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Implementing the recommendations
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3 - 7, October, 2021

Recommendations of the Algorithms Working Group from SATCON2

Jonathan McDowell

Center for Astrophysics

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What software does the astronomical community need to develop
in response to the challenge posed by satellite constellations?

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Algorithms Working Group:

Jonathan McDowell, Rob Seaman, Cees Bassa, David Galadi-Enriquez, Olivier Hainaut, Courtney Hogdson, Matt Holman, Moriba Jah, JJ Kavelaars, Keith Poletti, Morgan Schmitz, Pat Seitzer, Jan Siminiski, Rachel Street, Hossen Teimoorinia, Heidi Thiemann

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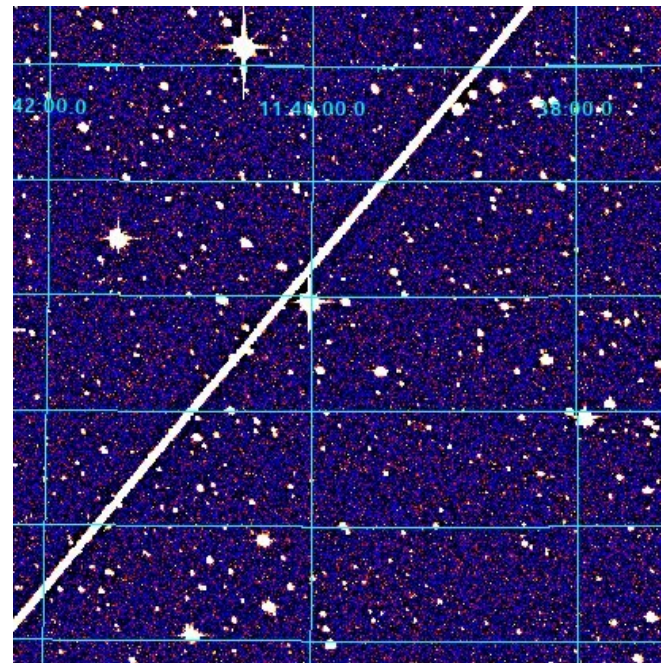**R1: New software tools needed: specifically PassPredict, TrailMask, and simulators**
R2: The SATCON2 report includes a study for the algorithms and interfaces needed for these tools

- New tools critical to partially mitigate impacts on astronomy

- 1) Will my observation be affected?   PassPredict will let us know in advance if a satellite is going to leave a trail on my image

    - where is my telescope pointing?

    - how much sky can it see, and how sharp are the images?

    - where are all the satellites tonight? How bright will they be?

    - is there a time tonight when I can take a picture of my
      object that won't be ruined by a streak?

- This needs accurate satellite orbit data, and ideally satellite
  brightness information

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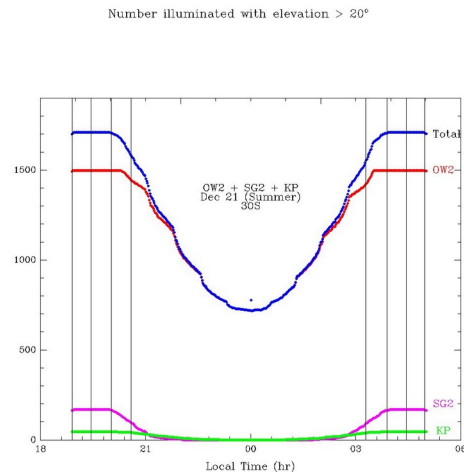3 - 7, October, 2021

New tools (continued)

- 2) TrailMask

  - My images have satellite trails across them, what can I do?

  - NOT JUST A COSMETIC ISSUE: astronomers measure brightnesses to 1% accuracy so just paintbrushing trails out isn't good enough

  - Trails can cause detector effects in other parts of the image

  - Automatic software to detect faint galaxies (etc) will be confused by the trails: we must locate and mark them. For big projects this must be done automatically

  - Added brightness across the image can affect whether or not we see the faintest stars and galaxies

  - Investigating various software approaches to handle this

Catalina Survey c/o R. Seaman

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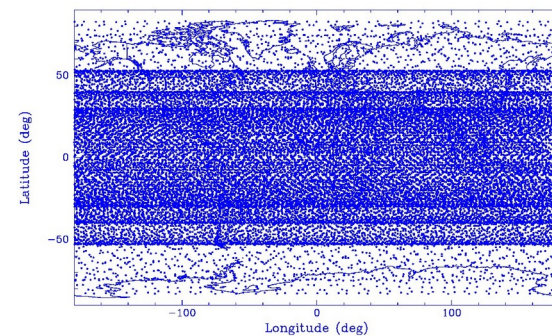3 - 7, October, 2021

New tools (continued)

- 3) Simulations for science impact assessment

  - What fraction of science will my proposed project lose?

  - How bad will it be 1, 5, 10 years from now given projected new constellations?

  - What problems will there be with a particular new kind of observation?

- We need the ability to simulate satellite trails on different kinds of detectors, taking into account the properties of both the satellites and the telescope

  - Is there a change to the constellations (orbits, brightness) that will significantly decrease the science impact? Sat operators want to know. So we need to be able to assess impacts...

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Simulations: What are we in for?

- Simulations show that science impact depends on the details of the constellation
- Lowest orbit satellites are brighest – so biggest impact for naked eye observers
- Higher orbit satellites are visible from a larger area on the ground, and illuminated later into the night, so although not naked-eye, much worse for professional astronomy

Simulated positions: Starlink Gen2

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R3: Incorporate use of existing software relevant to these tasks. Much of it needs to be generalized.

- e.g. some tools do some (but not all) of PassPredict's job

− For general public applications, Heavens-Above (by Chris Peat) is a good option

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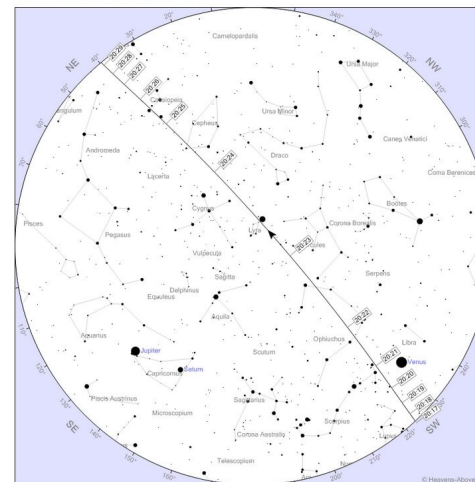
For professional analysis the U Texas/IBM AstriaGraph has interesting capabilities

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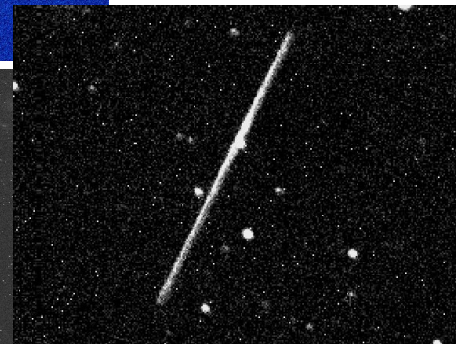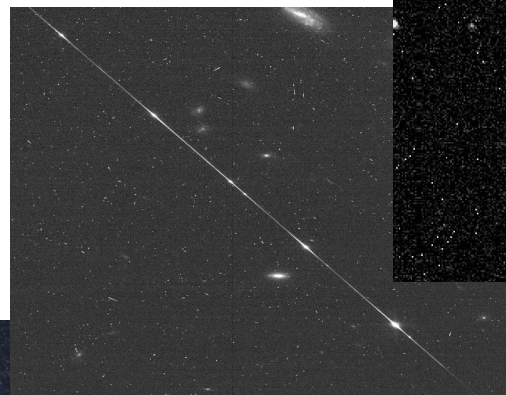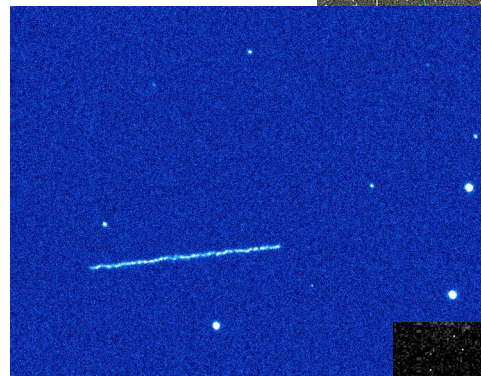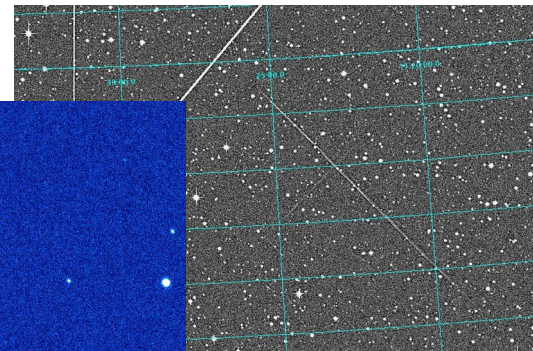3 - 7, October, 2021
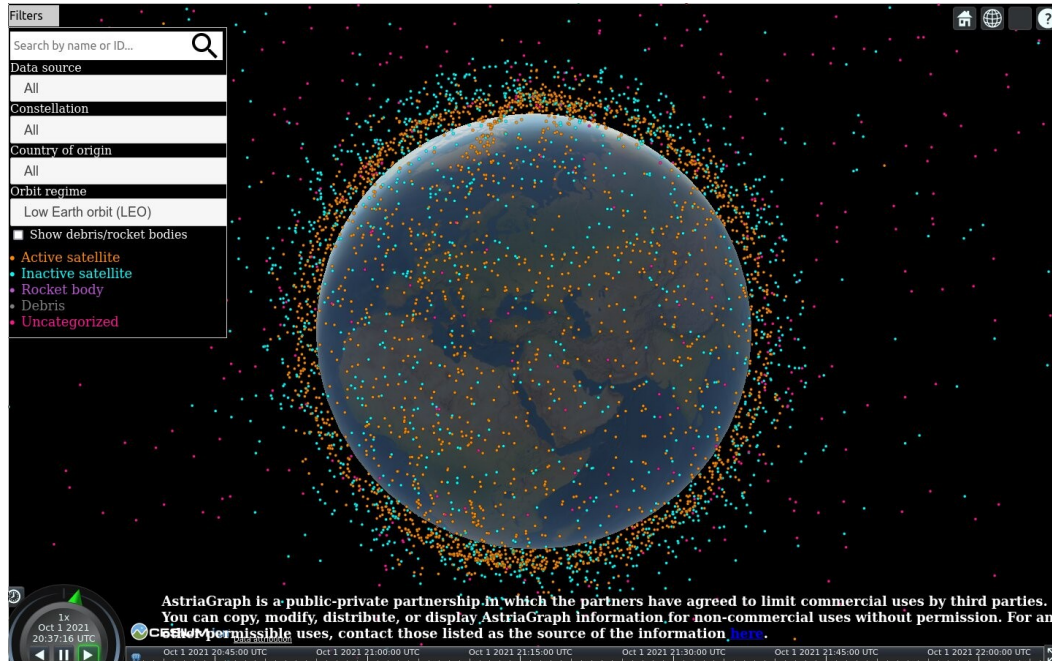
What did we do for SATCON2?

- Elaborated details of what these tools should do both in terms of interface and internal algorithms
- Reviewed what's already out there in the world that might do part of the job
- **R4: Noted the need for a significant software development effort**

  - software project management

  - documentation, user support and educational materials

  - long term support and maintenance

  - resources and funding to make all the above happen
- See the forthcoming SATCON2 report for detailed analysis

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SATCON software tools: not just for professionals

- **R5: Software must be provided in several forms**:
- We need to support a diverse community of night sky users
- Amateurs, planetarium community, educators, general public
- Means we need simple web interfaces as well as professional (Astropy, etc) ones

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Test suite

- **R6 : We recommended near-term development of a public test suite for satellite constellation related software**
- This will include documented examples of images with trails from a variety of types of telescope, large and small
- Also will include test cases of particular satellite pass predictions
- You need this to test the software as you develop it
  - make sure different people's programs get the same answer
  - make sure programs are robust for different situations (not just for data from one particular telescope!)

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Getting access to software and documentation

- **R7 A central portal (SatHub) should serve as a primary location** for the world to find

  - software tools

  - documentation

  - links to satellite ephemeris information (tailored to astronomer use)

  - test data

- We expect some centralized development (e.g. by the IAU centre) but SatHub could also host links to software developed by others in the community

- In addition to detailed documentation we advocate development of lesson plans for students to educate people about the issue

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Next Steps

- Implement `minimum capability' prototypes for PassPredict and TrailMask

    – and get them out to the community for near-term feedback!

    – Use this feedback to guide development for more robust and capable versions
- Coordinate existing simulation efforts
- Develop initial version of test suite
- Develop a prototype web page for the SatHub software section
- Organize a 'beta test' community

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R8: Constellations are being launched now but software takes time to develop. Resources should be made available as soon as possible.

- At present, efforts are mostly unfunded 'side efforts' by individual scientists

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Final conclusion: Software won't make the problems go away

- **R9. Software tools can help but won't prevent significant loss of science** – or changes to the night sky for everyone
- We will need these tools to minimize the impact of satellite constellations as best we can.
- But we also need international action to preserve the space environment and the night sky

Thank you for your attention!