support to NASA (telemetry and tracking) at HBK since 1960
- GreenSat (1991) and SunSat (L: 1999; F: 2001) from Stellenbosch Univ.
- SA Government Lead User Group work (2004 onwards) resulted in
  - Broad user needs and initial specifications for the National Space Strategy
  - Involvement in the ARMC process
- Sumbandilasat (2006; L: 2009; F: 2011) technology demonstrator
- SANSA Act signed (Dec 2008)
- ARMC agreement signed with Algeria, Nigeria and Kenya (Dec 2009)
- SunSpace defines the specs of an ARMC-compatible satellite (May 2010)
- SANSA launched (Dec 2010) and starts operations (Apr 2011)
- Broad Government and user consultations on needs and expectations (2011-2013) through user surveys and workshops
- SunSpace absorbed in Denel Dynamics (2013), tasked to build EO-SAT1

International context

- ARMC requirements (2009)
  - Pan-chromatic imager: 2.5 m
  - Multi-spectral imager: 4 Vis/NIR bands @ 12 m

- Existing offerings (as of 2014)
  - Landsat-8: Pan (15 m) + 5 Vis/NIR + 3 SWIR + 2 Thermal bands @ 30 m
  - SPOT-6: Pan (1.5 m) + 4 Vis/NIR bands @ 6 m
  - DigitalGlobe WorldView-3: Pan (0.5 m) + 4 Vis/NIR bands @ 2 m

- Planned offerings
  - Sentinel-2: 9 Vis/NIR bands + 3 SWIR @ 10-60 m
  - New commercial ventures?

- Implication: SA needs to propose a satellite that is different, better, and/or cheaper than, and complementary to, what will be available near the end of this decade…

Summary of recent progress

- Oct – Nov 2013:
  - Mission Advisory Committee (EO-MAC) prioritized objectives
  - Scientific Subcommittee (EO-MAC-SS) adopted a method to derive the measurements required for a set of priority products

- Jan – Feb 2014: SANSA-sponsored Exploratory Studies followed that approach and derived measurement requirements for key deliverables
  - Agriculture (crops and rangelands)
  - Land Cover and Forestry
  - Water Quality
  - Air Quality
  - Built environment
  - Natural Hazards and Man-made Disasters

- Mar 2014: First EO-SAT1 Science Workshop

- Next step: coordination with Spaceteq, SANSA and DST to evaluate what is technically possible and financially affordable

Prioritization of objectives

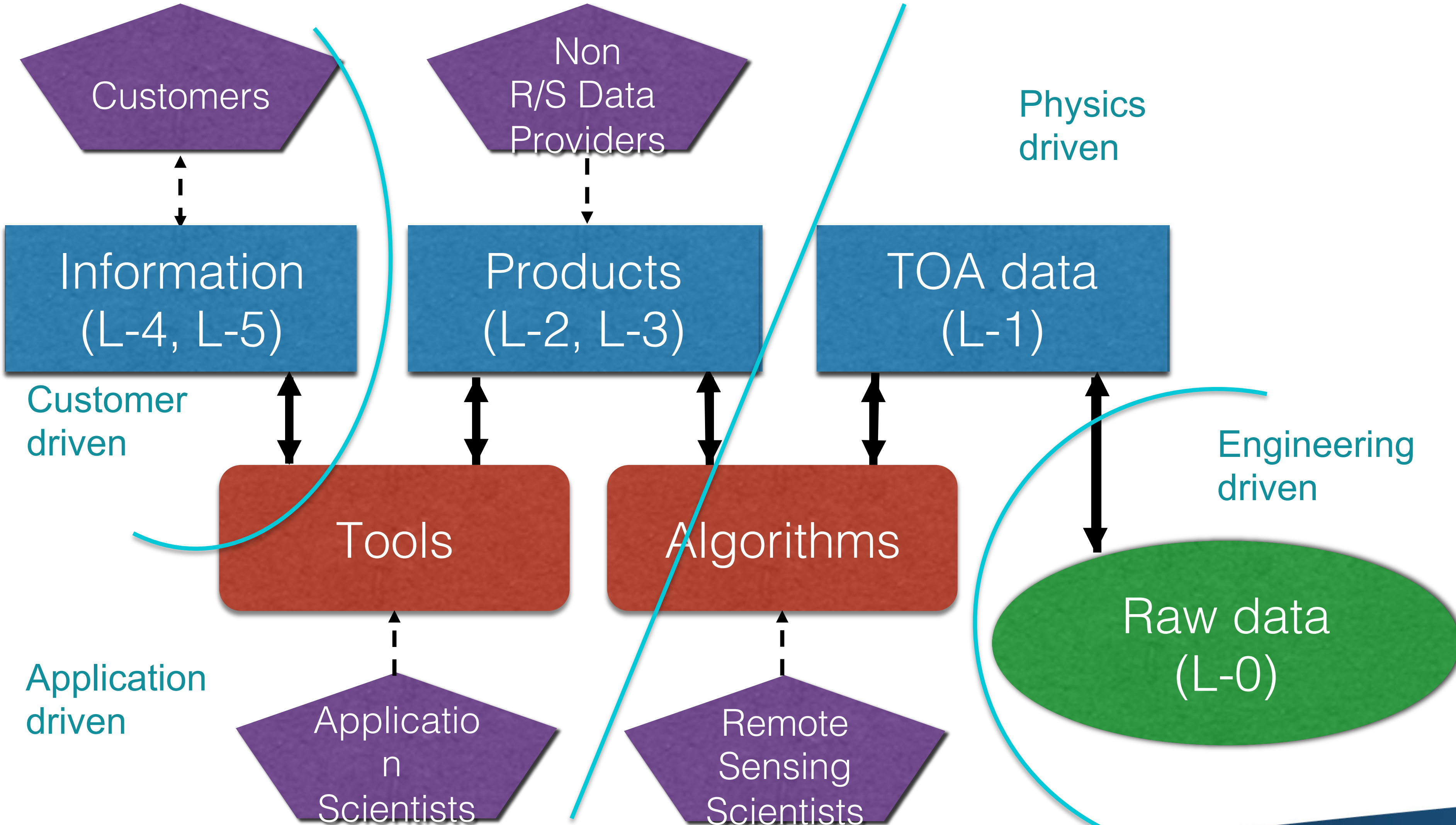
- Primary objective:
  - expresses the central, most important goal to be achieved
  - drives the design of the platform and payload, and
  - serves as the ultimate benchmark to evaluate the overall performance of the entire system
- Secondary objectives:
  - can be achieved with same resources, or
  - can be addressed within budget and without threatening primary objective
- Enabling objectives:
  - Essential to guarantee the performance of the mission and the quality of the products and services
- Ancillary objectives:
  - All other wishes and expectations

EO-SAT1 mission statement

- Primary objective:
  - Characterize the state and evolution of vegetation over selected land areas
- Secondary objectives:
  - Monitor water and air quality
  - Survey the built environment
  - Support the management of natural hazards and man-made disasters
- Enabling objectives:
  - Instrument calibration (characterization, on-board, Moon, cross/vicarious)
  - Algorithms benchmarking, intermediary and final products validation
  - Atmospheric corrections (gases, aerosols, clouds)

- Sampling versus wall-to-wall acquisitions

Measurement requirements and ground segment design



SANSA-sponsored exploratory studies

- Study 1: Agriculture (crops and rangelands)
  - Support to DAFF, ARC, agroindustry
- Study 2: Land cover and forestry
  - Support to DEA, DAFF, DHS, UNFCCC
- Study 3: Water Quality
  - Support to DWA, DAFF, fight against invasive species
- Study 4: Air Quality
  - Support to DEA, DH and SAWS
- Study 5: Built environment
  - Support to DHS, DRDLR (land reform), planning and auditing
- Study 6: Natural Hazards and Man-made Disasters
  - Support to NDMC, DWA, DAFF

User communities

- Group 1: Data-based applications
  - Vegetation (crops, rangelands, forests, land cover)
  - Water quality (bacteria and algae, invasive species, sediments)
  - Air quality (clouds, aerosols: dust, smoke, etc.)
  - ➢ Focus on biogeophysical properties of the environment
  - ➢ Broad swath, medium to high spatial resolution, narrow spectral bands, angular acquisitions, calibration, SNR, etc.

- Group 2: Image-based applications
  - Built environment (infrastructure, informal settlements)
  - Natural hazards and man-made disasters (drought, flood, fire, spills)
  - ➢ Focus on geo-spatial organization of the landscape
  - ➢ Narrow swath, very high spatial resolution

Spatial and temporal measurement requirements of Group 1

- Motivation for data-based applications:
  - Dynamics of vegetation and land cover, surface water, cloud and aerosol properties
- Swath (area):
  - As broad as possible to observe targets frequently: at least 150 km
- Spatial resolution (GSD):
  - Best achievable given the swath
- Revisit frequency:
  - 5 to 10 days for large areas (e.g., 10,000 km^2)

Spatial and temporal measurement requirements of Group 2

- Motivation for image-based applications:
  - Spatial organization of target areas
- Spatial resolution (GSD):
  - As fine as possible to distinguish small details, no more than 10 m
- Swath (area):
  - Best achievable given the spatial resolution
- Revisit frequency:
  - 2 to 6 months for limited areas (e.g., 100 km^2)

Spectral measurement requirements (VIS/NIR) for Group 1

- Motivation:
  - Quantitative estimation of biogeophysical properties of vegetation, soil, surface waters, aerosol properties, as well as target identification
- Vegetation: 4 spectral bands: red (665), red edge 1 (705), red edge 2 (740), NIR (779)
- Chlorophyll fluorescence: 1 very narrow spectral band: red (681)
- Land cover, veg. properties, bacteria: 1 spectral band: yellow (610)
- Vegetation properties, water turbidity: 1 spectral band: green (560)
- Aerosol effects: 2 spectral bands: deep blue (440) and blue (490)
- Water vapour effects: 2 spectral bands: NIR (865) and NIR (900)
- Emphasis on narrow bands (≤ 20 nm) and high SNR

Spectral measurement requirements (SWIR) for Group 1

- Motivation:
  - More and better land surface quantitative products
- Atmospheric correction (thin cirrus cloud detection): 1380 nm
- Forest properties, pest damage, dry/irrigated land: 1610 nm
- Live/dead vegetation, land cover, fractional cover: 2190 nm
- Live/dead vegetation, land cover, fractional cover: 2400 nm

Spectral measurement requirements (Sprites)

- Motivation:
  - Observations of lightning, sprites and auroras
- UV and NIR bands: 215, 240 and 777 nm
- Slanted observations (height discrimination)

Directional measurement requirements

- Motivation:
  - Stereo acquisitions for Digital Elevation Model (DEM, if small enough GSD)
  - Better atmospheric corrections (aerosols, clouds)
  - Surface anisotropy (vegetation/built environment structure, land cover classification)
  - Height of objects in the scene (airborne, dependent on size and spatial resolution)
- Number of angles:
  - At least 2 for stereo photogrammetry
  - 3 or more for atmospheric corrections
  - 5 or more for surface anisotropy
- Number of spectral bands at those angles:
  - At least 4 within (blue, green, red, NIR) + UV (for sprites)

Other measurement requirements

- Motivation:
  - Quantitative applications based on a low signal: forests, water
- Band-specific high Signal to Noise Ratio (SNR); quantization: 12 bits
- Low out-of-band contributions: < 1%
- Polarization sensitivity: < 1%
- Accurate knowledge of geolocation, pointing and time of acquisition
- Calibration of the instruments
  - Full characterization before launch
  - On-board calibration mechanism
  - Periodic deep space and Moon observations
  - Cross-calibration with other instruments
  - Vicarious calibration

Associated requirements and opportunities from EO-SAT1

- Motivation:
  - Specific measurements are only useful if they are effectively analysed, promptly delivered, over extended periods, and at an acceptable cost
- Reliability: lifetime of 5+ years; follow-up instruments (continuity)
- Latency: Near-real time (NRT) access for some applications
- Human Capacity Development needs, especially with respect to innovative aspects (University courses, User-centred training)
- Algorithms and tools: porting, adapting, upgrading, inventing
- National and international collaborations (e.g., SADC, ESA, NASA)
- Products validation: standards, benchmarking, concurrent airborne and field campaigns
- Clear data policy

Outlook: EO-SAT1

- Measurement requirements need to be confronted to engineering capabilities and financial affordability
- If a payload can be designed to address these expectations, it will
  - meet the original requirements of ARMC expressed in 2009,
  - meet the more advanced requirements of the user community today,
  - allow the generation of a broad range of products and services that fulfil the expectations of the various Government Departments,
  - boost the awareness and competencies of the national space industry, and promote it to world-class,
  - contribute greatly to HCD by stimulating interest in, research on, and applications using remote sensing data that will be state of the art
- Stay tuned for further announcements by the end of this year…