EasySpace Final Proposal

Volume I

Executive Summary

SpaceTech 5
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EasySpace offers a unique small business opportunity: a space mission that satisfies the need for scientific atmospheric data with a satellite kit concept. The satellite kits can be utilized for educational purposes and technology transfer as well as in-space technology demonstration activities using the satellite as a platform while collecting valuable atmospheric drag data.

EasySpace goals are to:

- **Become the key player in the nanosatellite market segment;**
- **Become the key player in the space technology demonstration and educational programs;**
- **Build a profitable business within 4 years.**

The EasySpace mission will last a period of about 11 years to gather scientific data over a solar cycle period with the launch of 200 satellites at different inclinations. The launches are all expected to be piggyback payload launches.

The end-to-end approach to the mission design, exercising all aspects of the system engineering, has been driven by a low cost philosophy derived from the basic business case. The business plan shows that EasySpace is a profitable commercial venture.

The EasySpace concept is being created and designed by the SpaceTech participants, an international group of 14 engineers, physicists and scientists with many years of experience within space agencies: Italian Space Agency (ASI), German Aerospace Center (DLR) and European Space Agency (ESA); commercial industries: Carlo Gavazzi Space, European Aeronautic, Defense and Space Company (EADS), SES ASTRA and Telenor; and academia (University of Trieste).

The EasySpace Company was established in 2001 within the framework of the post-graduate program of the Delft University of Technology in the Netherlands. Delft University of Technology has offered, for the past five years, a Master program, SpaceTech, in cooperation with the aerospace industry, user organizations, research establishments and academic institutions throughout the world. SpaceTech has a strong focus on cost-conscious end-to-end space systems and business engineering as a prerequisite for meeting market demands. This approach is specifically developed to enable employees in the space and space application sectors to successfully operate in the increasingly competitive environment.

EasySpace Final Proposal Contents

The EasySpace proposal is structured as follows:

Volume I	**Executive Summary**
Volume II	**Technical Proposal**
Volume III	**Business and Management Proposal**

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EasySpace Vision

" By combining an important scientific objective, with commercially valuable data, and a satellite kit concept, EasySpace opens a new access route to space with a low cost, easy-to-assemble and modular spacecraft.
It enables companies, organizations and small countries to realize a space presence independent of classic space structures and the related constraints. In the long term this concept stimulates new space opportunities and businesses, and act as a catalyst for growth in the whole space market. "

EasySpace: Create a new nano-satellite culture!

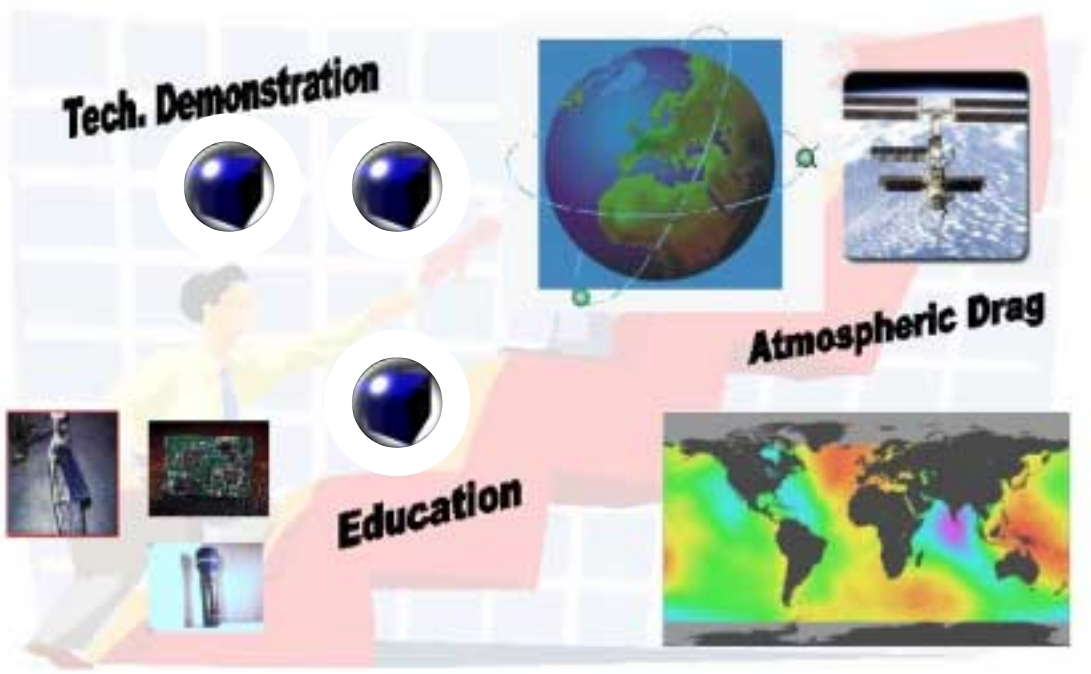

Figure 1. EasySpace Vision

EasySpace Concept for the Business

Figure 2. EasySpace Business Concept

The EasySpace venture is based on the collection of scientific atmospheric density data. This is achieved using a satellite platform, called EasySat, with a space mission that lasts 11 years and includes the launch of approximately 200 satellites. The valuable scientific data will be used to negotiate flight opportunities with governments and space agencies, while the innovative concept of the satellite kit will serve the needs of educational and technology transfer programs and in-flight technology demonstration activities.

EasySpace Mission Objectives

Atmospheric Density

Errors of the order of 10-20% are typical in atmospheric models and lead to uncertainty of the orbital decay and re-entry prediction of space vehicles and satellites.
The inaccuracy of the available atmospheric models is due to instantaneous errors in the density estimation (day-night variation) and the inability to predict the effect of the variation in the solar activity, which has significant fluctuations within a solar cycle period (approximately 11 years).
Though some satellite missions have collected atmospheric density data, little is available for altitudes below 300 km where the atmospheric density and the consequent drag effects increase exponentially. Furthermore the accuracy of the experimental data available is limited, as it is not derived from high precision accelerometers aboard spacecraft with well-known drag characteristics.

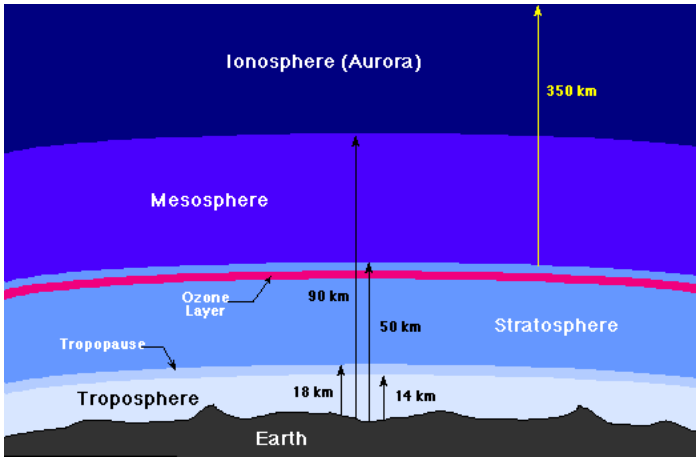

Figure 3. Atmosphere layers

A dedicated mission collecting atmospheric data enables scientists and engineers to:

- **Improve the orbital decay prediction models**
- **Refine the density models**
- **Optimize the fuel expenditures**
- **Calibrate the drag models**

EasySpace offers a dedicated mission of **200 spacecraft flights over a period of 11 years for the measurement of the atmospheric drag** with the following characteristics:

- **Measurement principle:**
  - A payload that measures the acceleration of a spacecraft with known drag characteristics in order to derive the atmospheric drag and density
  - Measurements correlated with time and spacecraft location, using a GPS receiver
  - Measurements provided as a data grid in time and space with a spatial **resolution in altitude of < 100 m** and **in longitude/latitude of < 0.01 deg** (~1 km)
  - **Near-real time data delivery** to the users, 24 h latency

- **Performance:**
  - Absolute discrete density measurement **accuracy better than 5%**
- **Orbit spatial and temporal coverage:**
  - Measurements covering altitudes from **300 km to re-entry**
  - Orbit inclination ranging from 0° to 90° to allow **global coverage**
  - Data collection from multiple spacecraft over the 11 years of a **solar cycle period**

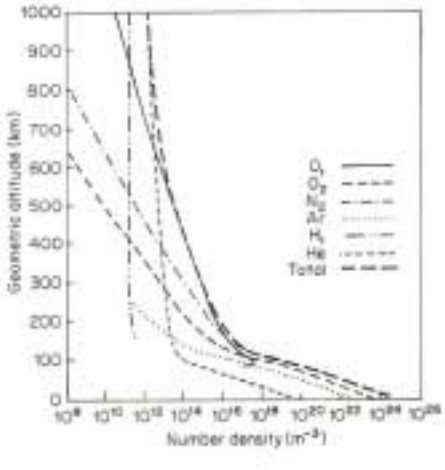

Figure 4. Atmospheric Particle Density at Different Altitudes

Satellite

To accomplish these scientific objectives a large number of spacecraft launched over a period of a solar cycle is required. This implies a clear potential to realize other important goals such as educational outreach, technology transfer and technology demonstration activities.
Many companies and universities already address these market segments, however EasySpace would successfully differentiate itself as a price leader offering the unique concept of the satellite kit.
EasySpace has designed a low-cost nanosatellite kit, called EasySat, that can be assembled, integrated, tested and flown by small groups of non-space professionals or university students.

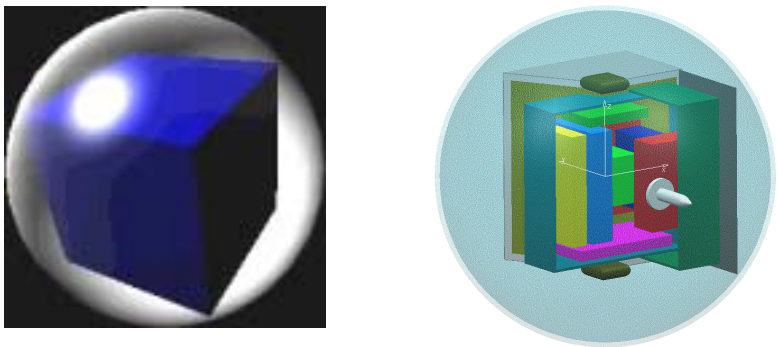

Figure 5. EasySat

Market Analysis

Product and Services

EasySpace offers a wide range of products based on the scientific data and the satellite kit. Several related services are also set up to satisfy the customer's needs and strengthen the EasySpace business.

Atmospheric Data

Near real-time position and raw acceleration data directly retrieved from the satellite.
For EasySpace customers who want to perform their own data processing.

Atmospheric density database.
A data grid in time and space. Spatial resolution of less than 1 km in longitude/latitude and less than 100 m in altitude. Absolute atmospheric density accuracy better than 5%.

Satellite

Education and technology transfer kit.
A kit including satellite components and equipment ready for assembly, integration and test, supported with documentations and assembling tools.

Fully integrated platform for in-flight experiments and technology demonstrations.
Beyond the atmospheric density payload EasySat offers the possibility to accommodate an additional payload to perform in-flight demonstration of new technologies and components.

Services

Transport; Spacecraft Launch; **Access to Mission and Housekeeping Data Service; Payload Command Service; Payload Integration Support; Final Test; Product Training; Telephone and E-mail Support**; **On-the-Spot-Trouble Shooting**.

EasySpace Package

The EasySpace products and services are offered as packages. However additional services can be engaged according to specific customers needs.

EasySpace Kit Basic Package
Components kit for Assembly Integration and Test (AIT) with manuals and documentation; Final tests;
Transport to launch site; Launch as piggyback passenger; Access to Mission and Data Control facilities.

EasySpace Kit Advanced Package
Components kit for AIT with manuals and documentation; Final tests; Transport to launch site; Launch as piggyback passenger; Access to mission and housekeeping data; Access to Mission and Data Control facilities.

EasySpace Platform Basic Package
EasySat assembled and tested; ready to integrate a host payload; Manuals and documentation; Final tests; Transport to launch site; Launch as piggyback passenger; Access to mission and housekeeping data; Access to Mission and Data Control facilities.

EasySpace Platform Advanced Package
Integration of a host payload delivered by customer into an EasySat, all necessary tests included; Transport to launch site; Launch as a piggyback passenger; Access to mission and housekeeping data.

Market Segments

EasySpace business addresses three main market segments:

- **Atmospheric Density Segment**

This segment will be served with near-real time raw data and the atmospheric density database.

- **Education and Technology Transfer Segment**

The satellite kit constitutes a great opportunity to satisfy the need for space hands-on educational programs.

- **Technology Demonstration Segment**

The possibility to perform in flight experiments is provided by the fully integrated satellite used as a demonstration platform.

Users and Customers

According to the market segmentation the following users and customers have been identified for the products offered:

- **Atmospheric Density Data**

Users and customers of the data are governmental organizations, public funded institutions, universities, consulting companies for spacecraft development, test, launch and operations, and private research laboratories.

- **Satellite Kit and Platform**

Several potential users and applications should be served by the kit and the fully integrated platform: **companies** looking for cost effective opportunities to test hardware, software and new technologies in space; **scientists**, searching for a cost effective platform; **universities**, seeking to educate their space systems and space science students; **developing countries**, wishing to be present in space and to gain the related technology expertise.

Competitors

- **Atmospheric Density Data**

No commercial competitor offers the atmospheric data related products with the same level of accuracy. This forms an outstanding basis for a partnership with governments and public institutions.

- **Satellite kit and Platform**

Several competitors are present in the market offering small satellites and providing opportunities for education, technology transfer and technology demonstration activities:

COMPETITORS	MARKET	Products/Services
Surrey Satellite Technology Ltd.	Commercial platform	SNAP-1
SpaceQuest	Commercial platform	AprizeSat
One Stop Satellite Solution	University program	CubeSat
Stanford University	University program	CubeSat
AMSAT Group	Commercial platform Amateur radio satellite	Several satellite (SQUIRT, StenSat, KiwiSat, Sapphire, etc.)
Arizona University, Colorado University, New Mexico State University	University program	3 Corner Sat
Stanford University, Santa Clara University	University program	EMERALD
Utah State University, Virginia Polytechnic, University of Washington	University program	ION-F
Boston University	University program	Constellation - Pathfinder
Carnegie Mellon University	University program	Solar Blade – Heliogyro nanosat.
Technical University of Berlin	University program	TUBSAT-N
STARSHINE	Educational program	5 satellites foreseen

Table 1. List of Competitors

Among them the main EasySat competitors are:

- **One Stop Satellite Solution (OSSS) and the Stanford Collaboration,** with the CubeSat platform, offer the possibility to perform technology transfer programs as well as in–flight demonstration of components and equipment compatible with the 1kg size of the spacecraft.
- **Surrey Satellite Technology Ltd. (SSTL),** with SNAP-1, offers a platform of about 10 kg for payload integration and in-flight experiments. SSTL has also a well–established reputation and experience in the technology transfer sector.

Market Size

The market analysis including a dedicated survey have shown that there are 167 potential users for the data (124 governmental institutions, 43 big space companies), 662 potential customers for educational (387 universities, 159 other institutions, 116 observatories), 361 potential customers for technology demonstration (316 space manufactures, 36 other scientific/governmental institutions, 9 big space companies).
The following diagram shows the number of potential customers in the technology demonstration and the educational market segments.

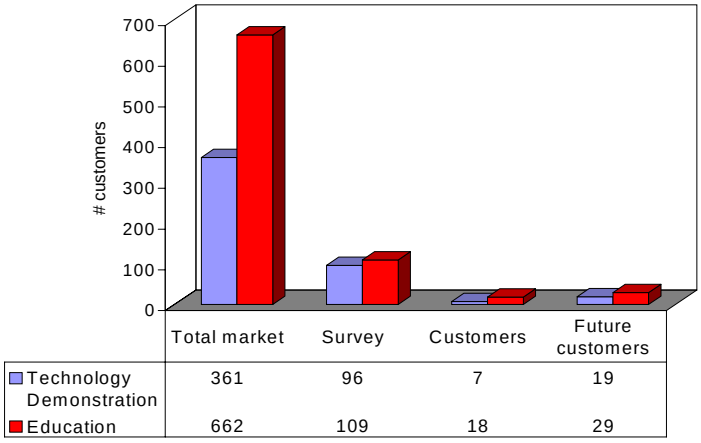

Figure 6. Market Size and Survey Results

Sales Forecast

Sales forecast for the first 5 years are provided in Figure 7. After this period the number of satellites sold will remain constant.

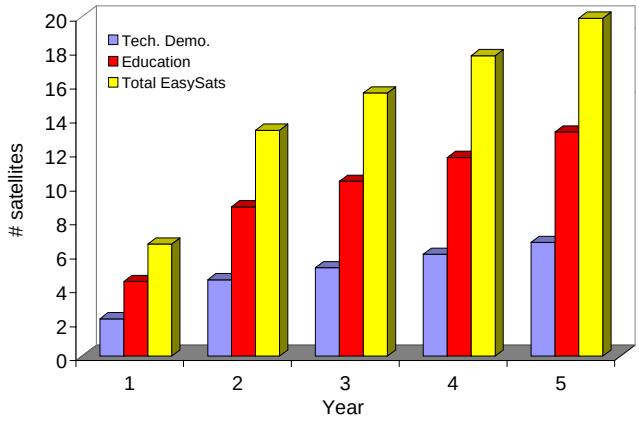

Figure 7. Number of Satellite Sold over 5 Years

Pricing

EasySpace aims to be a cost leader in the small satellite industry. Table 2 lists the very attractive prices that EasySpace proposes for its main products. This list does not include the atmospheric density based products as these are used to establish partnership with governments and space agencies. Pricing strategy over the planning period of EasySpace business is going to change and adapt to the market conditions and to the technology advances. However these quotations are a reasonable estimate based on the cost of the products. The two products derived by the EasySat satellite, the kit and the platform, are tailored for two types of market segments. Therefore different prices may be applied to EasySat kit and the fully integrated platform.

Product or Service	Price (k€)
Kit Basic Package	60
Kit Advanced Package	65
Platform Basic Package	175
Platform Advanced Package	190

Table 2. Pricing

Revenues Forecasts

Revenues forecasts are summarized in Table 3. The revenues breakdown at year 12, presented in Figure 8, shows that the main source of revenues is the satellite platform.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12
Revenues	**0**	**646**	**1 317**	**1 748**	**2 125**	**2 446**	**2 495**	**2 545**	**2 596**	**2 647**	**2 700**	**2 754**
KIT	0	250	510	715	862	947	966	985	1 005	1 025	1 046	1 067
PLATFORM	0	365	745	949	1 162	1 383	1 410	1 439	1 467	1 497	1 527	1 557
SERVICES	0	31	62	83	101	116	118	121	123	125	128	131

Table 3. Revenues Forecast

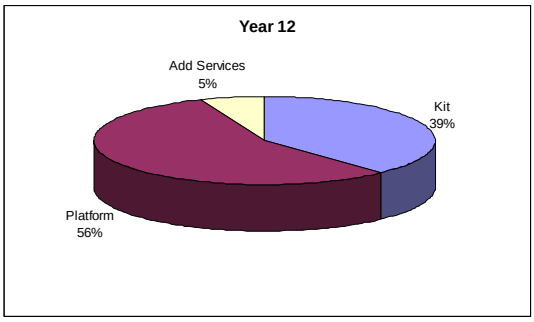

Figure 8. Revenue Breakdown

Business Case

Business Strategy

EasySpace financing strategy is based on a **Public-Private Partnership** (PPP) where extensive trade will take place based on a long-term exchange of values, rather than a conventional market priced exchange of services. The PPP framework effectively allows EasySpace to offer in-orbit delivery of its products at the same prices as competitors offer on-ground delivery. EasySpace will thereby become a cost leader. The figure below shows an outline of the strategic PPP agreement EasySpace will seek to realize.

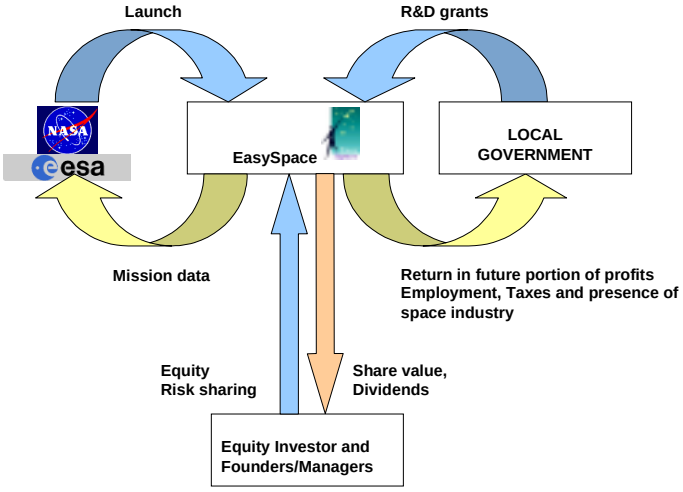

Figure 9. Public-Private Partnership Concept

The entities identified in Figure 9 will have the following roles:

- Private equity investors and EasySpace management team take the financial and personal risk of starting the venture and they will be rewarded with increased share value and potential dividends.
- Public entities like ESA, NASA and United States Department of Defence contribute with piggyback launch opportunities. In return, access to mission data will be granted according to terms and conditions to be negotiated for mutual benefit of the involved parties.
- The local government in the country where EasySpace will be located will support the venture with grants for financing the internal R&D efforts necessary to develop, industrialize and commercialize the EasySat kit and associated ground infrastructure and operations.

Business Model

EasySpace satellite customers can select two types of products, either the kit for integration in their own premises or the platform where EasySpace performs the integration of the customer's host payload. Differences in prices reflect the workload carried by the customer i.e. the kit is significantly cheaper than the integrated platform product.
EasySpace supplies the launch and in-orbit delivery is included in the prices given in Table 2.

EasySpace handles the purchase of the satellite components and equipment and arranges the satellite launch.
This business model offers a valuable advantage: customers do not have to interface with suppliers and launcher companies.
The responsibility for the platform remains with EasySpace during the whole process when the costumer purchases the fully integrated spacecraft. On the other hand kit customers are responsible for the integrated kit until successful completion of the launch acceptance test in the EasySpace facility.

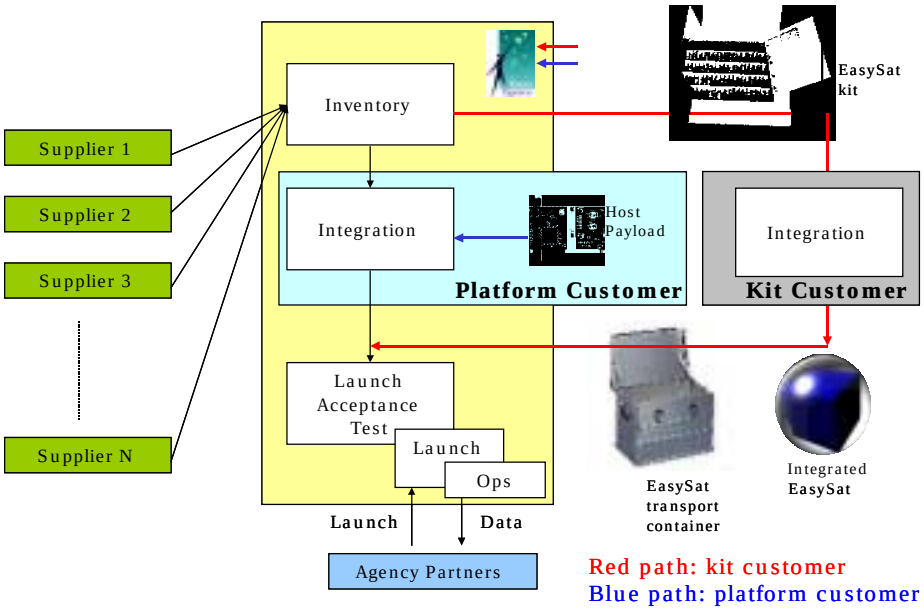

Figure 10. Business Model

Business Phases

Three main phases of EasySpace business are identified:

- Start-up (3 months)
  This is necessary to build the company, recruit the work force and to collect a first round of equity investments for development.
- Development (12 months)
  Detailed design, development of the prototype and in-flight demonstration are performed during this phase. Active marketing is also initiated.
- Sales and operation (11 years)
  This is the commercial phase with the starting of the products sale. Three sub-phases running in parallel are foreseen in this period: Sales/Procurement; Deployment; Operation.

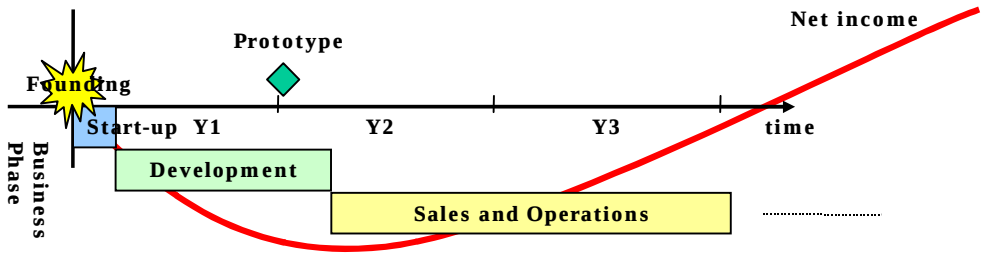

Figure 11. Schedule and Milestones

Organization

EasySpace, during the operational phase, employs 8 individuals. The company staffing should focus on people who have a multidisciplinary education or professional experience and who can have a high level of global understanding of the business and the products. Outsourcing of a number of functions minimizes the number of employees and the investment needed. The employment of 2 students during the development phase is foreseen.
The structure of the organization is shown in the following block diagram.

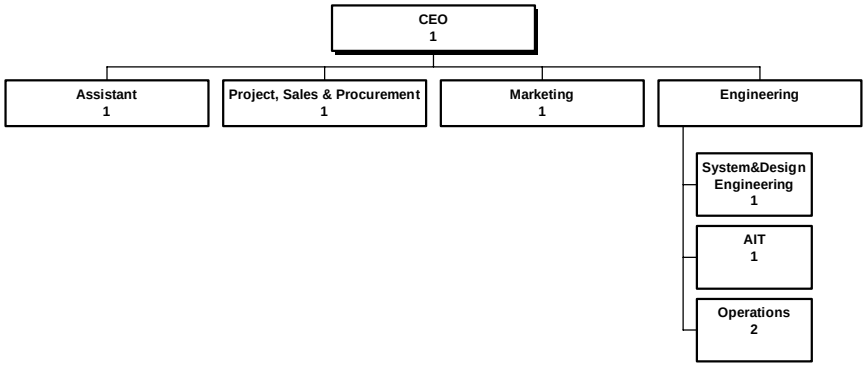

Figure 12. Company Structure

Financial Analysis

Extensive financial analyses demonstrate the feasibility and the profitability of this business.

Projected Profit & Loss Account

The Projected Profit & Loss Account presented in Table 4 gives a forecast of the main financial items.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12
Revenues	**0**	**655**	**1 336**	**1 773**	**2 156**	**2 480**	**2 530**	**2 581**	**2 632**	**2 685**	**2 738**	**2 793**
Gross Margin	**0**	**443**	**954**	**1 290**	**1 590**	**1 859**	**1 919**	**1 962**	**2 006**	**2 051**	**2 097**	**2 144**
Personnel	500	520	519	540	562	584	607	632	657	683	711	739
Operating expenses	201	243	245	223	229	213	213	213	213	213	213	213
R&D maintenance	0	100	100	100	100	100	100	100	100	100	100	100
EBITDA	**-701**	**-421**	**89**	**427**	**700**	**962**	**998**	**1 017**	**1 036**	**1 055**	**1 074**	**1 092**
Depreciation	327	328	329	102	103	104	113	114	115	125	35	35
Net Income	**-0**	**-781**	**-274**	**5**	**304**	**565**	**609**	**678**	**706**	**741**	**826**	**857**
Interest Payments	0	40	40	40	0	0	0	0	0	0	0	0
Interest Income	0	6	4	6	6	6	26	45	68	93	116	141
Grants & Subsidies	1 028	2	2	-286	-298	-298	-58	2	2	14	2	2
Tax	0	0	0	0	0	0	243	271	284	296	330	343
Cash Flow app	**327**	**-453**	**55**	**107**	**407**	**669**	**722**	**792**	**822**	**865**	**861**	**892**
Return on revenues		-1	-0	0	0	0	0	0	0	0	0	0
Revenue per Capita	0	65	167	222	269	310	316	323	329	336	342	349
%material		14%	14%	15%	14%	14%	14%	14%	14%	14%	14%	14%
%personnel		79%	39%	30%	26%	24%	24%	24%	25%	25%	26%	26%
NPV	**292**	**-69**	**-29**	**38**	**269**	**609**	**935**	**1 255**	**1 552**	**1 830**	**2 078**	**2 307**
IRR					**9%**	**36%**	**48%**	**54%**	**57%**	**59%**	**60%**	**61%**

Table 4. Pro-Forma Profit and Loss Account

Business Performance

EasySpace venture is profitable in 4 years. After 12 years, at the end of the business-planning period, the Net Present Value (NPV) of EasySpace operational Cash Flow is **2.3M€** with a typical discount rate of **12%**, while the Internal Rate of Return (IRR) is **60%**. This performance forecast proves that EasySpace is a very attractive business for potential investors interested in a small company operating in the space sector. A sensitivity analysis has been carried out and demonstrates the robustness of the EasySpace business.

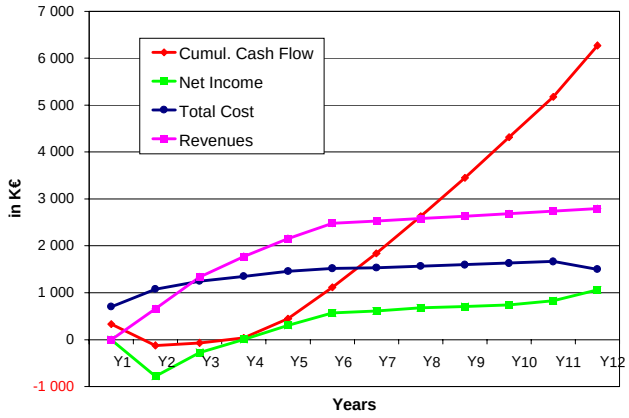

Figure 13. Business Performance

Financing Strategy

EasySpace is a venture characterized by the following key figures:

- Low initial investments: **1.6 M€**;
- Higher operational cost in the first years (for development of the EasySat product and associated services) than in the maturity phase of the business. Losses will be incurred the first 4 years of operation;
- Annual Net Income: **0.8 M€** in the mature phase of the business;
- Earnings Before Interest and Taxes Depreciation and Amortization (EBITDA): **1 M€** in the mature phase of the business;
- Total financing needed: **2.9 M€**;
- Internal Rate of Return on the operational cash-flow: **60%** at the end of the planning period;

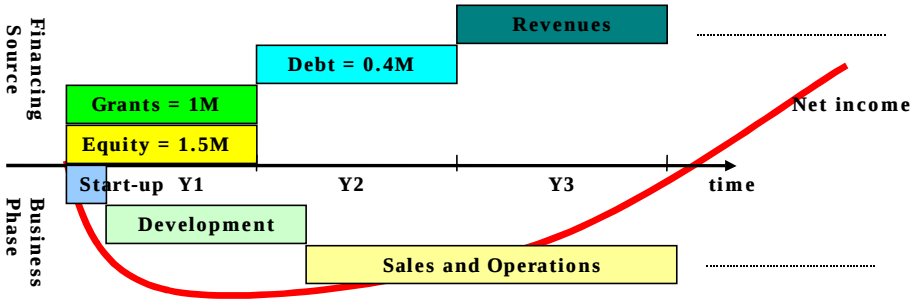

Figure 14. Financing Strategy

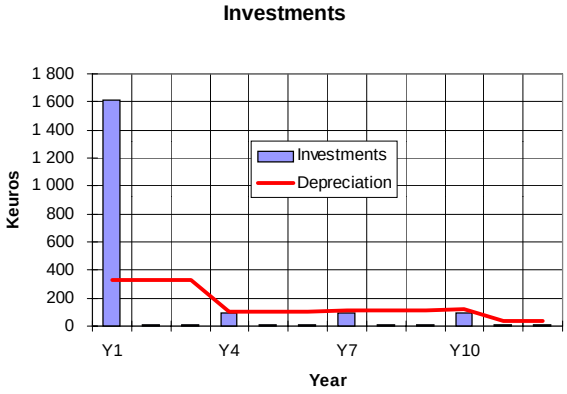

Figure 15. Investment Planning

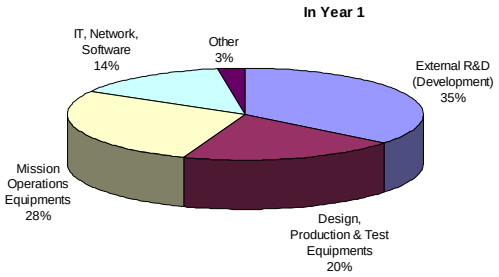

Figure 16. Financial Breakdown

Comparative Competitive Advantage

The EasySpace products have many advantages in comparison to competitive products.
The provision of a satellite kit composed by components-off-the-shelf ready to assemble, integrate and test is a complete new educational approach. No other player in the market offers a similar product. In this respect EasySpace acts as a market differentiator. The AIT process is easy to perform and it can be done in a limited time frame. Success is guaranteed. People that participate in this program touch the hardware and will afterwards observe the satellite fly.
The main advantage of the satellite platform is the periodic flight opportunity, which arises from the high number of spacecraft over 11 years. Technology testing and demonstration profit by standard interfaces and repeatability of the flight conditions.
The density data of better quality in terms of accuracy than existing is an other product without competition. Discrete measurements, continuous in time over a full solar cycle are the features, which meet the users requirements optimally.
The density database is considered as a trade basis for free launch opportunities with governments and agencies. In classical space missions the launch is the main cost driver. If these costs can be saved EasySpace products, kit and platform, can be offered to extremely low prices. This low-cost-strategy of EasySpace is considered as the main competitive advantage.

Business Risk

EasySpace Team has accurately investigated the robustness of the EasySpace business case analyzing all the potential business and technical risks. Most of them are tolerable. The only one that could imply a stop of the venture is the unavailability of free or at low cost launch opportunities for the 200 spacecraft. This issue has been carefully investigated from both the business and the system engineering point of views to assess the capability for EasySpace to negotiate free launches and to design a system that is benign and compliant with a large number of launchers.

System Design

Mission Architecture

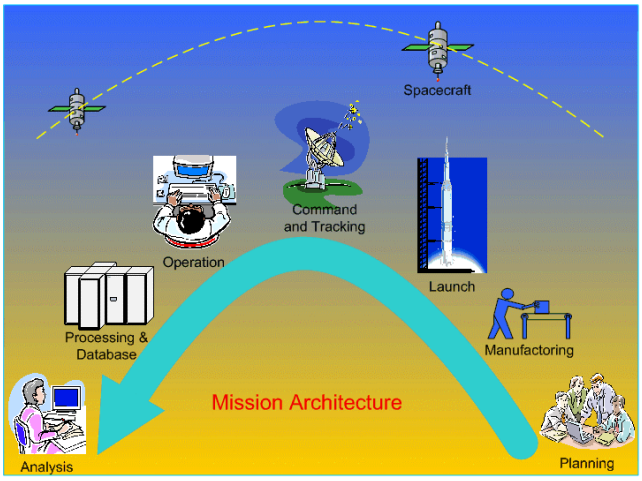

Figure 17. Mission Architecture

The end-to-end system provided by EasySpace consists of the following components:

- Mission Planning and Design;

EasySpace offers to the customer full support for the mission planning as well as assistance for the integration of the additional payload.

- Spacecraft Manufacturing;

The satellite kit will be assembled by the customer or by EasySpace and functionally tested before launch.

- Launch;

EasySpace organizes the launches as piggyback of primary payloads and supports all the activities related to the launch.

- Mission and Data Control and Operation;

The mission control center located inside the company area remotely operates the ground station and monitors the satellite and payload operations.

- Data Processing and Analysis;

The scientific data collected from the atmospheric drag instrumentation will be archived, processed and available for distribution within 24 hours.

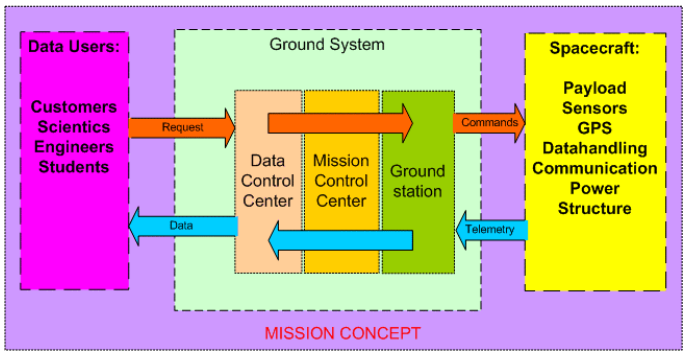

Figure 18. Mission Concept

Requirements and Design Drivers

The main mission requirements are:

- EasySat, in the baseline configuration, shall perform atmospheric drag/density measurements
- EasySat shall be a kit ready to be assembled, integrated and tested by customers
- The spacecraft shall offer the possibility to accommodate an additional payload
- Compatibility with different launchers shall be maximized to increase launch opportunities

The main driver coming from the market analysis is the cost, which constrains the EasySpace mission system design.

Design Summary

The following table presents the main characteristics of EasySpace mission and EasySat design:

Mission Objectives	• **Collection of atmospheric data measurements** • **Development of satellite kit for educational and technology transfer purpose** • **Standard platform to accommodate payloads**	
Payload	• **1-axis accelerometer** • **Extra payload accommodation**	
Launcher	**Compliant with large range of launch scenarios to:** • **Collect data at different inclinations** • **Exploit the possibility to benefit from free piggyback launch opportunities**	
Spacecraft	**Design lifetime**	**1 year**
	Total mass	**19.8 kg**
	Average power	**6 W**
	Spacecraft structure dimensions	**Spherical Plexiglas of 0.48 m diameter Cubic inner structure of 0.27 m**
	Attitude control	**Passive stabilization**
	Orbit determination	**GPS**
	Temperature	**5 - 35 °C**
	Antennas (L-Band) for GPS: Antenna (S-Band) for telecom:	**2 hemispherical patch antennas 2 hemispherical antennas**
	Data download	**0.25 - 0.5 MB /orbit**
Mission	**Orbit inclination: 0° - 90° depending on launcher Orbit altitude: depending on the launcher**	
	Nominal mission period: below 1 year (if launcher delivers the spacecraft below 400 km)	
Operations	**Data downlink 2 times per day**	
Programmatic	**Launch date (prototype): after 15 months from EasySpace creation Launch frequency: 10 - 20 spacecraft per year Mission duration: 11 years Technology used: Components–Off-The-Shelf**	

Table 6. Mission and Spacecraft Design Summary

Mission Analysis

Several types of orbits, defined by the launch opportunities, are feasible. EasySat delivery to LEO orbits can be achieved in different manners:

- release at 350 km, circular orbit and inclination of 51° i.e. with Shuttle and Arienne 5 to ISS.
- release in Sun-synchronous orbits or in eccentric orbits with perigee below 300 km i.e. with EELV.

For all these orbits the lifetime is not longer that 1 year. Re-entry analysis has shown that measurement performance is guaranteed down to 140 km. Below this altitude the drag coefficient varies deteriorating the data accuracy. Satellite will not survive during re-entry and no debris reaches ground surface.

Payload

EasySat accommodates a one-axis high accuracy (1 µg) accelerometer to measure the satellite acceleration due to atmospheric drag effect. This data correlated with GPS system readings provides the information necessary to retrieve the atmospheric drag parameters with a maximum error of 5% and a spatial resolution of 100 m in altitude and 1 km in longitude and latitude.

Figure 19. Accelerometer

The possibility to accommodate an additional payload is an essential asset for the technology demonstration market segment. The main interface parameters for the host payload are provided in the Table 7.

Host Payload Specification	
Mass of host payload	< 500 g
Power	1 W cont, 1.5 peak (5% duty cycle)
Connector	2 time 31 pin Sub-D connector male
Size	160 x 100 mm^2, 25 mm high
Temperature range	5° to 35° C
Processing power available	> 5 MIPS
Data Acquisition	8 channels in and 2 out, typical 80 dB S/N - 2 time 50 ksamples/sec max.
Data I/O lines	24 lines, max.5 MHz switching
Appendages outside the cube	not allowed
Deployment systems outside the cube	not allowed

Table 7. Additional Payload Interface Parameters

Spacecraft Design

The structure of EasySat spacecraft consists of a cubic box with side dimension of 0.27 m covered with a spherical plexi-glass structure of 0.48 m diameter. The total mass of the spacecraft is 19.8 kg.

The power is supplied by 6 GaAs solar panels mounted on the body of the inner cubic structure, providing an average power of 15.5 W. Lithium-Ion batteries are used for power storage.

In order to comply with the payload thermal requirements insulation and heaters are used for the eclipse period. The thermal control system guarantees a temperature ranging from +5 to +35 °C.

The attitude stabilization is obtained by means of passive aero stabilization with electromagnetic damping. The system is obtained with two coils of copper wire and the shift the center of gravity from the center of pressure. This provides an attitude pointing about the pitch and yaw axis of +/-8° and the momentum dumping following separation from the launcher. This solution represents a cost effective and innovative solution to achieve the coarse pointing required by the payload, the navigation and the telecommunication subsystems.

An on-board-data-handling, based on a digital signal processor and a 20 MB of memory, is used to manage the on board data flow, to control all the subsystems and to store 8 MB per day of payload data.

The satellite location and time is measured by a GPS system. The GPS receiver is an adaptation of commercial terrestrial receiver to operate in space. Two hemispherical GPS patch antennas guarantee the GPS satellites tracking regardless of the satellite orientation.

The satellite communication system operates at S-band frequencies and is designed to downlink the payload data and the housekeeping data and to receive commands from ground. The downlink data rate is 128 kbps and the uplink is 16 kbps.

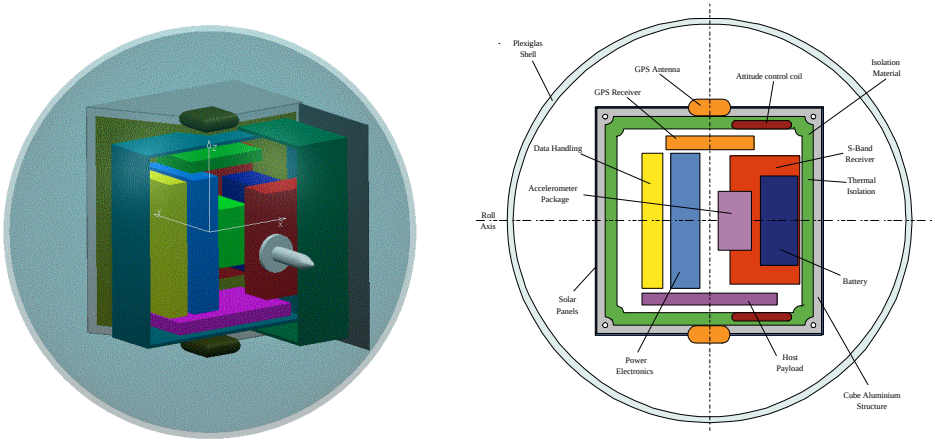

Figure 20. EasySat Configuration

Ground Segment and Operation

One S-Band acquisition station associated to a Mission Control and Data centers are the core of the EasySpace Ground Segment. The S-Band Station, located close to the equator, is unmanned and operated remotely from the Mission center. The Mission Control and Data Control centres are collocated. Implementation is based on low cost hardware: a PC with large disk for archiving. Data are stored in databases and retrieved through the internet by the customer using a dedicated interface.
The data flows and functions in place are automated in such a way that the complete operations are performed without any night shift by a team of 2 persons. Efficient monitoring of spacecraft and ground operations is in place to maximise the customer visibility on the status of its mission.

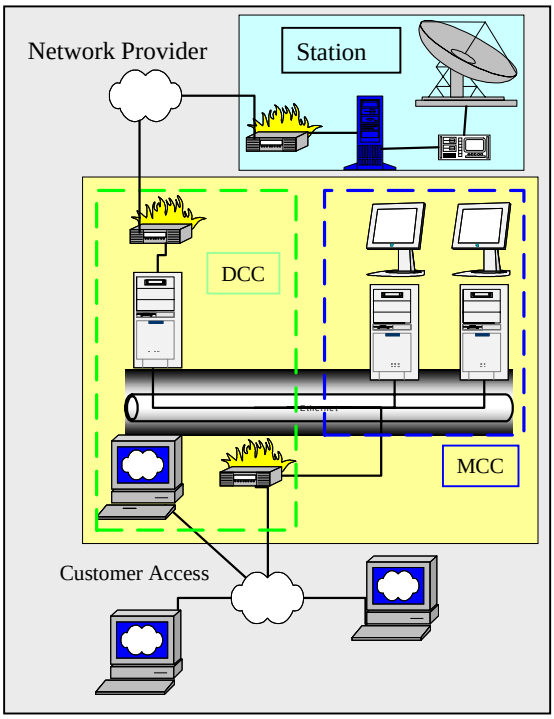

Figure 21. Ground Segment

Data Flow

Figure 18 presents the different data flows circulating within the ground segment, from data acquisition to customer access. Particular attention shall be paid to the monitoring flows. The system is scalable in order to cope with the constant renewal of missions and the associated variation of data volume circulation.

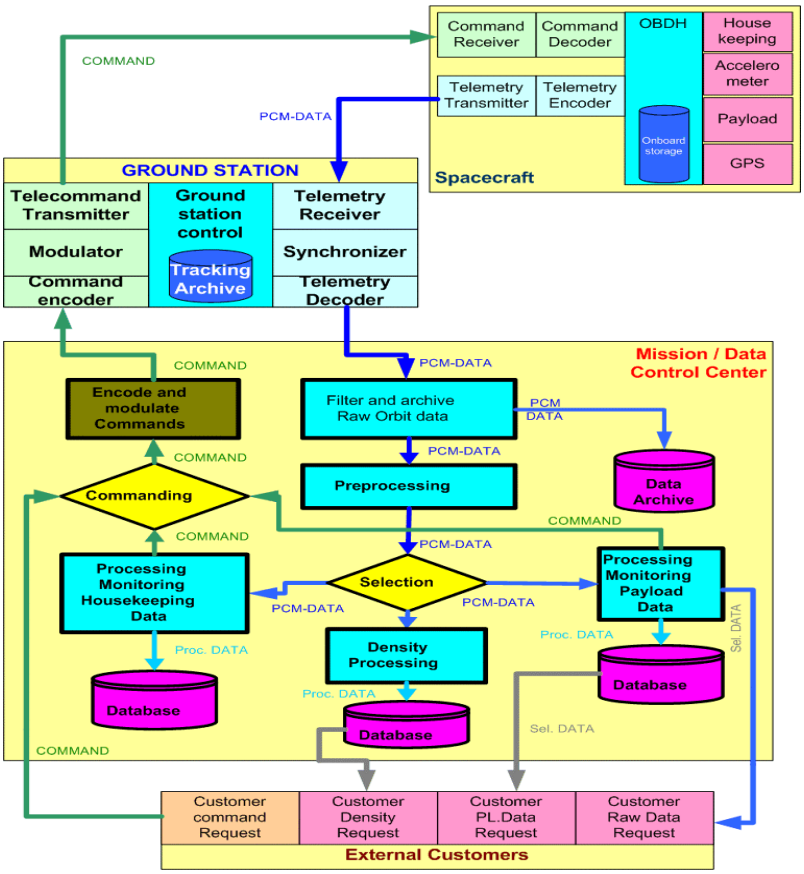

Figure 22. Data Flow

Launcher Segment

EasySpace is designed to comply, as a piggyback payload, with the interface requirements of a large number of launchers in order to maximize the flight opportunities. An investigation of the launchers available has shown that the following options could be actually considered and the corresponding interface adapter to launcher has also been considered: Ariane 5, ATV, Shuttle; EELV (Boeing Delta4 and Lockheed-Martin Atlas5). In Table 8 a summary of potential launch opportunity per year is given.

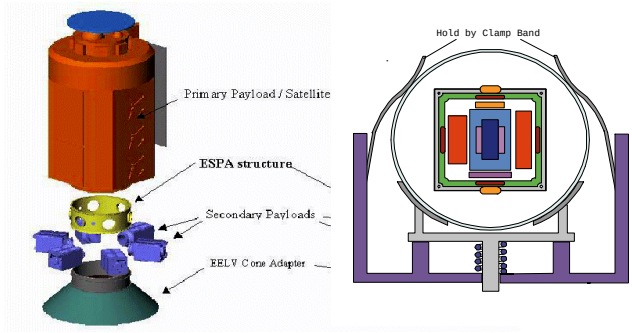

Figure 23. Accommodation and Launcher Adapter on EELV

Launcher	Mission	Number of flights (average*)	Capacity for # of EasySats
Ariane-5 (ATV)	ISS	8 in 10 years. First flight in 2004	~10 excluded cargo bay
Shuttle	ISS, other	4 per year	12 max.
EELV	commercial	20 per year	6 max.
Ariane-5	commercial	3 per year	~10 sats
* Figures taken for year 2002			

Table 8. Launch Opportunities Volume and Schedule

Manufacturing and Production

EasySat AIT activities can be performed either by the customer or by EasySpace according to the products selected (i.e. satellite kit, fully integrated platform). EasySpace always performs final verification and testing before launch.
EasySpace purchases the material and units that constitute the EasySat Kit components. Following inspection and pre-assembly of some of the equipment the kit components are packed and sent to the costumer. The costumers acquiring the kit perform the assembly and integration activities. When technology demonstration activities are also planned for the mission, the customer also develops or procures the additional payload.
The integrated satellite is sent to EasySpace were final testing is performed before the shipment to the launch facility.