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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

The Community Definition of Roman's Core Community Surveys

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Top Level Goal for Defining the Core Community Surveys

Maximize the overall science return of Roman's wide field infrared surveys

While meeting Mission requirements focused on cosmology and exoplanets

The existing survey strategies served their primary function in showing the mission can meet its requirements.

The actual surveys to be implemented will be defined by the astronomical community.

Strategy for Defining the Core Community Surveys

Roman Observations Time Allocation Committee

Provides recommendations to Roman Project on balance between each of the core community surveys

- High Latitude Wide Area Committee
- High Latitude Time Domain Committee
- Galactic Bulge Time Domain Committee

Evaluate initial community input; solicit additional, more targeted community input through a variety of channels; evaluate survey options against science metrics; produce recommendations for survey implementations with options for enhancements/descopes

Strategy for Defining the Core Community Surveys

Roman Observations Time Allocation Committee

Provides recommendations to Roman Project on balance between each of the core community surveys

High Latitude Wide Area Committee

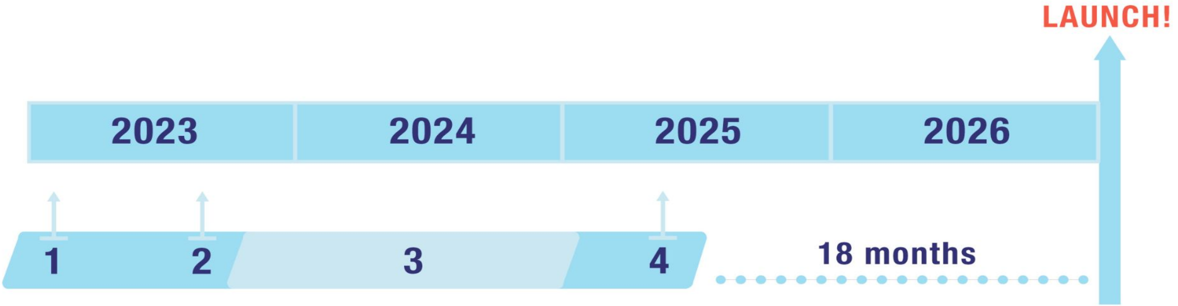
High Latitude Time Domain Committee

Galactic Bulge Time Domain Committee

These committees will be *your* committees, and will be charged with understanding and representing the full breadth of the astronomy community's interests in Roman's Core Community Surveys.

There will be no "survey teams" selected to define or implement the surveys.

Timeline for Defining the Core Community Surveys



(1) Initial Request for Community Input

(2) Formation of CCS Definition Committees

(3) Committee-driven investigations, deliberations, and gathering of additional community input, including community workshops

(4) Final report detailing CCS observations due to Project

Current Call for Input: First Step in Defining the Core Community Surveys

Two independent avenues to respond to the initial request for community input into the CCS definitions:

(1) A “Science Pitch” plus questionnaire was requested by February 17

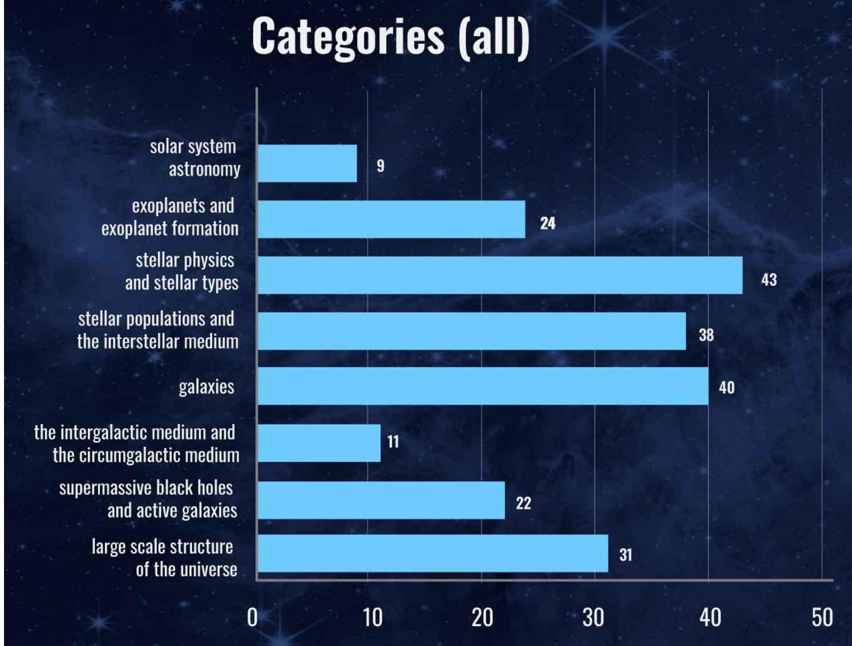
- science pitch: 1-2 paragraphs “pitching” a science investigation that could be done with an appropriately configured CCS
- an associated questionnaire to collect *high level* input on important survey characteristics for a given science pitch (e.g., survey area, depth, filters, cadence, etc.)

(2) A more traditional white paper, requested by June 16

All input will be given to the CCS definition committees and made available for interested members of the astronomy community.

Call for Initial Community Input

Science Pitches Cover a Broad Range of Science Topics



Science Pitch Submissions

Galactic Bulge Time Domain Survey: Science Topics

The GBTD Survey is ~<15 min cadence observations over few deg^2 towards Galactic Bulge for six ~70 day seasons spanning the prime mission phase.

Stellar Variability
- Stellar flares, eclipsing binary stars, cataclysmic variables, x-ray binaries, asteroseismology

Exoplanets
- Exoplanet microlensing (and extensions for additional companions, brown dwarfs), exoplanet transits (including transiting planets around white dwarfs, earth-like planets in earth transit zone), exomoons

Multimessenger Astrophysics
- White dwarf binaries/LISA counterpart sources

Stellar populations
- Astrometry, initial mass function

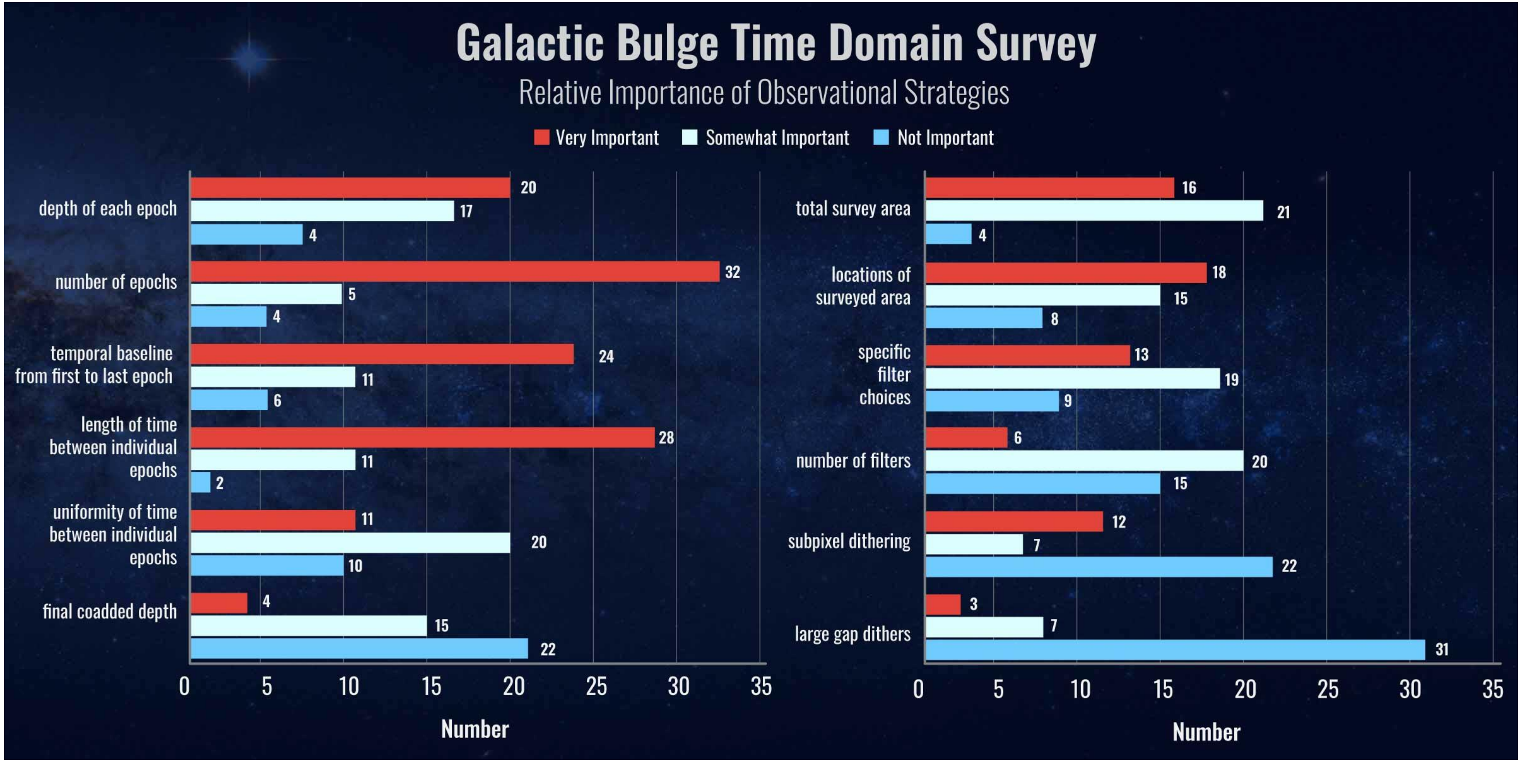
Transients
- Galactic center, XRBs etc

Compact Object Census
- Finding isolated black holes and neutron stars via microlensing

Looking behind the galactic bulge
- Quasars, supernova (exploring advantages of high cadence observations)

Synergies with other facilities

Importance of Different Observational Strategies



Newsletter Article Summarizing Science Pitches

High Latitude Wide Area Survey: Science Topics

The HLWA Survey is a wide area (>1700 deg^2) multiband survey with slitless spectroscopy.

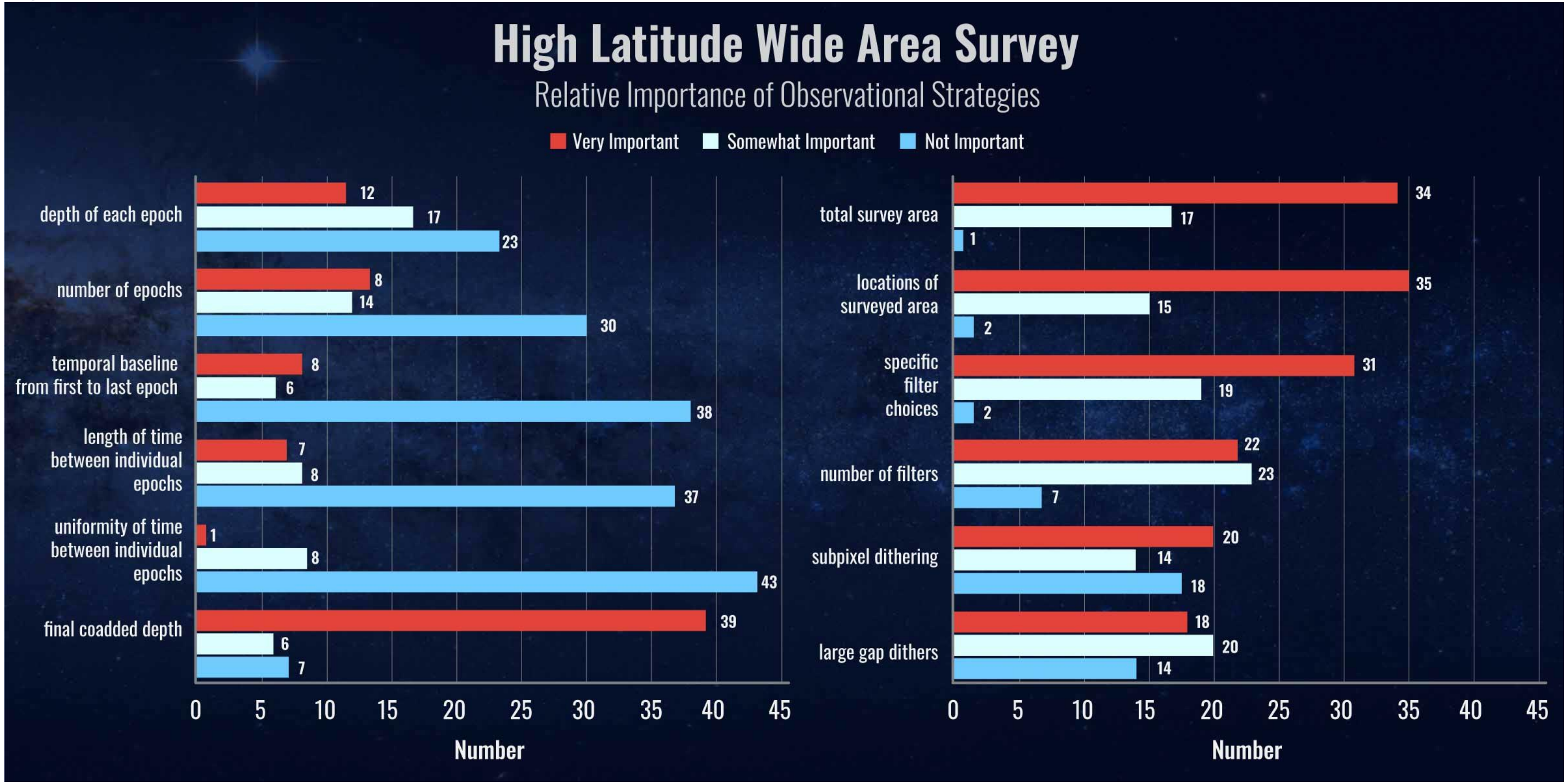
Cosmology and large scale structure
- **IR background**
- galaxy clusters **and gravitational lensing**
- IR transients

Milky Way
- Galactic structure and history (tidal streams, dwarf satellites, etc.)
- star formation and stellar evolution (stellar clusters, brown dwarfs, transients)

Nearby and Distant Galaxies
- galactic structure (tidal streams, groups and mergers, satellites, etc.)
- dwarf galaxies
- precision distance ladders
- star formation and stellar evolution
- active galaxies and galay evolution
- very rare transients, transients with long time baseline variations

Solar system science
- minor body discovery/tracking

Importance of Different Observational Strategies



Newsletter Article Summarizing Science Pitches

High Latitude Time Domain Survey: Science Topics

The High Latitude Time Domain Survey provides tiered, multiband time domain observations on timescales of days of 10s deg^2 at high latitudes.

All types of SNe

Rare Transients

- Strongly lensed supernova, tidal disruption events, statistical samples of rare and exotic (Pop III star) supernovae at high *z* (including z>10), fast blue optical transients

AGN

- evolution with redshift of AGN dust via dust reverberation mapping, low mass AGN beyond Local Universe, massive black hole binaries

Galaxy Evolution

- using survey as a deep field to study cosmic dawn, investigate the bright-end of the UV luminosity function and massive galaxy formation in the early universe at z>10

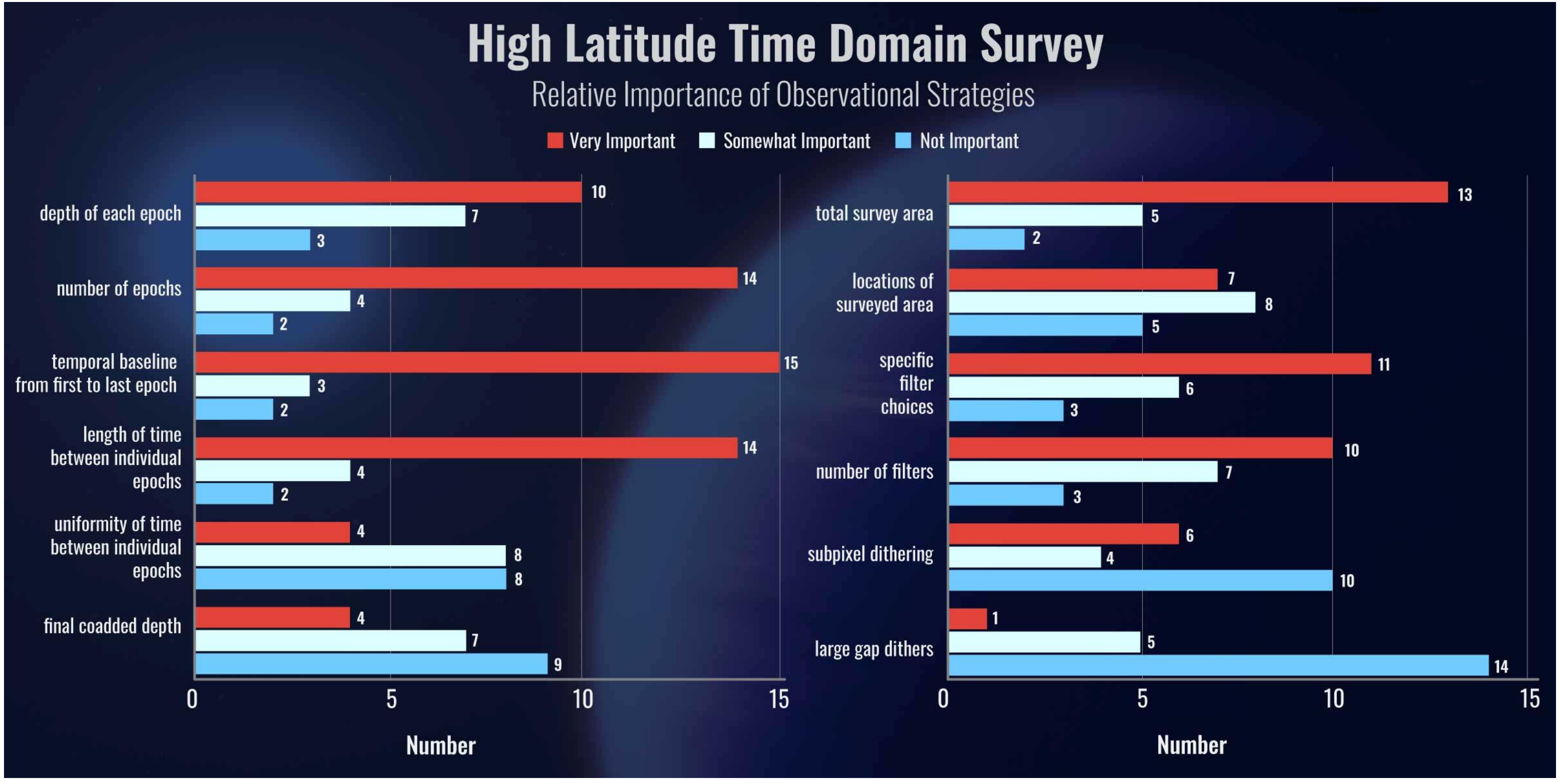
Multimessenger Astrophysics

- kilonova detection

Milky Way

- solar system planetary analogs, stellar mass black holes, detecting the stellar pulsation of stars near the tip of the red giant branch to measure distance and identify the edge of the MW's stellar halo, nearby bright stars for joint radial velocity/astrometry

Importance of Different Observational Strategies



Newsletter Article Summarizing Science Pitches

Avenue 2: White Papers due June 16

White papers should:

- Motivate the importance of the science investigation and how a Roman CCS will uniquely enable it.
  - Why should it be a science driver for designing the survey?
- Include quantitative discussions of what observational strategies will minimally enable, and optimize, a given science investigation.
  - e.g., survey area, location, filters, cadence, depth…
  - Discuss all survey parameters that are important for your science investigation
- Include figures of merit or other quantitative metrics by which a given observational strategy's impact on the science investigation can be judged.
  - How will success scale with different choices in survey parameters?
  - Within what boundaries of observational parameter space can trades be made without (significantly) impacting the science investigation?

Call for Initial Community Input

An extensive list of technical resources is available (see *Resources* links in call – QR code on right)

Avenue 2: White Papers

The most impactful white papers will:

- Consider the broader scientific landscape (including Roman science requirements)
- Make a compelling case for why the observations for your science investigation should be obtained as part of a Core Community Survey
- Illustrate scientific feasibility
- Speak to a broad range of expertise
- Be clear and concise

An extensive list of technical resources is available (see *Resources* links in call – QR code on right)

Details on the White Paper Call

Galactic Bulge Time Domain Survey

Microlensing Objective

Roman will carry out a statistical census of exo-planetary systems in the Galaxy, from the outer habitable zone to free floating planets, including analogs to all of the planets in our Solar System with the mass of Mars or greater, by monitoring stars toward the Galactic bulge using the microlensing technique.

Microlensing Science Requirements

- **EML 2.0.1:** RST shall be capable of measuring the mass function of exoplanets with masses in the range 1 $M_{Earth} < m <$ 30 $M_{Jupiter}$ and orbital semi-major axes ≥ 1 AU to better than 15% per decade in mass.
- **EML 2.0.2:** RST shall be capable of measuring the frequency of bound exoplanets with masses in the range 0.1 $M_{Earth} <$ $m < 0.3M_{Earth}$ to better than 25%.
- **EML 2.0.3:** RST shall be capable of determining the masses of, and distances to, host stars of 40% of the detected planets with a precision of 20% or better.
- **EML 2.0.4:** RST shall be capable of measuring the frequency of free floating planetary-mass objects in the Galaxy from Mars to 10 Jupiter masses. If there is one M_{Earth} free-floating planet per star, measure this frequency to better than 25%.
- **EML 2.0.5:** RST shall be capable of estimating η_{Earth} (defined as the frequency of planets orbiting FGK stars with mass ratio and estimated projected semimajor axis within 20% of the Earth-Sun system) to a precision of 0.2 dex via extrapolation from larger and longer-period planets.

Figure of Merit: Planet yield

Microlensing needs

- Monitor hundreds of millions of bulge stars continuously on a time scale of <15 minutes
- Minimum 60 day seasons
- Precise Relative Photometry
- Resolve main sequence source stars for smallest planets.
- Resolve unrelated stars for lens flux measurements.
- Longest possible time baseline for proper motion measurements

See Penny et al, 2019; Sam Johnson presentation from formulation science team workshop

Bounding conditions for GBTD Survey

- 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.

Scheduling considerations -GBTD Survey

- Want continuous coverage of a particular field for entire visibility period
  - ≤72 days, Spring and Fall (DRM is 62 days, Penny et al is 72 days)
- Visits at 15-minute cadence for the core survey
  - This does not preclude adding additional fields with a equal (or longer cadence)
  - Or increasing the cadence for one of the fields
- Longest possible total time baseline
  - accurate proper motions (broad science benefit)
  - maximizing separation of stars in lensing events

High Latitude Wide Area Survey

Roman Mission Objectives related to High Latitude Wide Area Survey

- NIR Survey
  - 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.
- Expansion History
  - Determine the expansion history of the Universe using Galaxy Redshift Survey, Weak Lensing, & Supernova Ia, at redshifts up to $z = 2$ with high-precision cross-checks between techniques.
- Growth Of Structure
  - Determine the growth history of the largest structures in the Universe using Weak Lensing, Redshift Space Distortion, & Galaxy Clustering, at redshifts up to $z = 2$ with high-precision cross-checks between techniques.

Science Requirements/FoM related to HLWA Survey

HLSS 2.0.1: RST shall be capable of executing a high-latitude spectroscopic survey that can, if allocated 0.64 years of total observing time, achieve BAO constraints that yield

$$FoM_{BAO} \geq 7533,$$

including statistical errors and observational systematic uncertainties, with FoM_{BAO} and $FoM_{BAO,ref}$ computed as described in Section 3.3.1.

HLSS 2.0.2: RST shall be capable of executing a high-latitude spectroscopic survey that can, if allocated 0.64 years of total observing time, achieve RSD constraints that yield

$$FoM_{RSD} \geq = 4047$$

HLIS 2.0.1: RST shall be capable of executing a high-latitude imaging survey that can, in 1.07 years of total observing time, achieve WL constraints that yield

$$FoM_{WL} \geq 327400,$$

FoM definitions:

WL: $1/\,\boldsymbol{\sigma}(F_W)^2$ where F_W is scaling of $\boldsymbol{\sigma}_m(z)$ (amplitude of mass clustering) wrt Λ_{CDM}

BAO: $1/\boldsymbol{\sigma}(F_D)\boldsymbol{\sigma}(F_H)$, where F_D, F_H are scaling of $D_A(z)$, $H(z)$ wrt Λ_{CDM}

RSD: $1/\,\boldsymbol{\sigma}(F_G)^2$ where F_G is scaling of $\boldsymbol{\sigma}_m(z)f(z)$ wrt Λ_{CDM}, $f(z)=d\boldsymbol{\sigma}_m(z)/d\ln a$

HLWA Survey Capability Requirements

Weak Lensing
(HLIS 2.0.x)

1: FoM_{WL}>327400
2: N_{eff}>27/arcmin^2
3: Additive shear error <2.7 10^{-4}
4: Multiplicative shear bias <3.2 10^{-4}
5: deep field

Galaxy Redshift
(HLSS 2.0.x)

1: FoM_{BAO}>7533
2: FoM_{RSD}>4047
3: Slitless spectra
4: Completeness > 0.6
5: Redshift accuracy: $\sigma_z < 0.001(1+z)$
6. Outlier fraction uncertainty <0.25%

Boundary conditions for HLWA Survey

- **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.

Scheduling Considerations for 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

Roman Mission Objectives related to High Latitude Time Domain Survey

- NIR Survey
  - 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.
- Expansion History
  - Determine the expansion history of the Universe using Galaxy Redshift Survey, Weak Lensing, & Supernova techniques, at redshifts up to $z = 2$ with high-precision cross-checks between techniques.

Science Requirements related to High Latitude Time Domain Survey

SN 2.0.1: RST shall be capable of executing a supernova Type Ia survey that can, if allocated 0.5 years of total observing time, achieve constraints that yield

$$FoM_{SN} \geq 325 \quad (\text{FoM is } 1/\det(\mathrm{Cov}(w_0, w_a))$$

SN 2.0.2: RST shall enable a supernova survey that can measure the distance modulus μ(z) over the redshift range $0.2 \leq z \leq 1.7$, with observational noise contributions to the uncertainty $\sigma\mu \leq 0.02$ per Δz=0.1 bin.

SN 2.0.3: RST shall enable a SN survey to observe more than 100 SNe-Ia per Δz=0.1 bin.

SN 2.0.4: RST shall enable a SN survey with the systematic bias in redshift, $\sigma_z /(1 + z)$, less than the values in the following table:

Z	0.3	0.6	0.9	1.2	1.5
σ_z / (1+z)	0.001	0.0016	0.0019	0.0022	0.0024

Boundary Conditions for HLTDS

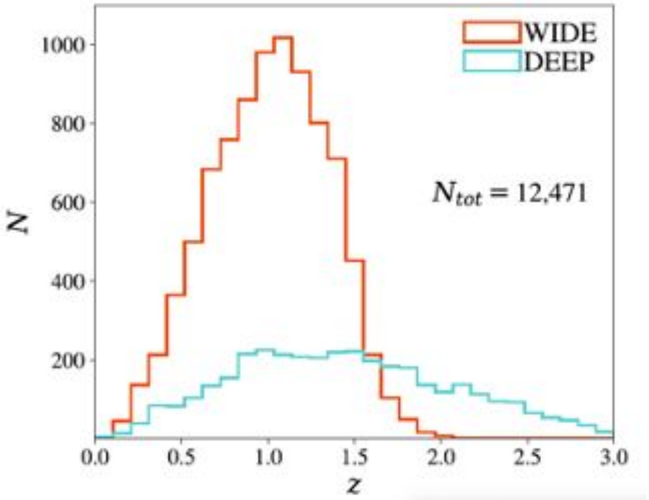
- Cadence, depth/area trade, choice of filters must provide a suitably large sample of SNIa in a redshift range sufficient to meet the required precision on luminosity distance vs. redshift
    - Notional survey had 5 day cadence over two years, 30 hr visits, area: wide - 19.04 sq deg, deep 4.12 sq deg (co-added limiting magnitude: wide ~28, deep ~29
- 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

Scheduling Considerations

- Want continuous coverage of a particular field for ~ 2 years ➞ CVZ

High Latitude Time Domain Survey - trade space

- **Reduce Survey Area**
  - Number of transients
  - Loss is greater than linear as smaller tiling pattern is less efficient: lose increasing fractions of light curve as tiling pattern rotates on the sky
- **Increased Cadence**
  - Ability to characterize SNIa
  - Coarse sampling of light curve reduces accuracy of light curve fits at low redshift end of sample
- **Reduced Imaging Exposure time**
  - Number of transients as a function of redshift
  - Ability to characterize transients
  - Reduces accuracy of SNIa luminosity distance determination
- **Reduced Prism Exposure times**
  - Redshifts, classification, standardization, systematics and evolution control
- **Reduced Number of filters**
  - Broad wavelength range to measure colors and build templates
  - Greatly reduced SNIa redshift coverage in each tier



Finding Technical Resources and Information

Roman Space Telescope/NASA

roman.gsfc.nasa.gov

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About | Science | Gallery | Resources

ROMAN SCIENCE

- What will Roman Study?
- Dark Energy
  - -Baryon Acoustic Oscillations
  - -Type Ia Supernovae
- Dark Matter
- Exoplanets
  - -Microlensing
  - -Direct Imaging
  - -Transit Method
- Large Area Near Infrared Surveys
- General Observer Program

OBSERVATIONS

- Observing Programs & Surveys
- Exoplanet Coronagraphy
- General Astrophysics
- Galactic Bulge Time Domain Survey
- High Latitude Time Domain Survey
- High Latitude Wide Area Survey

FOR SCIENTISTS

- Instruments & Capabilities
- Technical Resources
- Engaging with Roman
- Roman Science Interest Group
- Roman Early-Definition Astrophysics Survey Assessment
- Roman Science Team Community Briefing
- ROSES Proposal Document Library
- Call for Community Input into the Definition of the Roman Space Telescope's Core Community Surveys
- Roman Community Forum and Mailing List Signup

SCIENCE MATERIALS

- Roman Reference Information
- Document Library
- Scientific Image Gallery
- Science Events

SCIENCE TEAM

- FSWG Team Photo
- Science Team Members
- FSWG Member List
- FSWG Login

TAKE A TOUR

NEWS FEATURE

SPACE OBSERVER GAME

https://roman.gsfc.nasa.gov/science/technical_resources.html

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Technical Resources

Key Resources

Listed below are several resources which provide the mission and instrument parameters, technical performance models, and laboratory measurements.

Roman Observatory Overview

- **Mission and Observatory Technical Overview**
  - Spacecraft Parameters
  - Telescope Parameters
  - Observatory Instrumentation
- **Field, Slew, and available Roll Angle Information**
- **Notional Roman Observing Programs**

Wide-Field Instrument Reference Information

- **WFI Technical Overview**
- **Filters and Imaging**
  - Point Spread Functions
  - Effective Areas
  - Imaging sensitivity
  - Zodiacal Light, Thermal, and Background contributions
  - Imaging sensitivity calculator (ETC)
- **Grism and Prism**
  - Effective Areas
  - Zodiacal Lights
  - Spectroscopic Sensitivity
  - Dispersion
- **Detectors**

Anticipated performance Tables for the WFI

- **Overview of anticipated performance tables**
  - Exposure times and signal-to-noise ratios
  - Imaging signal-to-noise
  - Grism
  - Prism
  - Saturation of a point source

Downloadable Information

- **The Wide-Field Instrument**
- **Observatory**
- **Spreadsheets**

Roman Overview Papers

- **100 Hubbles for the 2020s (Akeson et al. 2019)**
- **2015 Report by the Science Definition Team (Spergel et al. 2015)**

Additional Resources

Listed below are several additional resources that provide information on the Roman mission.

Roman Project Websites

- **Goddard Space Flight Center (GSFC) NASA**
- **Jet Propulsion Laboratory (JPL) NASA**
- **Space Telescope Science Institute (STScI)**
- **Caltech/IPAC**

Roman Software and Simulation Tools

- **STScI Roman Science Planning Toolbox**
  - FOV Overlay Tool
  - PSF Simulation
  - Source Simulation and Exposure Time Calculator (Pandeia)
  - Complex Scene Simulation (STIPS)
- **IPAC Roman Simulation Repository**
  - WFI imaging and prism
  - Coronagraph
  - Dark Energy
  - Exoplanets

Roman Fact Sheets

- **Mission & Capabilities Overview** (.pdf)
- **Surveying the Sky** (.pdf)
- **Stars by the Billions** (.pdf)
- **Galaxies by the Millions** (.pdf)
- **Cosmology** (.pdf)

Roman General Astrophysics Ideas and White Papers

- **Roman Core Community Survey White Papers**
- **Selection of Roman-related ASTRO2020 decadal white papers**
- **List of Roman-related science papers**

SIT Resources

- **Web interface to Chris Hirata's WFIRST Galaxy Survey Exposure Time Calculator**
- **Cosmic Dawn SIT javascript WFI exposure time calculator**
- **Formulation Science Team Summary Workshop**

Core Community Survey Resources

- **Supernova Survey memo** (.pdf)
- **High latitude time domain survey presentation** (.pdf)
- **High Latitude Survey memo** (.docx)
- **HLS presentation** (.pdf)
- **Microlensing simulation paper (Penny et al)** (.pdf)
- **Galactic Bulge Time Domain Survey presentation** (.ppt)

These can be found at **https://asd.gsfc.nasa.gov/romancaa/** (under Design Reference Mission).

Questions?