

Satellite Mega-constellation Meeting

Date: 30 January 2020

Venue: The Royal Astronomical Society, Council Room

Present:

Robert Massey – RAS (Chair)
Lucinda Offer – RAS (Notes secretary)
Mark McCaughrean – Senior Advisor for Science and Exploration, ESA
Matt Darnley - Liverpool John Moores University
Chris Lee - Chief Scientist, UK Space Agency
Heidi Thiemann – Open University
Andy Williams – European Southern Observatory
Olivier Hainault – European Southern Observatory
David Brown – University of Warwick
Laurence Blacketer – University Southampton
Mark Aston - industry
Carolyn Kennet – Dark Skies Astronomer/Environmentalist
Brian Sheen – Rosalind Observatory
Colin Vincent - STFC
Paul Daniels – VP RAS/ Federation of Astronomical Societies
Simon Garrington – Jodrell Bank Observatory
Federico Bruno – SKA
Justin Bray - SKA
Simon Barry – SKA
Tim Stevenson – SKA
Alan Craggs – University Central Lancashire
David Williams – AMI telescope (via Zoom)
Patricia Cooper – SpaceX
Tim Mackay – OneWeb
Mel Ni – OneWeb
Martin Barstow - Space Park Leicester / University of Leicester (via Zoom)

RM welcomed delegates to the meeting - reminder that notes will be shared.
Agreed to ask Connie Walker (IAU) to attend future sessions, along with Dave Green and David Ticherington from AMI.

Aim of meeting to understand the impact of mega-constellations on ground-based astronomy, and how to mitigate it, with dialogue within the astronomy community, and with the satellite operators OneWeb and SpaceX.

Square Kilometre Array (Federico di Vruno)

Slides relating to this presentation are available at <https://ras.ac.uk/sites/default/files/2020-04/SKA%20Di%20Vruno%20Jan%202020.pdf>

Points raised in discussion included:

- The need to look at 'impulsive' astronomical sources, where output is not confined to protected radio spectrum bands
- Agreements in place with NSF (US) and radio observatories in US, EU and Japan. No buffer zone around protected bands - could at least encourage voluntary protection of these regions. SpaceX for example working with radio astronomers for last 3.5 years
- SKA is looking at the impact on their observations regardless of the protection of these bands.

ESO presentation (Olivier Hainaut) – Effect on observations for large optical telescopes

Slides relating to this presentation are available at https://ras.ac.uk/sites/default/files/2020-04/Hainaut_Satellites_RAS2020.pptx

Discussion points included:

- ESO telescopes typically operate at a zenith angle of 60 degrees or lower, so model uses this as a base
- Typically, 100 satellites will be in the sky at any one time, mostly from Starlink
- Major impact is on wide field telescopes during and immediately after evening twilight, before and during morning twilight
- Less of an impact for other instruments
- Naked eye limit set at $m \sim 5$ (note that e.g. CfDS use $m \sim 6.5$), rising to $m \sim 4.2$ at zenith
- Starlink satellites typically 1 m across, orbit at 550 km, so $m \sim 5$
- Satellites need to be 3 to 5 magnitudes fainter to eliminate problem - need confirmation from Vera Rubin Observatory
- Achieving this means smaller, higher or darker satellites
- SpaceX in detailed discussions with VRO, focusing on most sensitive instrument requirements and using these for mitigation standards
- SpaceX dark satellite not yet in target orbit (and not actually an operational part of constellation), so no data yet on brightness of deployed spacecraft
- SpaceX moving quickly to try to accommodate astronomers' needs - would have been easier to do this at the outset
- ESO model appears not to include other classes of satellites e.g. existing remote sensing and weather spacecraft
- SpaceX has requested FCC filings for 40k satellites over next six years
- Will de-orbiting of a large number of satellites have an impact on the composition of the upper atmosphere?
- Probably not, due to low volume of material compared with e.g. launches, but needs further study
- Passive de-orbiting (of failed satellites) takes place within three months
- Satellites are Krypton fuelled - not aware of global shortage of this gas

SpaceX (Patricia Cooper)

Slides relating to this presentation are available at

<https://ras.ac.uk/sites/default/files/2020-04/Starlink%20Slides%20for%20RAS%20Presentation%201.30.20%20shareable.pdf>

Discussion points included:

- SpaceX has International Telecommunications Union filings for up to 40k satellites total in various frequency bands - current planned constellation is 4,409 satellites in Ku/Ka-band
- Planning to fly at/below 550 km, original altitude was 1100 km and above
- Starlink project goal is to increase broadband access globally
- Many other companies also proposing to use space-based platforms for internet, but Starlink is largest planned constellation
- Sub-suburban and rural areas are primary targets for broadband service customers
- Launching 60 satellites per fairing, 240 as of early February (360 as of April 16)
- SpaceX must meet deployment milestones for its constellation set by the International Telecommunications Union and the US Federal Communications Commission
- Based on feedback from astronomers, SpaceX plans to continue deployment up to 1500 satellites, to allow both deployment and also room to identify, test and field mitigation techniques and discuss adjustments under consideration by astronomers
- Ongoing launches are also needed to reach a threshold deployment that can provide continuous service to users
- Specific design of deployed satellites is proprietary information
- Service will also rely on a ground network of gateways and end user terminals
- Allocated gateway downlink band is adjacent to allocated radio astronomy operations (e.g. ALMA in Chile)
- Not a single optical astronomer contacted SpaceX following initial May 2019 launch (disputed)
- Since then, SpaceX has been working closely with US astronomical organizations, like the AAS, NSF, AURA, IAU, Intl Dark Skies Assn.
- In the absence of astronomy community operational targets, SpaceX is referencing the impact at specific observatories that are likely to be affected the most (LSST/Vera Rubin)
- LSST / Vera Rubin team working with SpaceX under NDA - no request to cease launches
- Confirm that darkened satellite deployed in January 2020 to test effect of varying techniques to darken surfaces
- DarkSat focused on reducing brightness of / resulting visibility once on orbit at deployment altitude
- Plan to continue iterating mitigation approaches even after DarkSat test (Note – SpaceX has subsequently mentioned a further mitigation using a sunshade that it plans to field as a test soon)
- Planned lifetime of satellites is 5-7 years
- Requires ongoing launch, orbit-raise and de-orbit – so there always will be some at lower altitudes.
- Extensive safety plans are public on the FCC website

- Safety measures in place for de-orbiting – deploying to low altitude to test before orbit-raising and active de-orbit planned from low altitude.
- SpaceX confident in thrusters working well
- Any dead satellites would demise passively - low altitude allows quick demise (no grapple hook)
- SpaceX focused now on working step by step first on planned 4409 satellite constellation – not on longer-term constellation of 30k satellites.
- Debate on level of engagement so far - SpaceX state they will meet and discuss with any astronomy organisation that is open to productive engagement on the issue

OneWeb (Tim Mackay)

Slides for this presentation are not available for wider circulation.

Discussion points included:

- Do SpaceX and OneWeb communicate? Not usually on commercial issues. SpaceX information on FCC website
- OneWeb does the same - posts material on both FCC and ITU websites. Responsible use of space matters to them
- Does OneWeb have a similar obligation to meet timebound license?
- Xenon thrusters - is this a limited gas resource?
- Could bird migration be affected, if they use stars to navigate?
- Do investors have concerns about response from astronomers?
- OneWeb focused on responsibility - investors unlikely to back projects that fail to adhere to this, including collision prevention, de-orbiting reliability
- Investors see *irresponsibility* in space as a higher risk
- What are companies doing to drive regulations?
- Governing bodies (like the ITU?) find a middle ground, but space environment, and terrestrial impact, is not at the top of their list
- Companies willing to share solutions where there is no commercial impact

Next Steps (all):

RAS is only European national astronomy society with significant staff complement, with the capacity to complement IAU, AAS, EAS efforts. Important to continue dialogue between societies, and international astronomy organisations like SKA, ESO and ESA. RAS can also host further meetings, with for example sessions covering optical and radio astronomy. (Significant work on space debris being done by UKSA, ESA already.)

STFC can help facilitate these discussions, and consider how to support academic / industrial research into mitigation solutions.

Need to address 'Panama flag' situation, where much regulation attached to national jurisdictions, no overarching international rules covering optical astronomy.

Astronomical community needs to define:

- The problem

- Acceptable standards / guidelines for companies e.g. what is threshold magnitude for satellites to impact on telescopes
- Regulation proposals

UK (RAS etc) can work with AAS on this - correspondence already happening - with understanding that as many as 11 operators plan mega-constellations

Also need to share ephemeris (TLE) information and scheduling to avoid conflicts and help mitigate impact - a generic tool would help here.