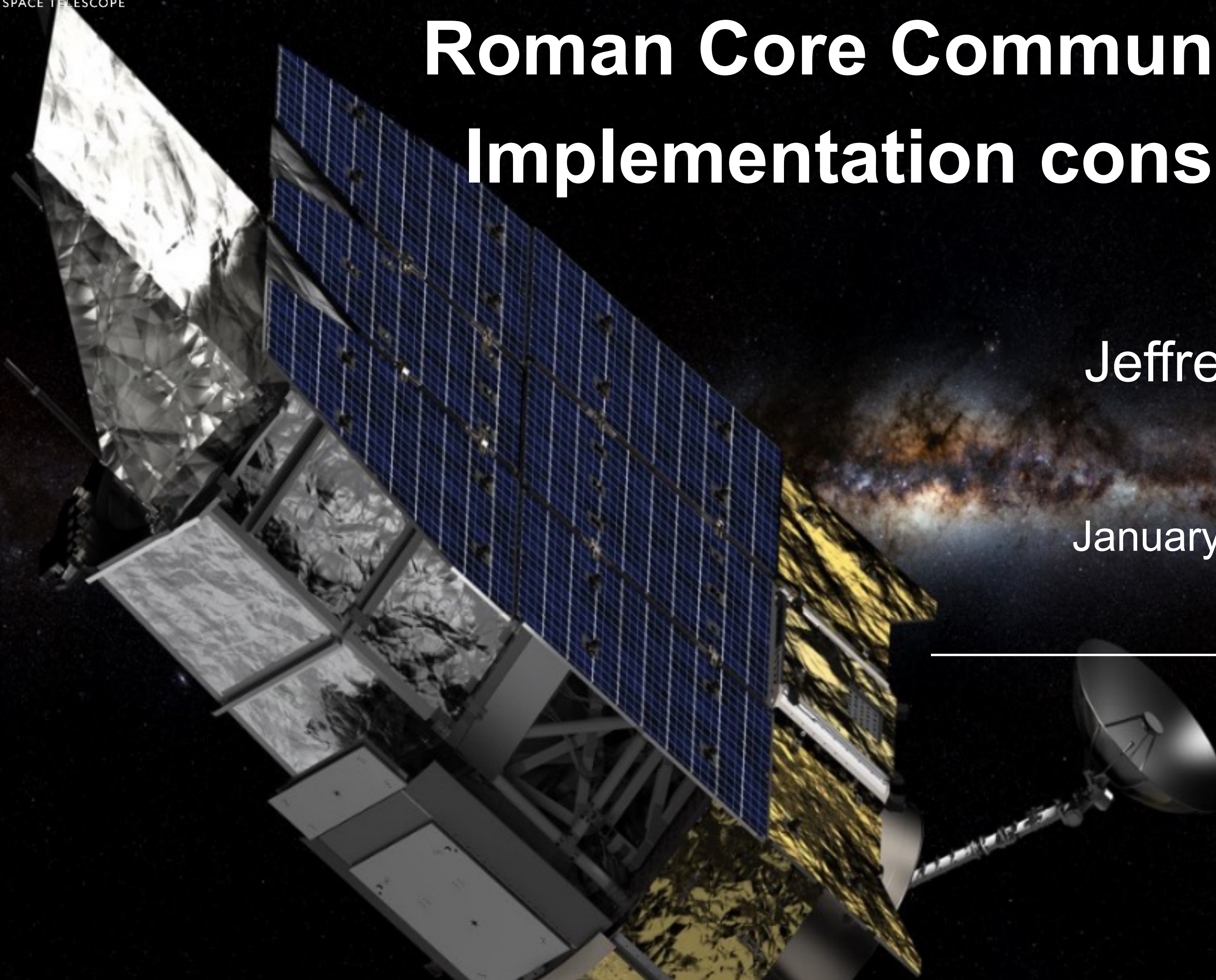
ROMAN
SPACE TELESCOPE

Roman Core Community Surveys
Implementation considerations



Jeffrey Kruk

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• NASA GODDARD SPACE FLIGHT CENTER • JET PROPULSION LABORATORY •
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Mission Objectives → Core Community Surveys

- **“Level – 1” Mission Objectives leading to CCS:**
  1. **Conduct near-infrared (NIR) sky surveys in both imaging and spectroscopic modes**, providing an imaging sensitivity for unresolved sources better than 26.5 AB magnitude.
  2. **Determine the expansion history of the Universe** using GRS, WL, & SN, at redshifts up to z = 2 with high-precision cross-checks between techniques.
  3. **Determine the growth history of the largest structures in the Universe** using WL, RSD, & Galaxy Clustering, at redshifts up to z = 2 with high-precision cross-checks between techniques.
  4. **Carry out a statistical census of exoplanets** from the outer habitable zone to free floating planets, including analogs to all of the planets in our Solar System $>M_{Mars}$, using microlensing.
- These have led to the present concepts for the High-Latitude Wide-Area Survey (HLWAS), the High-Latitude Time Domain Survey, and the Galactic Bulge Time Domain Survey.
- The present HLWAS addresses Objective #1 by design, but one can imagine a survey more narrowly focused on Objectives #2, 3 that did not do so.
  - *In that case an additional CCS would have to be defined to address Objective #1.*

Survey concepts developed thus far

- **The Formulation Science Working Group (FSWG) and predecessors developed survey concepts that address the mission objectives, with our best understanding to date of astrophysical and instrumental systematic effects.**
- **In most cases there are already one or more alternative survey concepts deserving further study***
  - *There is room for further optimization within the context of any single mission objective*
  - *And even more room for optimization in light of opportunities for pursuing unrelated science investigations*

* Info on motivations for survey design and some alternative concepts can be found in the talks from this workshop: https://roman.gsfc.nasa.gov/science/workshop112021/

Defining the CCS

- **The only requirement: the CCS satisfy the mission objectives**
- **In more concrete terms, the CCS must satisfy the more detailed requirements in the Science Requirements Document**
- **The Project will work closely with the CCS study groups in assessing survey concepts and providing whatever information may be needed to develop them.**
- **Starting with a truly blank slate is not helpful, as that can lead to a lot of wasted time**
  - Want to leverage the work done to date
- **However, we want to avoid being unnecessarily prescriptive, and avoid preempting innovative thinking.**
- **Hence we give some suggested boundary conditions on the following slides.**

Boundary Conditions for HLWAS

- **HLWAS – both imaging and spectroscopy**
  - The survey area should be contiguous, or consist of at most a small number of independent contiguous regions
- **HLWAS – Imaging**
  - Dithering strategy must provide good PSF sampling.
  - Tiling strategy in each filter must enable photometric self-calibration
  - Area/Depth trade must provide > 10^8 galaxies in at least one filter at S/N sufficient for shape measurement (minimum, goal is >$3*10^8$ galaxies)
  - Survey area must have data in optical bands appropriate for photo-z, (e.g. Rubin or Subaru HSC)
  - It is highly desirable for the shape measurements to be made in more than one NIR filter to enable tests of wavelength-dependent systematics.
    - Can relax this if new data (Euclid, Rubin) tells us otherwise
- **HLWAS – spectroscopy**
  - Depth/area trade must yield > 10^7 emission-line galaxies with limiting line flux of 1.e-16 erg/cm^2/s at 6.5 σ
    - Can consider relaxing to ~5σ if it can be shown that sample purity is adequate.
  - Survey area must overlap with imaging data in at least 1 NIR filter with a depth suitable for source localization.
  - Roll angle selection must serve to separate sources overlapping at any single orientation.
  - Roll angle selection must include near-180 degree offset to remove effects of emission line regions being separated from center of continuum emission,
    - Can relax this if new data or analysis shows this is not necessary.

Boundary Conditions for GBTDS

- **Cadence of repeat visits and S/N per visit must be sufficient for sensitivity to the chosen range of planet masses (0.1 - 10000 *M_{Earth}) in the Science Requirements Document.**
- **Area/cadence trade should provide monitoring for a minimum of 600 sq-degree-days, distributed over 6 seasons.**
- **The duty-cycle for observations devoted to this survey must be greater than 80% during each season.**
  - This includes time required for momentum unloading and station-keeping (~9 hours/month or ~1.25%) and any other mission overheads.

Boundary Conditions for HLTDS

- Cadence, depth/area trade, choice of filters must provide a suitably large sample of SNIa in a redshift range sufficient to meet the desired precision on luminosity distance vs. redshift.
- Location of survey must be in the continuous viewing zone to provide uninterrupted light curves, and in an area with low Galactic extinction.
- Tiling strategy in each filter must enable photometric self-calibration
- There must be greater than 100 SNIa in each delta-z=0.1 redshift bin with data suitable for the cosmological distance analysis.

Boundary conditions caveat

- The boundary conditions on the preceding 3 slides are intended to be suggestive, not definitive.
- They are not sufficient in themselves to define an adequate CCS, but they illustrate where we have flexibility and where deviations would require increasingly strong justification.

Representative Surveys

- **Cumulative point-source depth in wide-area surveys:**

	Wide 2000 deg^2	Deep 20 deg^2
HLWAS	**Wide 2000 deg^2**	**Deep 20 deg^2**
– Imagining in 4 filters (5σ)	AB ~26.5	AB ~28.2
– Grism (6.5σ line flux 1.8μ 0.2”r_{eff})	$8 \cdot 10^{-17}$	$3 \cdot 10^{-17}$
HLTDS (5-day cadence)	**Wide**	**Deep**
– Imaging in 4 filters (5σ)	AB ~28.1 19 deg^2	AB ~29.2 4.2 deg^2
– Prism (10 σ continuum)	AB ~25.3 3.3 deg^2	AB ~26.1 1.1 deg^2

- There are many possible SN survey implementations!

- **GBTDS:**
  - Monitor 2+ deg^2 of the Galactic Bulge, 15-minute cadence over ~70-days, S/N=100 @ AB=21.4 per visit
  - Exoplanet detections by microlensing, other time-domain astronomy,
  - Precision astrometry (tens of micro-arcsec)

Scheduling considerations - 1

- **High Latitude Wide-Area Survey**
  - No cadence requirements per se
  - Spectroscopic survey will want observations of any given field at roughly opposite dispersion directions
    - Have only one grism, so schedule revisits separated by ~6 months
  - Want survey regions to be contiguous, or at minimum not split into many sections
    - Could imagine a region in South and another in North perhaps
- **High Latitude Time-Domain Survey**
  - Want continuous coverage of a particular field for ~ 2 years ➞ CVZ
  - Visits at 5-day cadence
- **Galactic Bulge Time Domain Survey**
  - Want continuous coverage of a particular field for entire visibility period
    - $\lesssim$72 days, Spring and Fall
  - Visits at 15-minute cadence
  - Longest possible total time baseline
    - accurate proper motions and maximizing separation of stars in lensing events

Scheduling Considerations - 2

- **Likely layout over 5-year mission**
  - BGTDS seasons Spring and Fall of first year and last year, 2 more somewhere in between
  - HLTDS campaign somewhere in years 2-4 to avoid conflicting with GBTDS campaigns
  - HLWAS can be distributed throughout
  - General Astrophysics observations can be distributed throughout

- **The FSWG surveys were designed with conservative performance assumptions. As we move forward we will design the CCS with current best estimate performance. This will result in more powerful and/or more efficient surveys.**

Summary

- The CCS are required to meet the mission objectives.
- There is considerable flexibility in the design of the CCS.
- We want to take advantage of that to make the CCS as broadly useful as we possibly can.
- We will work closely with the community in the coming years to make this a reality

QUESTIONS?

The Design Reference Mission

- **What the DRM is:**
  - **A required product at major mission reviews**
  - **An existence proof that mission objectives can be met in the required mission lifetime**
  - **A mechanism for the iterative refinement of mission requirements**
  - **A tool for exercising the ground system & flight software**
    - Does proposal system support all the observing modes?
    - Can planning/scheduling tools build the timeline & command loads?
    - Will command loads execute on the spacecraft & instrument simulators?
    - Does observing efficiency in simulator match expectations?
    - Can we downlink all the data and transfer through the ground networks?
    - Does telemetry support data processing of all observing modes?
    - Are pipeline products properly ingested into the archive?

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- **What the DRM is not:**
  - **The actual observing plan**