Executive Summary

"Think beyond the traditional logistics"

Worldwide Intermodal Navigation Service

> **Intermodality** is a characteristic of a transport system whereby at least 2 different modes (road, rail, sea, air) are used in an integrated manner in order to complete a door to door transport sequence.
> Source: *European Commission DG VII*

WINS allows to determine the position of goods and their status anywhere in the world. The service also provides the possibility to communicate, and by that, to interact with the transportation company, allowing the user to redirect his goods to another destination, change their time of arrival at a destination, and even change their route or mode of transportation.

The WINS infrastructure features a satellite constellation of 18 spacecraft each with an integrated navigation/communication payload specifically designed to support this service. The single point of access to the customer is provided by the WINS User Service Centre supported by a globally distributed network of six Earth Stations, ensuring the communication and navigation services.

The end-to-end approach, exercising all aspects of space systems engineering, is tied closely to cost constraints derived from the basic business case. The business plan shows WINS to be a commercially viable business-to-business solution for global players in transportation with an attractive return on investment and a quick time to market.

The WINS concept is being created and designed by an integrated product team of thirteen international professionals from several different organisations in Europe (CNES, DASA, DLR, EUMETSAT, ESA, Kayser-Threde, MAN Technology).

WINS Executive Summary

The WINS Executive Summary addresses:

- The Vision (Part I)
- Market Analysis and Service Description (Part II)
- System Architecture and Design (Part III)
- Business Case (Part IV)
- The WINS Team (Part V)

The WINS Proposal

The WINS proposal reflects our vision, and is structured as follows:

Volume I	Executive Summary
Volume II	Technical Proposal
Volume III	Business and Management Proposal
Volume IV	Appendices

THE VISION

"Think beyond the traditional logistics !"

The **W**orld **I**ntermodal **N**avigation **S**ervice (**WINS**) provides a complete fleet and freight management service to all the companies that intend to offer a low cost and effective logistics system.

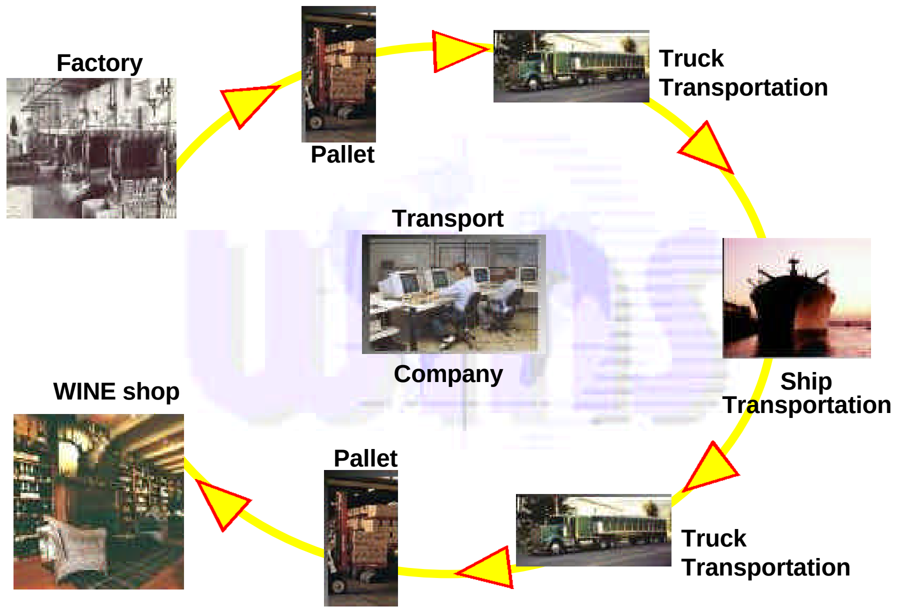
WINS CUSTOMERS NEEDS

WINS allows the transportation companies to:

- Provide faster, on-time delivery to any location in the world.
- Provide accurate, timely and reliable information on the current status of shipments and orders.
- Deliver product at the lowest laid-down cost.
- Have a seamless transportation system including transfers between carriers, efficient international custom clearance and less administrative paperwork.

The basic idea of the system is not just to track and trace transport vehicles, but the assets transported in a global way and across different means of transport (intermodal).

In this example, a pallet of bottles of wine is transported from the fabrication factory to the WINE shop via an intermodal way of transportation including road and sea transport. During the whole travel the asset status and position are monitored and transferred via WINS to the transport company main centre.



Having complete control of the WINS service chain, WINS is a service supplier as well as a partner of the transportation industry able to understand, support and participate to the evolution of methods and strategies.

A Message from our Captain:

SpaceTech's ambition is to support the space community in its essential drive towards adopting a real market-oriented approach

Dear Client,

Information is the most valuable commodity for future markets. Technical products and services have reached the point where the value added in terms of knowledge exceeds the cost of the original material and of the direct production labour.

The postgraduate Master of Space Systems Engineering has been created in this context by the Delft University of Technology. Without equivalent in Europe, it brings together some of the best young specialists in space-related disciplines, drawn from international organisations, large manufacturers and small high-tech commercial companies, all operating on the scene of space activities.

Obtaining a Master's degree is certainly a great personal satisfaction, but it is not Earth shattering at the scale of the respective companies of the graduates, not to mention the overall space economics. Nonetheless, we will make an impact. SpaceTech's ambition is to support the space community as its strives to leave the ivory tower and traditional sphere of influence by adopting a real market-oriented approach, for the benefit of customers. While remaining an exciting adventure, space is more and more a component of end-to-end systems answering real needs and being operated as a profitable business.

Integrated in a strong product team, the participants of the SpaceTech Course have founded a virtual company, WINS, and designed an end-to-end system, ready for operational development in view of an attractive return on investment. They intend to answer the current increasing demand by global transport companies for navigation and asset tracking with an original and competitive system using a new space segment for navigation signaling and message transfer.

The subject defined by the Core Curriculum Committee was a global navigation service including an independent space based positioning capability despite the fact of the existing GPS system.

I fully support the approach of the business case. The realisation of the new service presented in this Proposal is strongly encouraged. I appeal to all parties concerned to make the proposed WIN Service a reality.

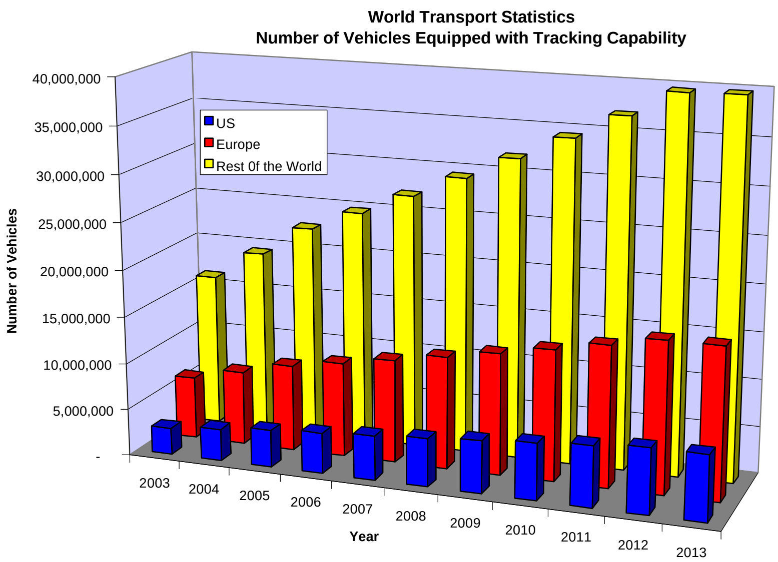
MARKET RESEARCH ANALYSIS

Market Size

Transport market analysis indicates that more and more freight shipments are now **intermodal**, i.e they use various modes of transportation such as railways, waterways, maritime, or airborne carriers. Several studies forecast a growing need for logistic tools for fleet management and asset tracking:

- 15% of the U.S. long haul truck market was using tracking systems in 1998 and will grow to 40% in 2005 [Source: Ovum].
- Automatic vehicle location devices in the U.S. will increase to nearly 2.2 million in 2003 (corresponding to 30% penetration), with more than $1 billion in revenues [Strategis Group].

World Market figures can be derived by assuming the number of vehicles proportional to the freight transport in tons-kilometre.



In addition to reviewing published, market figures the WINS marketing team discussed the market and proposed business case with potential distributors, dealers, sales representatives, customers, and competitors confirming the need for adequate logistic tools for fleet management and tracking of goods.
From this information a market projection of vehicles equipped with tracking capabilities was determined and represents the potential market for WINS.

Market evolution is based on current trends in the transport sector and on expected technology developments.

- The on-going concentration and globalisation of transportation companies will generate an increased demand of advanced logistic tools.
- As internet access and e-commerce applications grow, direct selling from the supplier to the end customer will increase the need for faster and more flexible transportation systems.
- The development of cheaper and smarter tracking tools will sustain the evolution from vehicle tracking to widespread tracking of containers and pallets.
- The availability of auto-networking tags will allow the automatic handling of the transport freight**.**

Future logistics and new distribution channels will generate customer and user demands for new tracking services.

COMPETITION

A variety of industrial initiatives
No competitor could be identified offering a dedicated global asset tracking service. Nevertheless, a more detailed analysis reveals a variety of industrial initiatives in the frame of fleet management, with asset tracking as one potential application area and competition will become an issue to be monitored over the next years.

OrbComm operates the first commercial LEO system providing global tracking, monitoring, and two-way messaging services. OrbComm partners (about 100 worldwide) are value added resellers offering products and services such as:

- combined tracking and messaging services for transportation
- pure messaging for utilities industry (e.g. meter reading)

OrbComm entered the European vehicle tracking market in 1997 and currently holds a share of about 7000 units.

QualComm's OmniTRACS provides two-way messaging and position reporting services to mobile users . QualComm and its partners offer the OmniTRACS service in 33 countries, using different brand names (e.g. EutelTRACS and BoatTRACS in Europe) and leased space capacity.

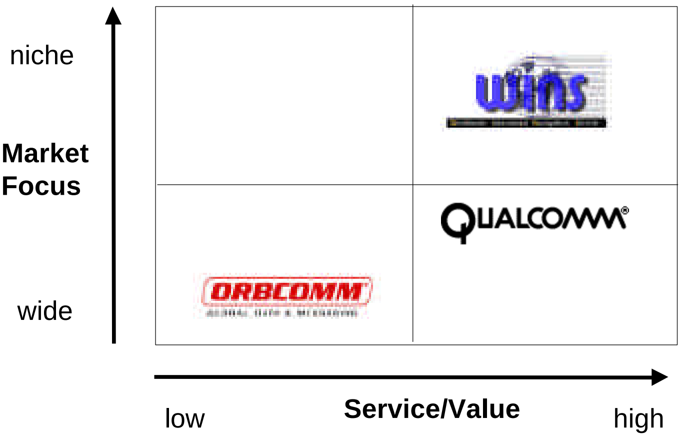
GPS/GSM

Telecom service providers offer tracking services based on GPS and cellular communication for messaging (Europe: GSM, America: DCS1800). The high number of regionally operating transportation companies and the good coverage of the European mobile network system opened the market to more than 70 providers. As cellular network coverage is less established in America, the number of providers is reduced. Only a few companies such as HighwayMaster cover this market.

Proposed future LEO constellations such as FaiSat of Final Analysis or LEO-One present a product portfolio similar to OrbComm. They estimate full operation in 2001 or 2002, respectively.

PORTFOLIO ANALYSIS

The Orbcomm System addresses a wide range of applications and does not provide an end-to-end type of service but delegates it to value added resellers. On the other hand, Qualcomm provides high value products for the transport industry but not concentrating on global intermodal transportation.



THE PRODUCT AND THE SERVICE

Our competitors' solutions are based on systems that must be integrated and adapted to the specific purpose. Their performance is compromised among the requirements of the different market segments they address. However, WINS is specifically designed to offer all the features the intermodal transportation process requires.

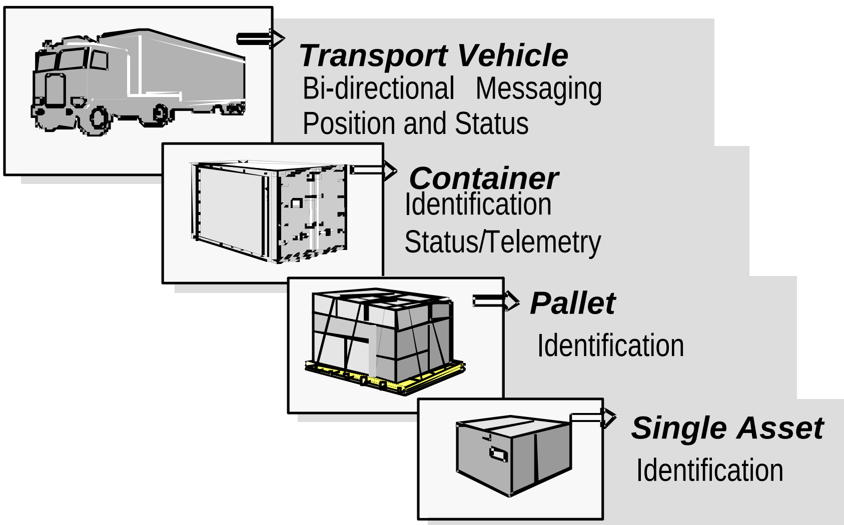
Having complete control of a dedicated service chain, WINS is not only the supplier of the service, and the operator of its own infrastructure, but mainly a partner of the transportation industry able to understand, support and participate in the evolution of methods and strategies.

Cost-wise the high market specialisation of WINS and its independence from other systems, offers the advantages of a single-point sale and optimisation of service cost - hence price - on a scale and on performance levels not economically achievable otherwise.

WINS offers two ranges of products aimed at satisfying the needs of modern intermodal logistics: Assets Tracking and Fleet Management.

UNIQUE SELLING PROPOSITION

Asset Tracking (A-Track)
An important feature for logistics companies is to establish and maintain accurate knowledge of the movement of goods. A-Track delivers quasi-real-time positioning and status information of any high value freight or freight element at any level of the freight nesting hierarchy on customer request.



A-track offers a superior service compared to many of the existing systems:

- **Fast**: Last minute loads can be integrated avoiding empty trucks and meeting the need for "just-in-time" delivery.
- **Reliable**: No more stories of lost shipments and long delays and therefore reduction of the average delivery time.

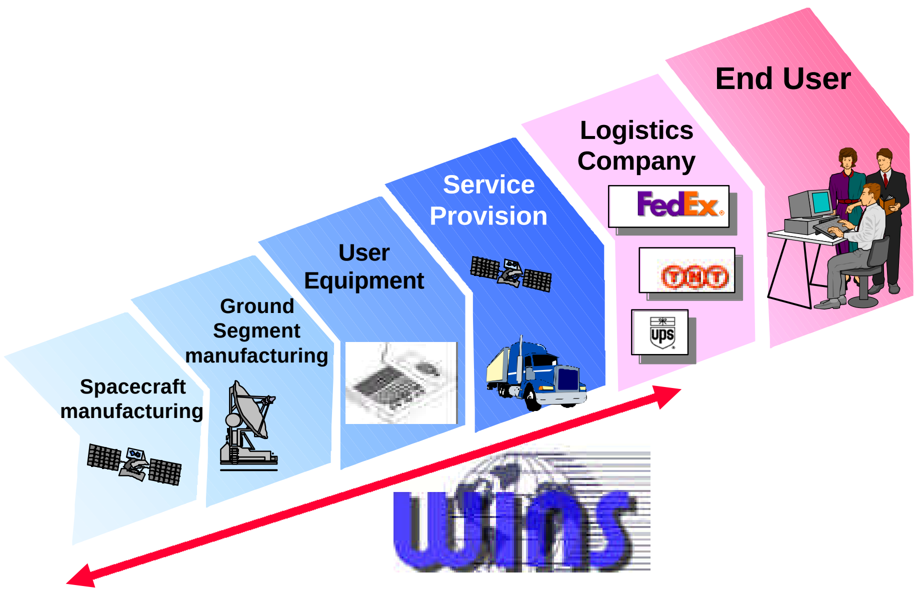
- **Safe**: Hazardous goods transport can be checked and the nature of the transported material carefully examined (temperature, liquid state) throughout the journey.
- **Easy**: Automatic handling of parcels will be easier, avoiding the overhead of bar code reading.

Fleet Management (F-Track)
The secondary business provides a service for vehicle fleet management. The product portfolio of F-Track is comparable to standard fleet management services. Objectives are:

- Tracking and positioning of vehicles.
- Driver messaging.
- Monitoring of vehicle status data such as fuel consumption, engine conditions, driving times, break intervals etc.

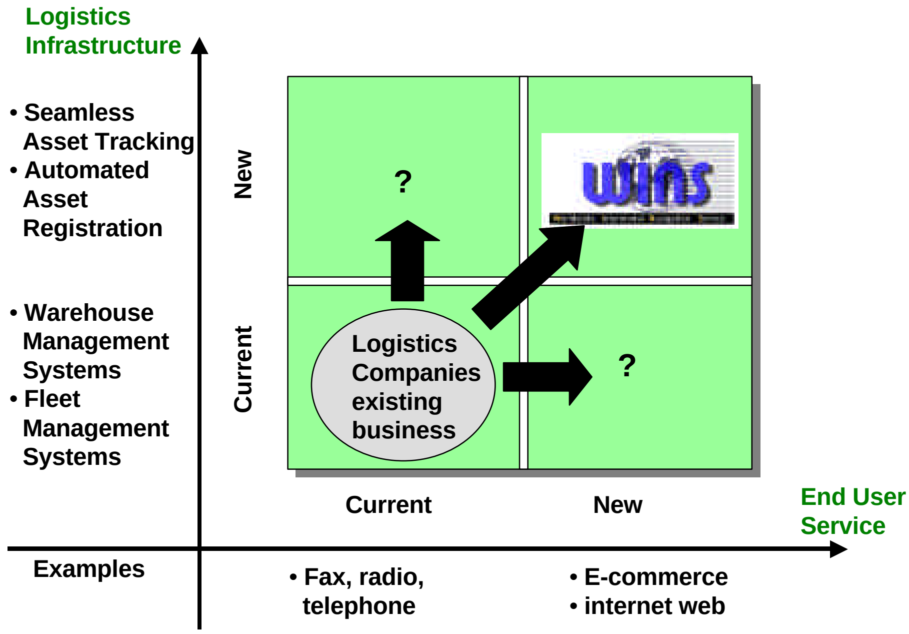
VALUE CHAIN

The control of each element of the value chain is the key WINS strategy to gain commercial advantage over present and future competitors. WINS will establish strategic partnerships with space segment and user equipment manufacturers. However, WINS maintains full system engineering control by releasing the system element specifications and keeping control of the interfaces.
The last step of the value chain is controlled by the logistics companies (our customer) providing to the end users value added applications based on WINS.



BUSINESS OPPORTUNITIES FOR WINS CUSTOMERS

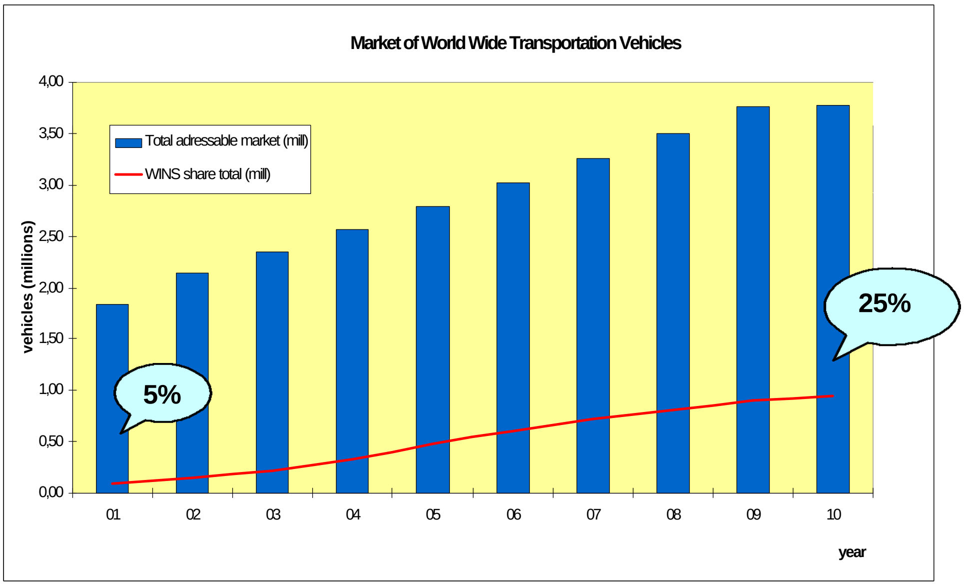
The combination of A-track and F-track provides an integrated service package that covers all aspects of modern logistics management tools. This combination is highly attractive to all customers who request a single-point business relation.



MARKET SHARE

The global intermodal transport market is estimated to be 6% of the total number of vehicles equipped with tracking capability. A market share of 5% out of intermodal transport in the first year of business shows credibility for potential investors, addressing road, rail and waterways transportation excluding flight transportation. After 10 years of operation the WINS market share should increase to 25%.

Airborne transportation is not part of the WINS service offer due to its limited market size and the related safety and regulatory issues.



MARKETING PENETRATION APPROACH

WINS addresses the intermodal transport market in a stepwise approach:

- *Step 1: Business–to–Business with global players*

As a first step in the first 2 years WINS addresses global companies offering world wide transportation service (e.g. DHL, FedEx, UPS, TPG).

- *Step 2: Business–to–Business with intermodal providers*

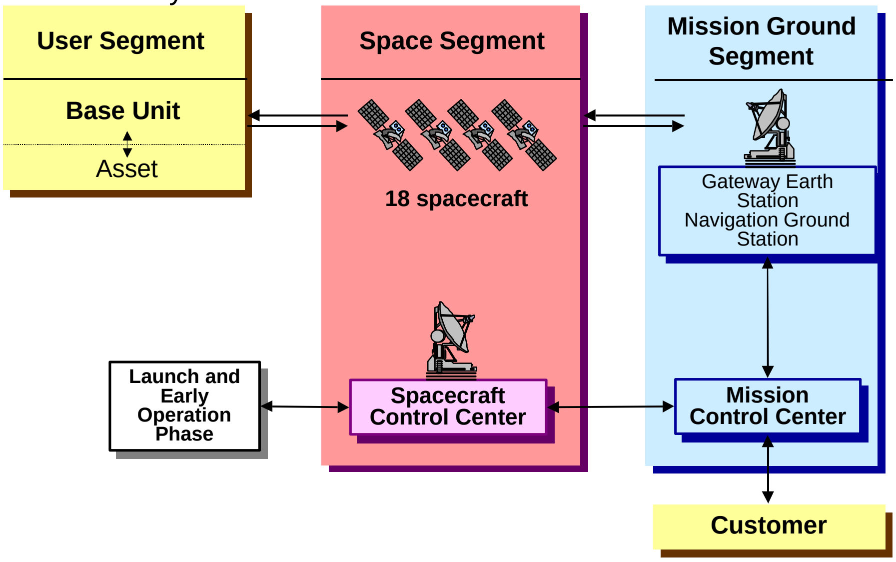
At least 65 companies offer world wide intermodal services. Servicing these companies requires WINS to install its own billing, distribution, and service sales system. Contracts are planned to be placed starting from the 2nd year of WINS operation.

- *Step 3: Business-to-End users*

As a last step, after the 4th year of operation, we intend to offer directly to end users the capability to track the assets they ordered.

SYSTEM ARCHITECTURE

WINS is implemented via a constellation of 18 spacecraft, each with an integrated navigation and communication payload independent of the GPS system.



The system can be divided into three entities:

The User Segment, consisting of two categories of terminals:

- Base units dedicated to the positioning and messaging tasks and used to relay information from the asset units;
- Asset unit or tag, which tracks a single packet up to a container or pallet, depending on the consignment to be tracked. The asset units can only be used in conjunction with a base unit.

The Space Segment includes the following elements:

- The constellation of 18 spacecraft;
- The Control Ground Segment, including the Space Control Centre and the Telecommand, Telemetry and Control stations (Primary and back up ground stations) and
- The interface with an external Launch Early Operation Phase network.

The Mission Ground Segment, whose function is to provide the service to the customer via:

- The Gateway Earth Stations, supporting the communication service;
- The Navigation Ground Stations, supporting the navigation service;
- The Mission Control Centre, ensuring the interface with the customer via communication channels comprising the Internet, telephones, pagers and fax, as required. It also executes mission management activities including message traffic and data routing, orbit determination and spacecraft on-board clock synchronisation, navigation data management as well as billing management.

FREQUENCY ALLOCATION

The communication signal frequencies have been selected in line with ITU (International Telecommunication Unit) recommendations to avoid potential interference with other satellite services.

Filing of L band and S band frequencies is considered as critical because of the strong demand in these bands coming from Mobile Satellite Systems (MSS). Frequency reuse has been assumed in the uplink from users to satellites and only 10 frequency bands are considered for the total 18 satellites.

Base Unit - Satellite	No. of Channels	Spectrum	Data Rate
Uplink	10 FDMA bands divided into 120 channels each	1626.500 – 1630.614 MHz	2.4 Kbps
	10 channels shared in Random Access		2.4 Kbps
Downlink	1 CDMA channel	2500.000 – 2503.069 MHz	4.0 Kbps

Gateway - Satellite	No. of Channels	Spectrum	Data Rate
Uplink	1 channel	5100.000 – 5100.006 MHz	4.0 Kbps
Downlink	1 band divided into 120 channels	5200.000 – 5200.411 MHz	2.4 Kbps
	1 Random Access channel		2.4 Kbps

NAVIGATION ARCHITECTURE

The navigation architecture is designed to provide each satellite with the information required to broadcast the navigation signal. It can be split into two parts:

- The navigation signal broadcasting;
- Orbit determination and time synchronisation.

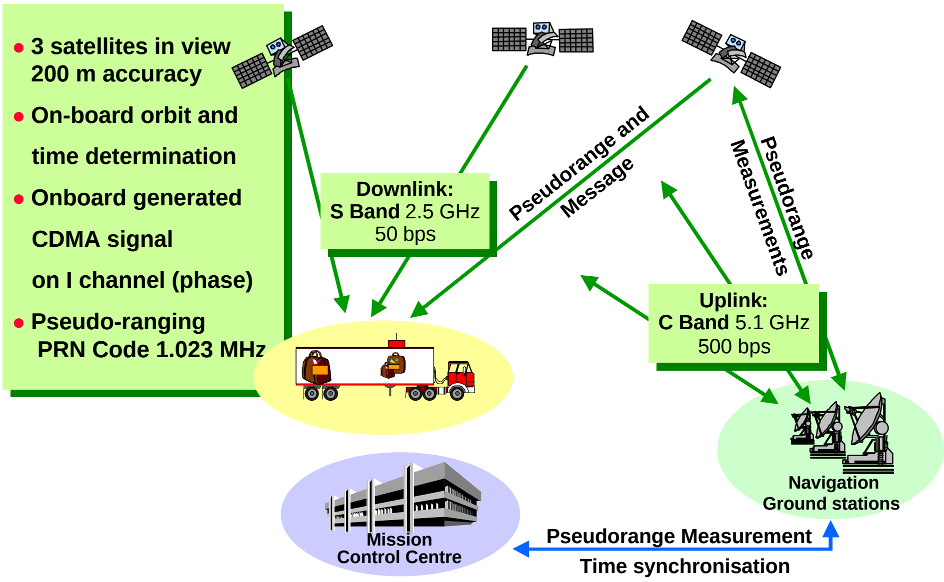
The navigation broadcast signal is compatible and interoperable with the GPS civil signal allowing the use of low cost single frequency receivers. The main features are:

- A C/A (Coarse/Acquisition) code at 1023MHz;
- S-band frequency at 2500 MHz, with a bandwidth of 4 MHz allowing the use of narrow correlator;
- A navigation message at 50 bps.

Pseudoranging measurements based on the navigation signals are performed by a network of navigation monitoring stations collocated with the Gateway Earth Stations. The data are uplinked using the on site C-band communication channel to facilitate on-board orbit determination and Ephemeris generation.
Time synchronisation of the satellites is similarly performed thanks to the Caesium atomic clocks located at each navigation monitor station.

Having each satellite perform these operations:

- minimises the ground data network requirements, since only a very short term extrapolation is necessary
- enhances the robustness of the system
- allows the use of less expensive Rubidium atomic clocks on board the satellites



COMMUNICATION ARCHITECTURE

DATA EXCHANGE

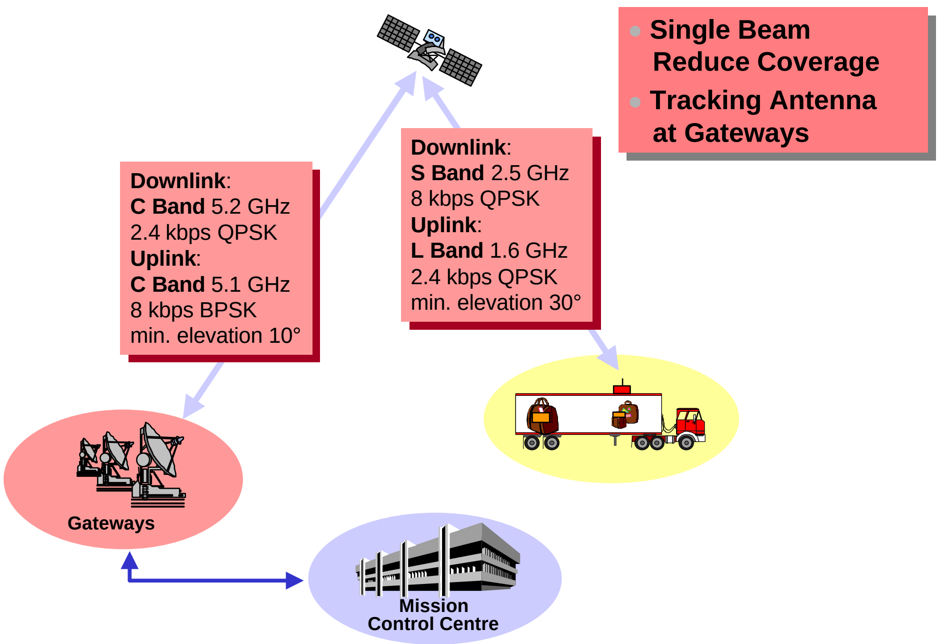
The WINS communication subsystem is capable of handling a maximum of 16,000,000 vehicles and 4,000,000,000 assets. It supports the following data exchanges:

Base Unit –Gateway

- Positioning and surveillance message
- Alphanumeric message
- Signalling message

Gateway-Base Unit

- Alphanumeric message
- Commanding
- Data traffic management

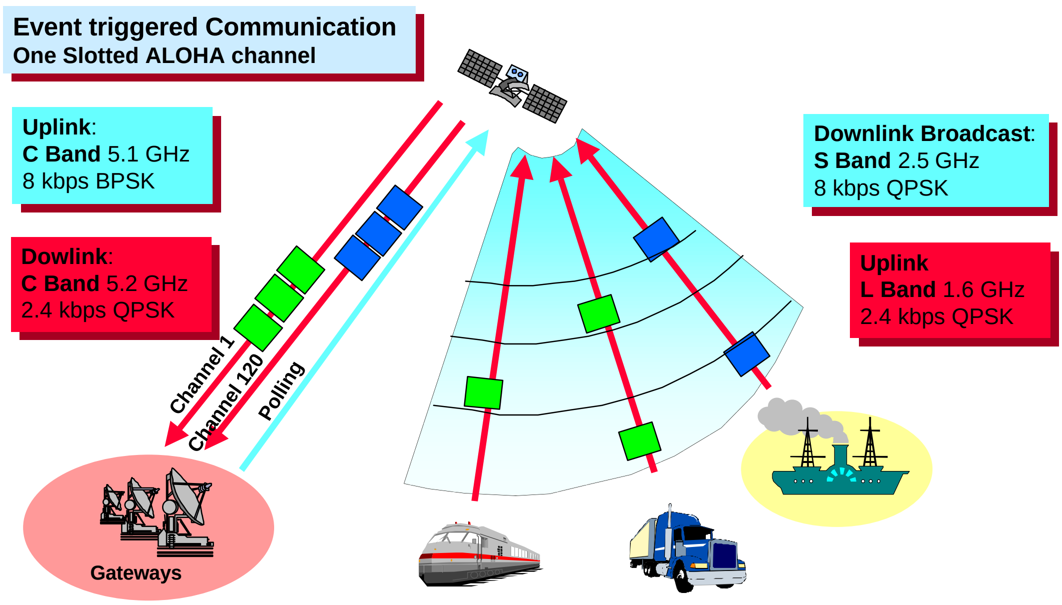


MULTIPLE ACCESS METHODS

Frequency Division Multiple Access (FDMA)
The transparent communication payload is composed of 121 channels occupying a total bandwidth of 4.1 MHz for all the satellites. Of the 121 channels, 120 are devoted to the positioning and surveillance service using TDMA and the remaining channel is devoted to data traffic management and the messaging service, using an ALOHA random access protocol.

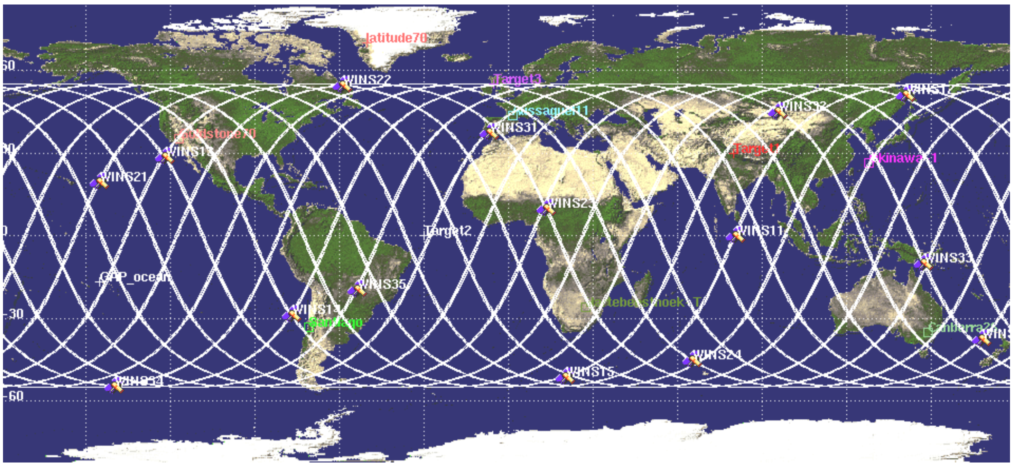
Time Division Multiple Access (TDMA)
Exploitation of on-request FDMA/TDMA communication from the Gateway Earth Station maximises the extent of the satellite network resource. The Base Units are polled at regular intervals, from once per day down to once every 15 min, by the Mission Control Centre that allocates a time and a frequency slot. In event of signal fading, a new messaging attempt is transmitted via the ALOHA channel.

- Capacity carrier: 2.4 Kbps
- Modulation: QPSK plus FEC1/2
- Frame period: 15 min
- Number of time slots: 1450



ORBIT AND CONSTELLATION

The constellation ground tracks shows full coverage of Earth's populated areas to 70^{o} North and South.

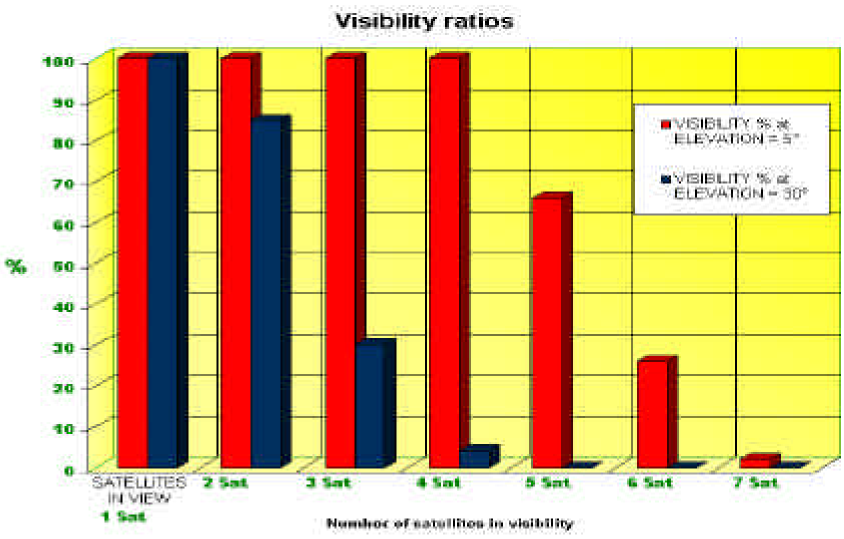


To realise this coverage, the selected satellite constellation is a Delta-Walker pattern 18/3/1 with the detailed characteristics shown in the table:

ALTITUDE	10 350 km
NUMBER OF SATELLITES	18
NUMBER OF PLANES	3
NUMBER OF S/C / PLANE	6
PLANE SPACING	120°
REL. PHASE BETWEEN PLANES	20°
IN PLANE SPACING	60°
INCLINATION	55°
ECCENTRICITY	0

The constellation has excellent performance for the nominal case where the NAVIGATION capability operates down to a minimum elevation angle of 5° and where the COMMUNICATION capability operates down to a minimum elevation angle of 30°. The robustness of the design is demonstrated by the fact that mission requirements can still be fulfilled even with a single satellite failure.

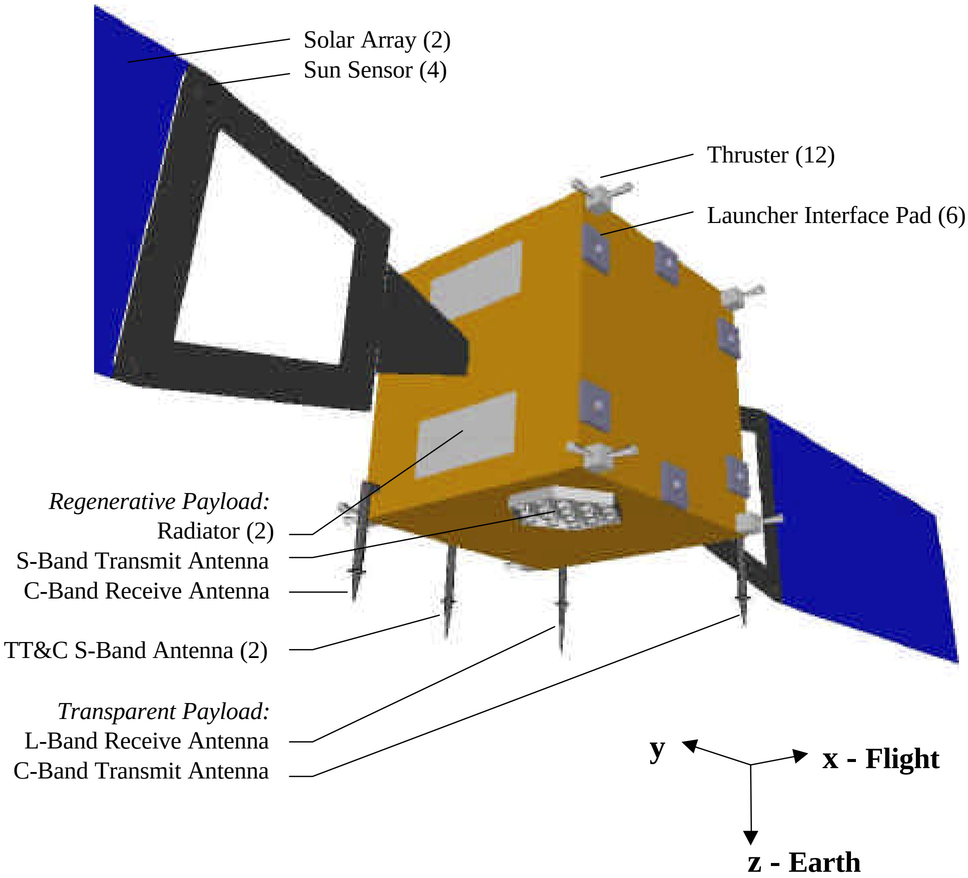
In this design, four WINS satellites are always in view to users with a 5° elevation mask angle for position determination. At least one satellite, and often two, are in view to users with a 30° elevation mask angle for communication between the base units and the WINS satellites.



SPACECRAFT

The body of the WINS spacecraft is a cubic box with side dimensions of 1.5 m. The total spacecraft mass is 530 kg with the center of mass located near the center of the cube.

EXTERNAL LAYOUT



REGENERATIVE PAYLOAD

The Regenerative Payload broadcasts the combined communication and navigation signal to the earthbound transport vehicles. It receives the communication signal from the Gateway Earth Stations and merges it with the navigation signal generated on-board. Therefore, the Regenerative Payload comprises:

- The Payload Computer, for payload monitoring and control.
- The Atomic Clocks, providing the on-board timing reference needed for navigation.
- The C-Band Receive Section to acquire the signals transmitted by the Gateway Earth Stations.
- A Navigation Baseband Processor, to generate the combined navigation/communication signal.
- An S-Band Transmit Section, including power amplifiers and the array of patch antenna.

TRANSPARENT PAYLOAD

The concept of a transparent payload has been selected to relay data transmitted by the base units of the transport vehicles to the Gateway Earth Stations. The Transparent Payload is composed of an L-Band Receive Section, including an up-converter, and the C-Band Transmit Section.

STRUCTURE

The primary structure of the WINS spacecraft consists of an Aluminium base frame and seven Aluminium honeycomb panels; six skin panels and one mid-panel. Defining the rectangular, right-handed coordinate system for the spacecraft as the x-axis being the in flight direction, the y-axis in line with Solar Arrays and the z-axis pointing to Earth, the subsystems and payloads are assembled as follows:

Panel		*Subsystem*
+x	:	Power, Thermal
-x	:	On-Board Data Handling; Telemetry, Tracking, and Command
+y	:	Regenerative Payload
-y	:	Transparent Payload
+z	:	Payload Computer, Atomic Clocks, Navigation Patch Antenna
-z	:	Attitude and Orbital Control
mid	:	Propulsion

POWER

The total power required for the WINS spacecraft is 1180 W. This power is generated by two gallium arsenide solar arrays of dimension 3.5 m x 1.5 m each. A deployment and tracking mechanism controlled by Solar Array Drives is implemented to deploy the folded solar arrays after separation from the launch vehicle and to orient them towards the Sun. During eclipses, power is provided by two Nickel-Hydrogen batteries. For power distribution and control, a decentralised architecture has been selected. This implies an unregulated power bus and therefore each load is equipped with a dedicated power converter.

THERMAL

The Thermal Subsystem maintains all spacecraft equipment within their specified temperature limits. In this respect, the most critical items are the sensitive clocks and filters of the navigation payload and the heat-generating power amplifiers of the communication payload. The power dissipated by the amplifiers amounts to 400 W. Therefore, these amplifiers are equipped with passive radiators comprised of Optical Solar Reflectors on the outer side of the spacecraft.

ON-BOARD DATA HANDLING

The On-Board Data Handling (OBDH) Subsystem provides the memory resources necessary to command, control, to monitor the spacecraft bus and its payloads. Only one spacecraft computer is implemented to perform both the data handling and the attitude and orbital control functions. The software has been estimated to 465 kByte coded in ADA language. As part of the digital OBDH Subsystem, telecommand decoding and telemetry encoding are performed according to the CCSDS Packet Telecommand and Telemetry Standard.

TELEMETRY, TRACKING AND CONTROL

The design of the Telemetry, Tracking, and Control Subsystem (TT&C) is based on a typical S-band system. To enable communication with the Control Ground Segment in any satellite attitude, two helical S-band antennas will be employed, one mounted on the nadir side, and the other on the zenith side of the spacecraft.

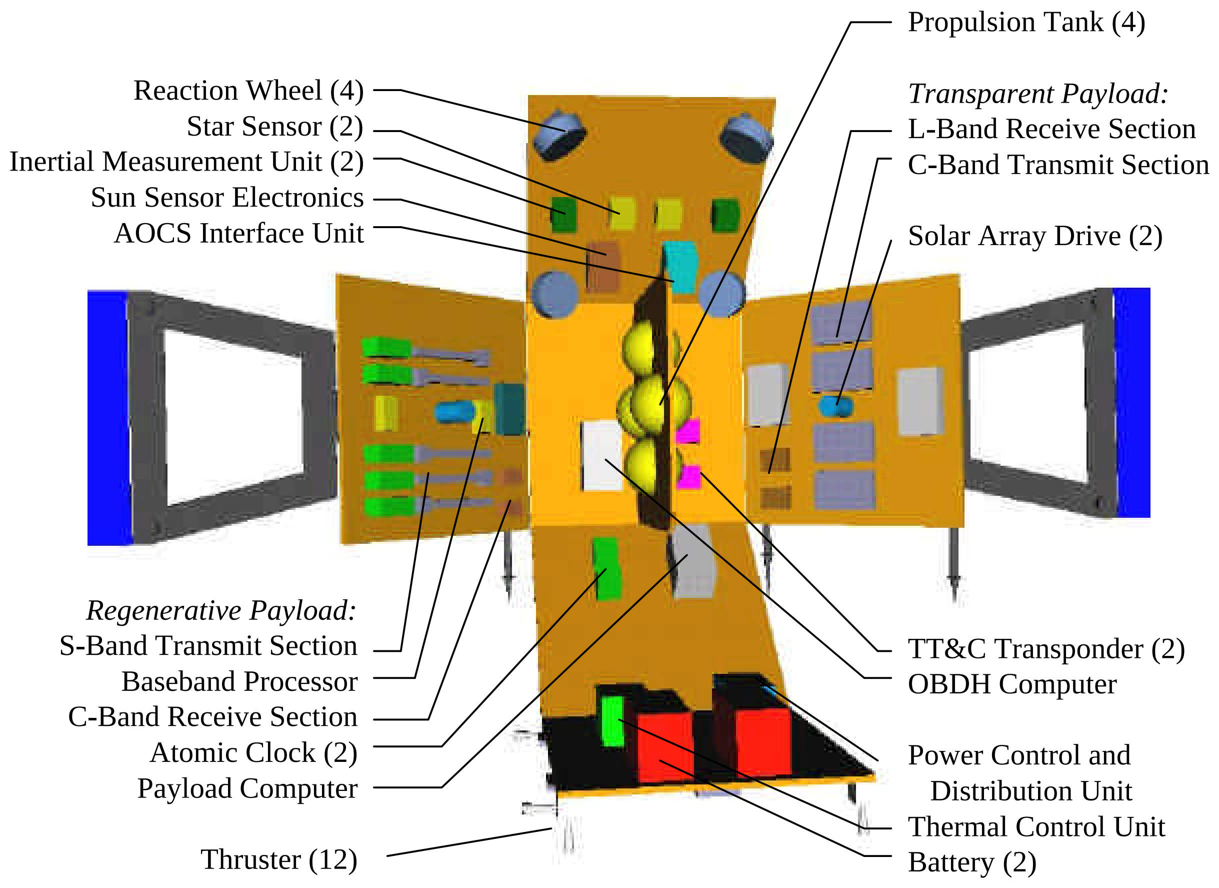
ATTITUDE AND ORBITAL CONTROL

The WINS satellites are Earth referenced and three axis controlled. With respect to the orientation of the solar array, yaw steering must be performed. The main drivers for the Attitude and Orbital Control Subsystem (AOCS) are the required pointing accuracy as well as the orbit inclination. Attitude determination is performed with the use of Star-sensors and Inertial Measurement Units (including redundant parts). Four Sun-sensors are used for solar-panel positioning towards the Sun and as back-up for the Star sensor. Four reaction wheels are used for attitude control.

PROPULSION

For the WINS satellite propulsion system, mono-propellant technology has been selected. A set of 12 thrusters, six operational and six redundant, are operated by means of electrical valves. The thrusters control the rotation of the spacecraft about its three axes necessary for reaction wheel de-saturation, as well as performing re-phasing manoeuvres. Due to the selected launch strategy of direct target orbit injection by the launch vehicle, the WINS propulsion subsystem does not require an apogee kick stage.

HARDWARE ARCHITECTURE



LAUNCH SEGMENT

The potential launch vehicles for the WINS mission were selected with respect to the requirements:

- one complete plane per launch (6 s/c within one plane, plus 1 spare),
- direct MEO insertion,
- spacecraft mass (530 kg),
- dimensions (1.5 m cube).

To populate a 18/3/1 Walker constellation, the optimum launch scenario is to insert six operational spacecraft directly into one orbit plane with a single launch. This strategy has the added advantage that the propulsion system of the satellites can be kept simple thereby reducing its cost and complexity.
Two launchers capable of directly inserting a 5000 kg payload to Medium Earth Orbit have been selected:

ARIANE 5 ESC-B:

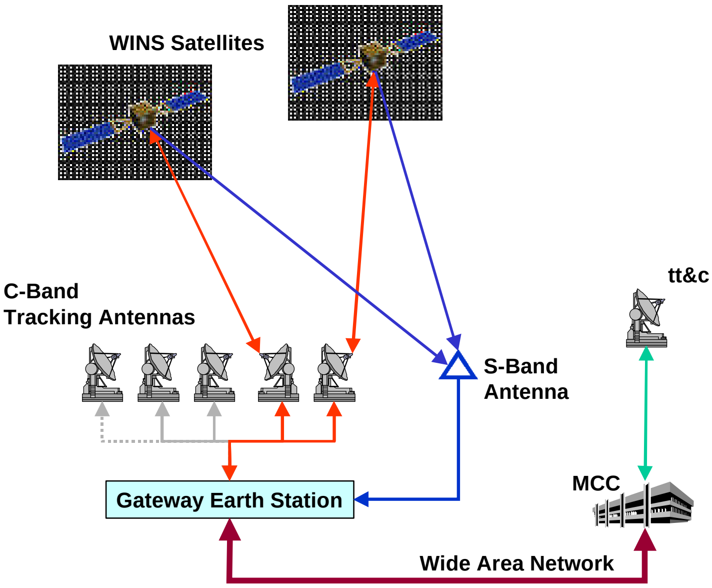
PROTON:

Both launch providers have a long heritage in offering reliable launch systems. The selected launchers will be capable of increased payload performance in the near future. Compatibility with respect to launcher shroud dimensions, mechanical and electrical interfaces, and maximum payload capability of the two launchers will allow a final selection of a launch system depending on availability and schedule.
The Atlas-5 heavy, Delta-4 heavy and Sea Launch have been selected as backup launch systems where the last is intended to be used for replenishment launches.

GROUND SEGMENT

The ground segment is constituted by the following main parts :

- ✓ Mission Ground Segment
  - Gateways Earth Station
  - Navigation monitor stations
  - Mission Control Centre (MCC)
- ✓ Spacecraft Control Centre
- ✓ Telemetry, tracking and command stations (TT&C)



Considering a Walker 18/3/1 constellation with an inclination of 55°, six Gateway Earth Stations (GES) locations will be needed based on a minimum elevation angle for the independent tracking antennas of 10°. Each GES would require a minimum of four independent tracking antennas with a fifth added for redundancy and allowing for a flexible maintenance schedule. The navigation ground stations have a single non tracking S-Band antenna while the TT&C functions will be handled by a separate steerable antenna.

The WINS Ground Segment

Ground Station	Location	Latitude	Longitude	Time	Function
MCC	San Diego, CA, USA	+33	-117	GMT-8	GES, NGS, CGS
GW2	Casablanca, Morocco	+33	-7	GMT	GES, NGS
GW3	Guangzhou, China	+23	+113	GMT+8	GES, NGS
GW4	Santiago, Chile	-33	-71	GMT-5	GES, NGS
GW5	Durban, South Africa	-29	+31	GMT+2	GES, NGS, CGS
GW6	Brisbane, Australia	-27	153	GMT+10	GES, NGS

GES = Ground Earth Station NGS = Navigation Ground Station CGS = Control Ground Station (TT&C)

The entire Ground Segment is tied together with a wide area network based on leased land lines capable of 1.5 megabits per second. Locations where this capacity is not available, direct communication between the GES facility and the Mission Control Centre will be done using a VSAT link.

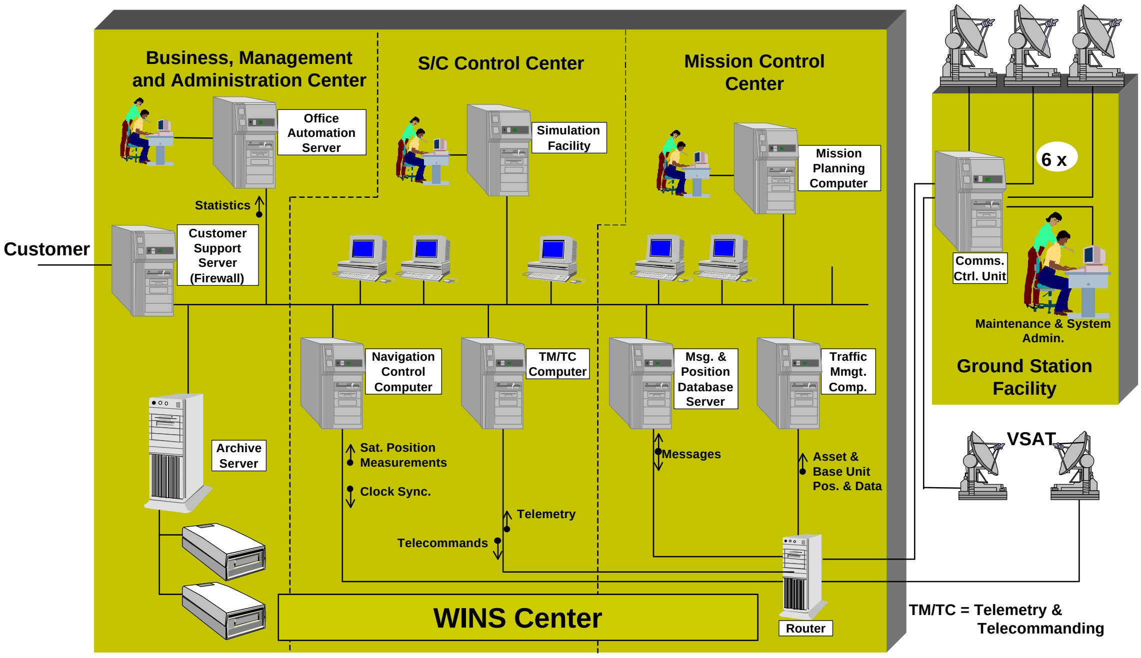
MISSION CONTROL CENTRE

The Mission Control Centre will provide the following functions:

- Location of unique data base of asset location logging
- Operational centre for the Control Ground Segment (TT&C)
- Traffic management centre for the WINS constellation
- Operational control centre for the WINS Navigation Ground Segment

In addition to the technical operations of the Mission Control Centre, operations with respect to all aspects of business, management and administration are part of the Mission Ground Segment operations encompassing:

- Staffing Management
- Management of user accounts
- Financial management
- Marketing and Sales
- Contracts acquisition and management
- Data archiving
- Statistics evaluation for business planning
- Maintenance of WINS ground infrastructure



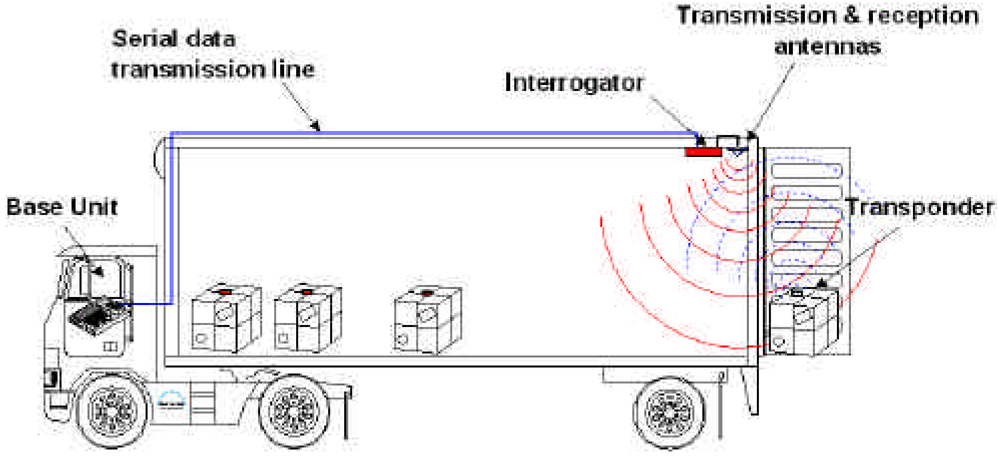
USER SEGMENT

The WINS User Segment is physically attached to the vehicles and assets. It is necessary for the identification and surveillance of vehicles and assets, the calculation of the vehicle asset position and the communication link to the satellites.

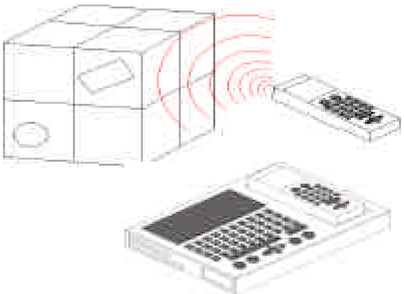
The associated User Equipment is designed for application in both land and maritime transportation systems.

Asset identification is performed by means of a transponder gate, which detects and reads tags attached to assets being loaded or unloaded. The surveillance of assets in the cargo bay can be performed with measurement equipment monitoring the entire cargo bay environment and, if necessary, individual assets in the cargo bay can have their own monitoring equipment.

AUTOMATED SCANNING SYSTEM

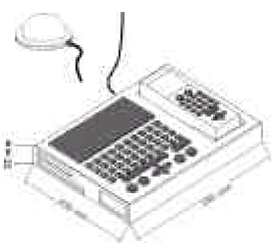
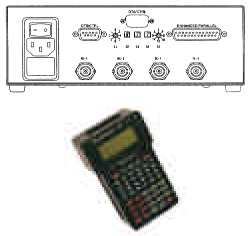


SEMI-MANUAL SCANNING SYSTEM



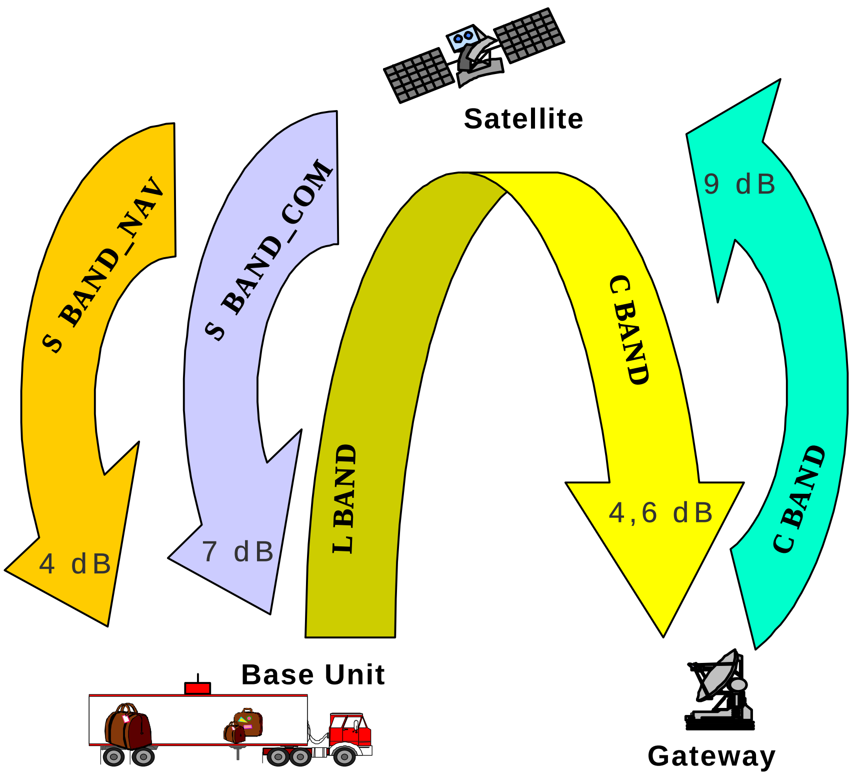
The data from the cargo bays and containers will be transmitted to the Base Unit by either a cable data link or by using radio frequency links employing active transponders attached to the containers. To keep track of assets inside a container stacked on a freighter or in a freight yard, a transmission chain will be established by using these active transponders themselves to relay information from a “hidden container” to the Base Unit.

The Base Unit, as the core element of the User Segment, will provide the transceiver function for the satellite communication link as well as the processing of the navigation algorithm. Each transportation vehicle supported by the WINS service is equipped with a Base Unit.
The main elements of the user segment are presented in the table below:

Base Unit	Interrogator	Asset Transponder	Measurement Equipment
			
28*20*3 cm	26*20,8*7,6 cm	5.6*3.3*0.7 cm	10*8*5 cm
60 W	85 .. 256 VAC	-	18 VDC

SYSTEM COMMUNICATION PERFORMANCE

The WINS communication links are shown in the figure below depicting the links together with their respective performances as the sum of the link margins and implementation losses.



The density of accesses permitted by the WINS design within a 45 minute interrogation time window is, on average:

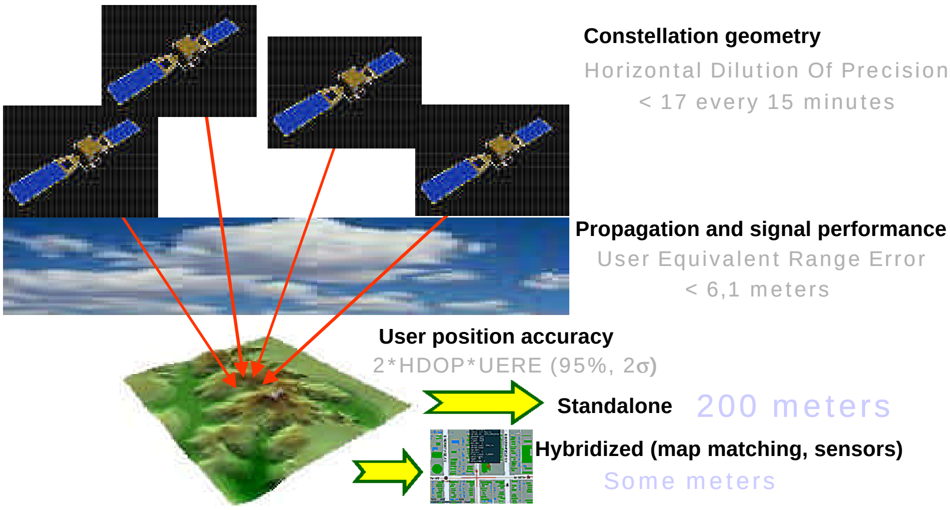
Base Units per [1000km*1000km] = 14300

Here is represented an approximate surface zone of 1000km*1000km and corresponding density of base units (not in scale proportions).

The density calculated here includes the main following hypothesis : 1 message required every 45 minutes, more than 1 satellite in view from each user (mean 2,2).

SYSTEM NAVIGATION PERFORMANCES

Navigation performance is assessed considering the different influencing factors : constellation geometry, propagation and signal performance.



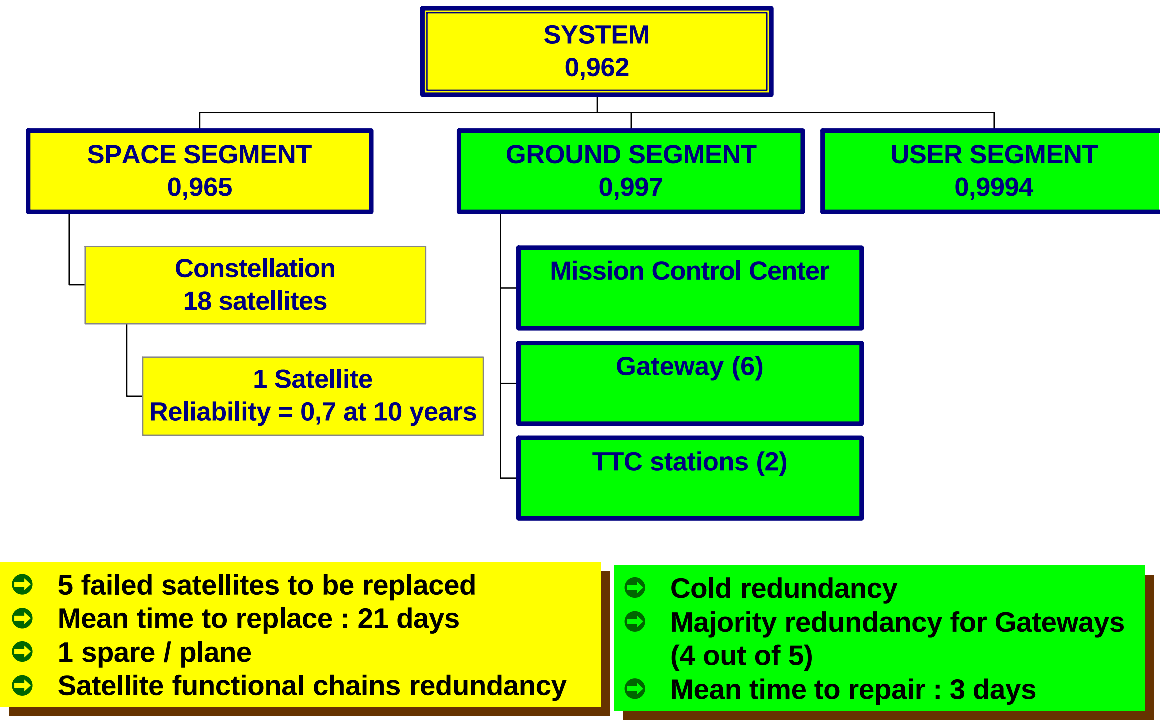
A 200 m horizontal position accuracy (95% confidence level) every 15 minutes is possible at user level at any moment. The final 200 m performance of the standalone satellite navigation service is achievable 89% of the time. Due to the Horizontal Dilution of Precision (HDOP) threshold filtering inside the user base unit, HDOP values resulting in a position accuracy worse than 200 m with a 12 minute or less duration time are rejected. Therefore, the 200 m service availability can be increased to values close to 100%.

To provide satisfactory accuracy of the navigation system, even in degraded conditions such as a bad satellite to user geometry, multipath, or obstructions, additional sensor equipment inside the vehicles and map matching methods may support the satellite navigation system.

AVAILABILITY

The availability of the WINS service is defined considering the main requirement for the service which is one message lost for every 10000 sent by the base units and received on the customer side. The Mission Control Centre will repeat polling in case of messages not acknowledged. This corresponds to a 96% system availability (relative amount of time when the system is operating with nominal performance).

The availability of the WINS system is a mean value integrated over the entire system lifetime of 10 years. The instantaneous availability depends on reliability of the different components and on the repair time required after failure.

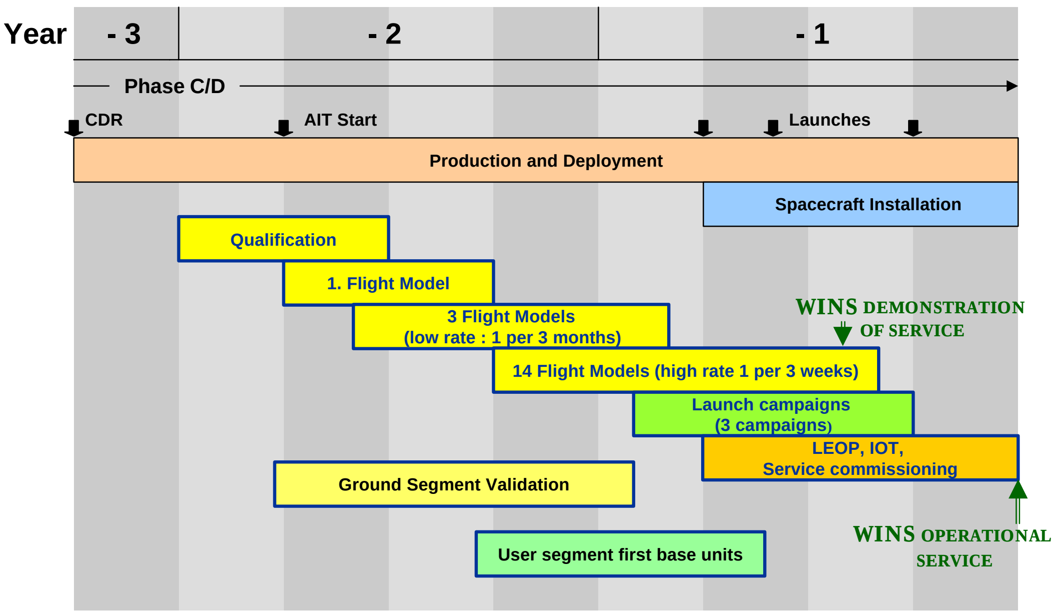


Five spare satellites will be required over the 10 year system lifetime. The constellation maintenance philosophy will be based on spare satellites being in orbit at the beginning of service with at least one per plane. A replacement satellite will be launched as soon as one satellite fails. This will allow for continuous operation of the WINS service even in the event of one satellite failure per plane.

SYSTEM VALIDATION PLAN

The WINS system verification plan includes all aspects of verification for an end-to-end system. The integration and validation activities concerning all the segments of the WINS system are included : Space Segment, Mission Ground Segment and the User Ground Segment. This is followed by the operational in orbit activities: Launch and Early Operations Phase, In Orbit Testing and Service Commissioning.

WINS Validation Plan



The first production model satellite must be thoroughly tested in order to allow a lighter test campaign for the subsequent production models. A series production in 2 main phases for the satellites is foreseen: a low rate production phase for the first four satellites with one every three months, and a high rate production phase for the remaining satellites at a rate of one per month.

As launcher injection is supposed to be made directly on the rough final orbit, the Launch and Early Operations Phase will mainly consist in correction manoeuvres to go to the precise final orbit.

In orbit testing and service commissioning will verify the system and service performances. The operational service will be implemented in two steps:
1) **demonstration of service** with the first 12 satellites in orbit for the initial customers, followed by,
 2) **nominal level of service** with the full constellation of18 satellites in place.

SYSTEM LEVEL CHARACTERISTICS	**User Needs** - service: messaging, positioning & surveillance of assets and vehicles - a minimum of 2,000,000 vehicles - coverage ($\pm 70^{o}$ latitude) - vehicle position accuracy better than 200 m - system operational lifetime: 10 years - start of the service within 5 years - service quality better than one message lost or corrupted over ten-thousand
	Architecture - constellation of spacecraft with an integrated navigation and communication payload - system availability: 0.962 - satellite reliability: 0.7 at end-of-life (10 years)
ORBIT CONSTELLATION	- Orbit altitude: 10,350 km - Number of satellites: 18 - Number of orbital planes: 3 - Number of satellites per plane: 6 - Plane spacing: 120°, In plane spacing: 60° - Inclination: 55° - No. of Spare satellites: 3 in orbit, 2 on ground
SPACE SEGMENT	**Spacecraft:** - Spacecraft mass: 530 kg, Power consumption: 1180 W - Structure: cubic box (1.5x1.5x1.5m) - GaAs solar power arrays, Nickel-Hydrogen batteries, unregulated power bus - Optical Solar Radiators - AOCS, three axis control: yaw steering, nadir pointing, Star/Sun-sensors, 4 reaction wheels - OBDH: distributed architecture, 450 Kbytes ADA software - Propulsion: 12 mono-propellant thrusters, propellant 74 kg - TT&C (S-band) **Payload:** - Power: 720 W , Mass: 80 kg - Regenerative payload: 30 dBW EIRP for communications and 20 dBW EIRP for navigation (C-band helix communications and S-band patch navigation antennas) - Transparent payload: 3 dBW EIRP (L and C bands helix communication antennas)
GROUND SEGMENT	- Six Gateway Earth Stations (GES) for communication (C-band) - Navigation Ground Stations (NGS – co-located with GES) (S-band) - Mission Control Centre (MCC) for central operations and customer interface - Wide Area Network for communication between MCC and GES - Spacecraft Control Centre; TTC Stations
LAUNCH SEGMENT	**Direct injection into orbit with:** - Proton-K (6600 kg) or Proton-M (7500 kg) - ARIANE 5 ESC-B
USER SEGMENT	- Passive or active asset identification transponders (tag) - Interrogator (data scanning & compilation device) - Base Unit: 28x20x3 cm, peak 60 W (during data transmission), 3 kg - Status measurement equipment (ME)

PRICING STRATEGY

A-Track Service:

The price for the **standard service** (asset positioning) is composed of a fixed monthly subscription fee per Base Unit and a usage fee based on the number of messages transmitted.

The service price is designed for "high value goods" which are defined to have an average value of at least 400 Euro.

For example, the A-track standard service daily fee is 10 Euro/day/vehicle. This is about 6% of the estimated transportation cost.

The **premium service** (surveillance on top of the standard positioning service) is offered for an additional price based on a daily usage fee. Additional measurement equipment such as sensors, data acquisition devices etc. for the A-Track premium service in many cases will be a customised product. Therefore, value adding retailers will deliver and charge these items.

F-Track Service:

The F-track pricing strategy is following the competitive market price. The fee will be based on a flat rate in the range of 1,200 Euro per vehicle per year and an additional monthly fee of 70 Euro.

Asset Tags:

The asset tags are off-the-shelf disposable products that will be sold to customers. Sales prices for asset tags range from 1 Euro for passive tags up to 25 Euro for active ones.

Pricing (EUR)

Product	Base Unit Interrogator	Subscription fee (per vehicle)	Usage fee
F-Track	1200	70/month	--
A-Track, standard	subsidised	200/month	0.02/asset message
A-Track, premium	subsidised	200/month	20/day

WINS OVERALL COSTS

The WINS costs are composed of start-up investments, user equipment procurement costs and operating costs.

The costs estimate assumes WINS fully operational four years after project start and 10 years operation (1998 inflation rate).

The total investment for the end-to-end system is 2,832 MEuro. The total operating cost is 1,306 MEuro. The share between investment and operating cost corresponds to 68% and 32% respectively.

Start-up Investments

The space segment procurement cost is estimated to be 601 MEuro. This figure includes 231 MEuro for the development phase (non recurring) and 370 MEuro for 18 flight units (recurring).

The average production cost of a single spacecraft is 20.6 MEuro, which is in the same order of a single GNSS-2 MEO spacecraft (28 MEuro).

The launch costs for 18 satellites including insurance are estimated as 150 MEuro for the WINS 3-plane-constellation (Ariane5 or Proton launcher). This is based on the assumption that future launch prices will drop, driven by the increasing competition of commercial launch providers.

Constellation refurbishment is also taken into account as additional 158 MEuro for 5 satellites including launch.

The ground segment cost estimate assumes that the ground stations are procured with 39 MEuro.

INVESTMENTS	TOTAL
	MEuro - 98
Total Space Segment Cost	601
Launch Segment Cost	150
Constellation refurbishment	158
Ground Segment Development Cost	39
Total start-up Investment	**947**

User Equipment Procurement Costs
The user equipment consists largely of commercial off-the-shelf elements. Strategic partnerships with potential supplier companies will be pursued to share responsibilities and investments.

The costs listed below have been derived from existing similar products such as:

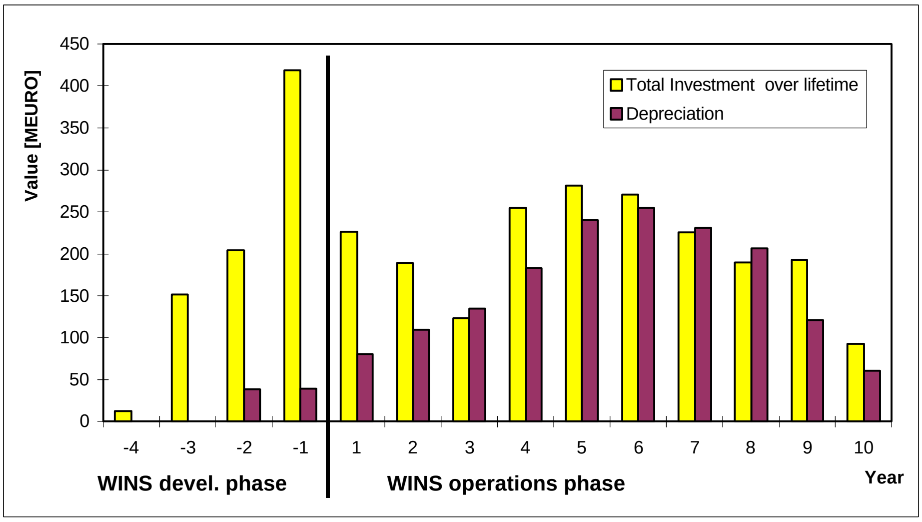
- Q-Free (Base Unit, Interrogator, Asset Tags)
- Mannesmann, Philips (Base Unit)
- Gantner GmbH, TSS (Interrogator, Asset Tags)

User Segment Procurement	Cost [Euro]	Comment
Base-Unit (BU)	800	Assuming large scale procurement
Interrogator (INT)	1200	
Asset Tag	1	

User equipment will be an inherent part of the service offer to the customer. The customer will be charged with a subscription fee to compensate the equipment cost.

The overall distribution of investment including the associated depreciation covers the whole period of 14 years.

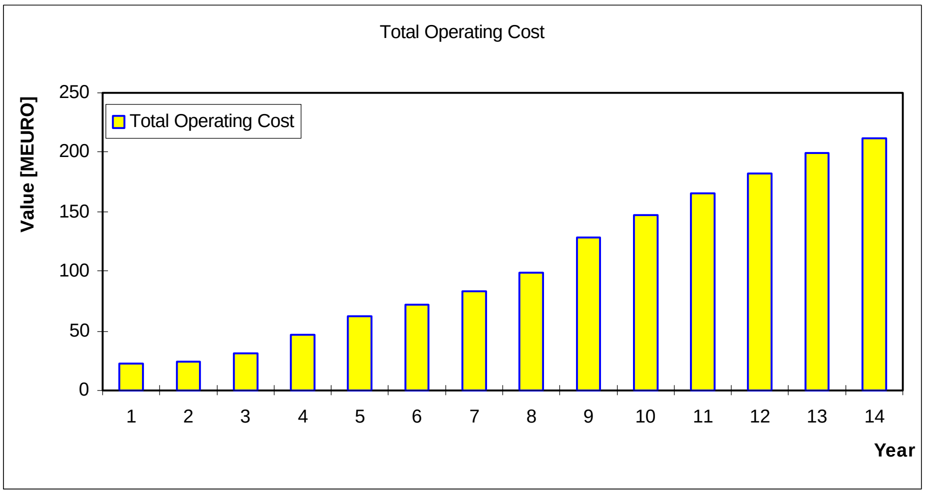
Depreciation is the cost element in the Profit & Loss Account related to the investment. During WINS operational phase depreciation almost balances the running investments coming from user equipment procurement.



Operating Costs
The total operating costs from start of development, including ground segment operation, spacecraft insurance, product improvement, marketing and sales are 1,306 MEuro.

Average personnel and marketing costs are the main drivers for the operating costs:

- 71 staff members (full time equivalent) are required to run the Mission Control Centre and the Ground Station operations
- 74 staff members (full time equivalent) are required for Marketing and Sales
- 20 staff members are required for WINS Headquarters.



FINANCING STRATEGY

The financial strategy to build up equity and acquire loans is based on the following rationale.

In the start-up phase the value of the company is only based on the intellectual property of the founders, in our case the 13 members of the WINS team. Assuming that the proposition of the founders is attractive and they are willing to invest in the WINS concept, they can attract venture capitalists.

On this basis, it will be possible to get initial long term loans.

The founders will continue to create added value to the company by defining more precisely the business and acquiring launching customers (e.g. global players in transportation).

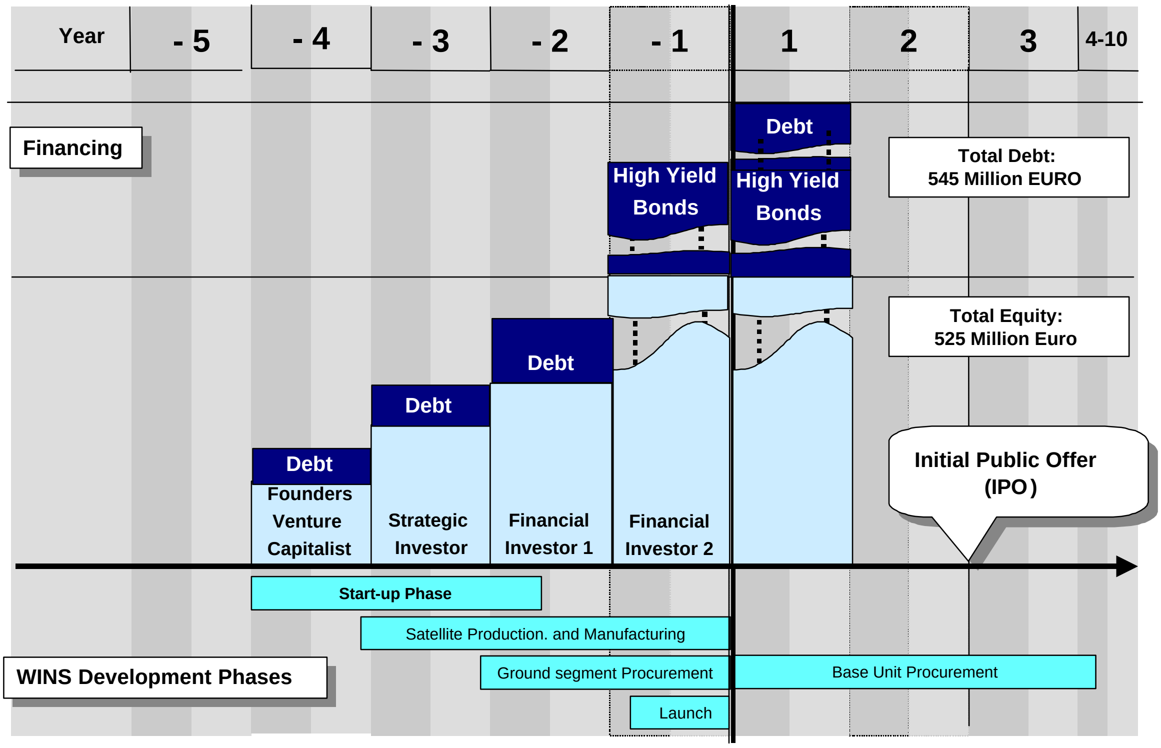
In the second year, strategic partners who are interested in the business (e.g. global players with high acceptance in the target market, satellite manufacturers, user equipment manufacturers) will become large-scale investors, with their support satellite procurement can be started.

At the end of the second year the perspective of the company has become very attractive and credible for financial investors. These financial investors will assign a value to the company derived from the expected Price over Earning ratio (P/E), expecting that this ratio will significantly increase through the subsequent years of the company development. Their investment and additional loans will allow to start procurement of the ground segment.

One year before the operational phase begins, the first 6 satellites will be ready for launch, attracting a second financial investor and allowing to acquire high yield bonds to cover the growing investment for the launches and the ground segment integration.

At the end of the fourth year, the total equity of the company has reached 525 MEuro and the loans sum up to 425 MEuro. On this basis the company starts to create revenues in the first year of operation (420 MEuro).

Provided that the business is successful, the value of the company will have increased significantly at the end of the second year of operation. This allows investors to sell their shares and WINS is ready for Initial Public Offer.



Courtesy Kreisel

PRO-FORMA PROFIT & LOSS ACCOUNT

The revenues show a significant growth rate from the start of operation, according to the expected market growth in the intermodal transportation and the WINS market share.

The cash flow forecast indicates adequate liquidity (cash) over the first years of operations (the most critical ones from a financing point view), underlining the credibility of the WINS company.

WINS PRO FORMA PROFIT & LOSS [Meuro]

Year	**-4**	**-3**	**-2**	**-1**	**1**	**2**	**3**	**4**	**5**	**6**
Total Sales Revenue	**-**	**-**	**-**	**-**	**421**	**688**	**969**	**1.222**	**1.736**	**2.211**
Cost of Sales	-	-	-	-	(182)	(297)	(419)	(660)	(937)	(1.194)
Gross Margin	**-**	**-**	**-**	**-**	**239**	**391**	**551**	**562**	**799**	**1.018**
Operating Expenses (incl. Personnel	(23)	(24)	(32)	(46)	(62)	(72)	(83)	(99)	(128)	(147)
Depreciation	(0)	(0)	(38)	(39)	(80)	(110)	(134)	(183)	(239)	(254)
Operating Result	**(23)**	**(24)**	**(70)**	**(85)**	**97**	**209**	**333**	**280**	**432**	**616**
Investments Grants	1	8	10	21	11	9	6	13	14	14
Interest Expenses	(0)	(5)	(12)	(56)	(66)	(64)	(48)	(37)	-	-
Income before Tax	**(22)**	**(21)**	**(71)**	**(121)**	**43**	**154**	**292**	**256**	**446**	**630**
Income Tax	-	-	-	-	(15)	(54)	(102)	(90)	(156)	(220)
Net Profit (Loss)	**(22)**	**(21)**	**(71)**	**(121)**	**28**	**100**	**190**	**167**	**290**	**409**
Accumulated Cash Flow	**(22)**	**(44)**	**(77)**	**(158)**	**(50)**	160	484	834	1363	2026

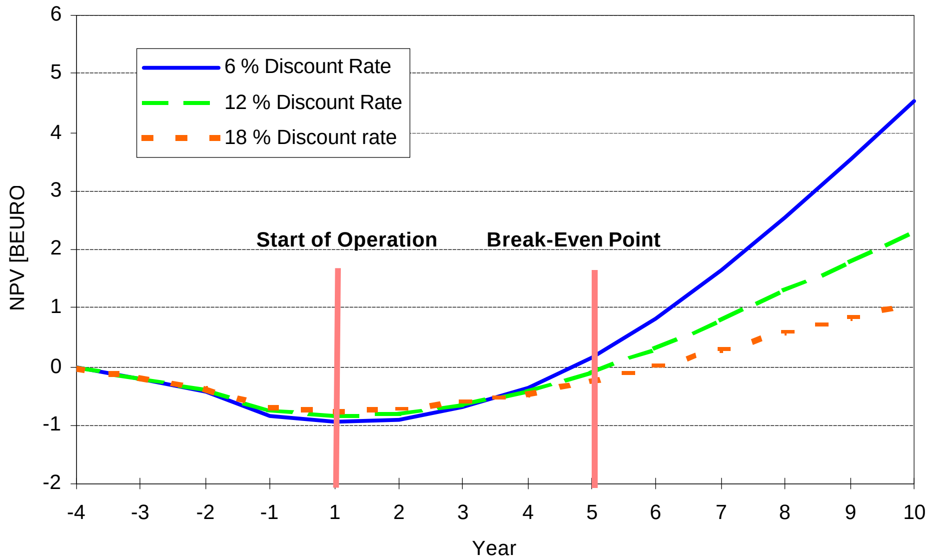
BUSINESS OFFER

Corporate View

The WINS offer to investors is expressed in Net Present Value (NPV) and Internal Rate of Return (IRR). These figures are given as an indication of the business sustainability over the entire project lifetime.

The NPV is the value of all future cash flows (revenues and expenses) corresponding to the integrated operating profit normalised with respect to time. The overall NPV at the end of operation in Year 10, with a discount rate of 12%, results in 2,300 Million Euro.

A parametric analysis of the NPV with respect to different discount rates is shown in the table below. WINS becomes profitable 5 years after start of operations.



The IRR is the interest rate received for an investment consisting of payments and revenues that occur at regular periods in the future. The total IRR is 33.5%.

Investor View

In order to illustrate the attractiveness of WINS based on the assumed development of the company value, the return on investment for different periods of investment has been calculated.

Based on the average value of the P/E of comparable companies on the so called European Stock Exchange new markets, WINS financial investors may get 7.4 times their invested capital back which corresponds to a return on investment of about 60% per annum entering 2 years before start of operation and exiting 2 years after.

BUSINESS RISK

WINS Manages Risk
To investigate the robustness of the business case, the internal rate of return after 10 years of operation has been determined for a number of cases that are considered as threatening for WINS.

	Business Downside Risk	**IRR [%]**
	Baseline	33.5
1	Price Cutting by Competitors (30% WINS prices reduction)	24
2	Development Cost 20% in excess of estimates	30
3	Operating Cost 50% in excess of estimates	31
4	Time to Market 1 year delay	29
5	Market Share not achieved (30% lower than expected)	26
6	Launch failure	29

The WINS business case is considered to be robust enough to attract partners.

All cases show a moderate decrease of the internal rate of return with the worse case still giving an IRR of **24** %.

On the other hand, different market scenario hypothesis lead to an upside potential for the business.

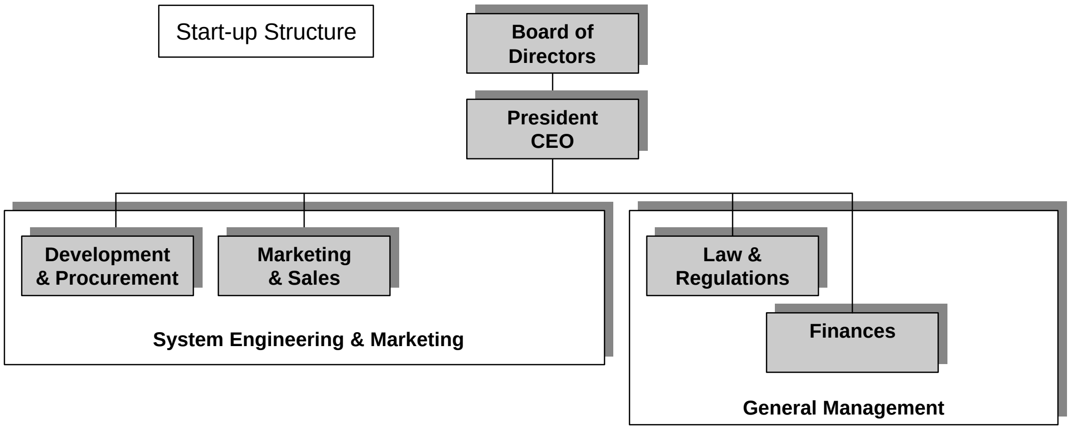
	Business Upside Potential	**IRR [%]**
	Baseline	33.5
1	No Base Unit subsidised	40
2	Procurement of Tags 30% cheaper	37

Marketing and Pricing strategy reveal to be the key factors to be taken into account in the following phases of the project.

ORGANISATION

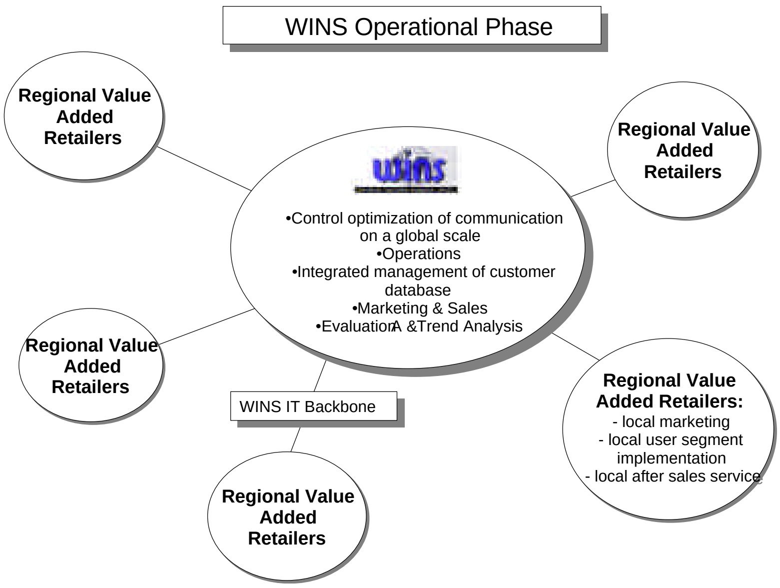
The WINS management structure reflects the operational needs of the company throughout all the service lifetime. Organisation will be evolutive : **start-up** phase including a very simple and interactive organisation between marketing and engineering teams, **development** phase implemented through a more classical organisation, **operational service** phase totally dedicated to service operations and commercialisation.

Start-up phase shows an integrated marketing and engineering structure :



As soon as the main investments are realised, the development phase will be implemented through a more classical organisation including parallel and interactive structures engineering and operations, marketing and sales, management and administration, human resources.

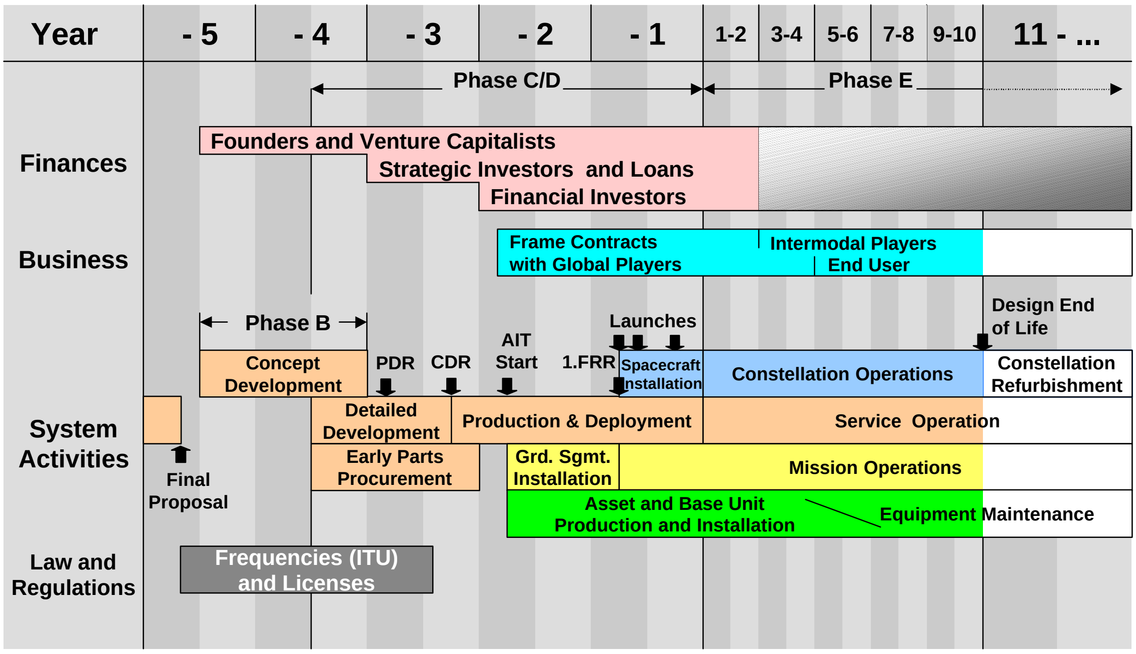
The final operational phase will be implemented through a service dedicated multi-regional organisation. It will be controlled through an Information Technology backbone linking the retailers distributed all over the world to the central WINS headquarters.



SCHEDULE & MILESTONES

The WINS Master Schedule shows the basic time frames and development milestones which follow a classical system development life cycle from Phase B to the Flight Acceptance Review.

WINS Master Schedule



Teaching Partners:

Delft University of Technology with its partner universities in Europe and abroad

and its international Centre for Postgraduate Education

TOPTECH STUDIES
TU DELFT

have created and organised the postgraduate programme

SPACETECH

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GO FOR WINS

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