RAIDS Update

The Remote Atmospheric and Ionospheric Detection System aboard the ISS

Jun 3, 2009

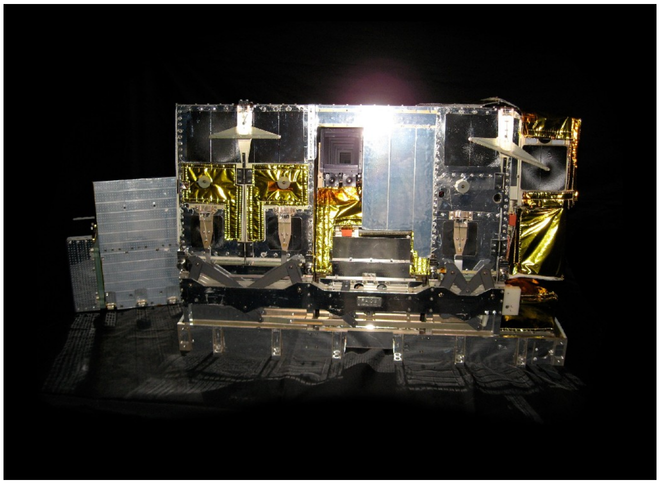

Figure 1: The RAIDS experiment after refurbishment was completed in July, including both the scan head and IR Detector Box (left side).

Introduction

After a long hiatus since the last *RAIDS Update*, we are pleased to report that several key milestones have been successfully completed. *RAIDS is ready to fly!*

During the summer of 2008 all refurbishment activities were concluded on the RAIDS hardware, and the experiment-level environmental qualification testing was successfully completed. Last September RAIDS was integrated into the HICO-RAIDS Experiment Payload (HREP). Payload-level environmental tests were conducted at the Naval Center for Space Technology facilities at NRL and completed in January.

After the completion of export-related paperwork in mid-April, HREP was flown, ferried, and trucked to the Japan Aerospace Exploration Agency (JAXA) Tanegashima Space Center (TNSC) in Japan. HREP passed post-shipment testing, ground processing by the HREP and RAIDS teams, and final inspections. On May 12, 2009 by mutual agreement between NASA and JAXA, HREP was transferred for launch on the H-II Transfer Vehicle (HTV), and JAXA and NASA signed the Certificate for Flight aboard HTV-1.

In these remaining months prior to launch, the RAIDS Team will focus upon preparing for mission operations, data management and distribution, and data product algorithms. The HREP nominal mission is only one year long, although an extension up to three years may be possible. Our chief goal for the next five months is to be prepared for science data analysis before HREP is commissioned on the Space Station.

Figure 2: HREP (with RAIDS visible) is lowered onto the Experiment Pallet in a clean room at Tanegashima Space Center, Japan in May, 2009.

Current Status

The major refurbishments to the RAIDS sensors and IR Detector Box were completed by June 2008. Most of the planned modifications were successfully achieved, including optional tasks. Most importantly, the new 765nm photometer filter was installed, the IR detector box was outfitted with a better radiator, and the bad photomultiplier tube was replaced. Two proposed refurbishment tasks were not performed. First, the drive electronics' scan profile was not customized, after the work was determined to be difficult and risky. Second, the FUV detector was found to be performing well and needed no refurbishment, though the low sensitivity at short wavelengths persists in the FUV spectrograph.

Aerospace refurbished and qualified the RAIDS IR Detector Box in Los Angeles, then delivered the component to NRL in mid-June. In mid-September RAIDS was integrated into HREP, followed by environmental testing at the payload level: electromagnetic testing in September, vibration testing in October, and thermal-vacuum testing in November-January. The payload underwent command/data handling and electrical testing at Marshall Spaceflight Center in February and March. HREP shipped to Japan for delivery, post-ship testing, and final inspections. Currently, HREP is integrated onto the Experiment Pallet for its flight aboard the HTV.

The RAIDS sensors, scan hardware, and electronics continue to perform well, with no serious anomalies. HREP/RAIDS ground system development and testing continues as we address network security issues.

Program Milestones

A brief overview of major milestones in this fast-paced program follows, highlighting activities for the RAIDS Science Team (orange), RAIDS hardware (yellow), and HREP (blue):

2007-Jan-23	***RAIDS Science Team Meeting***
2007-Mar-30	**HREP Kickoff TIM**
2007-May-02	***RAIDS Science Team Meeting***
2007-Jun-20	**RAIDS Refurbishment Review**
2007-Aug-06	**RAIDS Modification Design Review** *(PDR-level)*
2007-Aug-08	**HREP PDR**
2007-Sep-15	**HREP PDR JAXA**
2007-Dec-18	**HREP Phase 0/1 Safety Review**
2007-Nov-14	**RAIDS Critical Modification Review** *(CDR-level)*
2007-Dec-10	**RAIDS ΔCritical Modification Review** *(CDR-level)*
2008-Jan-14	**HREP CDR**
2008-Feb-04	**HREP Critical Interface Review JAXA**
2008-Apr-07	**RAIDS Test Readiness Review**
2008-May-29	**HREP Phase 2 Safety Review**
2008-Jun-13	**RAIDS Vibration Testing Completed**
2008-Jul-26	**RAIDS TVAC Testing Completed**
2008-Aug-15	**RAIDS Delivery to HREP**
2008-Aug-20	**RAIDS Support Proposals Meeting**
2008-Sep-09	**HREP Pre-Environmental Review**
2008-Oct-02	**HREP EMI Testing Completed**
2008-Oct-23	**RAIDS Science Team Meeting**
2008-Oct-31	**HREP Vibration Testing Completed**
2009-Jan-06	**HREP TVAC Testing Completed**
2009-Jan-12	**RAIDS Special Modes Tests**
2009-Jan-21	**HREP Phase 3 Safety Review**
2009-Jan-29	**HREP Pre-Ship Review**
2009-Feb-23	**HREP POIC Testing Complete**
2009-Mar-05	**HREP Ground System Review**
2009-May-12	**HREP Handover to JAXA**

Figure 3: The HREP Team stands with the payload integrated to the Experiment Pallet, showing RAIDS ready for flight with its red tag items removed.

Upcoming Events

2009-Jun-13	**Kibo JEM-EF launch on STS-127.** *This flight also carries NRL's Atmospheric Neutral Drag Experiment calibration spheres.*
2007-Sep	**DMSP F-18 Launch** *RAIDS will contribute to the SSULI Calibration-Validation effort.*
2007-Sep	**HREP Launch on HTV-1** *Specific launch date not identified*

Mission Overview

RAIDS is a multispectral (50-870 nm) remote sensing experiment to study the Earth's thermosphere and ionosphere—regions of the atmosphere with high societal relevance due to their effects upon communications, navigation, and satellite drag. The eight RAIDS sensors scan or image the limb of the Earth to measure vertical profiles of naturally occurring airglow spectra from atmospheric gases. RAIDS will make global measurements of the temperature and composition of the lower thermosphere, along with more limited measurements of the ionosphere. RAIDS data will be available in real-time with 60-70% coverage, with the remaining data dumped from on-board recorder. The environmental data products and scientific results from the RAIDS experiment will contribute to on-going programs to study the neutral upper atmosphere and ionosphere and will support operational space weather programs.

Mission Profile

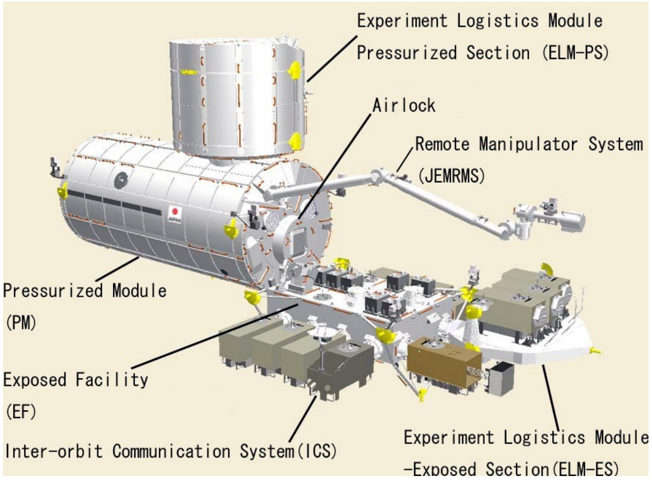

Figure 4: Schematic of the Kibo module showinging the JEM-EF and the payload attachment concept (Graphic credit: NASA.)

RAIDS has been approved by NASA and JAXA for for a September 2009 flight aboard the unmanned Japanese HTV-1 flight to the International Space Station, where RAIDS will operate from the Japanese Experiment Module – Exposed Facility (JEM-EF, Figure 4). RAIDS will fly with a companion experiment from NRL, the Hyperspectral Imager of Coastal Ocean (HICO). Both experiments will operate inside the HICO-RAIDS Experiment Payload (Figure 3), which is a structure about the size of a refrigerator that provides power and communications between the two experiments and the space station. RAIDS views aft (anti-RAM) from the open end of HREP.

After the HTV docks to the space station, an astronaut will use a robotic manipulator arm to remove HREP from the HTV and attach it to the JEM-EF. HREP will first be placed at a temporary location on the JEM-EF until astronauts have an opportunity to place HREP into its final location at Port #6. One year of mission operations will be provided by the Space Test Program, though the experiments could potentially operate aboard the ISS for a much longer period of time, if additional funding is secured. After mission operations cease, the payload is decommissioned and placed in a safe configuration, and the manipulator arm will load it into an empty HTV for de-orbiting and disposal by atmospheric re-entry.

Other Related Experiments. A number of contemporaneous experiments are expected to provide measurements that can complement RAIDS remote sensing observations or provide validation, context, or missing information relevant to RAIDS science. As the various hardware programs have progressed, we now have more definitive information about mission plans.

Figure 5: Deployment of ANDE calibration spheres on STS-116 in December 2006.(Photo credit: NASA)

During the RAIDS mission the Atmospheric Neutral Density Experiment (ANDE) from NRL will measure in situ thermospheric composition, total density, and winds in the ISS orbital plane over the course of approximately a year. In addition, the Defense Meteorological Satellite Program (DMSP) F18 satellite is scheduled to carry the Special Sensor Ultraviolet Limb Imager (SSULI) to orbit in September 2009, and RAIDS is expected to contribute to the SSULI Calibration/Validation effort.

Flying aboard the JEM-EF with RAIDS will be the Superconducting Submillimeter-wave Limb Emission Sounder (SMILES) experiment, which measures trace gases in the stratosphere. Future payloads on the JEM-EF facility include the Space Environment Data Acquisition equipment-Attached Payload (SEDA-AP), a Japanese experiment to measure the local space environment (plasma, atomic O, etc.) in the ISS orbit. In the third year of RAIDS operations Japan's Ionospheric, Mesosphere, Atmosphere, and Plasmasphere mapping (IMAP) experiment is planned to operate in the JEM port next to RAIDS, opening the possibility of collaborative science, such as volumetric remote sensing and cross-calibration.

RAIDS Science

RAIDS was originally conceived and built as a global remote sensing demonstration platform and as a survey experiment to completely characterize the aeronomically important species in the thermosphere and ionosphere. Nowadays, space science missions are generally expected to have objectives which are more tightly-focused than those of the original RAIDS mission. Though a global comprehensive thermospheric and ionospheric survey has never been performed, various space experiments over the last 15 years have advanced our understanding of the thermosphere. Yet compelling, fundamental science questions remain concerning (1) the structure of the thermosphere and ionosphere, (2) their responses to solar and geomagnetic forcing, and (3) the effect of tides and gravity waves upon the upper atmosphere. The RAIDS experiment will measure the composition, density, and temperature from which chemical and dynamical effects can be modeled or inferred to address aspects of these questions.

ISS Mission Science Objectives

The International Space Station platform is not well-suited to high latitude (auroral) or ionospheric observations due to its 51.6° orbital inclination and low 330–425 km orbital altitude. Consequently, the ability of RAIDS to address the science questions above will be limited to what can be accomplished in low- to mid-latitudes and in the lower portion of the thermosphere and ionosphere. As discussed at the August 2008 RAIDS Science Team Meeting, our mission objectives have been refined for this ISS mission:

Primary Objective: Measure the lower thermosphere temperature over altitudes 100-200 km to study the vertical temperature and compositional structure, the thermospheric response to solar UV variability, and search for the effect of tides and waves on the lower thermosphere.

Secondary Objective: Measure the O+ initial 83.4nm emission source in the lower F region ionosphere separately from the multiple scattering 83.4nm source near the F-region peak to validate remote sensing of the dayside ionosphere.

Secondary Objective: Measure the global distribution of minor species in the thermosphere to understand their role in chemical and ionic reaction in the lower thermosphere and ionosphere.

The primary objective of temperature measurements in the lower thermosphere is highly relevant to current community interest in the effects of tides on the thermosphere and ionosphere (Immel et al. 2006), the development and validation of improved empirical models of the thermosphere (Picone et al. 2002, Lean et al. 2006), and understanding the heat balance in the thermosphere with respect to global climate change and satellite drag (Qian et al 2006).

Mission Success Criteria

Based upon the scientific objectives and the instrument complement, we have developed mission success criteria. These criteria define the altitude range covered, the type of limb scan used, and the period of operation necessary to address the scientific objective. The success criteria also flow down to define other RAIDS mission requirements and provide guidance in prioritizing refurbishment tasks, mitigating technical risk, and planning mission operations.

HREP is a Class-D space experiment, which is defined as a higher-risk, minimum-cost effort. The characteristics of Class D experiments usually involve short operational life, low complexity, single-string designs, lowest cost, and short development schedule—all features of the HREP/RAIDS program. This HREP and RAIDS mission is not being designed to *ensure* comprehensive success.

However, RAIDS was originally built to approximately Class-B standards using rad-hard parts and built-in redundancies. Therefore, we fully expect RAIDS to far exceed its minimum success criteria. Minimum Success was achievable by RAIDS even before the RAIDS hardware refurbishment activities.

	Minimum Success	**Comprehensive Success**
Primary Objective	Thermosphere Temperature & Composition with Variability • 100-200 km alt. • discrete altitudes • 30 days continuous	Thermosphere Temperature & Composition with Variability • 100-350 km alt. • full altitude scan • 1 year continuous
Secondary Objective	Dayside Ionosphere Initial O+ 834 Source • 200-350 km alt. • full altitude scan • 1 day	Dayside & Nightside Ionosphere Variability • 200-350 km alt. • full altitude scan • 1 year
Secondary Objective	MLTI Chemistry and Microphysics • 100-200 km alt. • discrete altitudes • 2 weeks	MLTI Chemistry and Microphysics • 100-350 km alt. • discrete altitudes • 1 year

• 30-day minimum time for Primary Science Objective was defined by ISS precession rate to achieve 24-hour local time coverage, excluding sun-safe periods. (Not merely 30 random days over a one-year period.)
• At least 80% data coverage expected.

RAIDS Operations

Mission operations is an area of extensive on-going work. The missions operations are expected to occur in roughly four phases:

1. **RAIDS Checkout & Commissioning.** Once on-orbit and attached to Port #6 on the JEM-EF, HREP/RAIDS will undergo a thorough operational checkout, followed by a period where tunable parameters (such as scan angle range) are optimized.
2. **Thirty Days to Success**. Due to the high-risk nature of the HREP flight opportunity, RAIDS will focus upon a set of observations to achieve minimum mission success quickly. This mode is expected to gather complete spectral scans at a limited set of discrete altitudes.
3. **Regular Mission Operations.** After the period of discrete altitude spectral data, RAIDS will move into operations performing continuous limb scans with spectrometers fixed at designated wavelengths.
4. **Extended Operations and Campaigns.** As opportunities arise, RAIDS may alter its operations to support observational campaigns or to follow-up on early observations. These plans are yet to be determined.

The RAIDS check-out plan is currently being adapted from the original plan for TIROS. The commissioning plan is a new effort as it depends upon ISS-specific constraints that must be taken into account. The Thirty Days to Success concept is defined, but some issues, such as how many and which discrete altitudes is under discussion by the science team. Regular mission operations for the primary science objective are straightforward, but them approach to accommodating the secondary objectives is open for discussion.

Command Capability. To supplement command modes already built into RAIDS, the HREP interface includes a scripting capability, which can send repeated sets of RAIDS commands. RAIDS will operate most of the time in a default mode, with regular shutdowns for sun-safing or ISS operations and occasional campaign observations. RAIDS has a number of built-in sequencer modes that were checked during integration and testing. In addition, we tested alternate limb scaning modes, such as an angle-restricted dither mode, which could improve the useful duty cycle for science observations.

RAIDS Sensor Capabilities

The refurbished RAIDS instrument complement will differ slightly from the 1992 configuration. In particular the 589nm sodium photometer has been replaced with a 765nm O_2 band photometer. Other changes include new photomultiplier tubes in the four the NIR instruments, new narrowband filters for the three photometers, and sensitivity loss in the FUV sensor.

EUV Spectrograph	
Passband	55-111 nm @ 1.25nm res.
Field-of-View	0.1° x 2.4°
Integration Time	0.5 sec
Aperture Area	70mm x 70mm
Telemetry Rate	2560 bits/sec
Sensitivity	0.2-0.5 counts/sec/Rayleigh
FUV Imaging Spectrograph	
Passband	130-170 nm @ 0.7nm res.
Field-of-View	4.0° x 0.1°
Integration Time	64-90 sec
Aperture Area	21mm x 25mm
Telemetry Rate	4096 bits/sec
Sensitivity	0.1-1.5 counts/sec/Rayleigh
MUV Spectrometer	
Passband	190-317 nm @ 0.95nm res.
Field-of-View	0.1° x 2.1°
Integration Time	0.025 sec
Aperture Area	42mm x 50mm
Telemetry Rate	800 bits/sec
Sensitivity	2-6 counts/sec/Rayleigh
NUV Spectrometer	
Passband	295-399 nm @ 0.7nm res.
Field-of-View	0.1° x 2.1°
Integration Time	0.025 sec
Aperture Area	21mm x 25mm
Telemetry Rate	800 bits/sec
Sensitivity	5-8 counts/sec/Rayleigh

NIR Spectrometer	
Passband	722-874 nm @ 0.84nm res.
Field-of-View	0.1° x 2.1°
Integration Time	0.025 sec
Aperture Area	21mm x 25mm
Telemetry Rate	800 bits/sec
Sensitivity	0.05-0.13 counts/sec/Rayleigh
630 nm Photometer	
Passband	1.5 nm @ 630nm
Field-of-View	0.2° x 2.1°
Integration Time	0.1 sec
Aperture Area	42mm x 50mm
Telemetry Rate	200 bits/sec
Sensitivity	4.03 counts/sec/Rayleigh*
777.4 nm Spectrometer	
Passband	1.5 nm @ 777.4nm
Field-of-View	0.2° x 2.1°
Integration Time	0.1 sec
Aperture Area	42mm x 50mm
Telemetry Rate	200 bits/sec
Sensitivity	2.57 counts/sec/Rayleigh
765 nm Spectrometer (formerly 589 nm)	
Passband	1.5 nm @ 765nm
Field-of-View	0.1° x 2.1°
Integration Time	0.1 sec
Aperture Area	21mm x 25mm
Telemetry Rate	200 bits/sec
Sensitivity	0.86 counts/sec/Rayleigh
Notes: Sensitivities from post-refurbishment calibration.	

Science Traceability Matrix

At the RAIDS Science Team meeting at NRL in October, 2008 and at a follow-up meeting in Redondo Beach in February, 2009 we developed a science traceability matrix. The goals of this exercise were:

- to connect science objectives to particular observational requirements and strategies;
- to prioritize and coordinate observational strategies for meeting science objectives;
- and to identify scientific leads to coordinate algorithm development and data analysis.

At this point we have iterated on the traceability matrix several times, sent it out for comment to the Science Team, and incorporated suggested improvements. Currently, the medium- and high-priority objectives in the science matrix are well-defined. However, there is a wide variety of lower priority science objectives that are associated with a surprisingly small number of (otherwise busy) science leads. If you see a science question in which you would like to participate, please contact the designated science lead. Some of the lower-priority, smaller-scope topics might work well for student or post-doc projects.

Upcoming Meetings

Time is short to prepare for mission operations and data analysis. With a guaranteed mission length of only one year, we will need to hit the ground running. Science Team members will be key to these efforts, and we have several opportunities in upcoming months to discuss, plan, and coordinate activities.

- **CEDAR, Santa Fe, NM, June 28-July 2**
  RAIDS poster and oral presentations
- **CEDAR, Santa Fe, NM, June 29 9:30-11:30am**
  RAIDS Instrument Team meeting to discuss the Software Plan and mission ops status.
- **SPIE, San Diego, CA, Aug 6-8**
  RAIDS papers on the new mission, UV sensors & algorithms, and NIR sensors & algorithms
- **Aerospace, August (TBD, post-SPIE)**
  RAIDS Science Team meeting. Finalize mission operations plan, discuss data products and data distribution, review algorithm status

We look forward to hearing from you as we move quickly toward launch and science operations.

- Scott Budzien, RAIDS PI
  Naval Research Laboratory
- Rebecca Bishop, RAIDS Aerospace PI
  The Aerospace Corporation
- Andrew Stephan, RAIDS Project Scientist
  Naval Research Laboratory

Priority	Science Question	Measureable	Method	Altitude Range & Resolution	In-track Resolution	Cadence & Duration	Plat	EUV	FUV	MUV	NUV	NIR	7774	6300	7650	Lead
V0.2	***Atmospheric Dynamics***															
High	Which Tidal modes propagate up through lower thermosphere? What are the amplitudes of the modes?	Temperature vertically & horizontally	O2 line ratios, continuous limb scans	90-150+	1000 km	130 sec, 24 hrs	Scan					7600			Y	Budzien
		Temperature vertically & horizontally	O2 band shapes, discrete altitudes	90-150+	1000 km	130 sec, 24 hrs	Stepped					Scan				Budzien
Medium	What gravity waves are present in the thermosphere and what is their distribution and dissipation?	In-track density	N2, O2 neutral density	100-350 @ 3	15-1000 @ 3km	0.5 sec, 24 hrs	Stare			NO	2Pos	7600			Y	Hecht/Buc
		Density profiles (large scale waves)	N2, O2 density profile	100-350 @ 6	500-1000 @ 750	100sec, 24 hours	Scan			NO	2Pos	7600			Y	Hecht/Buc
	Atmospheric Thermodynamics															
High	What is the daytime temperature structure of the lower thermosphere? (characterization)	Temperature vertically & horizontally	O2 line ratios, continuous limb scans	90-200 @ 3 km	500 km	100 sec, 30 days	Scan				2Pos	7600			Y	Hecht
		Temperature vertically & horizontally	O2 band shapes, discrete altitudes	90-200 @ 3 km	500 km	100 sec, 30 days	Stepped				(2Pos)	Scan			Y	Hecht
High	How does NO and NO chemistry depend upon local time and influence thermospheric temperature?	NO density profiles, temperature profiles	O2 line ratios, NO profile, continuous limb scans	90-175?	1000 km	130 sec, 30 days	Scan			2150 2365		7600			Y	Bailey
		NO density profiles, temperature profiles	NO profile, O2 band shapes, discrete altitudes	90-175? ???	1000 km	130 sec, 30 days	Stepped?			Scan		Scan			Y	Bailey
	Geomagnetic and Solar Forcing															
Medium	What is the response of the ionosphere and thermosphere to solar and geomagnetic forcing? (Part 1) What is the quiet-time state of the thermosphere and ionosphere and how does this compare to models? (Part 2) What is the global morphology of storm-enhanced density structures? (Part 3) What is the response of the IT system to solar forcing from high speed streams at solar minimum?	NO density profiles	NO profile	90-200	500 km	100 sec, 24 hours (*extended per below); * (Part 1) 3 non-consecutive days * (Part 3) 2 consecutive days	Scan	Short/ Either	Y	NO, 2143, 2470, or scan?	2Pos	7600 (or scan)			Y	Bailey
		Dayside ionosphere O+ density	834 and 617 full limb scans	150-350 @10 km	500 km											Stephan & Bishop
		Temperature vertically & horizontally	O2 line ratios, continuous limb scans (or band shapes at discrete alt.)	100-200 @ 3 km	1000 km											Hecht
		Dayside thermosphere O, N2, O2 density profiles, Texo	1304, LBH, 2470, 2143 full limb scans	100-350 @ 10 km	500 km											Stephan
Low	What is the thermospheric ionospheric response to flares and geomagnetic storms? (Quick response observing mode)		Custom / same as above			100 sec, 15 min to 24 hrs	Scan	Short	Y	NO, scan?	2Pos	7600 (or scan)			Y	Budzien & Stephan
Low	What is the response of helium to geomagnetic forcing?	He profile	584 profile	100-350@ 20km	1500 km	200 sec	Scan	Short								????
	Ionosphere															
High	Self-consistent understanding of O+ production and radiative transfer on dayside (including initial source and cross section)	Dayside ionosphere O+ density, initial source brightness, O density	834 and 617 full limb scans	100-350, @6 km	1500 km,1 hr LST	100sec, 15 orbits	Scan	Short	Y							Stephan
Medium	Can 911 be used as a dayside ionospheric remote sensing method?	Dayside ionosphere O+	834 and 911 full limb scans;	100-350 @ 6 km	Any	20 full profiles, w/ ground truth	Scan	Long								Stephan & Coker?
Medium	How does equatorial ionization morphology relate to the occurrence and formation of scintillation depletions?	Afternoon/Evening ionosphere O+ density	1356, 911, (7774, 6300)	150-350 @ 10 km	500 km	100 orbits covering +-25 deg magnetic latitude??	Scan	Long	Y				Y	Y		Basu?
Low	What is the global (daytime) distribution of metallic ions and redistribution through fountain effect?	Mg+, Fe+, Ca+	Metallic ion spectra & profiles; spectral stare w/ vertical scan	90-350 @ 3km	1000 km	48 h consecutive	Scan			2599 2796 (2850)	3934					Bishop
		Mg+, Fe+, Na+, Ca+	Stepped altitude, spectral scan	90-350 @ 3 km	1000 km	48 h consecutive	Stepped	Short		Scan	Scan					Bishop
Low	Self-consistent understanding of nighttime recombination aeronomy	Nighttime O emissions	1356, 911, 7774, 6300	150-350 @10 km	Any	100sec, complete night half of orbit	Scan	Long	Y				Y	Y		Stephan
Low	Can 834 downward viewing be used to characterize HmF2	Dayside ionosphere O+ density	834 full limb scans; 617 optional	Disk view (sunsafe mode?)	Any	40 scans w/ ground truth	Stare	Either								Stephan
Low	Are first-principles models O2 and ionosphere consistent with observations?	6300 and 7774 (and 911) altitude profiles	Inversion of altitude profiles, nighttime	150-350 @10 km	500 km ?	1 orbit/day, 30 days	Scan	Long					Y	Y		Straus
	Chemistry and Minor Species															
Low	What causes low latitude NO density enhancements?	NO density profiles	2365 profile inversion?	90-175 @ ?? km	1000 km	130 sec, 30 days	Scan			2365						Bailey
Low	Hydrocarbons in the upper atmosphere?	??	??	??	??	??	??									????
Low	N+O recombination aeronomy at night	delta-band, Hertzberg altitude profiles	Emission altitude profiles	??	??	??	Scan?			Delta band		7600, 8600-8700			Y	Yonker

This eye chart is the The RAIDS Science Traceability Matrix (version 0.2). It connects science questions, measurables, ar
and lists priorities and science leads for topics. The assignment of priorities incorporates diverse factors in addition to scie
capabilities, technical risk, and staffing.