Introduction to the COMS Program and Development of COMS Meteorological Data Processing System

Hyo-Sang Chung/KMA

2005. 07. 12
Governmental Support for COMS

- MOST : Ministry of Science and Technology
- MIC : Ministry of Information and Communication
- MOMAF : Ministry of Maritime Affairs and Fisheries
- KMA : Korea Meteorological Administration

- Ka band Payload Development
- MI Payload Development
- System/BUS/AIT Development
- GOCI Payload Development
Mission Objectives of COMS

**Satellite Communication Mission**
- In-orbit verification of developed communication technologies
- Experiment of wide-band multi-media communication service

**Ocean Monitoring Mission**
- Monitoring of marine environments around the Korean peninsula
- Production of fishery information (Chlorophyll, etc.)
- Monitoring of long-term/short-term change of marine ecosystem

**Weather Monitoring Mission**
- Continuous monitoring of imagery and extracting of meteorological products with high-resolution and multi-spectral imager
- Early detection of special weather such as storm, flood, yellow sand
- Monitoring of long-term change of sea surface temperature and cloud
COMS in Space Dev.

- COMS Program
  - The only geostationary satellite program in the “National Plans for Long Term Plan for Space Development of South Korea (’05.02)”
Milestones for the COMS Program

1995.8    STEPI "Meteorological Sensors for Satellite" (Science & Technology Policy Institute)

1997.11 "Research on the Korean Meteorological Satellite"

2000.3    "Project for Centennial Meteorological Events"

2000.8    Meteorological Satellite Forum

2001.4    Feasibility study for COMS

2002.4    Preliminary work for COMS

2003.9    COMS Project Kick-off

2004      System Design Review

2005      Preliminary Design Review

2006      Critical Design Review

2007      Mission Readiness Review

2008      Pre Ship Review

2009      Data Service

2000.12   National Plan for Long-term Space Development

2002      Preliminary work for COMS
### Requirement of Ka-band Payload (TBC)

| Frequency (Ka-band) | Uplink : 29.6 ~ 30.0GHz  
| Downlink : 19.6 ~ 20.3GHz |
|---------------------|--------------------------|
| Minimum EIRP edge of coverage | 58dBW |
| G/T | 13dB/°K |
| Bandwidth | 400MHz (100MHz/channel) |
| Beamwidth | 0.6degree/each beam |
| Coverage | Refer to right figure |

### Ka-band Service Coverage

![Map of Ka-band Service Coverage]

**COMS Mission-1**
## COMS Mission-2

### Requirement of Ocean Sensor (TBC)

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial Resolution</td>
<td>500m X 500m</td>
</tr>
<tr>
<td>Coverage</td>
<td>2,500km X 2,500km</td>
</tr>
<tr>
<td>No. of Band</td>
<td>8 fixed band</td>
</tr>
</tbody>
</table>

#### Band Center & Band Width & Nominal Rad. & Max Rad. & NEdL & SNR (Sensitivity of sensor)

<table>
<thead>
<tr>
<th>Band Center [nm]</th>
<th>Band Width [nm]</th>
<th>Nom. Rad. [Wm^{-2} um^{-1} sr^{-1}]</th>
<th>Max. Rad. [Wm^{-2} um^{-1} sr^{-1}]</th>
<th>NEdL</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>412</td>
<td>20</td>
<td>100</td>
<td>150.0</td>
<td>0.100</td>
<td>1000</td>
</tr>
<tr>
<td>443</td>
<td>20</td>
<td>92.5</td>
<td>145.8</td>
<td>0.085</td>
<td>1090</td>
</tr>
<tr>
<td>490</td>
<td>20</td>
<td>72.2</td>
<td>115.5</td>
<td>0.067</td>
<td>1170</td>
</tr>
<tr>
<td>555</td>
<td>20</td>
<td>55.3</td>
<td>85.2</td>
<td>0.056</td>
<td>1070</td>
</tr>
<tr>
<td>625</td>
<td>20</td>
<td>32.0</td>
<td>58.3</td>
<td>0.032</td>
<td>1010</td>
</tr>
<tr>
<td>670</td>
<td>20</td>
<td>27.1</td>
<td>46.2</td>
<td>0.031</td>
<td>870</td>
</tr>
<tr>
<td>765</td>
<td>40</td>
<td>17.7</td>
<td>33.0</td>
<td>0.020</td>
<td>860</td>
</tr>
<tr>
<td>865</td>
<td>40</td>
<td>12.0</td>
<td>23.4</td>
<td>0.016</td>
<td>750</td>
</tr>
</tbody>
</table>

- MTF: \( \geq 0.3 \) at Nyquist frequency
- Dynamic Range: \( \geq 11 \text{bit} \)
- Sensor Calibration:
  - Calibration type: Solar Calibration
  - Accuracy of Radiometric Calibration: \( \leq 3\% \)
- Number of observation:
  - Total: 8 times
  - 10:00 ~ 17:00: 6 times,
  - 22:00, 02:00: 2 times

Ocean Sensor Coverage

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COMS Mission-3

- **Meteorology**
  - Continuous monitoring of weather events with multi-channel Imager
  - Early detection of severe weather such as tropical cyclones, heavy rainfall, dust out break, etc.
  - Long term data acquisition for climate study

- **Channels**

<table>
<thead>
<tr>
<th>Channel</th>
<th>Spectral band(μ)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIS</td>
<td>0.675</td>
<td>Daytime cloud imagery, Detection of special event (yellow dust, fire, haze, etc.), Atmospheric motion vector</td>
</tr>
<tr>
<td>SWIR</td>
<td>3.75</td>
<td>Nighttime fog/stratus, Fire detection, Surface temperature</td>
</tr>
<tr>
<td>WV</td>
<td>6.75</td>
<td>Upper atmospheric water vapor, Upper atmospheric motion vector</td>
</tr>
<tr>
<td>WIN1</td>
<td>10.8</td>
<td>Standard IR split window channel (cloud, Sea surface temperature, Yellow sand detection)</td>
</tr>
<tr>
<td>WIN2</td>
<td>12.0</td>
<td>Standard IR split window channel (cloud, Sea surface temperature, Yellow sand detection)</td>
</tr>
</tbody>
</table>
COMS System Architecture

- Ka-band RF Signals
- Command, Telemetry
- Raw Data, HRIT/LRIT

Satellite Operation Control Center / Back-up Data Processing Center

- Exclusive Line
- Meteo/Ocean Data Application Center (Primary Data Processing Center)

Meteo/Ocean Data Application Center

- Internet

Foreign Meteorological Data Receiving Station

Online Information Supply

Various Site

Foreign Meteorological Organization / Foreign User

Specialized Organization / Domestic & Foreign User

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Major Milestones for COMS Develop.

- Contract with EADS Astrium as a prime contractor: April 2005
- Kickoff Meeting at Astrium: 18-19 May 2005
- System Requirement Review: 13-14 June 2005
- System Design Review: 8-9 August 2005
- Preliminary Design Review: End of November 2005
- Critical Design Review: March 2007
- Launch: End of 2008
COMS Satellite Overall Configuration

- **Solar Array**
- **TMTC S band antenna**
- **MODCS S band antenna**
- **MODCS L band antenna**
- **MI**
- **Ka band antenna**
- **GOCI**
- **IRES**
- **Earth Direction**
- **Ram Direction**
Meteorological Imager (MI)

5 channel MI will be provided from ITT
GOCI will be the first Geostationary Ocean Color Imager and will be manufactured by EADS Astrium.
Ka band Communication Payload

Communication payload is under development by ETRI (Korea)
System Requirements (1)

Satellite Lifetime

- Operational Life > 7 years from the end of IOT period
- Design Life > 10 years

Spacecraft Stabilization

- 3-axis Stabilized Spacecraft for monitoring any regions at any time

Reliability

- > 0.75 for Meteorological and Ocean Monitoring Mission at End of Life
- > 0.85 for Communication Payload based on 12 years Design Life

Launch Vehicle Compatibility

- Compatible with Ariane, Delta, Atlas, Proton, H-IIA, Sea-Launch, etc.
- Compatible with the Launch vehicle Mission Profiles and Sequences
System Requirements (2)

Orbital Location

- Geosynchronous Orbit at 116.2E or 128.2E
- Location will be finalized after the approval from ITU

Stationkeeping Accuracy

- ± 0.05 ° in longitude and latitude of the nominal orbit location

Image Navigation and Registration (Imager)

- Image Navigation Error within an Image < 56 µrad (2km)
- Image Registration
  - Within-frame Registration < 42 µrad (1.5km)
  - 15min Frame-to-Frame Registration < 28 µrad (1km)
  - 90min Frame-to-Frame Registration < 42 µrad (1.5km)
  - 24hours Frame-to-Frame Registration < 112 µrad (4km)
- Band-to-Band Co-registration
  - Visible/IR < 50 µrad, IR/IR < 28 µrad
System Requirements (3)

Image Navigation and Registration (Ocean Color Imager)

- **Image Navigation Error** within an Image < 28 µrad (1km)
- **Image Registration**
  - Within-frame Registration < 28 µrad (1km)
  - Frame-to-Frame Registration < 28 µrad (1km)
- **Band-to-Band Co-registration**
  - Visible/Visible < 7µrad

- **Image Navigation**
  - determining the location of any pixel within an Image in terms of Earth longitude and latitude

- **Image Registration**
  - keeping any pixel within an Image pointed to its nominal Earth location within specified accuracy
**System Requirements (4)**

**Mode of Operation**

- **Stationkeeping Mode**
  - Stationkeeping Frequency shall be determined for the minimal Impact to the Payload Operation
  - Stationkeeping Maneuver and INR Performance Recovery < 60min.

- **Housekeeping Mode**
  - 2 times per day with a Maximum Duration of 10 min.

- **Safe-Hold Mode**
  - Ensure the Safety of the Satellite under an anomalous condition
  - Via Ground Command or By the On-board Computer

- **End-of-Life Mode**
  - Move the Spacecraft to 150km above the GEO. Orbit at End of Life

**Transfer Orbit Operation**

- **Arrive at the Target Orbit within 30days** after Separation from Launch Veh.
- **6 months IOT** to verify the Performance of the Spacecraft and Payloads
System Requirements (5)

Simultaneous Operation of Multiple Payloads

- MI, GOCI and Comm. Payloads shall be Operable Simultaneously
- Not Induce any Interference or Performance Degradation

Processed Meteorological Data

- Data Format: HRIT (High Rate Information Transmission), LRIT
- Delivery Timeliness: within 15min. after the End of Image Acquisition

Space-to-Ground Interface

- Polarization
  - Telemetry & Command (CP), Raw and Processed Data (LP)
- Modulation
  - Telemetry & Command – PCM/BPSK/PM
  - Raw Data – PCM/QPSK
  - Processed Data – PCM/BPSK
- Bit Error Rate (BER)
  - Telemetry & Command – 10⁻⁶, Raw and Processed Data – 10⁻⁸
COMS Frequency Registration

ITU Registration Orbit: 116.2°E, 128.2°E

ITU Registration Frequency Band

- For Ocean and Meteorological Service and Satellite Operation:
  - 1,670 ~ 1,710 MHz (L-Band): Sensor Data & Processed Data Downlink
  - 2,025 ~ 2,110 MHz (S-Band): Processed Data & Command Uplink
  - 2,200 ~ 2,290 MHz (S-Band): Telemetry Downlink

- For Communication Service:
  - 27.5 ~ 30.8 GHz: Ka-Band Uplink
  - 18.3 ~ 20.7 GHz: Ka-Band Downlink
Case Analyses

- July 31, 1998  Shoonchun 187mm/day
  Mt. Jiri’s Heavy rainfall
- July 15, 2001  Seoul 273.4mm/day
  Seoul/Kyungki Prov.
  Heavy Rainfall
- Aug. 31, 2002  Kangnung 870.5mm/day
  TY Rusa’s Heavy Rainfall
The Distributions of Daily Rainfall

Mt. Jiri Heavy Rainfall

TY Rusa Heavy Rainfall

Seoul/Kuingki Prov
Hourly Rainfall Intensity

- Mt. Jiri’s Heavy rainfall

![Bar chart showing hourly rainfall intensity with peaks at certain hours.]

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Distribution of Hourly Rainfall

- Seoul/Kyungki Prov. Heavy Rainfall

01LST  02LST  03LST  04LST  05LST  06LST
07LST  08LST  09LST  10LST  11LST  12LST

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Hourly Rainfall Intensity
- Seoul/Kyungki Prov

* Top 5 daily Rainfall: Seoul, Choonyang(*), Hongcheon, Yangpyeong, Incheon
Distribution of Hourly Rainfall

- TY Rusa Heavy Rainfall

<table>
<thead>
<tr>
<th>02LST</th>
<th>04LST</th>
<th>06LST</th>
<th>08LST</th>
<th>10LST</th>
<th>12LST</th>
<th>14LST</th>
<th>16LST</th>
<th>18LST</th>
<th>20LST</th>
<th>22LST</th>
<th>24LST</th>
</tr>
</thead>
</table>

No observed data due to record-broken rain
Hourly Rainfall Intensity

- TY Rusa Heavy Rainfall

* Top 5 daily rainfall: Gangneung, Daekwanryoung, Donghae, Sokcho, Chupungryoung
Summary

• Meteorological Effects:
  - Early detecting and continuous monitoring the high impact weathers
  - Improvement of NWP model using satellite data
  - Early detection of aerosol, such as Asian dust, and monitoring of its transport, etc.
  - Long term extraction of climate variation information

• Oceanographical Effects:
  - Reducing the property damages of fishermen
  - Preventing the ocean resources from damaging

• Communicational Effect:
  - In-orbit test of developed communication payload
II. The Outline of CMDPS
What is CMDPS?

- COMS Meteorological Data Processing System (CMDPS)
  - System to produce geophysical parameters from the satellite measured raw radiance data.
  - The system includes:
    - algorithms for each baseline products
    - various auxiliary data such as the surface emissivity, etc.
    - radiative transfer model
    - calibration monitoring scheme and algorithm
    - interfaces for between algorithms, and between CMDPS and OS
    - validation procedures.
CMDPS Data Flow

Pre-processing data
Aux. Data, response function, etc.

Level 1.5 data
Validation Data
Real Time
Distribution
Archive
Applications

Pre-processing data
Aux. Data, response function, etc.

Cloudy Clear
CMDPS
OLR
CLD
Unprocessed
Cloud free land
Cloud free sea
Cloud contaminated
Cloud filled
Snow/Ice contaminated
Unclassified

AMV
CTPCType
Fog
SC/Ice
SST
TPW

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The Outline of CMDPS

On-line (Dynamic) Data decoding and reformatting

- COMS Level 1.5 Image Data
- Meteorological Forecasts
- Meteorological Observation
- Foreign Satellite Data

Data Preparation

- Prepared & Inferred Image data
- Prepared Meteorological Observation
- Cloud Analysis, SST, AMV, CTTH Products

Product Verification

Product Processing

- Temporally interpolated Forecasts Temp. + Wind Profiles
- Temporally interpolated Met. Forecasts RTM table
- Met. Forecasts RTM table & Met. Observation RTM table

Application Data Pre-Processing

- Static Application data:
  - Background surface data
  - Coastline data
  - Spectral response curves for the COMS channels

- Foreign satellite data
- COMS Spectral response Function

Calibration Support

- For Next Repeat Cycle
- Previous CSR

Scenes Analysis Output

- Verified SST, LST

Off-line

16 Products

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## Baseline products

<table>
<thead>
<tr>
<th>Group</th>
<th>Product</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
<th>Accuracy (Thres.)</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Cloud Detection</td>
<td>CLD</td>
<td>1x1 pixel</td>
<td>=obs</td>
<td></td>
<td>METRI</td>
</tr>
<tr>
<td></td>
<td>CSR</td>
<td>~ 100km</td>
<td>=obs</td>
<td></td>
<td>METRI</td>
</tr>
<tr>
<td>AMV</td>
<td>AMV</td>
<td>~ 50km</td>
<td>3 hr.</td>
<td>9 m/s</td>
<td>METRI</td>
</tr>
<tr>
<td>Surface Information</td>
<td>SST</td>
<td>1x1 pixel</td>
<td>hourly</td>
<td>1.2 K</td>
<td>SNU</td>
</tr>
<tr>
<td></td>
<td>LST</td>
<td>1x1 pixel</td>
<td>hourly</td>
<td>2 K</td>
<td>Kongju NU</td>
</tr>
<tr>
<td></td>
<td>Sea Ice/SC</td>
<td>1x1 pixel</td>
<td>daily</td>
<td></td>
<td>METRI</td>
</tr>
<tr>
<td></td>
<td>Insolation</td>
<td>1x1 pixel</td>
<td>hourly</td>
<td>10 %</td>
<td>Pukyoung NU</td>
</tr>
<tr>
<td>Water vapor Information</td>
<td>UTH</td>
<td>~ 50km</td>
<td>=obs</td>
<td>20 %</td>
<td>Kyoungpook NU</td>
</tr>
<tr>
<td></td>
<td>TPW</td>
<td>~ 50km</td>
<td>=obs</td>
<td>20 %</td>
<td>Kyoungpook NU</td>
</tr>
<tr>
<td>Cloud Information</td>
<td>CLA</td>
<td>3x3 pixel</td>
<td>=obs</td>
<td></td>
<td>SNU</td>
</tr>
<tr>
<td></td>
<td>CTT/CTH</td>
<td>1x1 pixel or 3x3 pixel</td>
<td>=obs</td>
<td>3 K 1 km</td>
<td>SNU</td>
</tr>
<tr>
<td></td>
<td>Fog</td>
<td>1x1 pixel</td>
<td>=obs</td>
<td></td>
<td>EWU</td>
</tr>
<tr>
<td></td>
<td>PI</td>
<td>1x1 pixel</td>
<td>=obs</td>
<td>20 % bias</td>
<td>Kangnung NU</td>
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<tr>
<td></td>
<td>OLR</td>
<td>~ 10km</td>
<td>hourly</td>
<td>10 %</td>
<td>SNU</td>
</tr>
<tr>
<td>Aerosol Information</td>
<td>AI</td>
<td>1x1 pixel</td>
<td>=obs</td>
<td></td>
<td>Pusan NU</td>
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<tr>
<td></td>
<td>AOD</td>
<td>10x10 pixel</td>
<td>=obs</td>
<td>35 %</td>
<td>YSU</td>
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</table>
## Baseline products

<table>
<thead>
<tr>
<th>Name</th>
<th>New?</th>
<th>Issues</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLD/CLR</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Probability Info., Use of NWP products, SFC¹</td>
</tr>
<tr>
<td>LST</td>
<td>Yes</td>
<td>New with enough acc.</td>
<td>SFC is mandatory for enough accuracy,</td>
</tr>
<tr>
<td>SST</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Different algorithms for spatial and temporal scale</td>
</tr>
<tr>
<td>Insolation</td>
<td>Yes</td>
<td>New regression coeffs.</td>
<td>Better reference ground data and CLD information</td>
</tr>
<tr>
<td>Snow/Ice</td>
<td>Yes</td>
<td>Important in LSM</td>
<td>Combining with SSM/I, AVHRR, and MODIS</td>
</tr>
<tr>
<td>AMV</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Height assignment using IR1/WV, IR1/IR2</td>
</tr>
<tr>
<td>TPW</td>
<td>Yes</td>
<td>NWP application</td>
<td>Regression with better database</td>
</tr>
<tr>
<td>UTH</td>
<td>Yes</td>
<td>NWP application</td>
<td>Regression and Physical approach</td>
</tr>
<tr>
<td>CLD Info.</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Use of NWP products, better understanding of Chs.</td>
</tr>
<tr>
<td>CLD Cls.</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Use of NWP products with better RTM</td>
</tr>
<tr>
<td>CLD Phs.</td>
<td>Yes</td>
<td>Important for nowcasting</td>
<td>Better understanding of Chs.</td>
</tr>
<tr>
<td>Fog</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Better threshold values for different conditions</td>
</tr>
<tr>
<td>OLR</td>
<td>Yes</td>
<td>Expect better accuracy</td>
<td>Better calibration with improved aux. data</td>
</tr>
<tr>
<td>PI</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Use Microwave data and precise topography</td>
</tr>
<tr>
<td>AI</td>
<td>No</td>
<td>Accuracy Improvement</td>
<td>Better threshold and SFC information</td>
</tr>
<tr>
<td>AOD</td>
<td>Yes</td>
<td>Became important info.</td>
<td>Accurate LUT and SFC information</td>
</tr>
</tbody>
</table>

¹ SFC includes the surface information acquired by both off-line and on-line
Baseline products

- OLR: Outgoing LW Radiation
- AOD: Aerosol optical depth
- COD: Cloud optical depth
- CTT: Cloud top temp.
- CTH: Cloud top height
- SST: Sea surface temperature
- LST: Land surface temperature
- TPW: Total precipitable water
- UTH: Upper Tropospheric Humidity
- PI: Precipitation index
Cloud Phase-I

- **Key issues**
  - Is WV channel useful for cloud phase
  - How accurate for multi-layer cloud?

- **Approaches**
  - Simulation
    - 8.7 vs. 6.3
  - Application to MODIS data
    - comparison
Cloud Phase-III
Aerosol Optical Depth-I

Cloud Removal

COMS Vis. Channel TOA Reflectance ($\alpha'_p$)

RTM (6S)

$\tau_a = F(\theta_0, \varphi_0, \theta_s, \alpha_p, \alpha_s)$

Look Up Table

$\theta_0 = 0-70^\circ, 5^\circ$
$\varphi_0 = 0-180^\circ, 10^\circ$
$\theta_s = 0-70^\circ, 5^\circ$
$\tau_a = 0-3, 0.1$
$\alpha_s = 0-1, 0.1$

GOES-9 Vis. Channel Surface Reflectance ($\alpha'_s$)

$\alpha'_s = F(\theta_0, \varphi_0, \theta_s, \alpha_p)$
$\tau_b = 0.0 \ldots$ in 6S

COMS Vis. Channel TOA Reflectance ($\alpha_p$)

LOOK UP TABLE METHOD

$\alpha'_s = F(\theta_0, \varphi_0, \theta_s, \alpha_p)$
$\tau_b = 0.0 \ldots$ in 6S

$\alpha_s$ (1 month 2nd min. reflectance)

AOD($\tau_a$)
Comparison of Aeronet with GMS5 AOD (2002/3/30-4/30)

Shirahama (lat=33.69, lon=135.36)
Osaka (lat=34.65, lon=135.59)
Che-Ju (lat=33.28, lon=126.17)
Anmyon (lat=36.322, lon=126.195)

Y = 0.9381454401X + 0.0389830969
r² = 0.6327175486
## Aerosol Optical Depth-VI

### Sources of uncertainty (Knapp et al., 2002)

<table>
<thead>
<tr>
<th>Source</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric</td>
<td>aerosol optical properties (e.g., sphericity, $w_o$, $n(r)$, refractive index)</td>
</tr>
<tr>
<td></td>
<td>location of the aerosol layer</td>
</tr>
<tr>
<td></td>
<td>Rayleigh optical depth</td>
</tr>
<tr>
<td></td>
<td>gaseous absorption</td>
</tr>
<tr>
<td>Surface</td>
<td>reflectance uncertainty</td>
</tr>
<tr>
<td></td>
<td>bidirectional reflectance contamination</td>
</tr>
<tr>
<td>Instrument</td>
<td>calibration</td>
</tr>
<tr>
<td></td>
<td>noise</td>
</tr>
<tr>
<td>Radiative transfer model</td>
<td>plane-parallel approximation</td>
</tr>
<tr>
<td></td>
<td>multiple scattering</td>
</tr>
</tbody>
</table>

2005. July 12, CIMSS Silver Symposium, Madison, WI.
Future Plans

- **2003**: Conceptual Design

- **2004**
  - Cal. concept
  - S/W Development
  - Simulation Data

- **2005**
  - Cal. Development(I)
  - S/W Prototype
  - Interface design

- **2006**
  - Cal. Development(II)
  - S/W Standardization
  - CMDPS
  - Integration to OS
  - Validation

- **2007**
  - Evaluation Data
  - Real time operation

- **2008**

Other major Task
- Development of validation strategy for the raw and derived products
- Preparation for the user service