Outline

- Science Goals
- Overview
- Accommodation on the Spacecraft
- Top Level Requirements
- Instrument Characteristics
- Ion Optics and Focusing Scheme
- Measurement Modes
- Measurement Sequences
- Modes of Operations
- Segment Allocations
- Instrument Commanding
- Instrument Scripts
- Measurement Predicts
- Data Products
- Data Reduction Flow
- Synergy with Curiosity SAM measurements
Science Goals

NGIMS science goals
- establish structure & composition of upper NEUTRAL atmosphere
- measure ISOTOPE ratios
- measure thermal and supra thermal IONS

Measurement focus
- every orbit below ~500 km
  → altitude profiles from the homopause to above the exobase
- over mission duration
  → changes in atmosphere with perturbations from above and below

Relationship to MAVEN science goals
- state of upper atmosphere established for neutrals, ions, and isotopes
- response to solar perturbations established
- NGIMS measurements in concert with other MAVEN data sets provide a basis for models of present and past atmospheric loss and a better understanding of the history of Martian climate
NGIMS Overview

- MEB AND HARNESSES
- Thermal Radiator and Blankets
- DET ELECTRONICS
- RF ELECTRONICS
- QMS SENSOR
- MICROVALVES
- Breakoff Assembly
- NGIMS Baseplate
Accommodation on the Spacecraft

- Mounted on the MAVEN Articulated Payload Platform (APP)
- Pointing of NGIMS open source axis in ram direction during observations
NGIMS Top Level Requirements

NGIMS measurement requirements:

- Profiles of He, N, O, CO, N₂, NO, O₂, Ar, and CO₂ and their major isotopes
  - From the homopause up to one scale height above the exobase (130 km for He, ~12 km for CO₂)
  - Vertical resolution of one half scale height for each species
  - 25% accuracy

- Profiles of thermal O₂⁺, CO₂⁺, NO⁺, O⁺, CO⁺, C⁺, N₂⁺, OH⁺, and N⁺
  - From the ionospheric main peak (~120 km) up to the nominal ionopause (~400 km)
  - Vertical resolution of one half O₂⁺ scale height
  - 25% accuracy.

The combination of NGIMS sampling performance and spacecraft and attitude and orbit give:

- Required profiles of neutral and ion species
- Neutral temperature from scale height.
- Isotopes: (¹³C/¹²C, ¹⁸O/¹⁶O, ¹⁵N/¹⁴N, ⁴⁰Ar/³⁶Ar, ³⁸Ar/³⁶Ar)
Neutral Gas Sampling:
   (1) closed source (non wall reactive species)
   (2) open source (wall reactive species)

Positive Ion Sampling:
   thermal and suprathermal (< 30 eV)

Ion Source: electron beam ionization

Electron Energy: 75 eV

Mass Range: 2 to 150 amu (H₂ to Xe)

Quadrupole Radio Frequencies: 2

Resolution/Crosstalk: 10⁻⁶ for adjacent masses

Detector System:
   redundant pulse counting multipliers
   sample period 30 ms, integration period 27 ms
   dynamic range 10⁸

Scan Modes:
   (1) programmed mass or mass band scan
   (2) survey (scan in 1/10 or 1 amu steps)

Electrical Interfaces: RS-422, power, heater, PRT, actuator

Deployment Mechanism:
   jettisoned metal ceramic break-off cap

Internal Bayard-Alpert Pressure Gauge: 10⁻⁸ to 10⁻³ mbar

Inheritance: CONTOUR NGIMS, Cassini INMS, MSL SAM
Ion Optics and Focusing Scheme
Measurement Modes

Neutral Mode

Neutral Mode

Ion Mode

Neutral Mode

Ion Mode

Neutral Mode

Ion Mode

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Measurement Sequences

Neutrals Mode

Ion mode
- Most of science operations are done at periapse.
- Apoapse segment is used for calibrations and decontaminations.
- Campaign relies on repeatable measurements to determine atmospheric behaviors and variability.
- No difference in instrument commanding during Deep Dip operations.
Nominal instrument commanding is accomplished through the execution of scripted commands (code written in Basic):

- high heritage from past missions.
- provide all the flexibility needed to accomplish the science goals.

Scripts are parameterized to allow flexibility and minimize file uplinks.

Scripts are stored:

- on the instrument to be executed when needed,
- on the spacecraft memory, to be loaded to NGIMS and executed when needed.

During the execution of scripts the FSW generates message logs and housekeeping telemetry that come to supplement the science telemetry.
The instrument executes typically one of these operations:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Exec. by</th>
<th>Description</th>
<th>S/C requirement</th>
<th>Duration (min)</th>
</tr>
</thead>
</table>
| Aliveness Test (AT)              | NGIMS    | ▪ Power level check  
▪ C&DH basic functions check                                                  | None                             | 15             |
| Electrical Baseline Test (EBT)   | NGIMS    | ▪ BA gage pressure check  
▪ RF circuit check  
▪ Electrodes voltage check  
▪ Current, voltage and monitors check  
▪ Energy scans for each electrode  
▪ Background scans for each source  
▪ Pulse height distribution for each detector  
▪ Variable integration period scans | None                             | 60             |
| Background Scans (BScan)         | NGIMS    | ▪ Instrument background for each source                                     | Above 1000 km  
Off-ram pointing  
Off S/C pointing  
Away from thruster firing times | 60             |
| Calibration Scans (CScan)        | NGIMS    | ▪ Closed source scan with calibration gas                                   | Above 1000 km  
Off ram pointing  
Off S/C pointing  
Away from thruster firing times | 60             |
| Neutral Mode Science (NMS)       | NGIMS    | ▪ Predefined closed source scans                                            | Ram pointing                    | 35 (nominal)  |
| Ion Mode Science (IMS)           | NGIMS    | ▪ Predefined open source scans                                              | Ram pointing                    | 35 (nominal)  |
| Break-off Cover Deployment       | MAVEN    | ▪ Bellows fired by S/C while NGIMS is off                                   | Anti-ram pointing  
Apoapse                                           | NA                          |
| Decontamination                  | MAVEN    | ▪ Heaters enabled by S/C while NGIMS is off                                 | Outside periapse                | NA            |
Predicted NGIMS counts/sec from Jane Fox model – High solar activity

Measurement Predicts (1)
Predicted NGIMS counts/sec from Jane Fox model – Low solar activity
NGIMS Data Products

<table>
<thead>
<tr>
<th>Data Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Files of Binary packets as produced by the instrument.</td>
</tr>
<tr>
<td>1</td>
<td>Calibrated Data Record: Time and altitude stamped spectra (counts per second per unit mass and bands) separated by mode (ion or neutral) and source (close or open) and calibrated for detector response.</td>
</tr>
<tr>
<td>2</td>
<td>Derived Data Record: Single species abundance vs. time or single species energy distribution vs. time corrected for background, pointing and ram effects</td>
</tr>
<tr>
<td>3</td>
<td>Re-sampled Data Record: Altitude re-sampled abundances and energy distributions.</td>
</tr>
</tbody>
</table>

- **Level 0 ⇒ Quicklook & Level 1:**
  
  Level 0 packets will be separated by measurement mode and ionization source to generate the Neutral Close Source (NCS), the Neutral Open Source (NOS), and the Ion Open Source (IOS) data sets. These data will be checked for anomalies, time and altitude stamped (using reconstructed ephemerides) and calibrated for detector response then merged with their relevant housekeeping information in engineering units to form Level 1 files. Quicklooks will be generated in the same fashion by the SDC using predicted ephemerides.

- **Level 1 ⇒ Level 2:**
  
  Single species information (counts/energy band/time) will be extracted from the Level 1 data and reprocessed into physical units (abundances in particles/cc, and energy in eV) by correcting for background, pointing direction, and ram enhancement corrections due to the spacecraft motion during deep dips.

- **Level 2 ⇒ Level 3:**
  
  Level 2 data will be resampled into iso-altitudes for all the measured species using spacecraft reconstructed trajectory profile.
Synergy with atmospheric composition and isotopic data from the SAM investigation on the Curiosity Mars Science Laboratory rover
Synergy with Curiosity/SAM atmospheric composition and isotopic data

QMS provides, to date, significant updates from Viking and Phoenix for mixing ratios, C, O, N, and Ar isotope abundances.

TLS provides, to date, significant updates from Viking, Phoenix and ground based remote sensing for C and O isotopes in CO2 AND methane volume mixing ratio upper limits.