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Global Geodetic Observing System

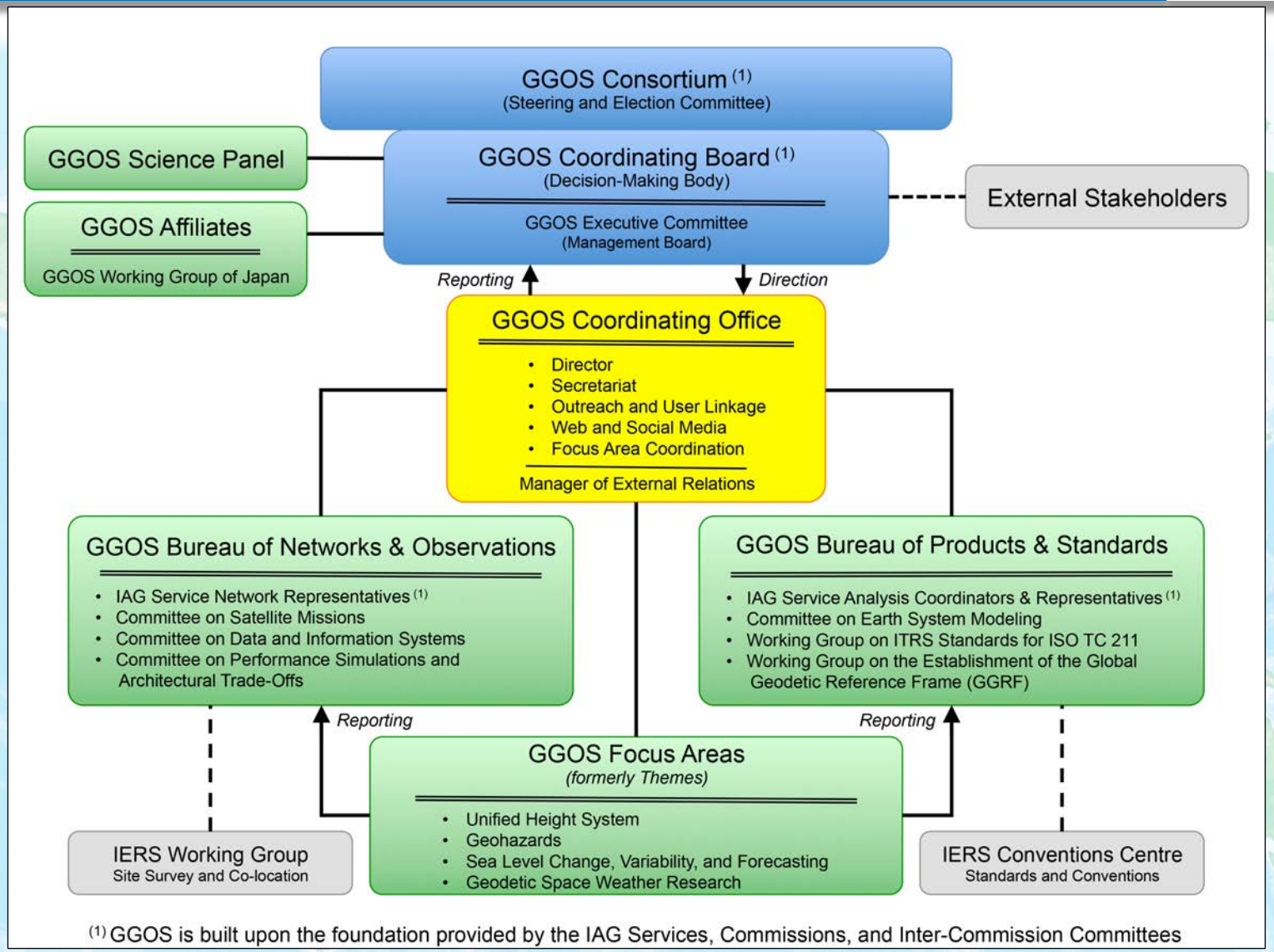
# GGOS Bureau of Networks and Observations

Mike Pearlman
Carey Noll

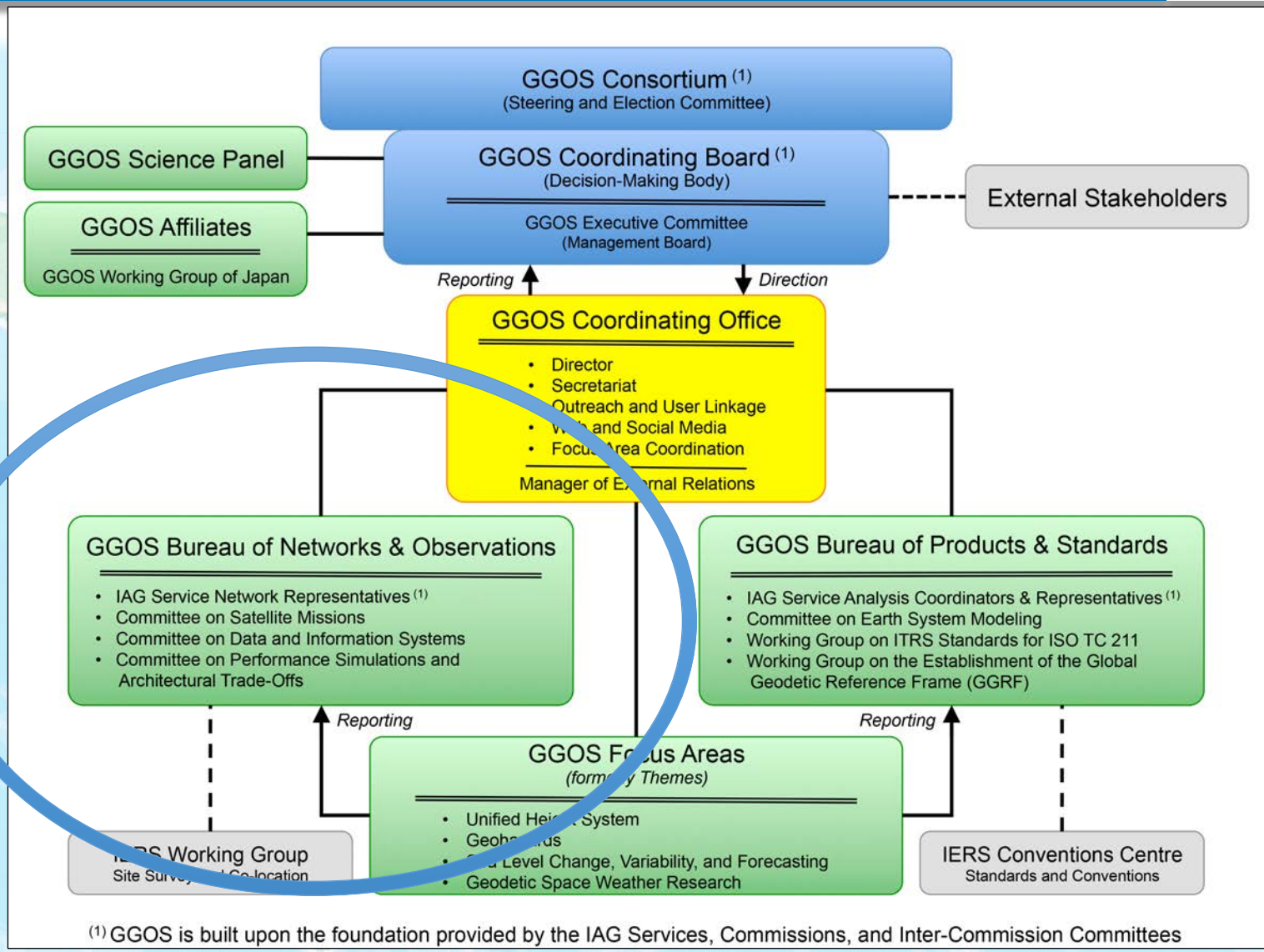
Implementation of the GGRF in Latin America
Buenos Aires, Argentina

September 19, 2019

# GGOS Organization



# GGOS Organization



# GGOS Bureau of Networks and Observations

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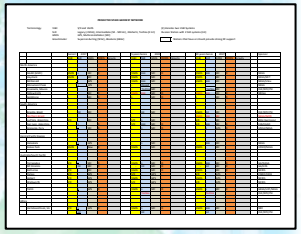
- Advocate for the expansion and upgrade of the space geodesy network for the maintenance and improvement of the reference frame and other GGOS priorities;
- GGOS Requirements for Core Sites and co-location sites; recognize that it will be a combination of core and co-location sites with global distribution for many years;
- Continue recruiting station membership in the GGOS Network; issued membership certificates (great response);
- Monitor network status; projected network evolution based on input from current and expected future participants, estimate performance capability 5 and 10 years ahead;
- Worked with the ILRS, IGS, ICG and the IERS to agree on an SLR tracking strategy to meet range of GNSS user requirements;
- Simulation studies and analyses to assess impact on reference frame products of: network configuration, system performance, technique and technology mix, co-location conditions, site ties, and network trade of options (PLATO);
- Metadata System development for a wide range of users including GGOS; near term strategy for data products (Carey Noll at GSFC) and a more comprehensive longer-term plan for an all-inclusive system (Nick Brown at GA) (Committee on Data and Information);
- Provide the opportunity for representatives from the Services and the Standing Committees to meet and share progress and plans; discuss issues of common interest; meetings at EGU, AGU, GGOS Days, etc.;
- Talks and posters on the Bureau at EGU, AGU, JPGU-AGU, AOGS meetings, etc.;
- Letters/documentation to support stations, current/ new missions, and analysis centers;








# Space Geodesy Provides a Suite of Ground-based Metric Tools for Studying the Dynamics of the Earth System

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VLBI

SLR

GNSS

DORIS

Tide Gauge/GNSS

Gravimeters

# Local Ground Survey is an Essential Part of Co-location

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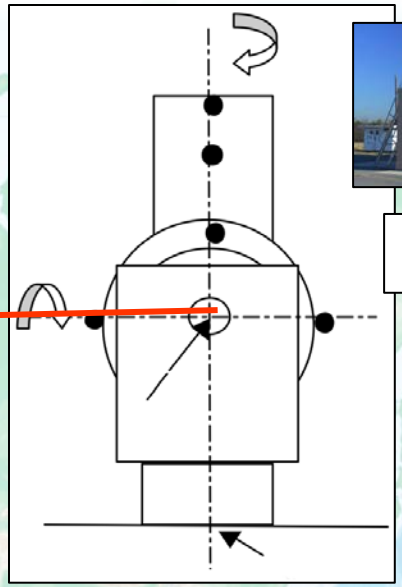
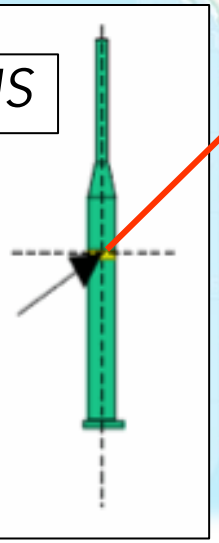
VLBI

Co-Location System

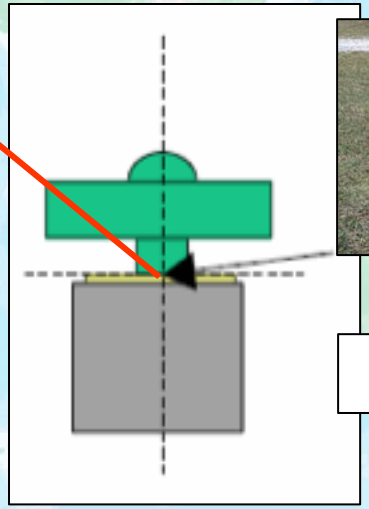


SLR

DORIS



- Local survey is an essential part of co-location, but
- Great care must be taken to identify the system reference points



GPS

# Co-location in Space

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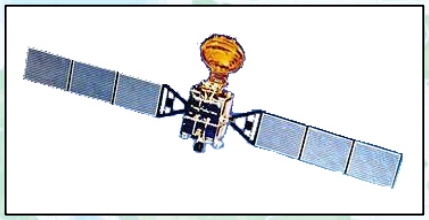
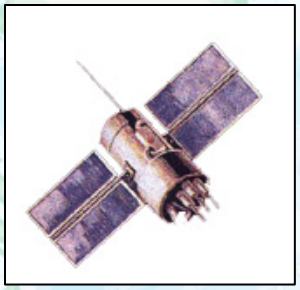
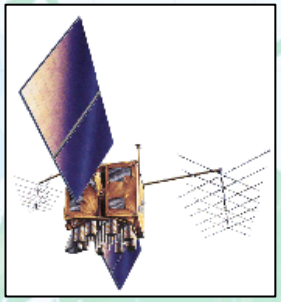


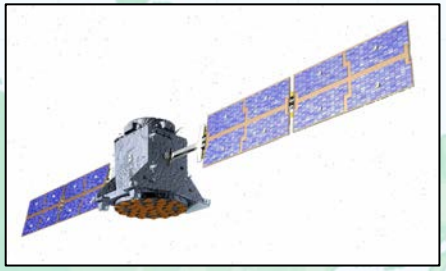
*BeiDou*
*GNSS/SLR*



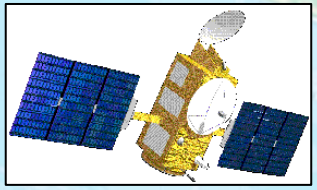
*GLONASS*
*GNSS/SLR*



*GPS*
*GNSS/SLR*

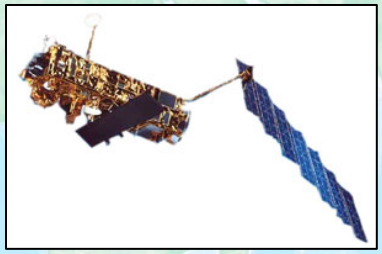


*Galileo*
*GNSS/SLR*

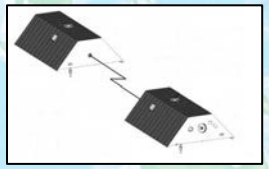


*Jason*
*DORIS/GNSS/SLR*

*CHAMP*
*GNSS/SLR*



*Envisat*
*DORIS/SLR*



*GRACE*
*GNSS/SLR*

# Global Network Supporting GGOS

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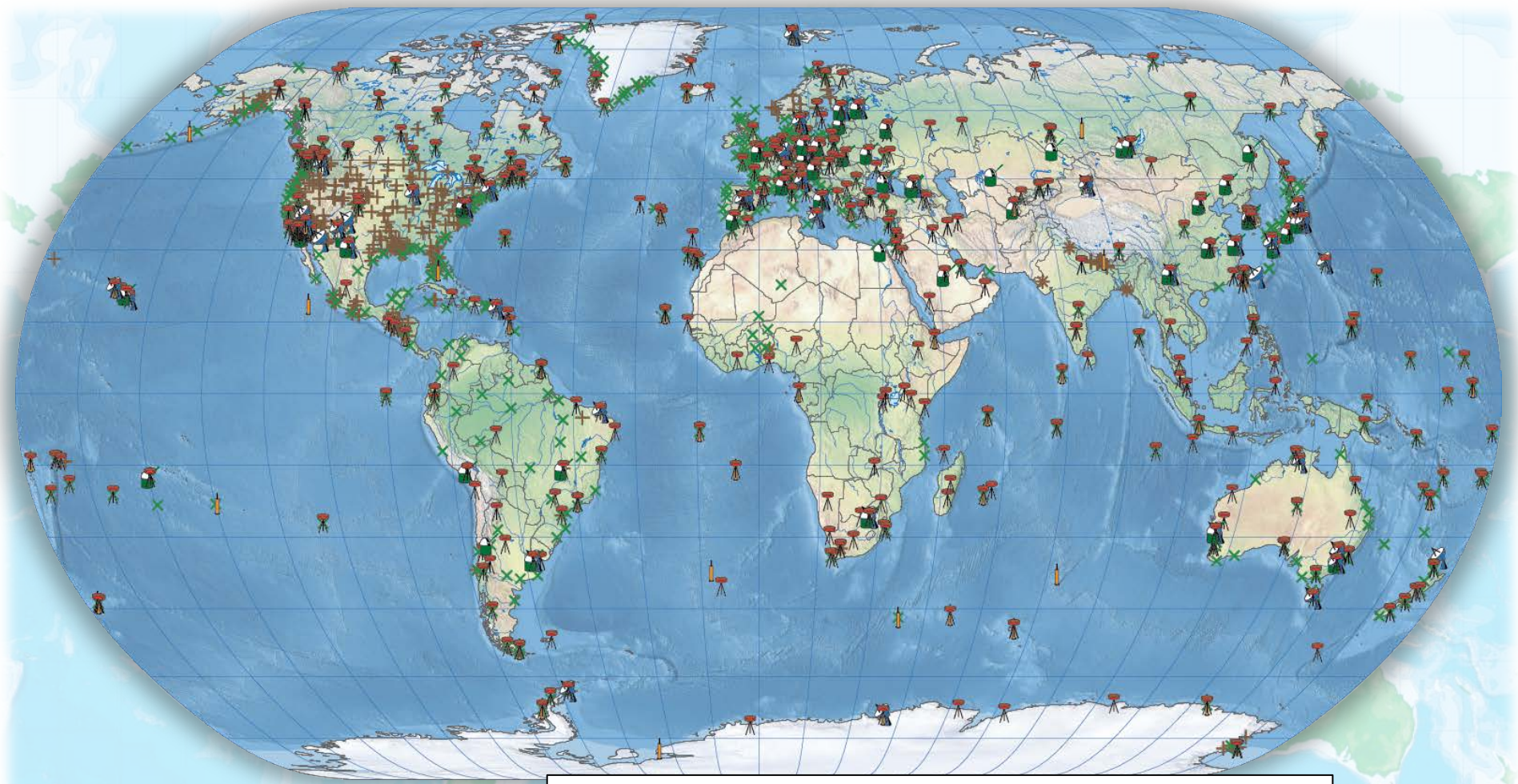
IAG GGOS Global Geodetic Observing System



- *Three big initiatives: NASA, BKG, and ROSCOSMOS*
- *Number of stations still need to "join the club"*
- *Continue to recruit station through the CfP*

# GGOS Network Certificate

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The Global Geodetic Observing System

IUGG

Global Geodetic Observing System

## Yarragadee Geodetic Observatory

is a member of the
GGOS Space Geodesy Network

Richard Gross, Chair
Global Geodetic Observing System

Michael Pearlman, Director
GGOS Bureau of Networks and Observations

# Current and Projected Core Sites

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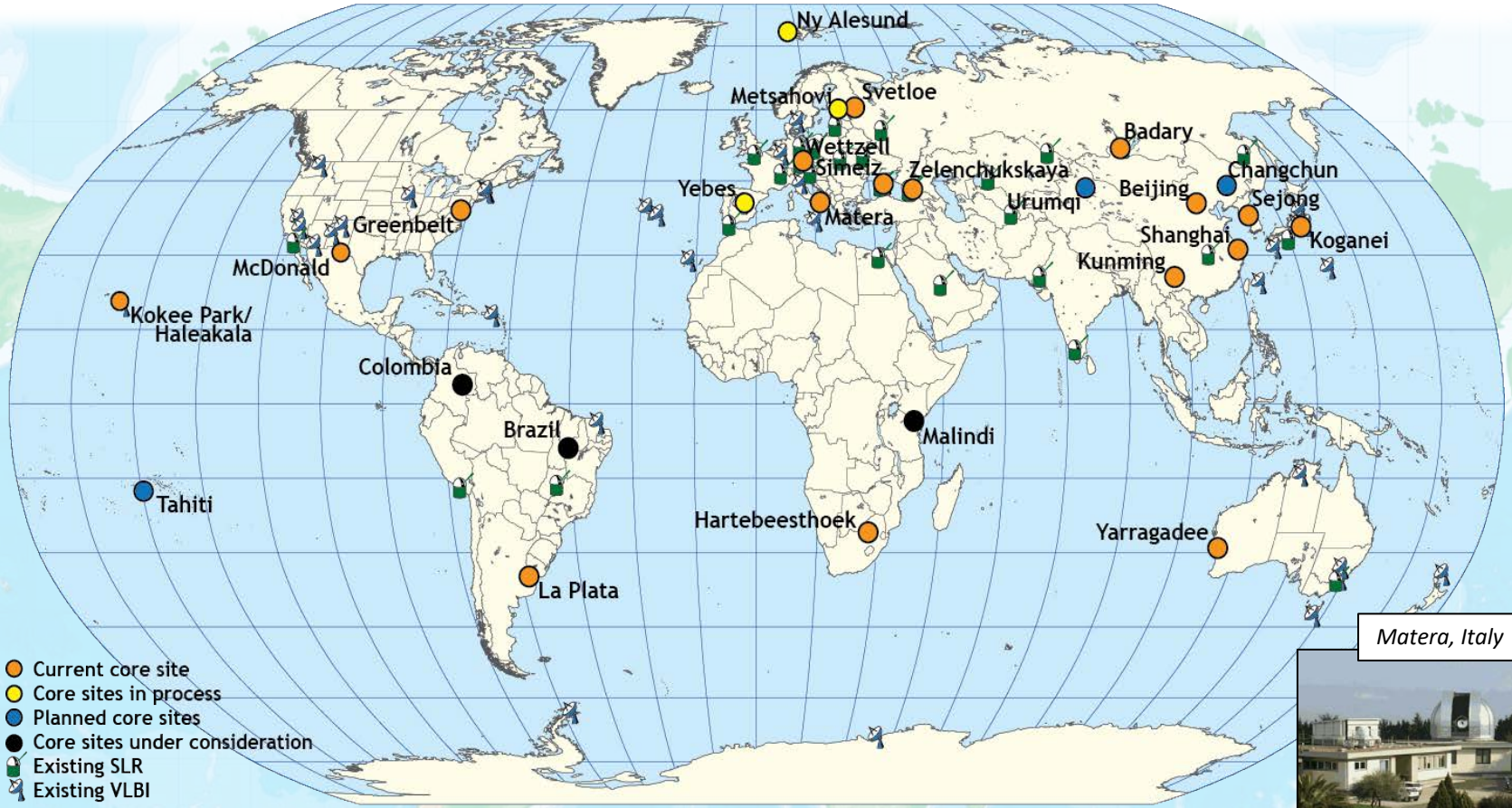


*Matera, Italy*



*Ny Ålesund, Norway*

*Greenbelt, MD USA*

*AGGO, Argentina*

*Metsähovi, Finland*

# Projected Space Geodesy Network

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**PROJECTED SPACE GEODESY NETWORK**

| | | | |
|---|---|---|---|
| Terminology | VLBI | S/X and VGOS | (2) denotes two VLBI Systems |
| | SLR | Legacy (<50Hz), Intermediate (50 - 500 Hz) , Kilohertz, Tochka (2 Int) | Russian Station with 2 SLR systems (Int) |
| | GNSS | GPS, Multiconstellation (MC) | |
| | Gravitimeter | Superconducting (SCGr), Absolute (ABGr) | Stations that have or should provide strong RF support |

| | | Current | 2017 | | | | 5 years hence | | 2022 | | | 10 years hence | | 2027 | | | Sponsor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VLBI | SLR | GNSS | DORIS | Gravity | VLBI | SLR | GNSS | DORIS | Gravity | VLBI | SLR | GNSS | DORIS | Gravity | |
| North America | | | | | | | | | | | | | | | | | |
| | GGAO (GSFC) | VGOS | L | MC | D | | VGOS | kHz | MC | D | | VGOS | kHz | MC | D | | NASA |
| | Haystack | VGOS | - | MC | - | | VGOS | - | MC | - | | VGOS | - | MC | - | | NASA/MIT |
| | McDonald | - | L | GPS | - | | VGOS | kHz | MC | - | | VGOS | kHz | MC | - | | NASA/Utex |
| | Monument Peak | - | L | GPS | - | | - | Closed | | | | - | | | | | NASA |
| | Ensenada, Mexico | | | | | | - | Tochka | MC | - | | - | Tochka | MC | - | | OJC/RPC/PSI |
| | Yellow Knife | | | MC | D | | VGOS | kHz | MC | D | | VGOS | kHz | MC | D | | NRCan |
| | Goldstone | L | | MC | D | | L | | MC | D | | L | | MC | D | | |
| South America | | | | | | | | | | | | | | | | | |
| | Brasilia, Brazil | - | Int | MC | - | | - | Int | MC | - | | VGOS | Int | MC | - | | OJC/RPC/PSI |
| | Northern Brazil | - | - | - | - | | - | - | - | - | | VGOS | kHz | MC | - | | NASA/IMPE |
| | La Plata, Argentina | S/X | | MC | - | | S/X | L | MC | - | | S/X | L | MC | - | | BKG (Germany) |
| | San Juan, Argentina | - | L | | D | | S/X | kHz | MC | D | | S/X | kHz | MC | D | | CAS/FAAO |
| | Arequipa, Peru | - | L | MC | D | | - | L | MC | D | | - | L | GPS | D | | UNSA/NASA |
| Central Pacific Region | | | | | | | | | | | | | | | | | |
| | Haleakala | - | L | GPS | - | | - | L | MC | - | | - | kHz | MC | - | | NASA |
| | Kokee Park | VGOS | - | New | D | | VGOS | - | MC | - | | VGOS | - | MC | - | | USNO/NASA |
| Australia/South Pacific | | | | | | | | | | | | | | | | | |
| | Yarragadee | S/X | L | MC | D | | VGOS | L | MC | D | | VGOS | kHz | MC | D | | GA/NASA |
| | Mt Stromlo | - | Int | MC | D | | - | Int | MC | D | | - | Int | MC | D | | GA/EOS |
| | Katherine | S/X | - | MC | - | | VGOS | - | MC | D | | VGOS | - | MC | D | | NCRIS |
| | Parkes | S/X | - | GPS | - | | S/X | - | GPS | - | | S/X | - | GPS | - | | CSIRO/CASS |
| | Hobart | S/X | - | GPS | - | | VGOS | - | GPS | - | | VGOS | - | GPS | - | | NCRIS |
| | Warkworth | S/X | - | GPS | - | | S/X | - | GPS | - | | S/X | - | GPS | - | | NCRIS |
| | Tahiti | - | L | GPS | D | | VGOS | L | MC | D | | VGOS | L | MC | D | | GRGS/UFP/NASA |
| | | | | | | | | Tochka | | | | | Tochka | | | | OJC/RPC/PSI |
| Africa | | | | | | | | | | | | | | | | | |
| | Hartebeesthoek, SA | S/X | L | GPS | D | | VGOS | L | MC | D | | VGOS | kHz | MC | - | | NRF |
| | | | Int | | | | | Int | | | | | Int | | | | OJC/RPC/PSI |

# GGOS Site Requirements Document


Global Geodetic Observing System (GGOS)

GGOS Requirements
for
Core Sites
(Revision 2)



Contributors:

| | |
|---|---|
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| David McCormick | NASA GSFC |
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| Erricos Pavlis | UMBC |
| Pascale Ferrage | CNES |
| Michael Pearlman (Lead) | CfA |
| Jerome Saunier | IGN |
| David Stowers | JPL |
| Scott Wetzel | HTSI |

GGOS Requirements for Core Sites Revision 2

- Introduction and Justification
  - What is a Fundamental Station?
  - Why do we need the Reference Frame?
  - Why do we need a global network?
  - What is the current situation?
  - What do we need?
- Site Conditions
  - Global consideration for the location
  - Geology
  - Site area
  - Weather and sky conditions
  - Radio frequency and optical Interference
  - Horizon conditions
  - Air traffic and aircraft Protection
  - Communications
  - Land ownership
  - Local ground geodetic networks
  - Site Accessibility
  - Local infrastructure and accmmodations
  - Electric power
  - Site security and safety
  - Local commitment

# Site layout needs to recognize the issue of RF interference among the new technology systems

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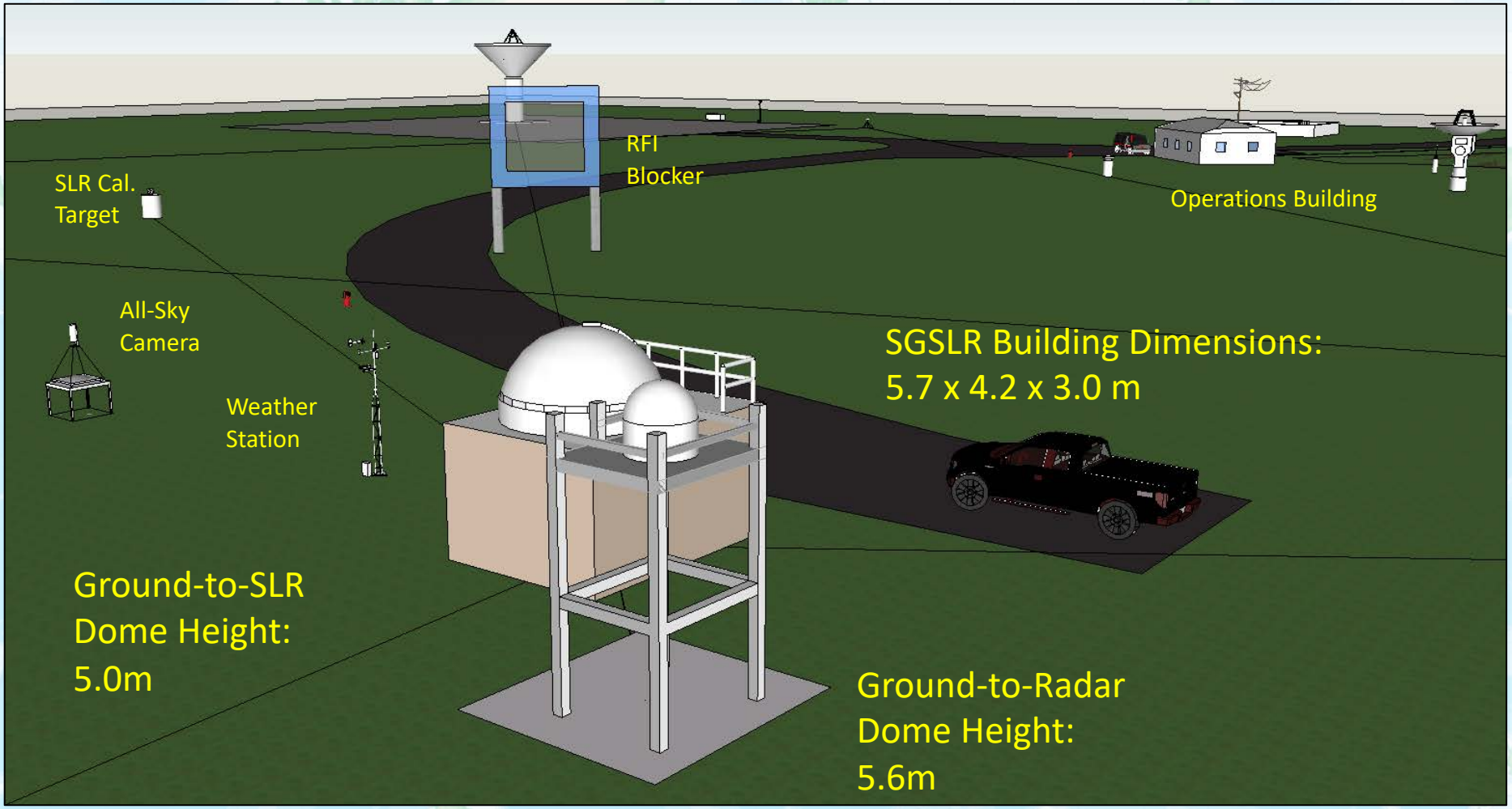


*Approximate building dimensions shown*

# Standing Committee on Performance simuLations & Architectural TradeOffs (PLATO)/D. Thaller, B. Männel

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- Examining trade-off options for station deployment and closure, technology upgrades, impact of site ties, etc. and project future network capability using projected network configuration in new system implementation;
- Conducting simulations to assess impact on reference frame products of: network configuration (e.g., new and additional sites), system performance (e.g., SLR station performance), technique and technology mix, co-location conditions, site ties;
- Conducting simulation studies to assess impact on reference frame products of: co-location in space, space ties, available satellites (e.g., tracking priorities for LAGEOS and Etalon);
- Developing improved analysis methods for reference frame products by including all existing data and available co-locations (e.g., consistent processing of LEO and ground-based observations);
- Conducting ongoing analysis campaign with exchanged simulated observations.

# Standing Committee on Satellite Missions (CSM)/ J. Müller, R. Pail

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- List of satellite contributions to fulfill the GGOS 2020 goals (1 mm / 0.1 mm/yr) has been prepared and will be regularly updated;
- Inventory of the GGOS satellite infrastructure has been prepared and will be regularly updated;
- Both lists are published at the CSM section of the GGOS website;
- ESA's Earth Explorer 10 call: CSM has contributed to proposal MOBILE (future gravity satellite mission) – not selected;
- Exchange with PLATO has been initiated by identifying joint interests and possible collaborations

# Standing Committee on Data and Information System/ H. Titz, C. Noll

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- Adopting and implementing a metadata system to provide access to GGOS relevant data products (Carey Noll);
- Work continues at CDDIS on collection-level metadata efforts (Carey Noll);
- Developing a full metadata system including site information and relevant tools and capability (Nick Brown/the Australian GL scheme)
  - Definition of the requirements;
  - Resolve issues and applicability of the Australian GL scheme and recommend schema;
  - Metadata implementation plan including definition of tasks, roles, and distribution of tasks, and plans for integration of components.

# IERS Working Group on Site Survey and Co-location Tasks/ S. Bergstrand

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- Geometric VLBI telescope deformation measurements have been shown to isolate apparent reference point movements that hitherto have been aliased into space geodetic processing at an order of several millimeters;
- High priority to have such measurements done at legacy VLBI telescopes before they are decommissioned to provide the best possible time series for future International Terrestrial Reference frames (ITRFs);
- Starting mid-2019, the GeoMetre Project (18SIB01) has been granted three years European Commission funding in the European Metrology Programme for Innovation and Research (EMPIR) to improve traceable long-distance measurements and local tie research.

# Reality

Recognizing that:

- Many sites will not be at ideal locations nor have ideal conditions;
- Some new technology stations are being deployed, but not co-located;
- Core site deployment will occur over many years;
- We will have a mix of new and legacy technologies for many years;

As a result:

- Co-location sites (non-core sites) will continue to play a vital role in our data products;
- Quality of our output will be the product of network Core Sites, Co-location sites, mix of technologies, adherence to proper operational and engineering procedures, and making best use of the data once it leaves the field;

But:

- Many groups are taking the initiative to join, build and upgrade

# Summary

- Challenging program with very important science and societal benefits
- Technologies are maturing
- Global distribution is essential
- Very large opportunity for participation in analysis and scientific research
- Need to engage young scientists and students
- Success will depend on partnerships