Development of Distributed Space Object Tracking and Data Sharing as a Means of Achieving the UN 2030 Sustainable Development Goals

5th Manfred Lachs International Conference on Global Space Governance

5-6 May 2017, Montreal QC

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Agenda

- What is “Global Space Governance”?
- UN 2030 sustainable development goals
- Trends in space
- A global space governance idea to foster development
- Distributed ground-based space situational awareness data collection
- International space object data sharing
- How the outputs of this endeavor map onto the sustainable development goals

Abstract

- Access to space remains difficult and expensive, even with the advent of small, low-cost satellite platforms (*e.g.,* “CubeSats”). This high barrier to entry may impede would-be actors in the space arena from participation and development in space-related activities, and associated benefits from such participation. Yet there exist less expensive endeavors that may be undertaken even before initial satellite deployment that would allow actors to develop technically, while in addition making a significant contribution to the long-term sustainability of outer space.
- This paper outlines potential governance mechanisms related to global outer space activities that could contribute to achieving the UN 2030 agenda for sustainable development goals. We outline our ideas for aligning the UN Office of Outer Space Affairs (UN OOSA) with the International Astronomical Union Office of Astronomy for Development (IAU OAD), to bring together interested parties for the furtherance of ground-based space object tracking along with international space object data sharing. Ground-based efforts of this nature offer a much lower barrier to entry for developing countries (and non-governmental organizations) to participate in the space enterprise, while at the same time furthering international cooperation, the development of educational and economic opportunities, environmental sustainability in space, as well as peace and security via transparency and confidence building measures.

Global Space Governance

- What is 'Global Governance'?
- Here exploring a definition put forward by Prof. Nükhet Kardam[1]:
  - » Global Governance: "an international regime in a particular issue area" *e.g.*, "nonproliferation, the environment," SPACE
  - » "Governance can also be understood within the context of national development as used by many donor agencies in tandem with democratization, and participation"
- 'International regime:' *UN COPUOS & IAU OAD*
- 'Particular issue area:' *long-term sustainable use of Space*
- 'National development:' *via entry into space activities for new actors, e.g., space object tracking and data sharing*
- 'Donor agencies:' *UNOOSA + participating contributors*

[1]N. Kardam, "Institutional Mechanisms and Global Governance," http://www.un.org/womenwatch/daw/csw/kardam.htm, Accessed 22 February 2017.

IAU OAD:
International Astronomical Union Office of Astronomy for Development

UN 2030 Sustainable Development Goals*

Sustainable Development Goals

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5. Achieve gender equality and empower all women and girls

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts*

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

***"Transforming our world: the 2030 Agenda for Sustainable Development," Resolution adopted by the General Assembly on 25 September 2015. United Nations, A/RES/70/1, 21 October 2015.**

Trends in Space

Movement from handful of space actors to many, with more wanting to join: Bi-lateral -> Multi-lateral

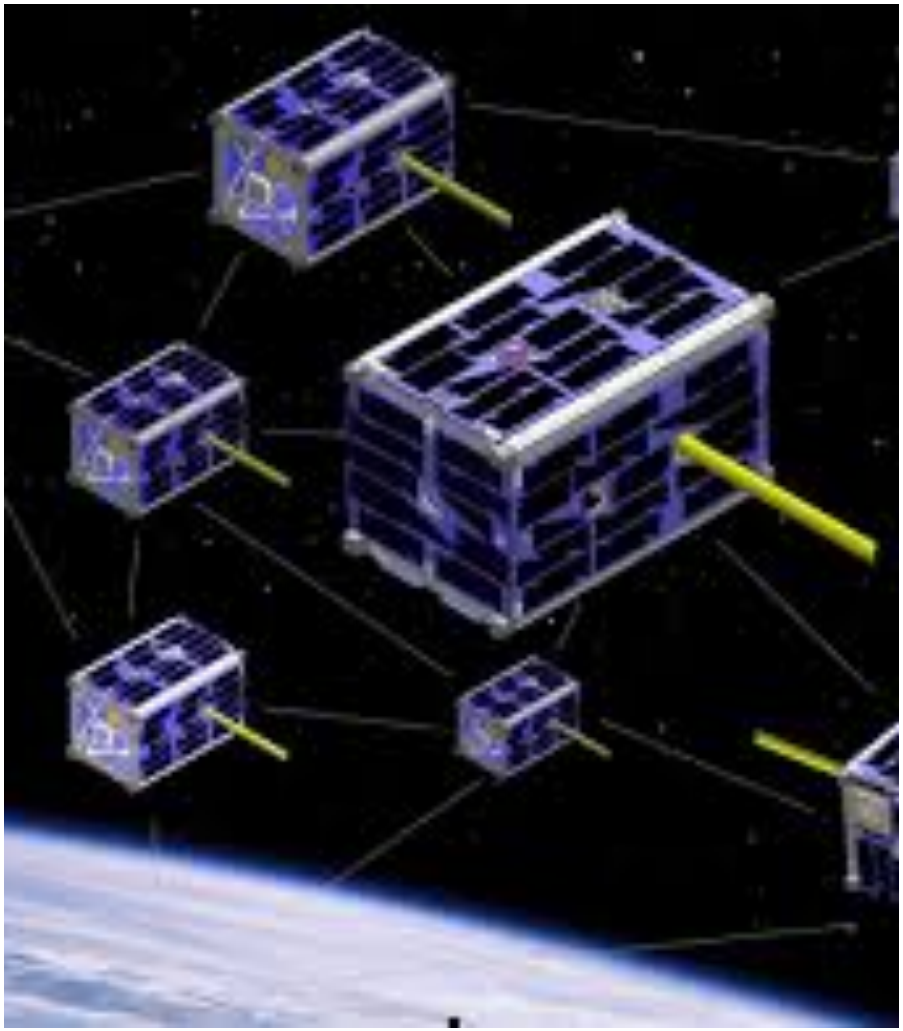
State/Military -> Commercial/ Non-state actors

Expensive/few-> Cheaper/many

But Space is still expensive, and beyond the reach of most

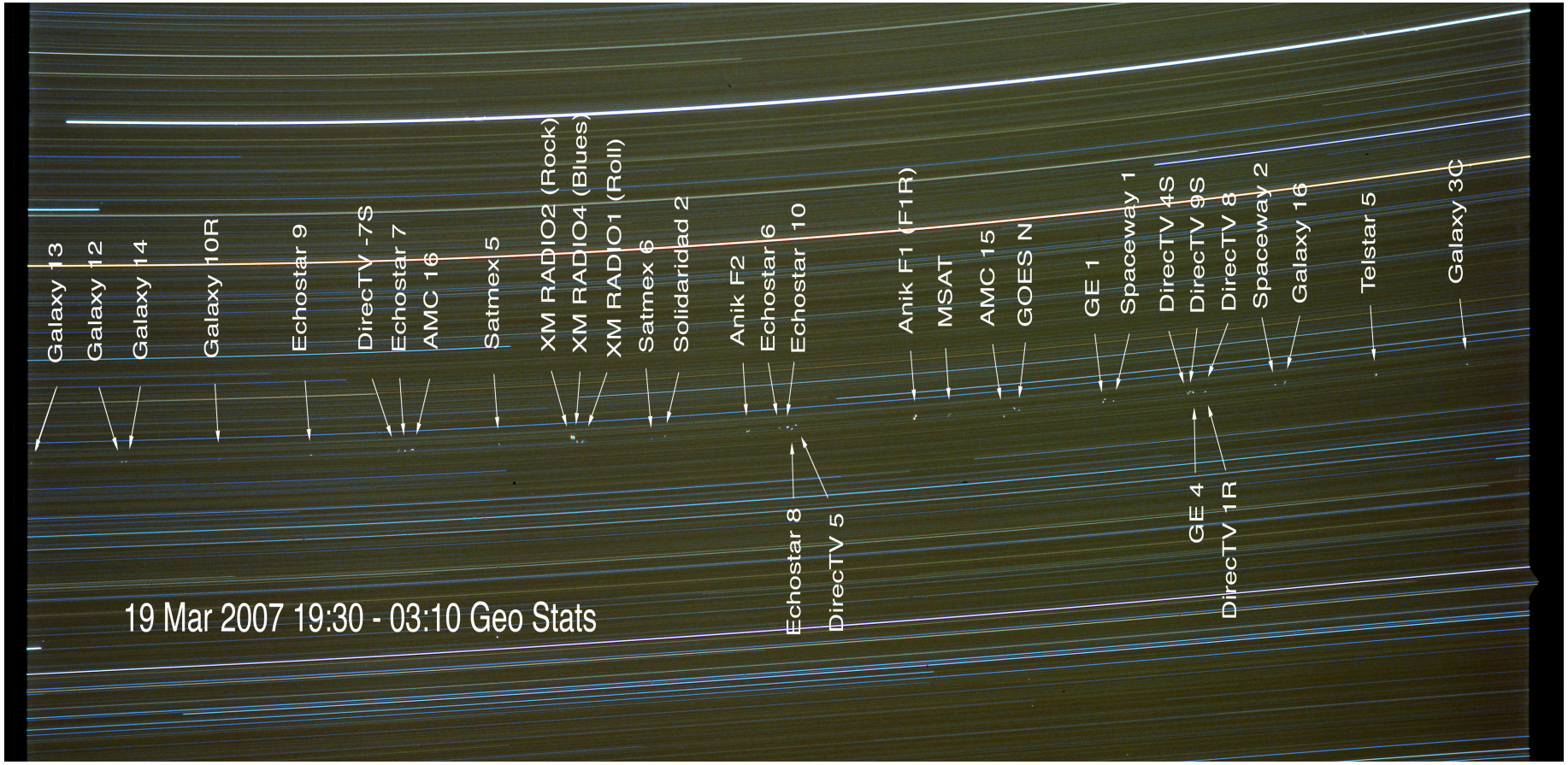
Distributed space *use* should entail distributed space *monitoring*

Desire for enhanced *transparency* in space activities, and *confidence building measures* between space users



EDSN CubeSat Swarm – NASA image
http://www.nasa.gov/content/what-are-smallsats-and-cubesats

1/12th of the GEO belt, viewed from the ground



Geostationary Satellites. Photograph was taken on Kitt Peak in Arizona (lat=31.95°, long=248.5°), 20 Mar 2007, 2:30-11:00 UT. Camera was fixed and spanned 232.5° to 266.5° east longitude along the celestial equator. Setting was f/6.3; focal length=80 mm; film: Ektachrome 100 G.

Photo by Bill Livingston, National Solar Observatory. Used with permission.

Idea: UN OOSA & IAU OAD partner to create governance structure to match donors and recipients

Donors:
Member States
NGOs
Commercial companies
Universities

Recipients:
Universities
"Space Agencies"
PPPs

Funding
Equipment
Expertise

UN Office of Outer Space Affairs

IAU Office of Astronomy for Development

Suggested partnership between UN OOSA and IAU OAD

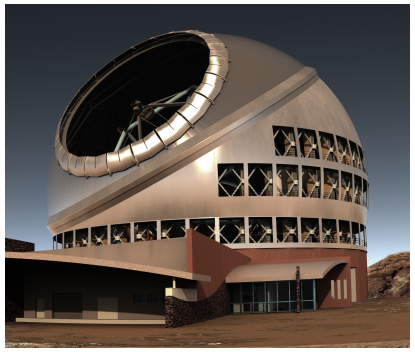
Distributed space object tracking and data sharing for development

- **Space is still expensive**
  - » **Launches ~$M 10's-100's**
  - » **Needs a significant ground segment**
- **A less expensive entry point for new actors in the space arena?**
  - » **Ground-based space situational awareness**
    - – **Collect the data**
  - » **International data sharing**
    - – **Share it with others for benefit of all**

GBSSA: ***Utilize small, COTS terrestrial e/o sensors (telescopes + digital cameras) to observe man-made space objects to derive useful information on them.***

Photo courtesy Dr. Rita Cognion. Used by permission.

What level of technology is needed?



http://www.tmt.org/gallery/
photo-illustrations

A 40 CM. T/S CAN DETECT A ~1 M² OBJECT AT GEO. THAT SIZE HAS BEEN AVAILABLE SINCE THE 1700'S.

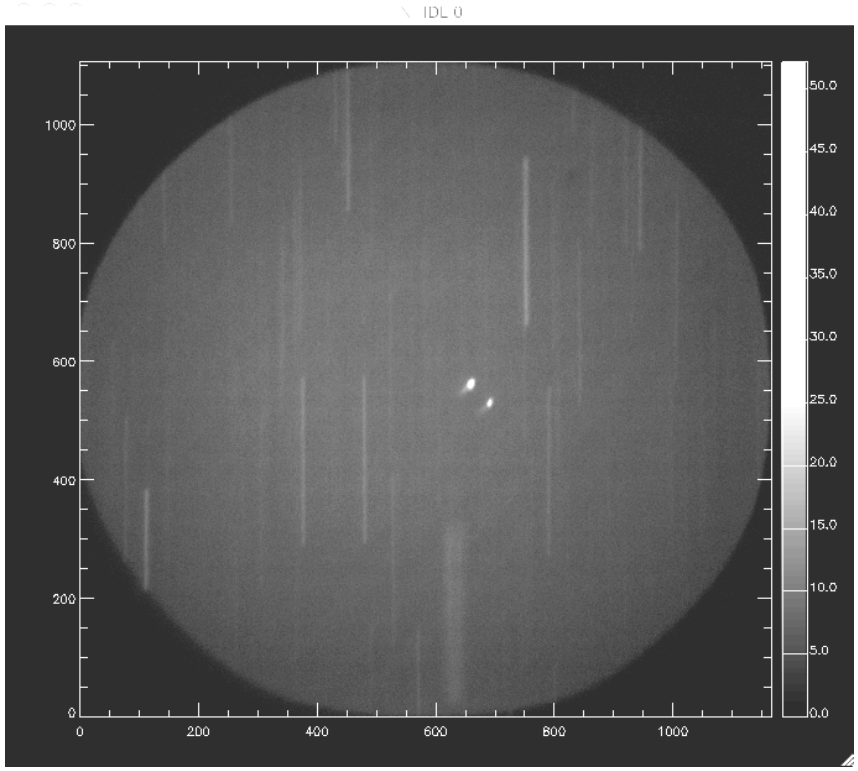
Euro 50	50 m	2035?
TMT	30 m	2030?
GMT	21.4 m	2024
Gran Telescopio Canarias (GTC)	10.4 m	2009
Keck 1	10 m	1993
BTA-6	6 m	1976
Hale Telescope (200 inch)	5.08 m	1948
Hooker 100-Inch Telescope	2.54 m	1917
Leviathan of Parsonstown	1.83 m	1845
Herschel 40-foot (126 cm d.)	1.26 m	1789–1815
Rev John Michell's Gregorian reflector	75 cm	1780–1789
Fr Noel's Gregorian reflector	60 cm	1761
James Short's Gregorian reflector	50 cm	1750
James Short's Gregorian reflector	38 cm	1734
Christiaan Huygens 210 foot refractor	22 cm	1686
Christiaan Huygens 170 foot refractor	20 cm	1686
Christiaan Huygens 210 foot refractor	19 cm	1686
Hooke's reflector	18 cm	16??
Hevelius refractor	12 cm	1645
Hevelius Scheiner's helioscope	6 cm	1638
Galileo's 1620 telescope	3.8 cm	1638
Galileo's 1612 telescope	2.6 cm	1612
Galileo's 1609 telescope	1.5 cm	1609

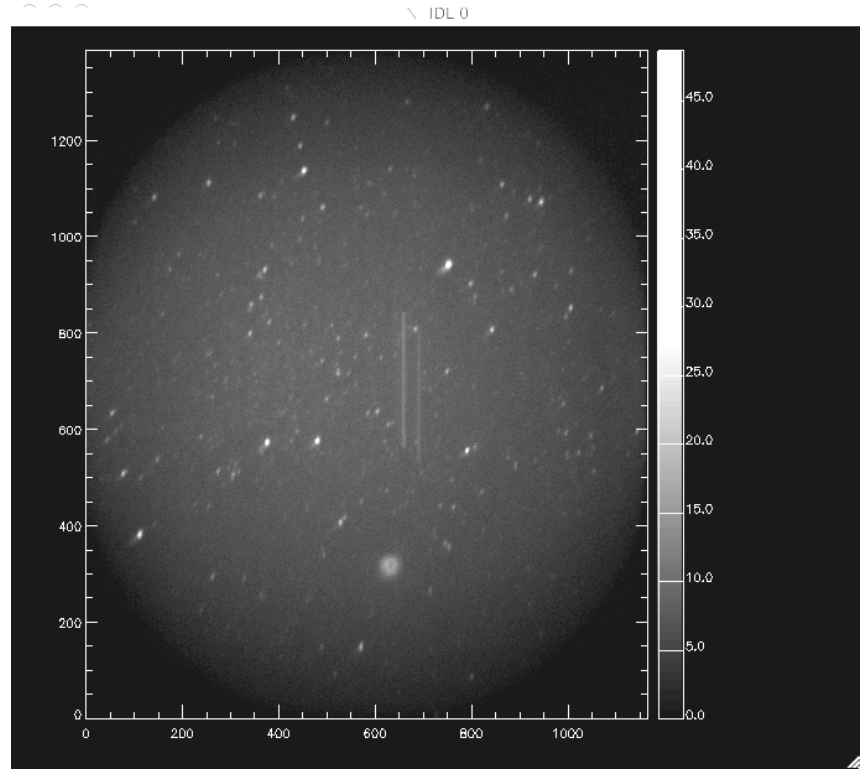
*But need a sensitive CCD camera (happily, a Moore's law device)

Requirements are modest…

Single system parts break-out			
Item	Price Estimate	BOE	notes
Celestron C14	$6,000	Vendor website	telescope
Paramount ME	$14,500	Vendor website	The mount
ME Tripod	$2,500	Vendor website	tripod
Grade 2 SBIG ST8XMEI	$4,000	Vendor website	CCD camera
Optec IFW	$2,000	Similarity to previous acquisition	Filter wheel
Optec TCFS	$2,000	Previous quote for similar system	Focus system
Mounting plates & brackets	$500	Previous recent machine shop charges	
Field-use laptop	$2,000	Similar to previous acquisitions	
Symmetricom BC637PCIe	$2,500	Previous quote for similar item	GPS card
Software Bisque suite	$1,000	Vendor website	Control software
Misc.	$2,000	Previous experience	Shipping, crating, cables, misc. parts
	$39,000		

Examples of space object tracking using a small (40 cm) telescope





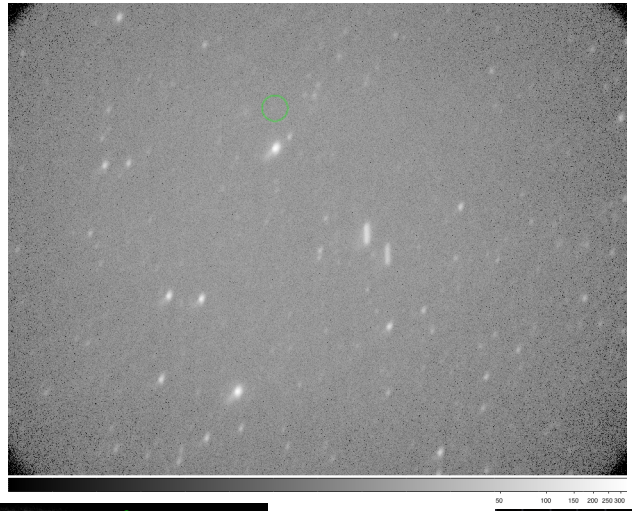
Data collected in *rate track* mode show the objects being tracked as points, while the back-ground stars appear as streaks. This is the preferred mode for observing a specific object(s)

When observing in *sidereal* mode (tracking at the rate of the stars), the stars are points, and the space objects streak across the frame. This mode is useful when searching for unknown objects.

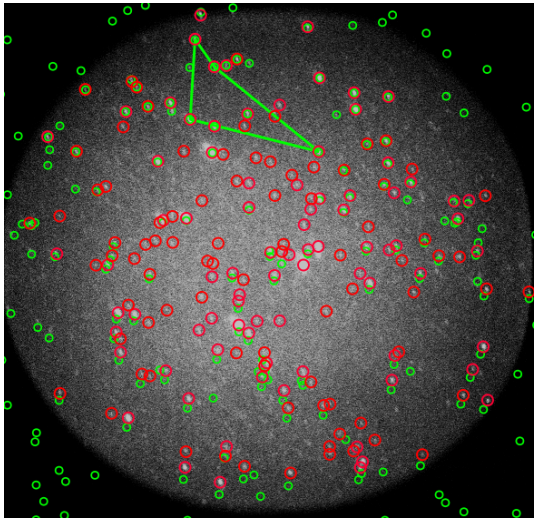
Photos by the author.

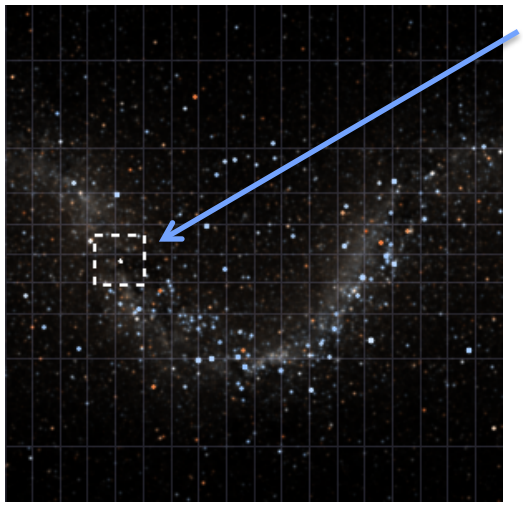
How do we derive useful information from pictures of space objects?

Stars used to calibrate data (position & brightness scales)



1] Stars in the image feed into plate solution tool (lower left)





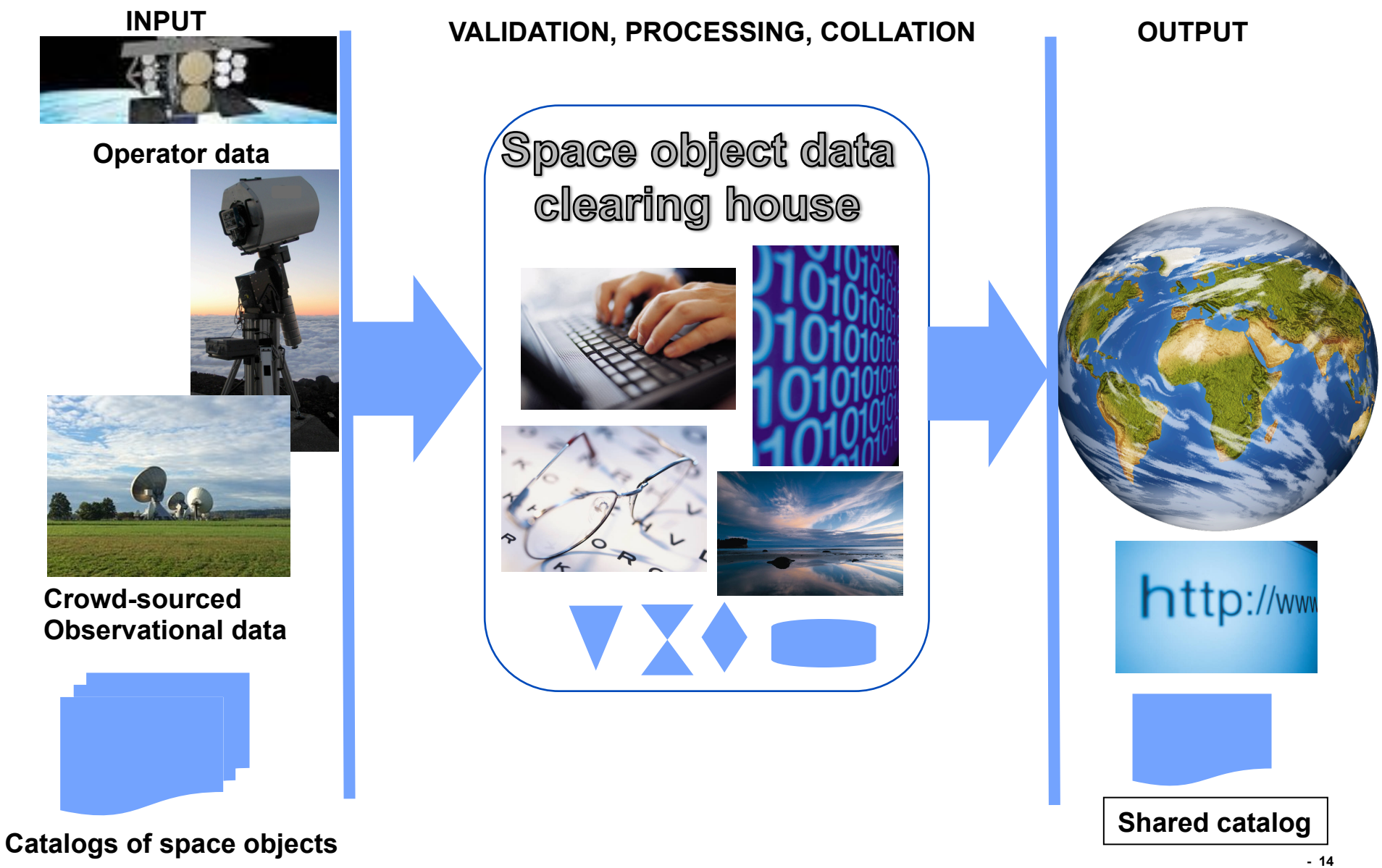
3] RA & DEC allow us to associate image coordinates with location on the sky. Results feed into orbit determination processing.

[2]Bertin, E. and Arnouts, S.: 1996, 117, 393, Provided by the NASA Astrophysics Data System.

2] Plate solution tool[1] recognizes star[2] paterns to determine location on-sky (RA & DEC)

[1]Lang, D., *et al.*, 2010, *Astrometry.net: Blind astrometric calibration of arbitrary astronomical images*, AJ 137, 1782-1800.

Once the data are collected, how to share them?



Precedents for governance models for international data exchange

Proposed: International Space Object Data Exchange (ISODEX)
Existing organizations we can look to:

Minor Planet Center (MPC)

- Following 120,000 natural space objects with 6 FTEs
- NASA, IAU ties

Int'l GNSS Service (IGS)

- Voluntary federation of >200 int'l entities to share GNS data
  - Participant funded

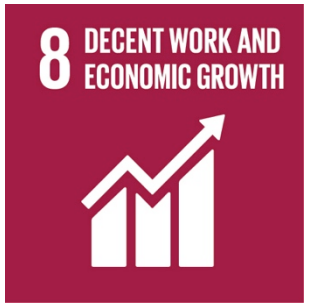
ISODEX

- Crowd-sourced observations
- UN COPUOS, IADC ties
- Funded by participants (cash or in-kind)
- Virtual, International, non-profit LLC

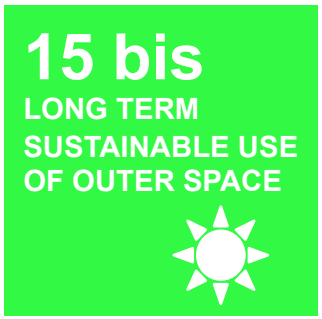
Space Data Association
23 Commercial Operators
3 Civil Space Agencies
Participant funded
Isle of Man Limited Corp.

Minor Planet Center logo used by permission.

Mapping project outputs onto UN Sustainable Development Goals



Lower barrier to entry for developing countries for space activities
Furthering international cooperation
Development of educational & economic opportunities
Environmental sustainability in space
Peace and security via TCBMs



In Conclusion

- It is suggested that the UN OOSA might partner with the IAU OAD
  - » To create a donor-recipient pipeline to support developing/new space actors with ground-based SSA and sharing of space object data
- Launches and activities in space remain expensive, and this can act as a barrier blocking space-related development
- Ground activities can be a low-cost entry-point into space and satellite technology
  - » Modest hardware and software requirements
- In addition to aiding the development of technology infrastructure of a given recipient, collection and dissemination of data on space objects can be important to the long-term sustainability of space, and enhance transparency and confidence building measures
- Although modest in scope, this proposed idea could support several of the UN 2030 development goals.