Title: «Satellite Constellation for Monitoring of Chemical Composition of Earth Atmosphere»

Primary POC: Sergii Moskalov
Organization: Yuzhnoye State Design Office
POC email: space@yuzhnoye.com

Need

Many countries and global organizations require in content monitoring (regional and global) of different gases in the atmosphere (including gases that create a greenhouse effect). One satellite is applied in the conventional space control systems of atmosphere gases content . It is utilize probe solar beams reflected from the Earth surface. The above-mentioned method allows to perform sensing only in the direction of solar beams reflection. Therefore, implementation of continuous and global monitoring of atmosphere is impossible.

Mission Objectives

The main mission objective is creation of orbital constellation of two-three satellites that ensure through Earth atmosphere sensing for determination of atmospheric gases density. The data received from the orbital constellation could be applied for solving the following tasks:

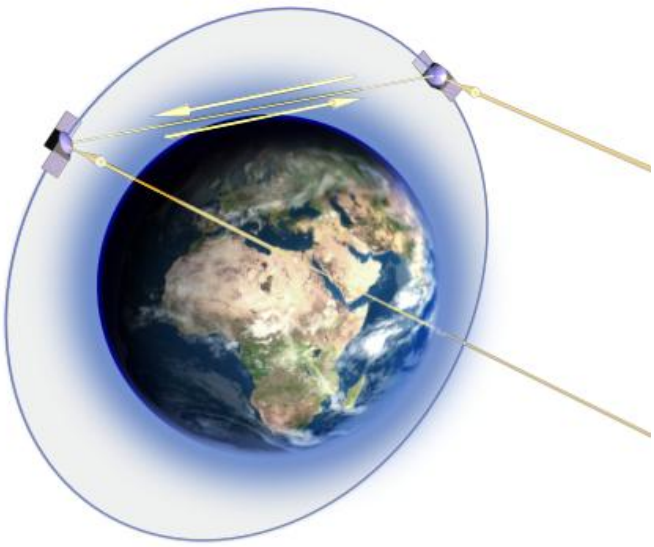
- formation of vertical profiles and thematic maps of gas allocation in the atmosphere above the specified areas of the Earth;
- determination of atmospheric gases content of greenhouse effect (carbonic acid (CO_2), methane (CH_4), nitric oxide (N_2O) and others);
- determination of geographical (regional and global) distribution of greenhouse gases;
- estimation of temporary (seasonal and annual) changes in stream of greenhouse gases (estimation of emission and absorption) ;
- forecast of future climate change;
- control of Kyoto Protocol restrictions adherence and others.

Concept of Operations

Key elements of the mission:

- space segment in a composition of 2-3 satellites;
- ground segment consists of ground station of control, reception and data processing from satellites.

Satellites are launched into the orbit by one launch-vehicle as a piggy-back payload. Satellites are separated along the orbit on specified distance by own propulsion systems that provide a maintenance of this distance. The mentioned distance provides a passing of mutual LOS (line of sight) through the atmosphere mass (including refraction).



Through sensing of Earth atmosphere is implemented by light beam radiated from the board of one satellite through atmosphere mass towards to another satellite.

Light beam is formed by calibrated radiation source with known spectral characteristics or/and specular surface that reflects solar beams. Laser radiation sources could be applied for sensing of specified atmospheric gases. There is a possibility of through sensing implementation in opposite direction (from second satellite to the first satellite).

In case of passing of probe beam through atmosphere mass the beam spectral characteristic changes in connection with dispersion and absorption by molecules of atmospheric gases. Analysis of spectral characteristics changes gives an opportunity to determine a density of these gases in the atmosphere. Probe beams can pass through the atmosphere mass at different altitudes from Earth surface (it is a possible to implement a satellite maneuvering along the orbit or use a third satellite in order to receive different beams).

Ground station provides the following:

- planning and conducting the radio-communication contacts with satellites;
- formation and transmitting the command-program data to the satellite board for control of satellite functioning;
- receiving, processing and analysis of telemetry data from satellite board;
- performing of trajectory measurements;
- calculation of ballistic data, forecasting of satellite movement parameters, formation of input data for maneuvers implementation;
- receiving and processing of payload information from satellite board, received by emission onboard receivers ;
- archiving, storage and delivery of information to users.

Key Performance Parameters

Determination of atmospheric gases density depends on the following key parameters:

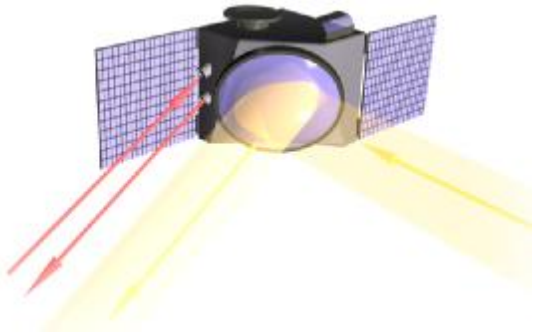
- accuracy of angular distance maintenance between satellites;
- accuracy of satellites' orientation;
- angular field of view of on-board radiation receivers;
- brightness of on-board radiation sources (in case of solar beams reflection the brightness depends on area of specular surface);
- sensitivity and spectral resolution of on-board radiation receivers.

All key parameters are interconnected and theirs optimal value will be determined during the design stage.

Space Segment Description

Each satellite consists of:

- payload including:
  - reflecting mirror,
  - radiation source,
  - radiation receiver,
  - spectrum analyzer,
  - unit of photo detectors;
- control and data-processing system including:
  - on-board computer,
  - telemetry module,
  - altitude determination and control subsystem,
  - subsystem of satellite navigation;
- communication system;
- propulsion system;
- electric power supply system;
- thermal system;
- on-board electric harness;
- construction.



Optimal values of key specifications of on-board systems (and satellite a whole) will be determined at the design stage.

Orbit/Constellation Description

Satellites operate at circular sun-synchronous orbit with the following parameters:

- orbit altitude 600…700 km (depending on orbit altitude of the main payload that launched by launch-vehicle);
- orbit inclination 97.8…98.2° (provides a solar synchronism depending on orbit altitude);
- local time in orbit node 6 or 18 h. (provides a possibility of continuous and global monitoring);
- angular distance between satellites 46.7…51.4° (provides a passing of probe beam through the atmosphere mass depending on orbit altitude and altitude of beam passing under the Earth surface).

Implementation Plan

Yuzhnoye State Design Office in cooperation with other Ukrainian Companies will provide design, development, assembling, integration, tests, launch and operation of constellation of satellites.

Ukraine has all means and facilities required for Project implementation. There is a possibility of purchasing of on-board equipment in Japanese Companies.

It is possible to create ground stations for data receiving and processing from satellites in the territory of the interested countries.

Project's implementation plan:

Milestones of work	**Term**
Start of Project implementation	T0
1. Designing (issue of preliminary design)	T0+4 months
2. Development (issue of design documentation)	T0+10 months
3. Manufacturing and development testing of satellites' component parts	T0+16 months
4. Assembling, integration and tests of satellites	T0+22 months
5. Preparation of satellites for launching at the launch site	T1*****-2 months
6. Launch of satellites	T1*****
7. System commissioning	T1*****+3 months

Note * - These values depend on readiness of the main LV payload for launch.

Total cost of lifecycle is about 6 000 000 USD (excluding the cost of the satellite launching)

Possible risks of Project implementation and ways of theirs decreasing:

Possible risks	Ways of decreasing
Increasing of development terms in terms of late delivery of components for satellites and ground station of control, reception and data processing	Development with application of components from different manufactures. Entering into a contract in time with manufacturers on delivering of components and control for their implementation. Application of components logistic structures, which decrease a duration of delivery process. Utilization of standard equipment for nonprofessional radio communication and university satellites.
Increasing of development terms and costs in connection with identification of unaccounted (during the designing) factors at the development testing stage	Modeling and prototyping in a maximum possible value with maximum possible accuracy
Increasing of development terms and terms of commissioning in connection with late reception of frequency assignments	Issuing an application on receiving of frequency assignments in time and control for its implementation before the start of development, testing and commissioning. Application of standard equipment for non-professional radio communication and university satellites
Increasing of commissioning terms in connection with mismatch of required launch time with launch schedule	Development of satellites with a possibility of its launching by different launch-vehicles. Entering into a contract with launch provider in time. Possibility of satellites operation on orbits differ from calculated in condition of certain decrease of efficiency

References

“Laser Remote Sensing. Fundamentals and Applications” Raymond M. Measures
Professor of Applied Science and Engineering University of Toronto
Institute for Aerospace Studies