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Master degree Thesis

“Data Dissemination Tools for University Nanosatellites”



Supervisor:

Professor Leonardo Reyneri

Candidate:

Sharjeel Hayat Khan 176292

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DEDICATIONS

*I dedicate my thesis to beloved parents **Agha Khizar Hayat** and **Musarat Afza** whose prayers and encouraging support was always there for me, who made me to be what I am today.*

*A very special dedication goes to my sister **Agha Shumaila Hayat**, **Agha Saman Hayat** and my brother **Agha Rameez Hayat** who has been always there for me in every matter of life and been encouraging me, while living abroad far from parents and family, to make this happen.*

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Abstract

Data dissemination is the distribution or transmitting of statistical or other data to end users and is getting more and more importance as the technology is advancing day by day. There are many ways organizations use to release data to users. Although the most popular dissemination method today is the non-proprietary open systems using internet protocols but in order to protect our sovereignty and copyright of the data we will choose to disseminate data using proprietary way so that we can avoid unauthorized access to our systems.

Idea is to provide a timed and secure access of resource applications of University nanosatellite ground station setup to end user so that he can make experiments and collect information from any location through internet. For this I have a secure online reservation system where user must reserve his timeslot to access the resource application and also I make sure that he cannot have access before or after the reserved timeslot. Setup includes a complete hardware system to control University Satellites to make experiments and collect related information.

Although resource sharing through web is not a new concept but it's not a simple resource sharing or information sharing I am providing a complete setup to user to perform experiments of his own choice on University nanosatellites connecting to ground station without making any destructions.

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Index of Contents

1	Introduction	13
1.1	Introduction to Data dissemination and Nanosatellites	13
1.1.1	Data dissemination tools.....	13
1.1.2	University Nanosatellites.....	14
1.1.3	Ground station.....	15
1.2	Thesis organization.....	17
2	Problem Statement and Solution Design	19
2.1	Problem statement.....	19
2.2	Solution design.....	19
2.2.1	Step 1: Web based reservation system.....	19
2.2.2	Step 2: Publication of software products.....	20
2.2.3	Step 3: Security matters	20
3	Website: a communicating/dissemination tool	23
3.1	Ideas and techniques.....	23
3.2	Webpage design.....	24
3.2.1	Dreamweaver: web developing software.....	24
3.3	Coding languages.....	24
3.3.1	PHP: Hypertext Preprocessor.....	24
3.3.2	JavaScript.....	25
3.4	User registration and booking system.....	25
3.4.1	Login/Signup page.....	25
3.4.2	User page.....	26
3.4.3	Server page.....	27
3.5	Database	28
4	Orbitron: the central software	29
4.1	Orbitron.....	29
4.1.1	What is a satellite tracking system?	31
4.1.2	Features and working capabilities.....	31
4.1.3	System requirements.....	32
4.2	Reasons to book.....	32
5	Remote Spark: gateway to ground station	33
5.1	What is Spark View?	33
5.1.1	What is RDP?	33
5.2	Specifications and capabilities.....	33
5.3	Architecture, Work routines & configuration files.....	34

5.3.1 What's the difference?	35
5.4 Example & testing.....	35
6 System Architecture and Configurations (Admin Manual)	37
6.1 Components.....	37
6.1.1 Hardware.....	37
6.1.1.1 Desktop Computers.....	37
6.1.1.2 Controller Rack.....	37
6.1.1.3 Antennas.....	37
6.1.1.4 Cameras.....	40
6.1.2 Software.....	41
6.1.2.1 Operating Systems.....	41
6.1.2.2 Orbitron	41
6.1.2.3 SparkView	42
6.2 System architecture.....	42
6.3 Installation guide: step by step	44
6.3.1 Server installation	44
6.3.2 Gateway installation	61
6.4 Security Matters	65
6.4.1 Security: a hot issue	65
6.4.2 Security types	65
6.4.2.1 Computer Security	65
6.4.2.2 Information Security	65
6.4.2.3 Internet Security	66
6.4.2.4 Network Security	66
6.4.2.5 Data Security	67
6.4.3 Implementations	68
6.4.3.1 Physical protection of Assets	68
6.4.3.2 Firewall	68
6.4.3.3 Secure Communication Channel	69
6.4.3.4 Web Security	70
6.4.3.5 Database Security	70
7 System Specifications and Guideline (User Manual)	71
7.1 System Specifications	71
7.2 User Guideline	72
8 Conclusions and Future Improvising	77
8.1 Conclusions	77
8.2 Future Improvising	77
Reference	79
Annexure A	81

List of Figures

Figure 1.1: Satellite path view	14
Figure 1.2: Nanosatellite	15
Figure 1.3: Cameras	16
Figure 1.4: Internal hardware	16
Figure 1.5: Parabolic antenna	16
Figure 1.6 Yagi antenna	17
Figure 3.1: Homepage	23
Figure 3.2: Login/Signup page	26
Figure 3.3: User page	26
Figure 3.4: Reservations of all users	27
Figure 3.5: Server page	27
Figure 3.6: Database and Tables	28
Figure 4.1a: Orbitron	29
Figure 4.1b: Orbitron	30
Figure 4.1c: Orbitron	30
Figure 5.1: SparkView architecture	34
Figure 5.2: Example and Testing	36
Figure 6.1: Control rack	38
Figure 6.2: Parabolic antenna	39
Figure 6.3: Yagi antenna	40
Figure 6.4: IP Camera	41
Figure 6.5: System Architecture (logical)	42
Figure 6.6: System Architecture (physical)	43
Figure 6.7: Server installations	44-60
Figure 6.8: Gateway installations	61-64
Figure 6.9: Security Implementations	68
Figure 7.1: Website	72
Figure 7.2: Signup	73
Figure 7.3: Login	73
Figure 7.4: User page	73
Figure 7.5: Reservations	74
Figure 7.6: Booking	74
Figure 7.7: Server Login	75
Figure 7.8: Downloading	76

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Chapter 1

1 Introduction

1.1 Introduction to Data dissemination and Nanosatellites

As my thesis is entitled “**Data Dissemination Tools for University Nanosatellites**”. Title is combination of two parts a) Data dissemination tools b) University Nanosatellites. Let’s have a brief introduction to these two parts separately.

1.1.1 Data dissemination tools

Data dissemination is the distribution or transmitting of statistical or other data to end users and is getting more and more importance as the technology is advancing day by day. There are many ways organizations use to release data to users. Although the most popular dissemination method today is the non-proprietary open systems using internet protocols but in order to protect our sovereignty and copyright of the data I will choose to disseminate data using proprietary way so that we can avoid unauthorized access to our systems. There are many possible media ways like paper publication, electronic format, fax response to a request, public speeches, press releases etc. According to **SDDS** (Special Data Dissemination Standard) of **IMF** (International Monetary Fund) there are two format categories of dissemination “hardcopy” and “electronic”.

Data dissemination on the internet is possible through many different types of communications protocols. The internet protocols are the most popular non-proprietary open system protocol suite in the world today. They are used in data dissemination through various communication infrastructures across any set of interconnected networks. Despite the name internet protocol, they are also well suited for local area networks (LAN) and wide area network (WAN) communication.

Dissemination tool is any tool or a setup of different tools that can be used to spread data to end user. As such tools are usually very expensive to be afforded by organizations so they make use of already available software products and protocols to make a customized setup for this purpose. To obtain my objective of data dissemination I also have adopted same approach of customized dissemination tool. I am combining some software products and protocols which are free sources to everyone.

Software products used in this project include **Orbitron**, Orbitron is a satellite tracking system for radio amateur and observing purposes. It's also used by weather professionals, satellite communication users, astronomers, UFO hobbyist and even astrologers. Application shows the positions of satellites at any given moment (in real or simulated time). It's free and probably one of the easiest and most powerful satellite trackers. A few features of this application are:

- NORAD SGP4/SDP4 prediction models
- 20000 satellites can be loaded from TLE file(s) and all can be tracked at the same time
- Sun and Moon tracking
- Real-time mode / Simulation mode (free time control)
- Miscellaneous options of visualization
- Nightlife (dark color-scheme for night usage)
- Orbit info

This software works on a computer that is an essential part of a complete hardware system installed on university ground station that is used to control, experiment and collect information from satellites using this software. Path view of a satellite by this software is shown below in Figure 1.

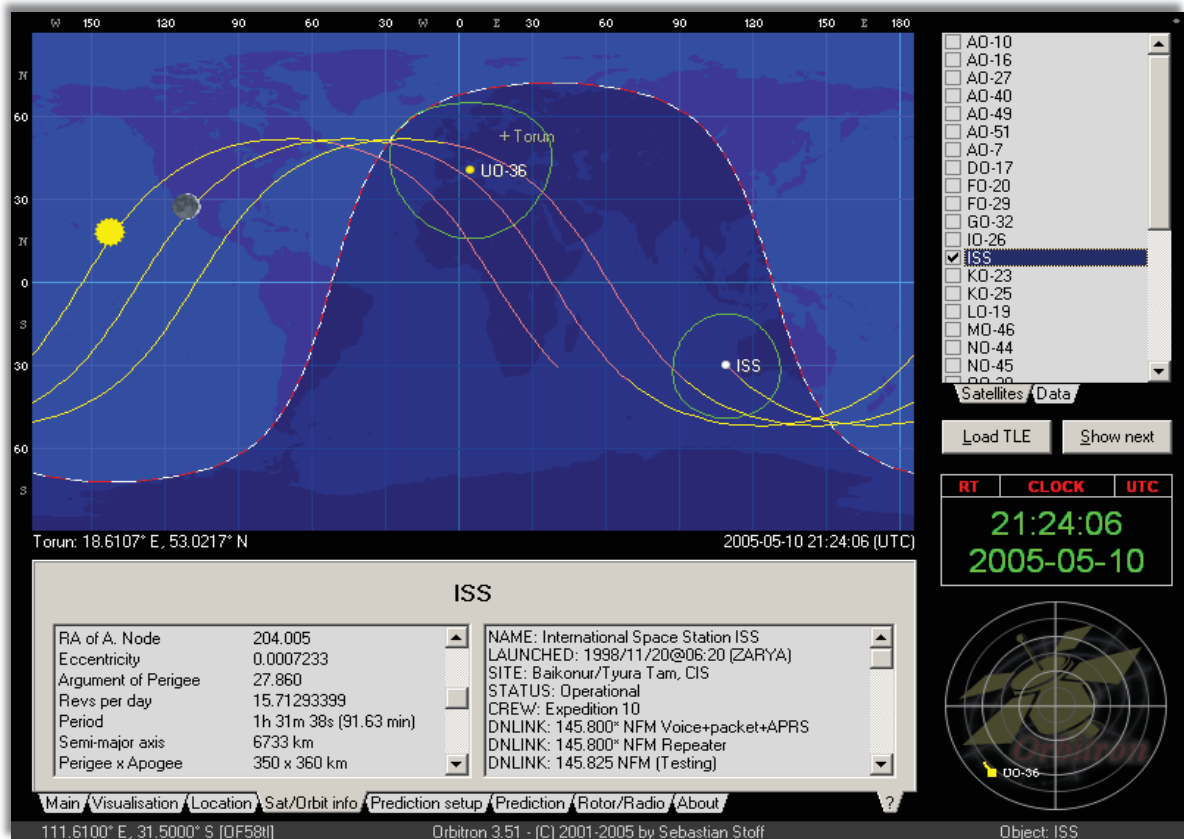


Figure 1.1: Satellite path view

So, communicating tool will grant access of this software product to end users to make all operations defined above depending upon the type of user. Ideas, components and design of this tool will be elaborated later in this document.

1.1.2 University Nanosatellites

A miniaturized satellite is an earth-orbiting device having lower mass and smaller physical dimensions than a conventional satellite, such as a geostationary satellite. Miniaturized satellites have become increasingly common in recent years. They are well-suited for use in proprietary wireless communications networks, as well as for scientific observation, data gathering and the Global Positioning System (GPS).

Miniaturized satellites are often placed in low earth orbits and are launched in groups called "swarms." In this type of system, each satellite operates in a manner similar to a repeater in a cellular communications system. Some miniaturized satellites are placed in elongated (elliptical) orbits.

Miniaturized satellites can be classified according to mass in kilograms (kg) or weight in pounds (lb). A microsatellite (or microsat) masses between 10 kg and 500 kg, a weight range of 22 pounds (lb) to 1100 lb. A **Nanosatellite** (or nanosat) masses between 1 kg and 10 kg (2.2 lb and 22 lb). A picosatellite (or picosat) masses less than 1 kg (2.2 lb).

As there are many advantages of nanosatellites as lower manufacturing cost, ease of mass production, lower launching cost, ability to be launched in groups or "piggyback" along with larger satellites, minimal financial loss in case of failure but they also have many limitations as generally shorter working life, reduced hardware-carrying capacity, lower transmitter output power capability, more rapid orbital decay.

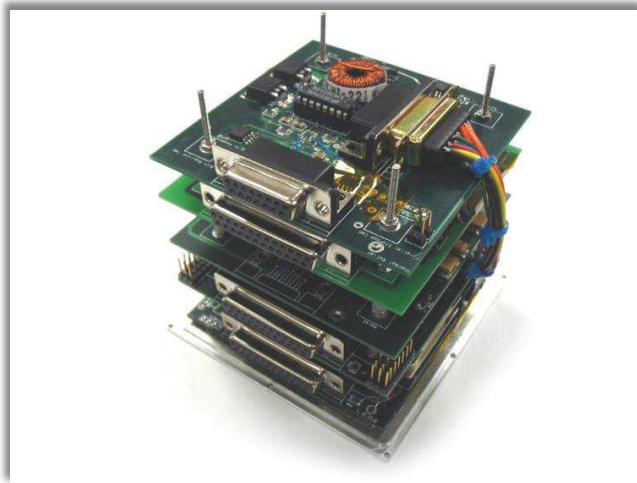


Figure 1.2: Nanosatellite

So the title “Data Dissemination Tools for University Nanosatellites” means to provide all or partial information from these nanosatellites to end users regarding their type of control.

1.1.3 Ground station

A ground station, earth station, or earth terminal is a terrestrial radio station designed for extra planetary telecommunication with spacecraft, or reception of radio waves from an astronomical radio source. Ground stations are located either on the surface of the Earth or in its atmosphere. Earth stations communicate with spacecraft by transmitting and receiving radio waves in the super high frequency or extremely high frequency bands (e.g., microwaves). When a ground station successfully transmits radio waves to a spacecraft it establishes a telecommunications link and vice versa. A principal telecommunications device of the ground station is the parabolic antenna. Specialized satellite earth stations are used to telecommunicate with satellites like chiefly communications satellites. Other ground stations communicate with manned space stations or unmanned space probes. A ground station that primarily receives telemetry data, or that follows a satellite not in geostationary orbit, is called a tracking station.

Ground station has few components including internal Hardware, Cameras and Antennas. All components are shown in figures here and will be discussed in details later in Chapter 5.



Figure 1.3: Cameras

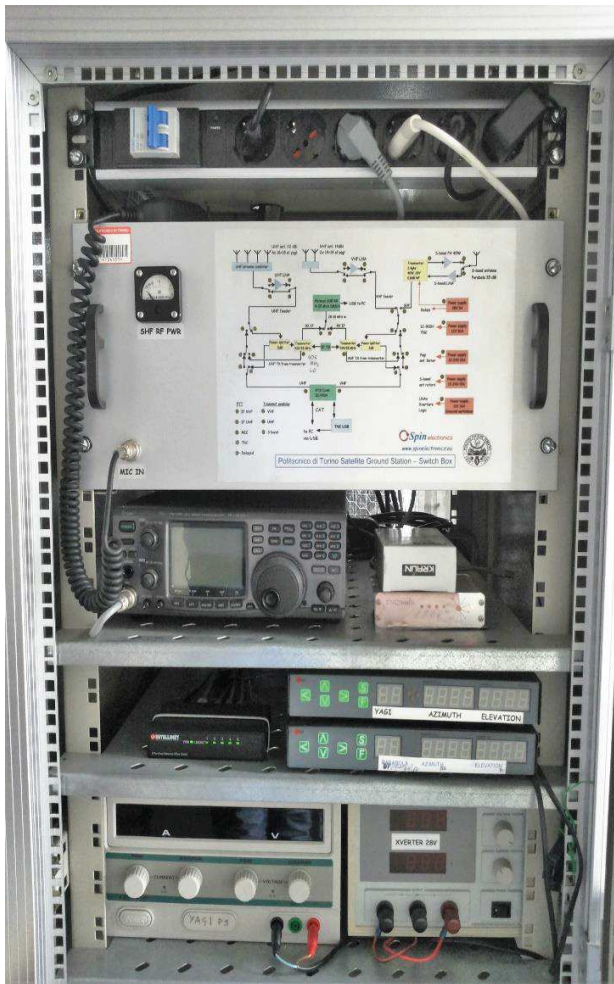


Figure 1.4: Internal hardware



Figure 1.5: Parabolic antenna



Figure 1.6 Yagi antenna

1.2 Thesis organization

Thesis is organized in seven chapters. Every chapter describes some specific topics as first chapter of *Introduction* introduces about nanosatellites and ground station.

Second Chapter named as *Problem Statement and Solution Design* states the project problem describing whole work scenario with solution design.

Third chapter named as *Website: a communicating/dissemination tool* is all about website which is a secure way of communication between user and ground station. This chapter discusses purpose and need of website in the project.

Fourth chapter named as *Orbitron: the central software* describes all the features and working of this software. It's a free source software a satellite tracking system for radio amateur and observing purposes. It's also used by weather professionals, astronomers, satellite communication users, UFO hobbyist and even astrologers. This is central software of my project that is source of all the transmissions and information from ground station to satellite and vice versa.

In chapter five named as *Remote Spark: gateway to ground station* is also another free source software I am using is actually a gateway to ground station which passes all the traffic and communication between website and ground station. It works as an authenticator and also responsible for secure communication between users from website and ground station.

Chapter six, *System Architecture and Configurations (Admin Manual)* shows the complete system architecture of project. It also describes components and their working in details. Finally it shows the results, of experiments made on ground station by a random user, in the form of screenshots.

As Security is a very hot issue and key point of all communications. This chapter also discusses *Security Matters*: the importance need of security and also discusses its types and implementations in the project. This is very important part of the project that assures to avoid all insecurities and keeps whole system safe from unauthorized access.

Second last Chapter 7 named as *System Specifications and Guidelines (User Manual)* gives a complete features of this project and describes specifications of every part of system and also contains a complete usage guideline called user manual that states each and every procedure to work on this system.

Every job is not a complete job. It opens doors to new work and research so in last chapter of *Conclusions and Future Improvising* I am giving some ideas for future improvement of this work which can be used to make this system ore reliable and efficient in terms of work, security and user friendly.

Chapter 2

2 Problem Statement and Solution Design

2.1 Problem statement

There is a complete setup installed on the university roof that is controlling University Nano-satellites, may be known as control system for these Nanosatellites. This control means to control the functionalities and positions of these Nano-satellites. Functionalities include perform operation on given instructions, collection of information and sending back to ground station. Timing and sequence of all these functions may vary depending upon the instructions given by the control system on ground station. As mentioned above I am using a few software products to work on my control system properly and perform all the operations with reliability. This whole setup is an investment and contain good resources but only available locally for all users who want to make use of this setup has to visit ground station to get their job done. So if we are not making benefit of these resources properly then it is useless to have such an investment.

There can be much more reasons to make this setup useful but I am only interested in objective of making these resources available to authenticated users anywhere in the world so that they can make benefit of these resources and get their jobs done. I have to make sure of some key points of our problem as listed below

- Availability of resources to end users
- Authenticated users to avoid unauthorized access
- Limited control on resources to keep them safe
- Access to provided software products only
- Reservation of timeslot before or on time (if available)
- No access before or after reserved timeslot
- Secure communication between user and resources

That's the main objectives of this project. Let's go to solution design topic below to find how I made this objective achievable.

2.2 Solution design

So start is to make a link of users to ground station, idea is to make a web based complete reservation system through which user can reserve a timeslot of his own choice (if available) to access ground station and also to authenticate user. Then connecting that authenticated user to ground station via a secured communication between that web terminal and ground station. Next to publish those software to user making available for him to explore, make experiments on satellites and collect data and also make sure that user do not affect the resources.

2.2.1 Step 1: Web based reservation system

I developed a complete website putting some general information about Nanosatellites. I worked in PHP, Java and HTML programing languages providing signup procedure to any user who wants some information about satellites. Then after log on to website user goes to his page where he finds

some more specific information about university satellite and ground station and also he can see the reservations made by him or any other user(s) just to remind him about his reservations. There he also finds some instruction manual for time slot reservation and how to use software on ground station to make experiments and collect data. Actually he has a complete guide of booking system and of working on ground station. Also user can reserve more than one time slots (if available) in case he wants to work for more time.

For the security reasons I save all the information about user in my database and authenticate him by own. User makes a reservation from his page and he sees his reservations table on his page that is updated indicating his booking is succeeded. We also make sure that he cannot connect to ground station before or after his reserved time slot. Here he must choose a session name and password for connecting to ground station. More than one user cannot have same session name even a single user cannot have same name for more than one sessions. One session has maximum duration of one hour.

2.2.2 Step 2: Publication of software products

In this phase the software products are published to user so that he can use these apps and make his required tasks. To do all this I am using Remote Desktop web access feature of Microsoft Server 2012 R2. This setup includes installation of a server with two roles of a) Domain Controller (DC) and b) Remote Desktop Server (RDS). RDS publishes software products and provides web interface of these apps to user. DC controls all this communication between user and RDS, authenticates user and ensures encrypted communication. Once user is authenticated he can use any software product available to him regarding his type and level of authorized control. As explained in step 1.3.2, I am using Spark View.

2.2.3 Step 3: Security matters

Security matters are very important for every point of view. User also must be secure that his communication is encrypted, none can attack his communications and he is connected to original website or ground station. This avoids the shadow server attack. Similarly on the other hand it must be assured that an authenticated user is connecting to ground station to avoid unauthorized usage of resources. All the information is exchanged using asymmetric encryption. User level authentication and Server level authentication are made sure. To make sure all this all the traffic from website to ground station passes through a gateway. I am using **Spark View** (HTML 5 solution by RemoteSpark) as gateway.

Spark View includes the gateway (a WebSocket/HTTP server) and client side JavaScript library. The gateway allow user connect to your internal hosts (Supports RDP, RFB, SSH, TELNET protocols) with only a browser. You can easily integrate the client side JavaScript library into your web applications.

Spark View is installed on a normal computer having Microsoft Windows operating system (XP, Vista or any later version of windows). It keeps the record of published software products and as user tries to connect it authenticates user's credentials from Domain Controller and takes user to software products page that are available for that user. At this page user can run the software and work per his remaining time period he already reserved. User must save all his work before he

closes running program as closure will end his session for that product and he/she will lose all the work done. I have a complete chapter below where more detailed features and workings of Spark View are explained.

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Chapter 3

3 Website: a communicating/dissemination tool

A website, also written as web site or simply site, is a set of related web pages typically served from a single web domain. A website is hosted on at least one web server, accessible via a network such as the Internet or a private local area network through an Internet address known as a uniform resource locator (URL). All publicly accessible websites collectively constitute the World Wide Web.

3.1 Ideas and techniques

Here comes the idea of having website as a communication tool between user and ground station. This topic explains a bit about webpages and working of website. The main idea and working of all the project has already been briefed above website is an interface of communication and I have to make sure authorized users are connecting to ground station so to have a website and a complete registration and reservation system was the main objective of website then I worked on this idea.

Website has a *Homepage* that contains a general information about satellites and ground station, a *Satellite Imagery* page that shows some pictures captured by satellites and a page of *Operation Information* that describes the working of satellites and software products used to operate these satellites. Then we have *User registration and booking system* where any user can register and only a registered user can book a timeslot (if available) to use ground station resources to get his job done. Once user reserves a timeslot with a session name and password, user may use same password used for general login to website, he can connect to ground station. All is explained in more details below.

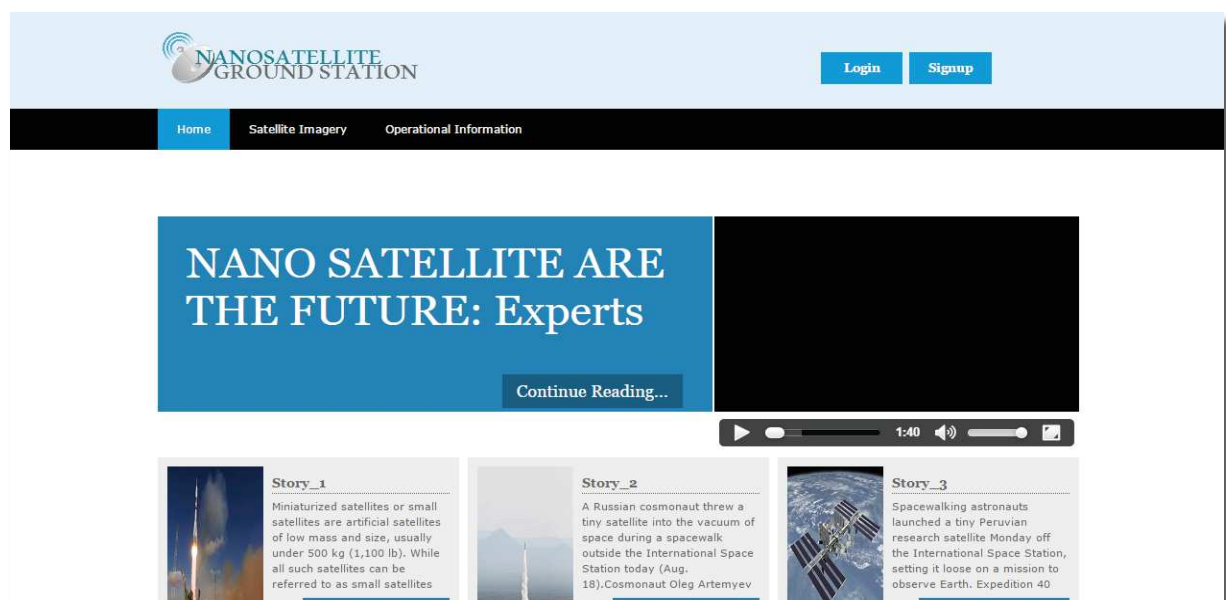


Figure 3.1: Homepage

3.2 Webpages design

To design webpages I used Adobe Dreamweaver as web developing tool with scripting languages PHP and Java. The idea was to achieve the goal with a simple website then upgrading it later making more professional and increasing quality of graphics. Also making my codes more secure, efficient and reliable.

3.2.1 Dreamweaver: web developing software

Dreamweaver was created by Macromedia in 1997 and they maintained it up to 2005, since then it is a proprietary web development tool of Adobe Systems as they acquired it in 2005. Adobe Systems are improving this software day by day and the most recent version of this tool is much more compliant with World Wide Web Consortium (W3C) standards. It supports latest web technologies like JavaScript, Cascading style sheet (CSS) and also server side scripting languages and frameworks including ASP (ASP JavaScript, ASP VBScript, ASP.NET C#, ASP.NET VB), ColdFusion, Scriptlet, and PHP.

As website development is not objective of this project but a part of solution so I started learning to use this tool by tutorials available online. It is very helpful tool to write an efficient code and design styles for the web page. While developing a webpage it becomes easy to work using this tool.

3.3 Coding languages

In our project mainly I have coded in two scripting languages PHP and JavaScript. I learnt basic PHP and JavaScript languages by *W3Schools*, a free website with great tutorials on all web developing languages. W3Schools made it very easy to learn and practice our code in a very short time period. I have been very successful in developing a basic level website with a few web pages to get my objective done.

3.3.1 PHP: Hypertext Preprocessor

PHP is a server scripting language, and a powerful tool for making dynamic and interactive Web pages. PHP is a widely-used, free, and efficient alternative to competitors such as Microsoft's ASP.

PHP code is interpreted by a web server with a PHP processor module which generates the resulting web page: PHP commands can be embedded directly into an HTML source document rather than calling an external file to process data. It has also evolved to include a command-line interface capability and can be used in standalone graphical applications.

PHP language was created in 1995 and designed for web development but also used as a general purpose programming language. Originally created by Rasmus Lerdorf in 1994, the reference implementation of PHP (powered by the Zend Engine) is now produced by The PHP Group.

PHP code can be simply mixed with HTML code, or it can be used in combination with various template engines and web frameworks. PHP code is usually processed by a PHP interpreter, which is usually implemented as a web server's native module or a Common Gateway Interface (CGI) executable. After the PHP code is interpreted and executed, the web server sends resulting output to its client, usually in form of a part of the generated web page; for example, PHP code can

generate a web page's HTML code, an image, or some other data. PHP has also evolved to include a command-line interface (CLI) capability and can be used in standalone graphical applications.

3.3.2 JavaScript:

JavaScript is a dynamic programming language. It is most commonly used as part of web browsers, whose implementations allow client-side scripts to interact with the user, control the browser, communicate asynchronously, and alter the document content that is displayed. JavaScript is also considered an "assembly language of the web" – a compile target of source-to-source compilers – for making client side web applications, using other programming languages, supported by all the major browsers without plug-ins. It is also used in server side network programming with runtime environments such as game development and the creation of desktop and mobile applications.

JavaScript is classified as a prototype based scripting language with dynamic typing and first class functions. This mix of features makes it a multi paradigm language, supporting object oriented, imperative and functional programming styles.

Despite some naming, syntactic, and standard library similarities, JavaScript and Java are otherwise unrelated and have very different semantics. The syntax of JavaScript is actually derived from C, while the semantics and design are influenced by the Self and Scheme programming languages.

3.4 User registration and booking system

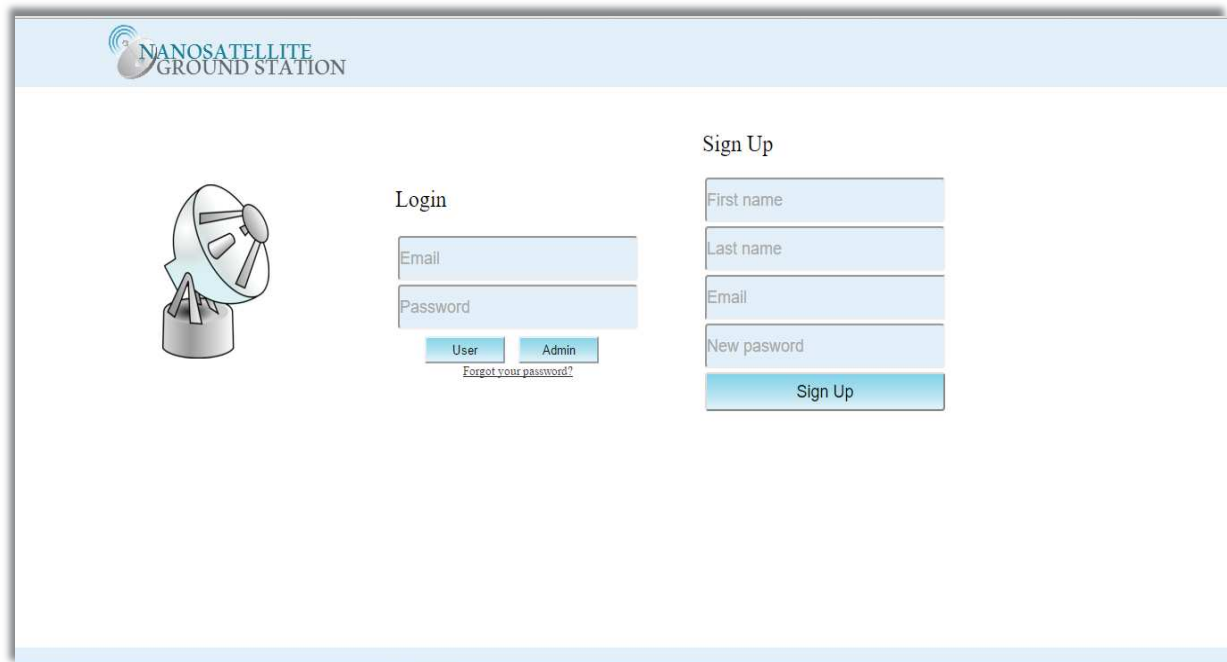
Despite providing general information, specifications, working, features and other useful data about nanosatellites, user registration and booking system is the main objective of this website. Anyone can register on website to have a more specific information about ground station, installed software products and hardware, guideline and instructions to use these products and reserve a timeslot to make benefit of installed hardware for his work and experiments using these software products. To make this all very simple and easy we have a procedure of few steps that is


- Go to login/signup page from Home page
- Provide your credentials to get registered
- Login to website to go to your personal page
- Reserve your timeslot to work on ground station
- Provide booking credentials to connect to ground station
- Strictly follow guidelines to get your work done and save work


We divide above procedure in on three pages *Login/Signup page*, *User page* and *Server page*

3.4.1 Login/Signup page

At the home page there is a login/signup tab that takes visitor to login/signup page where user can either login to his page or can sign up if he is not registered user on website. Below is the screenshot of this page.







Login

User
Admin

[Forgot your password?](#)

Sign Up

Sign Up

Figure 3.2: Login/Signup page

3.4.2 User page

User page is a page on website that contains information of that specific user including his name and email id. Actually this page is all about user on which he can reserve a time slot to work on ground station and this page also shows his previous and forthcoming reservations as shown in the picture below.





Welcome
sharjeelhayatkhan@gmail.com
[Logout](#)

Educational Network for Satellite Operations

The Global Educational Network for Satellite Operations (GENSO) is forming by a worldwide network of ground stations and spacecraft which can interact via a software standard. The GENSO aims to increase the return from educational space missions and changed the way that these missions are managed, dramatically increasing the level of access to orbital educational spacecraft. In November, 2007, a kickoff meeting was held at the CubeSat workshop. This short presentation (at Aalborg University in Denmark) to the rest of the GENSO groups described work at Cal Poly for the project. This workshop kicked off the Alpha Test phase of the project. The entire project was successfully demoed in front of a live audience (us), and it worked beautifully. The Mission Control Client booked downlink sessions with the Ground Station Server, and the Ground Station Server controlled the radio and rotors at the AAU ground station (across the building). The running Authentication Server authenticated people and registered satellites on the network.

In Feb. 2009, the ROBUSTA project joined the GENSO initiative. ROBUSTA is the first French university CubeSat. The objective of the payload experiment is to measure the radiation induced degradation of electronic devices. Flight data will be compared to the results of a novel prediction method taking into account the Enhanced Low Dose Rate Sensitivity. The second interesting point of this project is that it's a real educational project. Although the system hasn't yet grown to the hundreds of ground stations identified in Alexandru Munteanu's Thesis from 2009, testing and integration continue to proceed. The GENSO project initiated under the guidance of the International Space Education Board (ISEB) has many existing capabilities and is accumulating the interest of large groups inside and outside of the United States. However, it is still lacking a fully equipped ground station that can complement its capabilities.

Ground Station

Booking

Booking succeeded.....!!

Login

Ground Station Status

Your Bookings				
Date	Time	You	Session	Delete User
2016-07-12	20:00:00	sharjeelhayatkhan@gmail.com	sharjeelkk	<input type="button" value="Delete"/>
2016-07-14	20:00:00	sharjeelhayatkhan@gmail.com	sharjeelsh	<input type="button" value="Delete"/>
2016-07-16	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel ds	<input type="button" value="Delete"/>

Figure 3.3: User page

Educational Network for Satellite Operations

The Global Educational Network for Satellite Operations (GENSO) is forming by a worldwide network of ground stations and spacecraft which can interact via a software standard. The GENSO aims to increase the return from educational space missions and changed the way that these missions are managed, dramatically increasing the level of access to orbital educational spacecraft. In November, 2007, a Kickoff meeting was held at the CubeSat workshop.

This short presentation (at Aalborg University in Denmark) to the rest of the GENSO groups described work at Cal Poly for the project. This workshop kicked off the Alpha Test phase of the project. The entire project was successfully demoed in front of a live audience (us), and it worked beautifully. The Mission Control Client booked downlink sessions with the Ground Station Server, and the Ground Station Server controlled the radio and rotors at the AAU ground station (across the building). The running Authentication Server authenticated people and registered satellites on the network.

In Feb. 2009, the ROBUSTA project joined the GENSO initiative. ROBUSTA is the first French university CubeSat. The objective of the payload experiment is to measure the radiation induced degradation of electronic devices. Flight data will be compared to the results of a novel prediction method taking into account the Enhanced Low Dose Rate Sensitivity. The second interesting point of this project is that it's a real educational project. Although the system hasn't yet grown to the hundreds of ground stations identified in Alexandru Munteanu's Thesis from 2009, testing and integration continue to proceed. The GENSO project initiated under the guidance of the International Space Education Board (ISEB) has many existing capabilities and is accumulating the interest of large groups inside and outside of the United States. However, it is still lacking a fully equipped ground station that can complement its capabilities.




Ground Station

Booking

2016 ▾ 07 ▾ 16 ▾
20:00:00 ▾

Booking succeeded...!!!

Login

Ground Station Status

Your Bookings

Date	Time	You	Session	Delete User
2016-07-12	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel kk	<input type="button" value="Delete"/>
2016-07-14	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel sh	<input type="button" value="Delete"/>
2016-07-16	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel ds	<input type="button" value="Delete"/>

All Bookings





Date	User Id	Session	Time
2016-07-12	sharjeelhayatkhan@gmail.com	sharjeel kk	20:00:00
2016-07-14	sharjeelhayatkhan@gmail.com	sharjeel sh	20:00:00
2016-07-16	sharjeelhayatkhan@gmail.com	sharjeel ds	20:00:00

Figure 3.4: Reservations of all users

3.4.3 Server page

Server page is actually link to ground station resources user comes to this page if he already has made a reservation for this time slot. This page is also controlling user's time on ground station and warns him about remaining time on server and takes session down as his time slot is expired. Here he finds a link to ground station where he finds his applications and can run any application issued to him. A snapshot is shown below

My Computers and Programs:

Calculator
Control_Box
Orbitron
Paint

▾
☒ Open in existing window

Figure 3.5: Server page

3.5 Database

I created a database on the server to store user credentials. I divided this database into three tables named as *Admin*, *Users* and *Bookings*. Admin table contain credentials about the admin and also about the user who have been approved as admin. Users table contains credential details about users who will register on website and these credentials will be used to get users login to website. Bookings table keeps the details of server reservations date and time including the credentials of user who has reserved time slot.

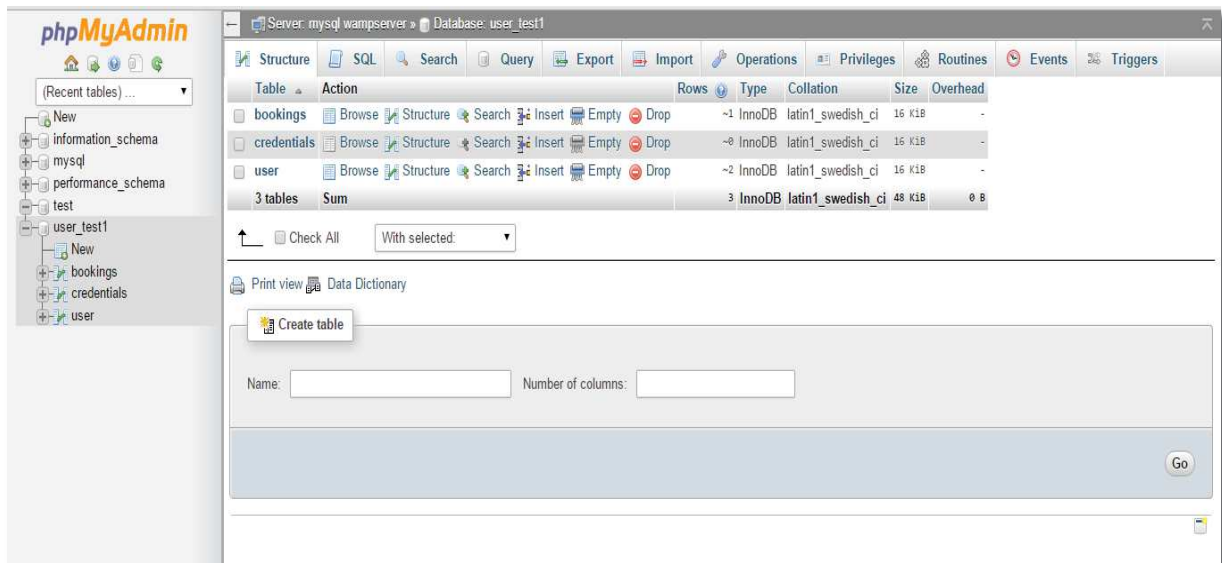


Figure 3.6: Database and Tables

Chapter 4

4 Orbitron: shared software

4.1 Orbitron

Orbitron is a very good satellite tracking system for radio amateur and observing purposes. It's also used by weather professionals, satellite communication users, astronomers, UFO hobbyist and even astrologers are making benefits of this software.

It shows the positions of satellites at any given moment (in real or simulated time). It's free and one of the easiest and most powerful satellite trackers, according to opinions of thousands of users from all over the world. This software is being updated continuously and being made more efficient. I captured a few screenshots as shown

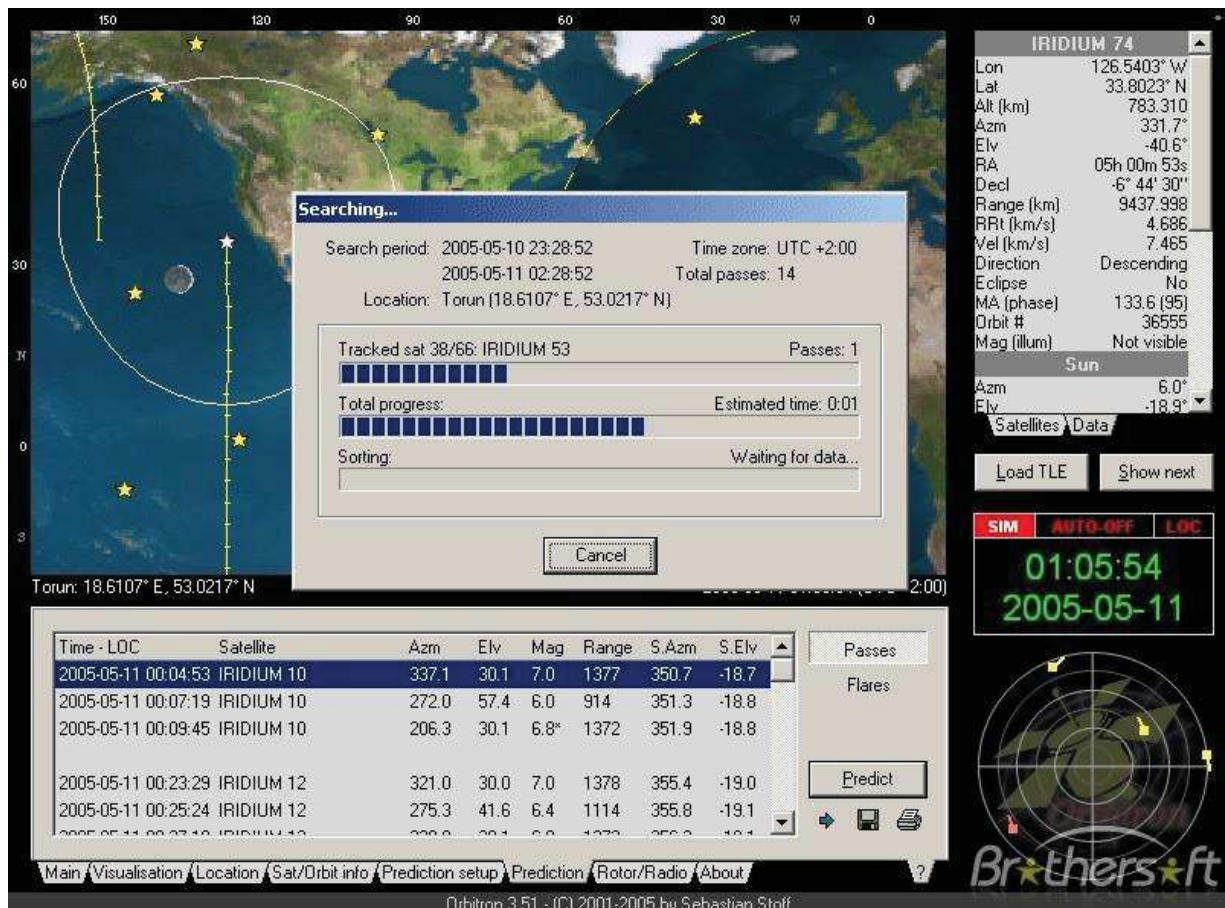


Figure 4.1a: Orbitron

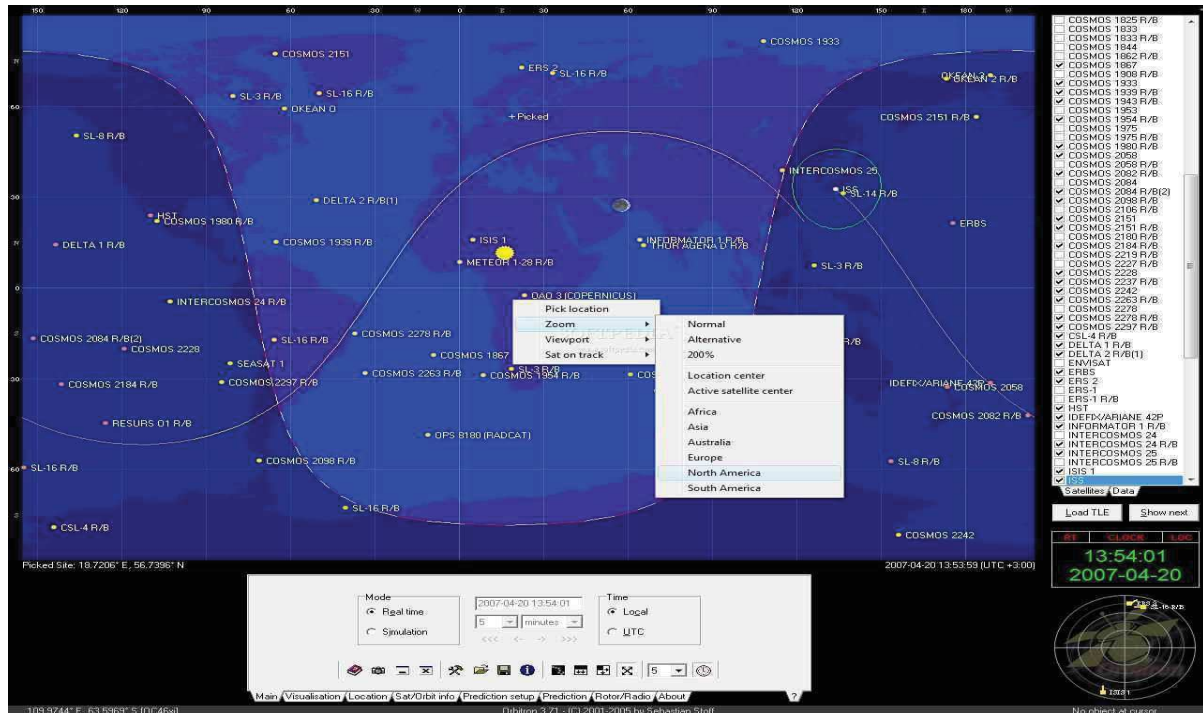


Figure 4.1b: Orbitron

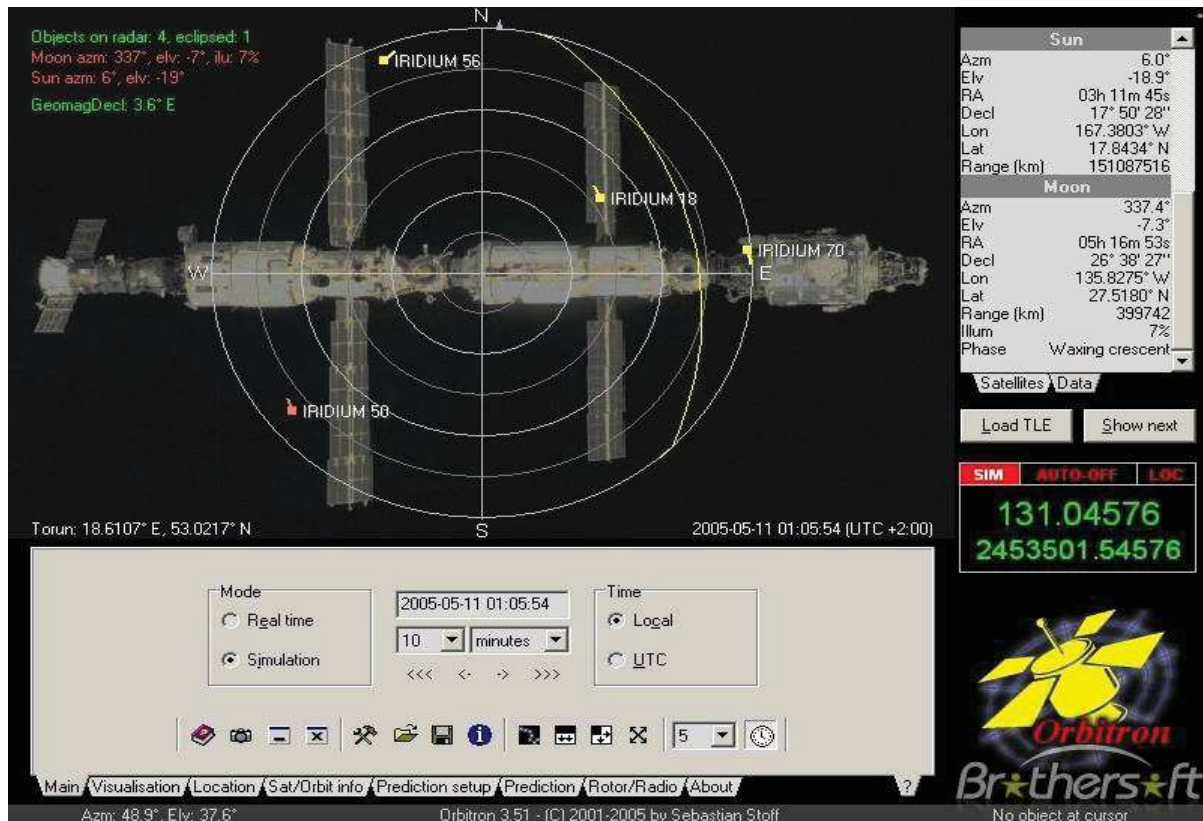


Figure 4.1c: Orbitron

4.1.1 What is a satellite tracking system?

Any system that is used to track a satellite is known as satellite tracking system. Here tracking means to watch the nanosatellite and see its position, movement direction, speed and time (real or estimated). I am using Orbitron which has much more features including these.

Due to predictable conditions of satellite movement in space (lack of atmosphere) computer software can calculate a satellite's position for given moment. Calculations are done based on known orbit parameters determined at epoch. Known orbital parameters like inclination, eccentricity, argument of perigee, mean motion (revolutions per day), we track satellite for a reasonable period of time after epoch. Orbital data for each object is grouped, and distributed as a Two Line Element (TLE) file.

4.1.2 Features and working capabilities

Orbitron has many features few of those are as follows

- NORAD SGP4/SDP4 prediction models
- 20,000 satellites can be loaded from TLE file and can be tracked simultaneously
- Sun and Moon tracking
- Full-screen, presentation modes
- Supported screen resolutions from 640x480
- Real-time mode / Simulation mode (free time control)
- Advanced passes & Iridium flares search engine (results printing)
- Miscellaneous options of visualization
- Nightlife (dark color-scheme for night usage)
- Orbit info
- Notes for each object
- Radar
- Easy, flexible interface
- Database of cities around the world
- Database of satellite frequencies
- PC clock synchronization via NTP
- Internet TLE updater (with ZIP support) via HTTP
- Rotor/radio control (built-in or user's driver support)
- Windows screen-saver included

NORAD SGP4/SDP4 prediction models are most recent models being used for satellite tracking. There are number of models in use but most commonly used models are SGP4/SDP4 model. These models were developed by NORAD/AFSPC in 1970 for space catalogue use. Officially, these models were published in 1980 when there was found a huge unacceptability of Two-Line Element (TLE). These models are very common because of availability of continued matching orbital elements.

It is VERY IMPORTANT to remember that all orbital models are different, and for accuracy you must use the same theory to propagate the orbital elements as was used to generate them.

Orbitron is easiest satellite tracking system that is much more user friendly. It includes a TLE package by which we can track up to 20000 satellites at the same time including sun and moon tracking. It has many visualizations also for night mode. It has user friendly interface very flexible. It uses NTP for computer clock synchronization. *Network Time Protocol (NTP)* is a networking protocol for clock synchronization between computer systems over packet-switched, variable latency data networks. It also includes huge database of cities from all over the world and database of satellite frequencies. Orbitron has much more other features which can be used for many other purposes I am not explaining as those are beyond this project.

4.1.3 System requirements

Followings are minimum requirements for a hardware and operating system to run Orbitron smoothly. It can give better performance by having better system.

- Windows 9x/2k/Me/XP/2003/Vista, Linux [with Wine emulation]
- 150 MHz processor (300 MHz)
- 16 MB RAM (32 MB)
- 5 MB free space on hard drive
- 640x480 screen resolution (800x600x16 bit)

A system must fulfil these basic requirements to run Orbitron which are found in every hardware these requirements are very less even to run a simple operating system like windows.

All the configurations and working of Orbitron is given in Chapter 5.

4.2 Reasons to book

There are many reasons to reserve to use this software. Actually pre-reservation to work on ground station does not belong only to Orbitron but also belongs to hardware installed. A few reasons are described below

Orbitron support for multiusers: Orbitron does not allow multiusers at same time, more than one users cannot work simultaneously. So it is one of important reasons to book a timeslot to work on it. It is unacceptable situation that more than one users are using same instance of the software at the same time and they get their own required results.

Hardware support for multiusers: same reason as for Orbitron also holds for installed hardware that it is impossible for a single instance of hardware to support more than one user at the same time. It is impossible situation than more than one users are working on the same hardware and it produces results for all of them.

Main reason to reserve a timeslot before one can work on ground station is that I don't want to allow more than one users working on ground station simultaneously. Although I can track every user who is working on at current time but for make our system more reliable and efficient and avoid too much load on our hardware.

Chapter 5

5 Spark View: gateway to ground station

Spark View is an HTML5 solution that provides remote access to resources in a secure way. By access I mean to reach these resources to use. These resources can be a storage to download and upload data, a software product to work on and much more applications. It works very similar to remote desktop clients but with very enhanced features.

5.1 What is Spark View?

Spark view is an HTML5 client without any plugins. Its fastest and best HTML5 solution as compared to other RDP clients. It just takes users to another level because of so many features. It includes a gateway (WebSocket/HTTP server) and a client side JavaScript library that allows user to connect to my internal hosts through a browser. These hosts contains some shared software products like Orbitron users will use.

5.1.1 What is RDP?

Remote Desktop Protocol (RDP) is a proprietary protocol developed by Microsoft, which provides a user with a graphical interface to connect to another computer over a network connection. The user employs RDP client software for this purpose, while the other computer must run RDP server software.

Clients exist for most versions of Microsoft Windows (including Windows Mobile), Linux, UNIX and OSX, iOS, Android and other operating systems. RDP servers are built into Windows operating systems; an RDP server for UNIX and OS X also exists. By default, the server listens on TCP port 3389 and UDP port 3389. Microsoft currently refers to their official RDP server software as Remote Desktop Connection, formerly "Terminal Services Client".

Actually RDP allows users to connect remotely from anywhere to a computer as a user of that computer but I am not using this type of remote access to avoid any problems. I am providing remote access to users through Spark View to make it secure connection and also user does not access system as a computer user but as a remote user who has access to only allowed software products on which he can work in his given session of time.

Spark View has much more preferences on native RDP client explained above.

5.2 Specifications and capabilities

Here I am describing some features of Spark View as follows

- It supports all those browsers which support Web Socket and canvas like Chrome, Firefox, Safari, Opera and Internet Explorer 10
- As it's an HTML solution need no installation on both ends, client and host
- Does not require any plugins to be installed like flash, java etc.
- Works on every device iPad, Android tablets, Smartphones
- Also supports Transport Layer Security (TLS) and Network level Authentication (NLA)

- Can connect to Hyper-V and “Enhanced session mode” from anywhere and any device
- RD web access portal integration: user can login with his username and password
- RemoteApp: allows to use RemoteApp from anywhere in the world
- File sharing: just drag files in or out and get those files shared, easy sharing
- Supports printing and device and URL redirection
- RDP session recording
- Allows user and server management with Active Directory integration, user can login with his domain user account
- Security against DDoS attack and prevention
- Spark gateway required between client and host
- A replacement to native RDP client in operating systems
- Remote assistance, fast evolving and many more features
- International keyboard support

Spark View also supports RFB (VNC), SSH and Telnet protocols.

5.3 Architecture, Work routines & configuration files

Spark View includes 2 components:

- Gateway, which is a WebSocket server and simple web server
- Web resources (HTML files, CSS, JavaScript, images), which can be installed on Gateway or any other web servers.

This diagram describes how the components of Spark View work together.

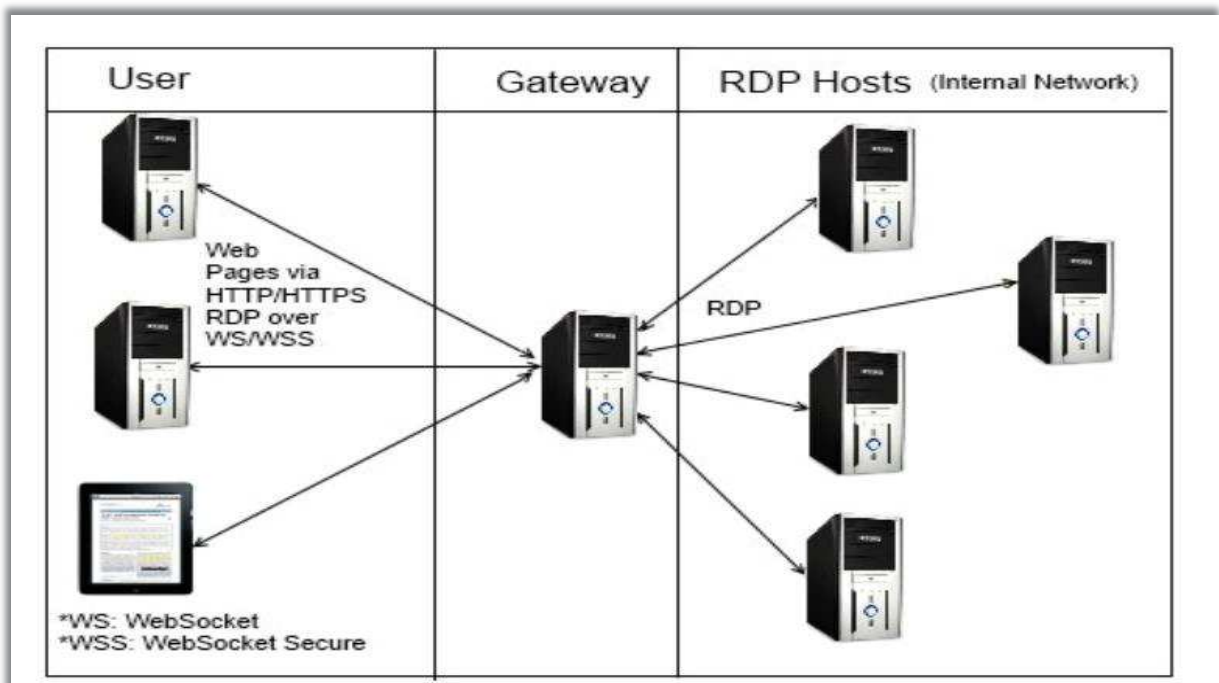


Figure 5.1: SparkView architecture

There are three majors as shown in the figure above

- *Users:* user or client is any device that connects to host passing through gateway, actually user is connecting through browsers from any device and as explained above SparkView supports almost all the devices and allow these devices to connect to hosts via gateway.
- *Gateway:* is an intermediate passage between client and host. It makes sure that there is always a secure and reliable communication between these two parties. No communication can be made if client bypasses this gateway which is SparkView.
- *RDP hosts:* are those servers which are providing resources in the form of data, storage, software products and hardware to clients so that they can work according to their required feasible accesses. RDP host communicates only with gateway not to the client directly.

5.3.1 What's the difference?

Spark View is quite different compared with other similar solutions:

- It is designed to be a replacement of native client, not a complementary solution
- It is designed for speed. It's even faster than our Java applet
- It is feature rich, not feature less as compared with native clients
- Spark View only features
 - RemoteApp (not Start program on connection)
 - Session Recording/Playback
 - Session Shadowing
 - Hyper-V console connection
 - Network Level Authentication
 - Windows 8 and 2012 with touch remoting support
 - RD Web Access Portal Integration
 - OpenID integration
 - Support both PostScript and PCL printers.
 - Support more audio encodings. 80% less bandwidth usage (when playing audio) compared with other HTML5 solutions
 - Client side IME support. You can use client side IME directly (Microsoft RDC doesn't support client side IME).

5.4 Example & testing

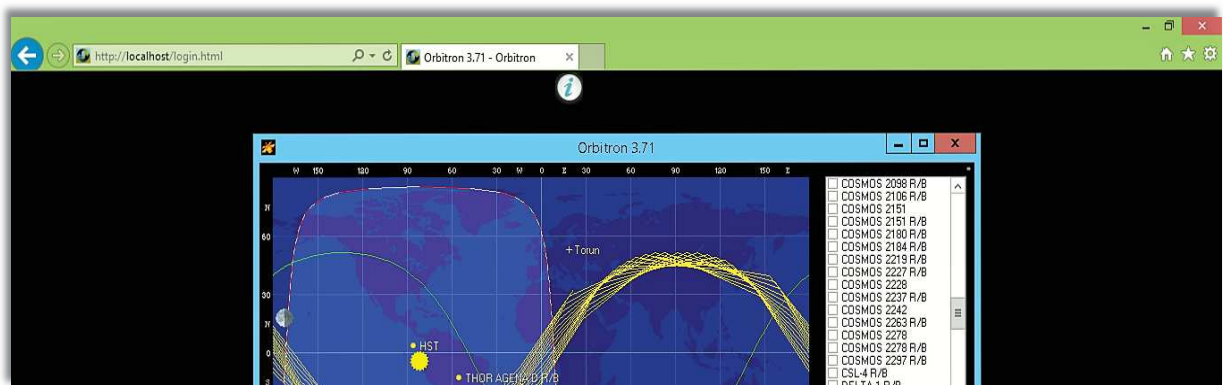
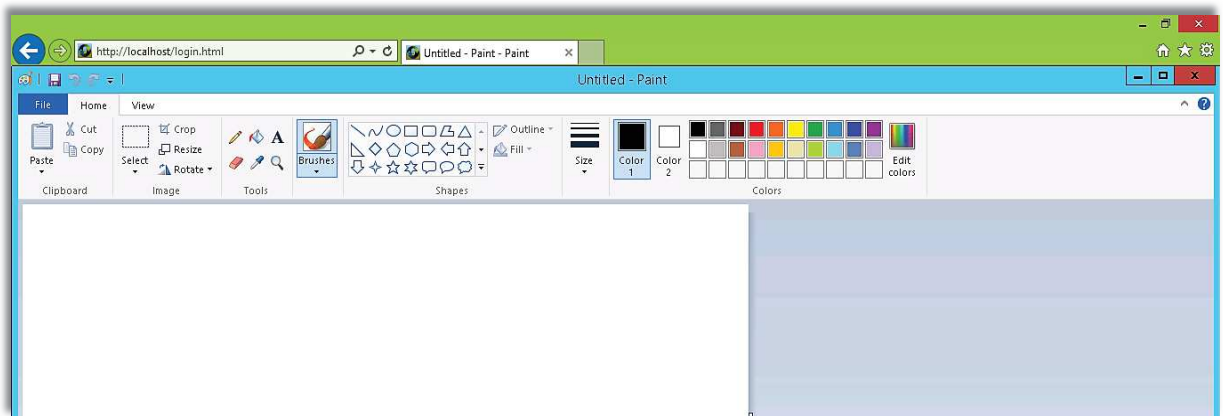
I am using SparkView as a gateway between client and ground station. Clients passing through this gateway can connect to ground station. Once everything is configured properly as described in Chapter 5 and a client connects to ground station (host of apps) he sees a page that has some software apps as shown in the figure below. I named this page as server page in Chapter 2.

He can run any app he wants to work on. As I am having two apps Orbitron and Control box. So on this page I am giving only these two apps. Client can choose app to run in the same page or in another browser window.

Client sees Server page as



Paint app opened in user's browser.



Above figures show the server page of ground station host's shared apps to clients and some operations performed by the user.

Chapter 6

6 System Architecture and Configurations (Admin Manual)

This is main and most important chapter of thesis document that describes whole configurations with complete operational setup and testing examples and finally shows the results in the form of software apps in working condition during user's reserved timeslot.

6.1 Components

This section describes about the components of project. As Project is a complete system that consists of a combination of hardware and software. I am describing every part as following.

6.1.1 Hardware

Hardware components consist of

6.1.1.1 Desktop Computers

I have two desktop computers one installed with Microsoft Windows Server 2012R2 and one with Microsoft Windows 7 Operating Systems installed respectfully. Both systems do not have extra ordinary hardware but basic requirements for running these operating systems smoothly.

6.1.1.2 Controller Rack

I have a controller rack that is major part of the hardware and controls the whole setup installed on ground station. It contains a Control box, Amplifier and Power supply as shown in the figure 5.1. Control box controls movement and direction of antennas. I can change their direction by using a simple control software installed on Server. Amplifier works on signals and used to change the frequency modes and values. Very basic frequency modes are UHF and VHF. Controller software handles everything and I can also switch on and off any device. Power supply maintains the power level for every device to work efficiently and assures to avoid any power issues to devices.

6.1.1.3 Antennas

There are two types of antennas installed. One is parabolic antenna and other is Yagi antenna.

Parabolic Antenna

Parabolic antenna uses a parabolic reflector, a curved surface with the cross-sectional shape of a parabola, to direct the radio waves as shown in Figure 5.2. The most common form is shaped like a dish and is popularly called a dish antenna or parabolic dish. The main advantage of a parabolic antenna is that it has high directivity. It functions similarly to a searchlight or flashlight reflector to direct the radio waves in a narrow beam or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains, that is, they can produce the narrowest beamwidths, of any antenna type. In order to achieve narrow beamwidths, the parabolic reflector must be much larger than the wavelength of the radio waves used, so parabolic antennas are used in the high frequency part of the radio spectrum, at UHF and microwave (SHF) frequencies, at which the wavelengths are small enough that conveniently-sized reflectors can be used.

Parabolic antennas are used as high-gain antennas for point-to-point communications, in applications such as microwave relay links that carry telephone and television signals between nearby cities, wireless WAN/LAN links for data communications, satellite communications and spacecraft communication antennas. They are also used in radio telescopes.



Figure 6.1: Control rack



Figure 6.2 Parabolic antenna

Yagi Antenna

Yagi antenna, also known as a Yagi-Uda array or simply a Yagi, is a directional antenna commonly used in communications when a frequency is above 10 MHz, it is popular among Amateur Radio and Citizens Band radio operators.

It is used at surface installations in satellite communications systems. A basic Yagi consists of two or three straight elements, each measuring approximately $1/2$ electrical wavelength and can be balanced or unbalanced. The Yagi is inherently a balanced antenna, but it can be fed with coaxial cable and a device called a balun at the point where the feed line joins the driven element.

The driven element of a Yagi is the equivalent of a center-fed, half-wave dipole antenna. Parallel to the driven element, and approximately 0.2 to 0.5 wavelength on either side of it, are straight

rods or wires called reflectors and directors. A reflector is placed behind the driven element and is slightly longer than $1/2$ wavelength; a director is placed in front of the driven element and is slightly shorter than $1/2$ wavelength. A typical Yagi has one reflector and one or more directors. The antenna propagates electromagnetic field energy in the direction running from the driven element toward the director(s), and is most sensitive to incoming electromagnetic field energy in this same direction.

The Yagi antenna not only has a unidirectional radiation and response pattern, but it concentrates the radiation and response. The more directors a Yagi has, the greater the so-called forward gain. As more directors are added to a Yagi, it becomes longer. Some Yagi antennas have as many as 10 or even 12 directors in addition to the driven element and one reflector. Long Yagi antennas are rarely used below 50 MHz, because at these frequencies the structure becomes physically unwieldy.



Figure 6.3 Yagi antenna

6.1.1.4 Cameras

There are three IP cameras installed used to see direction and movement of antennas. I can access any camera by its IP which I want to see.

An Internet protocol camera, or IP camera, is a type of digital video camera commonly employed for surveillance, and which, unlike analog closed circuit television (CCTV) cameras, can send and receive data via a computer network and the Internet. Although most cameras that do this are webcams, the term "IP camera" or "netcam" is usually applied only to those used for surveillance. The first centralized IP camera was Axis Neteye 200, released in 1996 by Axis Communications.



Figure 6.4: IP Cameras

6.1.2 Software

Software components consist of

6.1.2.1 Operating Systems

As already described above I have installed two desktop computers one installed with Microsoft Windows Server 2012 R2 and other installed with Microsoft Windows 7. So I used both operating systems by Microsoft.

Windows Server has a service named as Remote Desktop Service that can publish a collection of software applications installed on that computer and one can assign permissions to a user or group of users to access these applications and run on their own computers. I exploited this feature service in my project and published my software products like Orbitron and Control software to users.

6.1.2.2 Orbitron

As I already have described in much details in Chapter 3 that Orbitron is a very good satellite tracking system for radio amateur and observing purposes. It's also used by weather professionals, satellite communication users, astronomers, UFO hobbyist and even astrologers are making benefits of this software.

It shows the positions of satellites at any given moment (in real or simulated time). It's free and one of the easiest and most powerful satellite trackers, according to opinions of thousands of users from all over the world. This software is being updated continuously and being made more efficient. One can see more details about Orbitron in Chapter 3.

6.1.2.3 SparkView

Spark view is an HTML5 client without any plugins. Its fastest and best HTML5 solution as compared to other RDP clients. It just takes users to another level because of so many features. It includes a gateway (WebSocket/HTTP server) and a client side JavaScript library that allows user to connect to my internal hosts through a browser. These hosts contains some shared software products like Orbitron users will use.

I have a complete Chapter 5 on this software so one can see everything about it.

6.2 System Architecture

Here is the complete system architecture that describes the whole working scenario of the system. It also shows all components and their responsibilities.

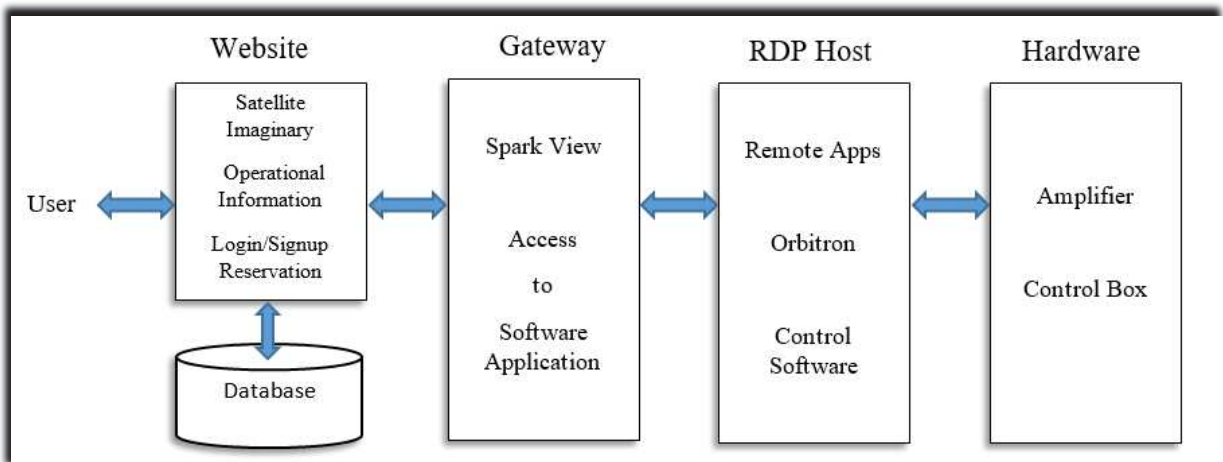


Figure 6.5: System Architecture (logical)

As working features and responsibilities of these components already have been described in previous chapters, so here I will brief shortly.

System Architecture (Physical):

As shown in the figure below that RDP Host (Groundstation) is installed in Panel Room at 5th floor of Department of Electronics and Telecommunications (DET) and it also shows Database, Website, Software Apps and Controller Hardware is also installed and configured with RDP Host. To make any changes or configure something related to RDP Host, Website, database, Software apps or other Hardware he needs to visit this room.

Gateway (Groundstation2) is located 3rd floor of DET in Microelectronics Software laboratory (Laboratorio Software Microelettronica). So if one want to configure SparkView or this system he needs to visit this lab with the permission of Administrator.

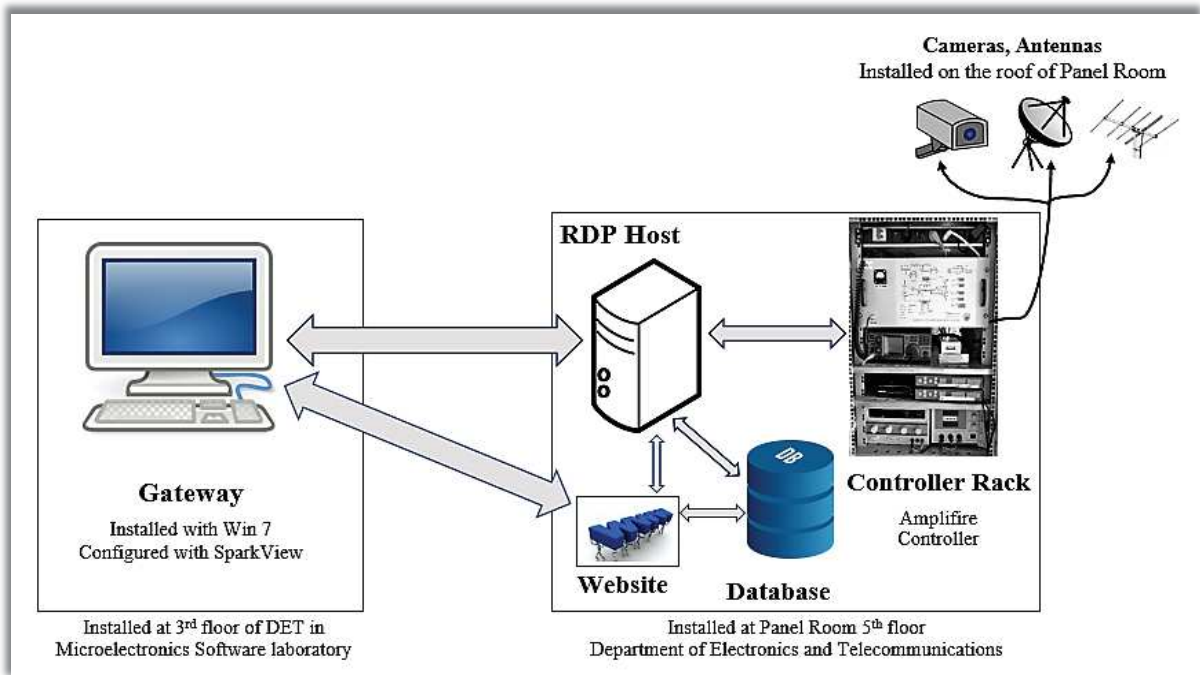


Figure 6.6: System Architecture (physical)

Working procedure:

User is any client who wants to access ground station *Hardware* will sign up and login to *Website* and there he finds all the information about satellites and a reservation tab to book his timeslot on which he will use remote apps. *Website* has a *Database* to store *User*'s credentials and his reserved timeslot information and uses these credentials to authenticate user at the time of login to *Website* and access to ground station *Hardware*.

Gateway is an intermediate node that provides access of software applications or remote apps to *User*. *RDP Host* publishes remote apps and *Gateway* has access to these apps. It makes sure none can access *RDP Host* directly and also assures secure communication between *User* and *RDP Host*.

Remote Desktop Protocol Host is responsible for publishing software products like Orbitron and Controller Software which are used to collect satellite data and control the *Hardware* respectively. User coming from *Gateway* can work on these software apps to perform his jobs and collect results in his reserved timeslot.

Hardware has controller and amplifier, Amplifier works on frequencies to change its working modes and values. Controller controls movement and direction of antennas. It's a short summary of Architecture and working procedure.

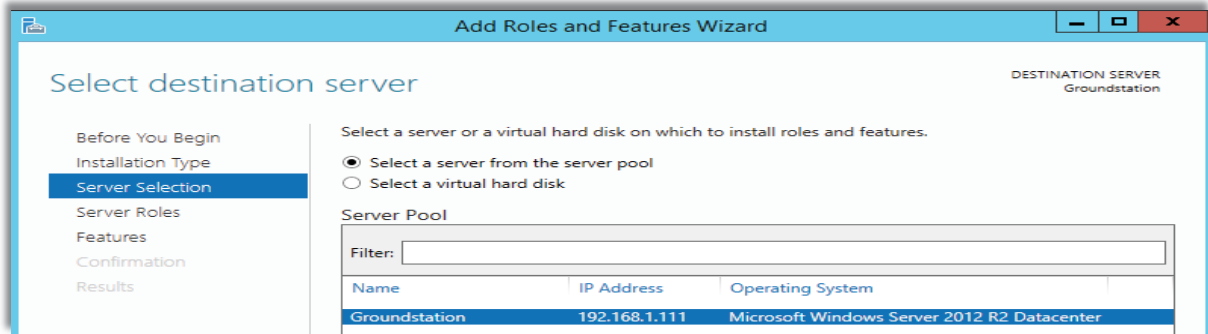
Complete guideline on Hardware installed is given in Annexure A: Satellite Ground Station (Technical Manual).

6.3 Installation guide: step by step

This guide explains every single step taken during installation procedure.

6.3.1 Server installations

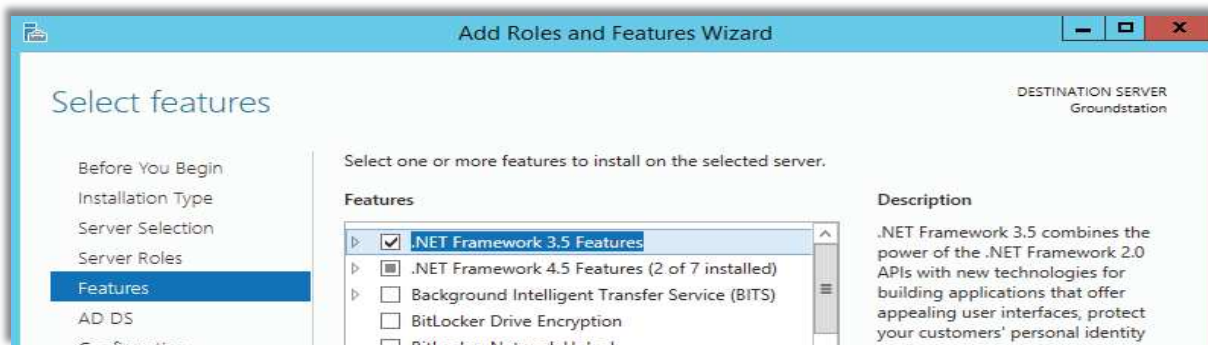
I prepared RDP Host named as Groundstation by following method shown below. Go to Start menu>Server Manager>Add roles and features



Added Active Directory Domain Services as a role



Added .NET Framework 3.5 as a feature



Configured this server as a Domain Controller in a new forest: nsat.local to do this

Select Role-based installation



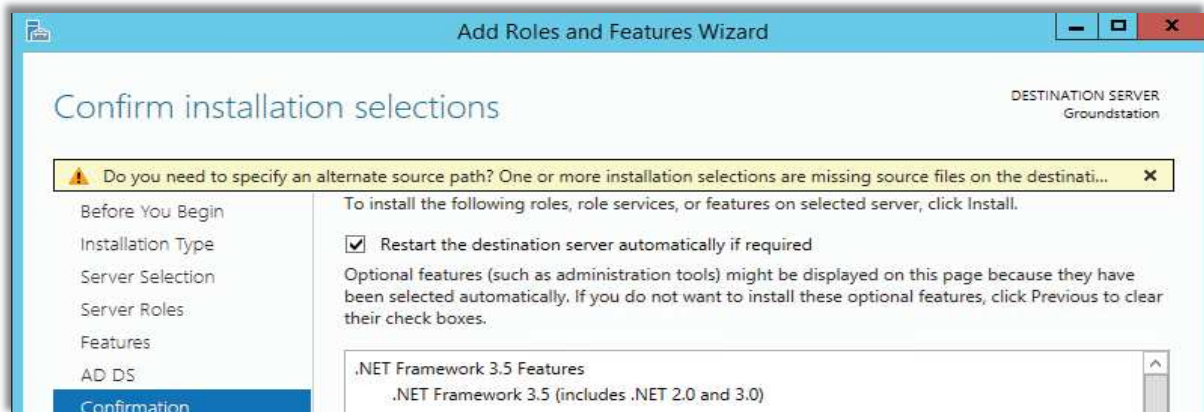
Set a DSRM password



Add a new forest nsat.local



Select Restart checkbox and complete installation.



After completing and restarting computer I am done with this procedure. Now I have to install remote services for this I proceeded as shown below.

Select Remote Desktop Service installations in Add Roles and features Wizard



Select Standard deployment



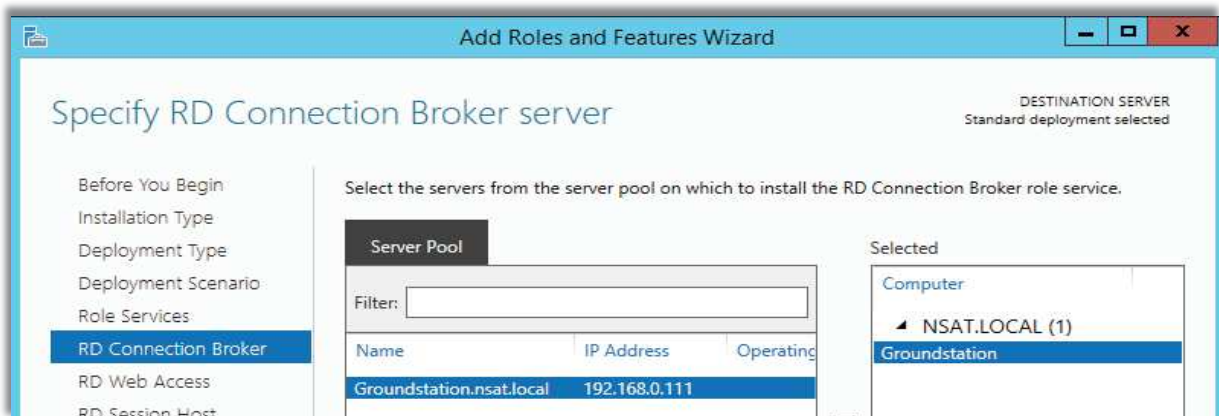
Select Session-based desktop deployment



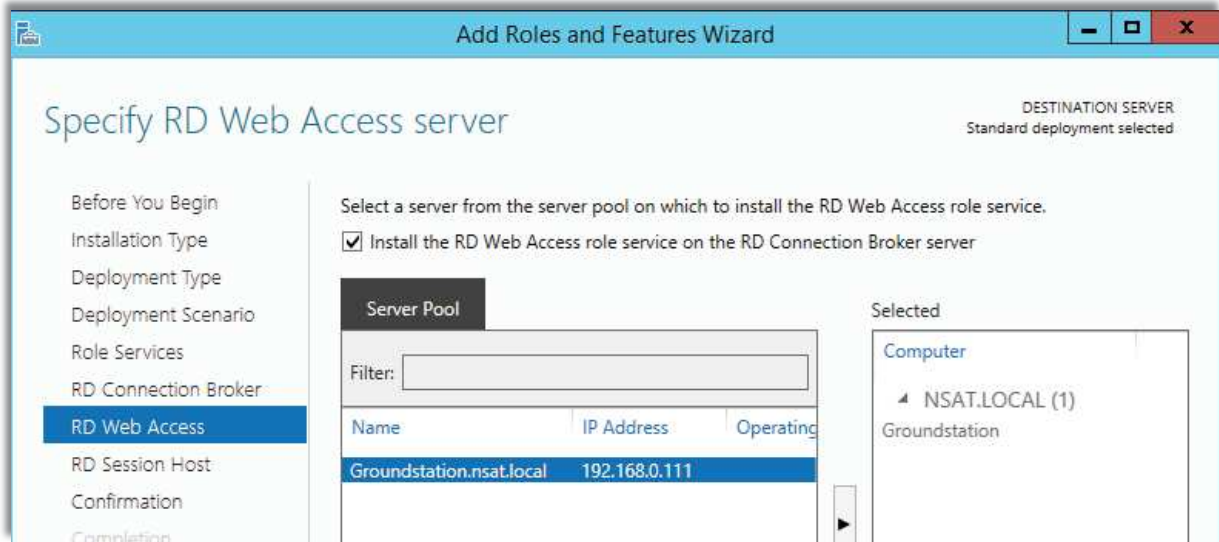
Review Role Services



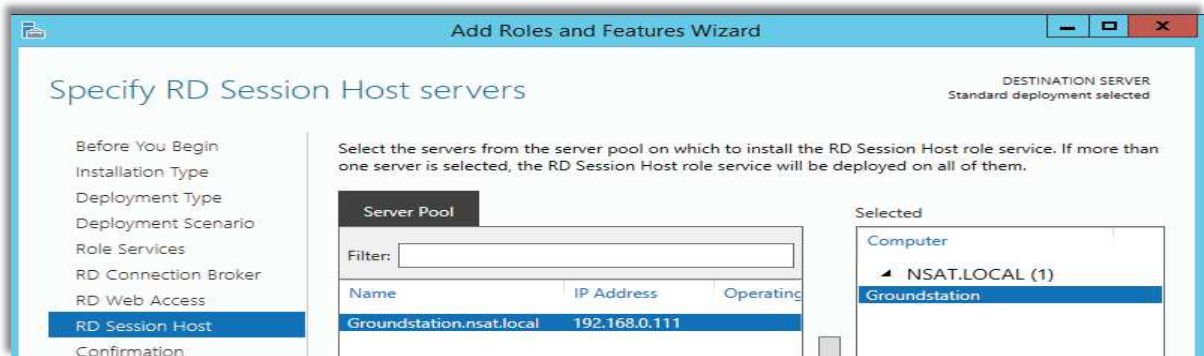
Select RDP Host



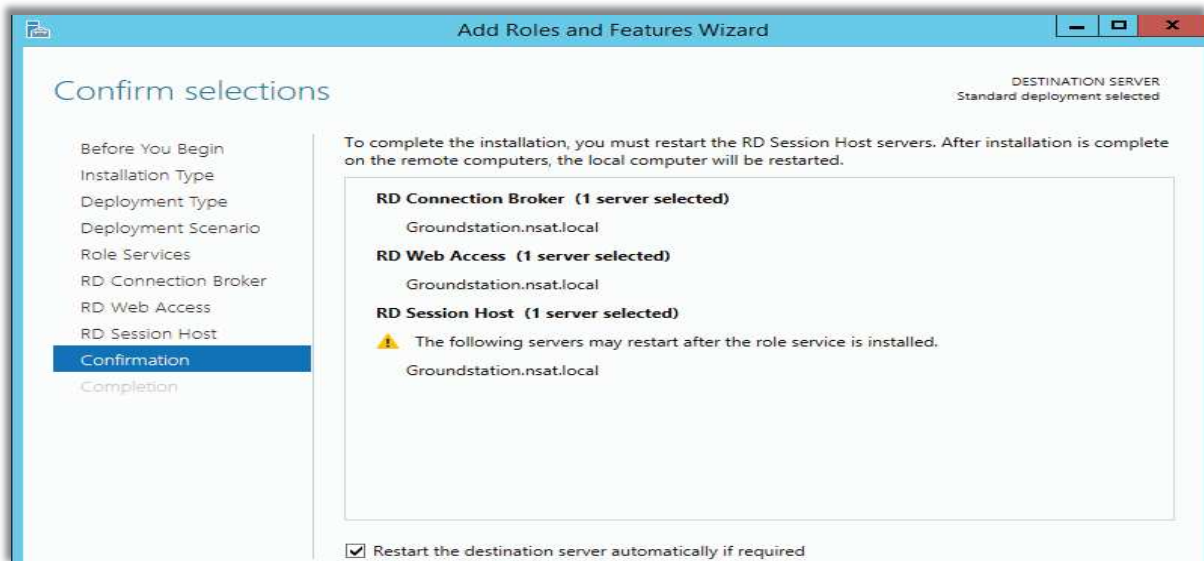
Select checkbox for RD Web Access role service



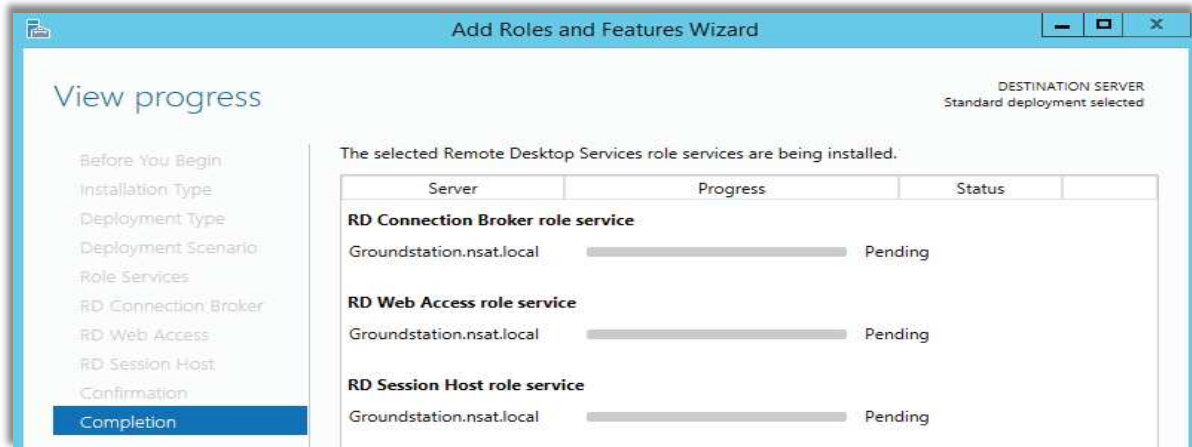
Select RD Session Host



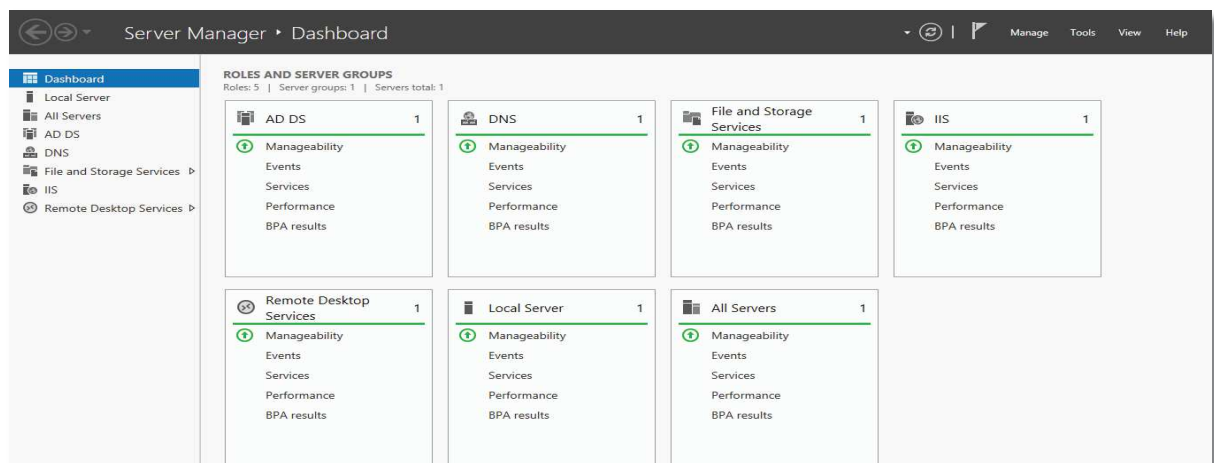
Confirm selections and check restart option.



Wait for completion and restart of machine

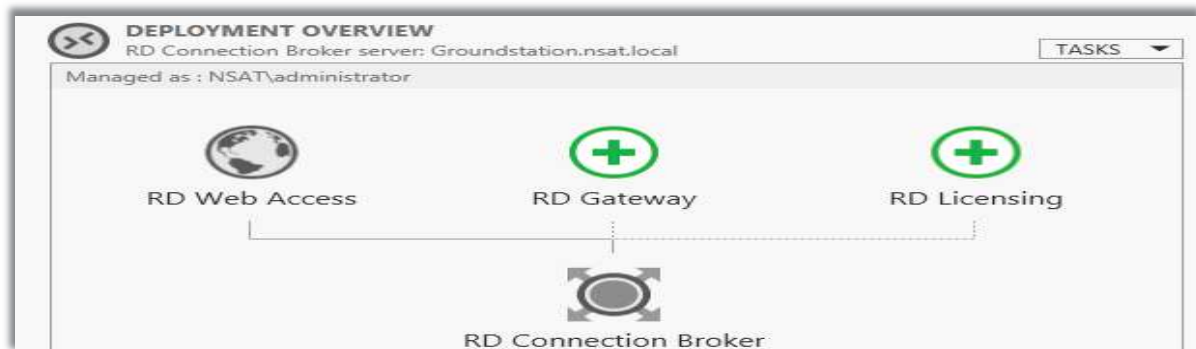


After machine has restarted it completes installations Manager appears as shown below

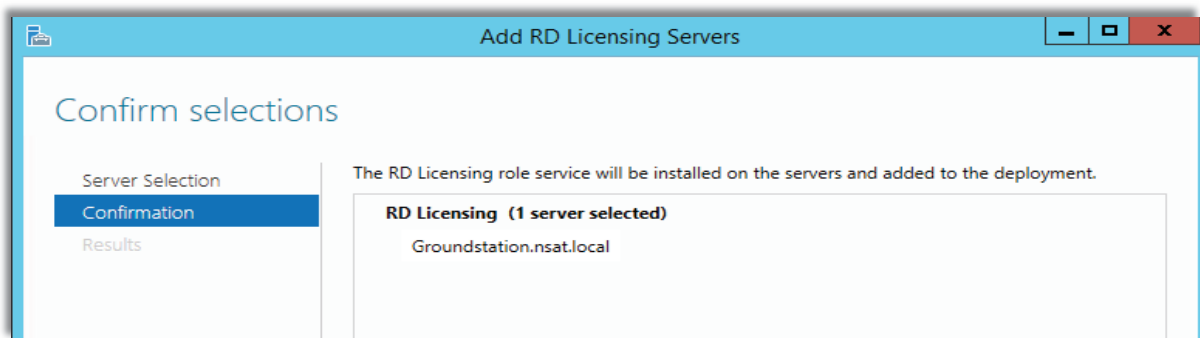
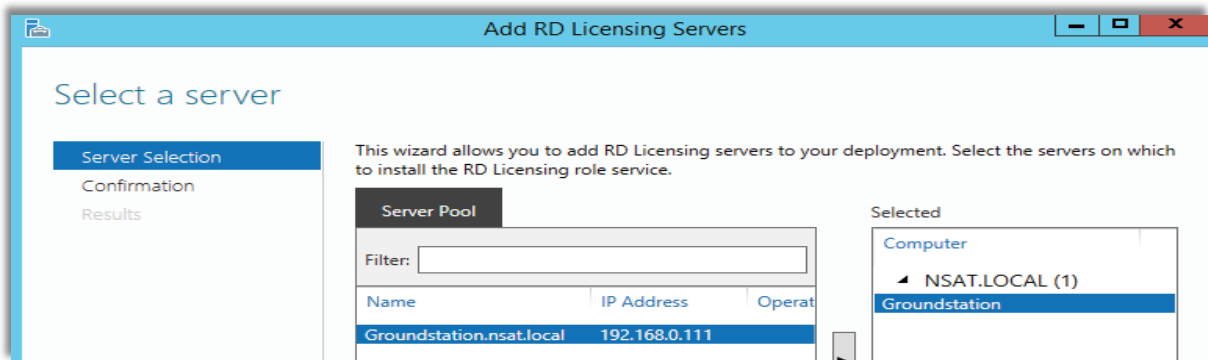


Now, I have to publish remote apps for users for which first I configured RD Licensing server and Gateway server.

Select Remote Desktop Services in Server Manager and open RD Licensing



Select server and confirm to proceed installations



Similarly configure RD Gateway as shown below



Set SSL certificate name as FQDN that is Groundstation.nsat.local

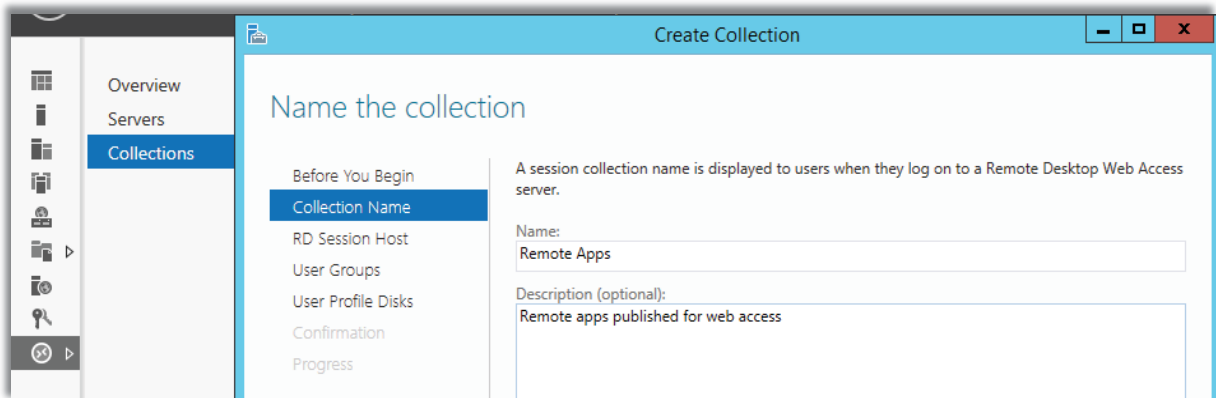


Confirm selections

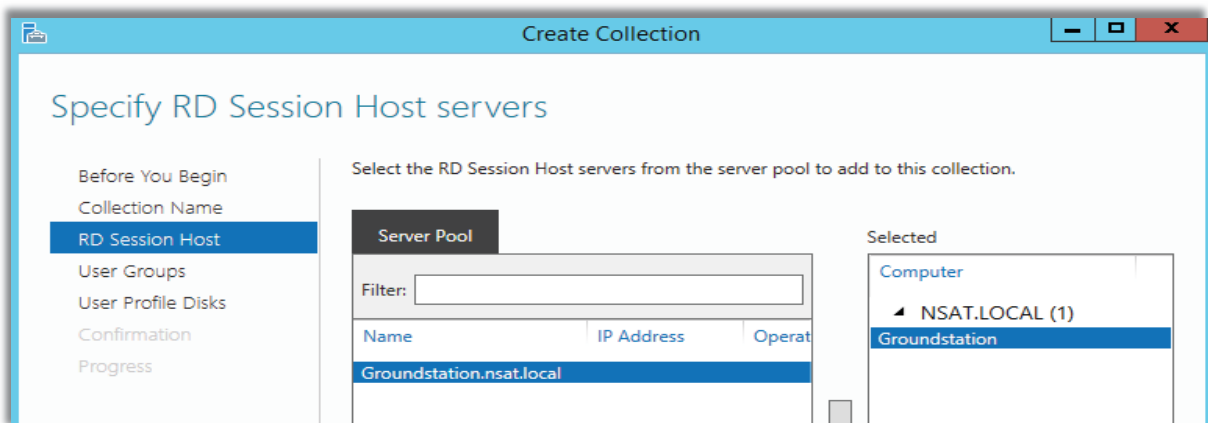


Create a collection named as Remote Apps and publish software products as follows.

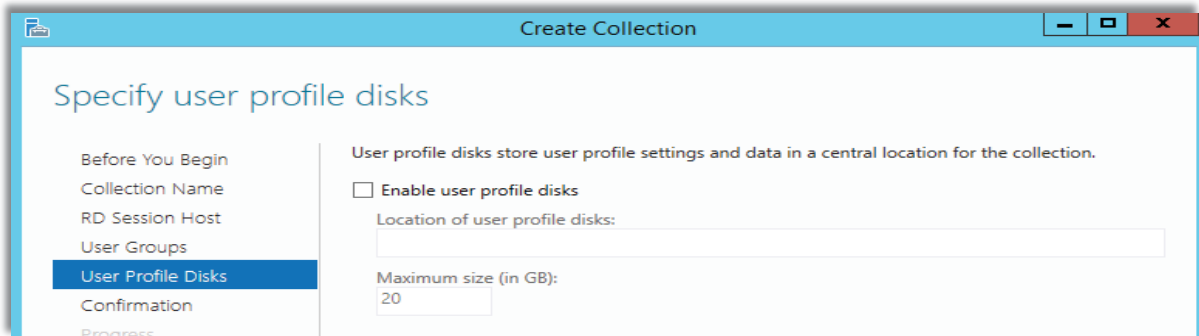
Select collection name Remote Apps and description



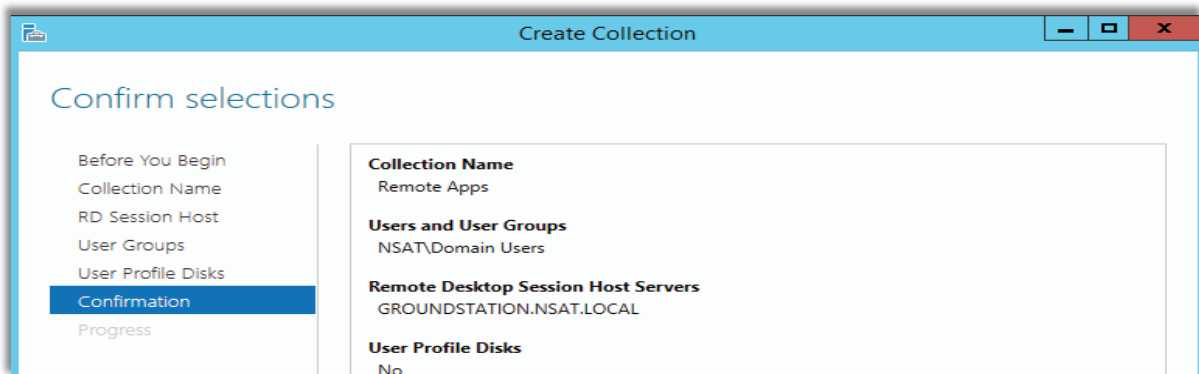
Select Session host server



User profile disks, I didn't enable this feature

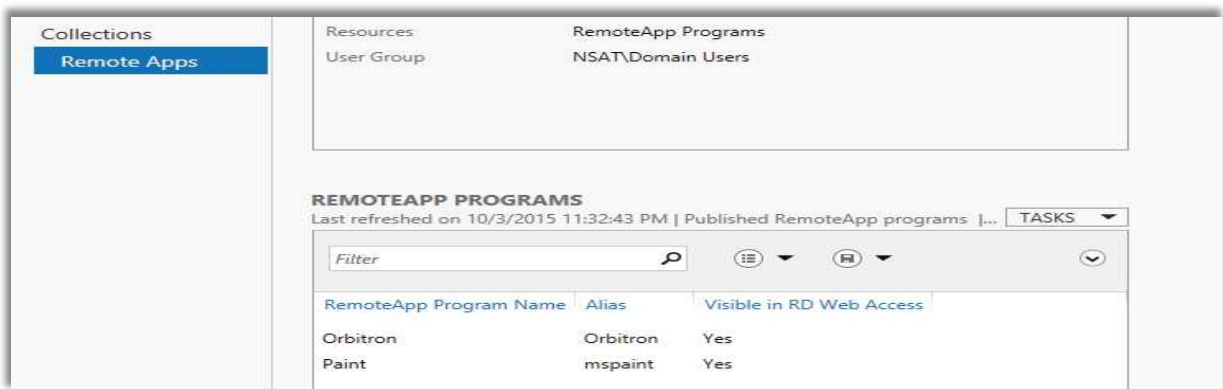
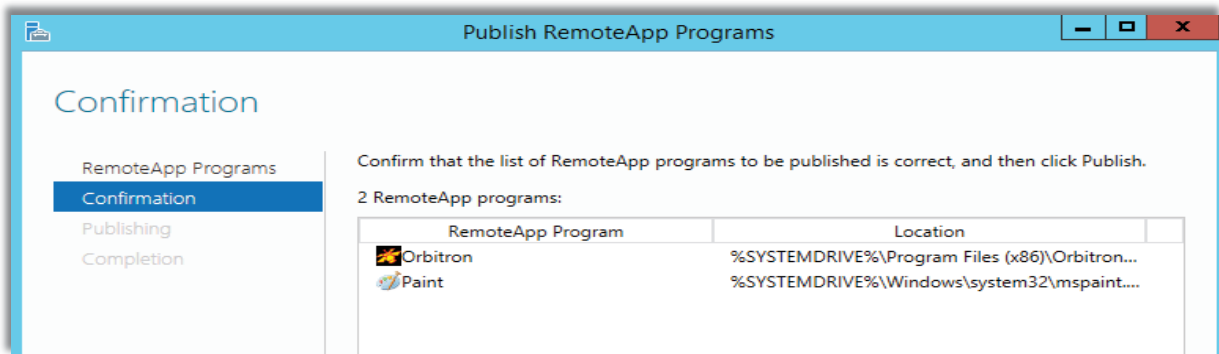


Confirm selections



Now go to Remote App collection and choose apps to publish and confirm





Finally, I have two remote apps Orbitron and Paint. This completes Server installations.

6.3.2 User Database configuration, IIS, Mysql, PHP, Phpmyadmin

1. Install MySQL

- Download the MySQL database server on windows server 2012 r2. We will do this using the 'MSI' one-click installer for Windows. Go to <http://dev.mysql.com/downloads/> and download the 'MySQL Installer for Windows'.



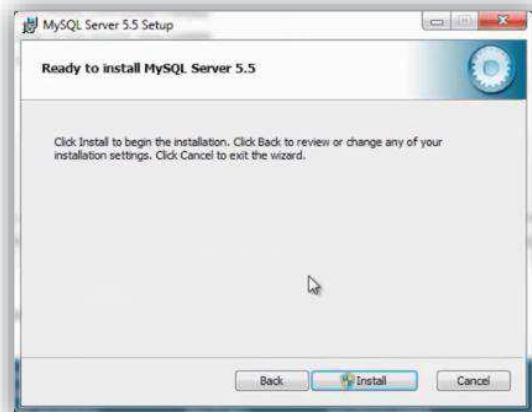
Run the installation.

- Install MySQL products
- Accept the license

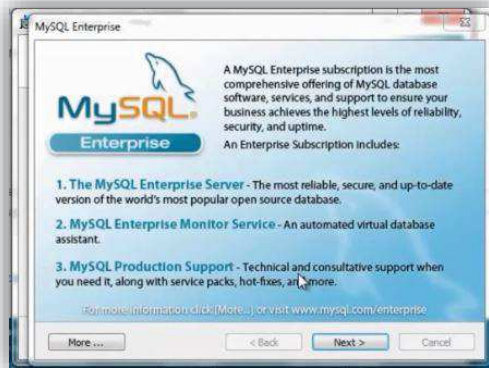


Choose a Setup Type

- Select "Typical"
- Click Install



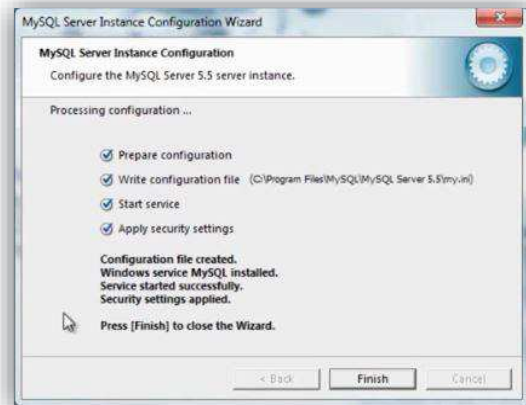
- Accept all the defaults on the 'MySQL Server Configuration' and hit Next
- Choice Best Support For Multilingualism then Click Next



- On the password screen, supply a password for the 'root' (main administrator) user. Make sure it's one you won't forget. You can also create a 'User' account just for Moodle with more restricted access if you like. This would be good practice on a public server but just using the 'root' user will suffice for testing.

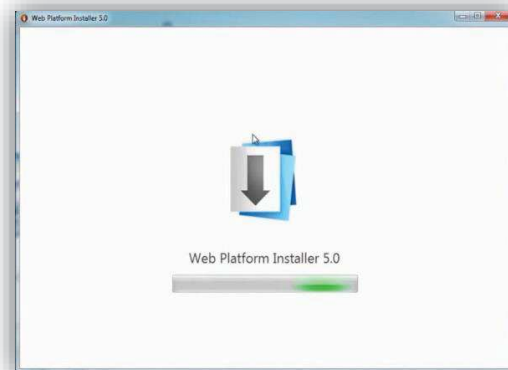
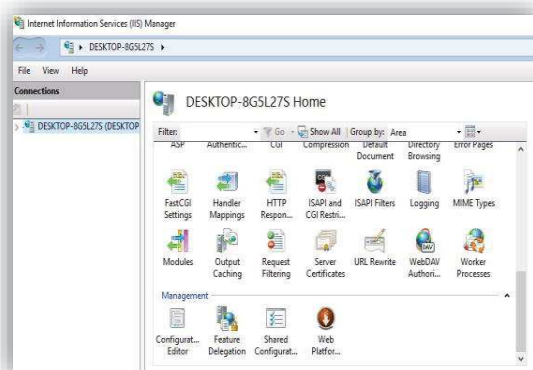


- On the Service details page, accept the defaults and hit Next and then Next a couple more times for the configuration progress, Click Finish. Job done



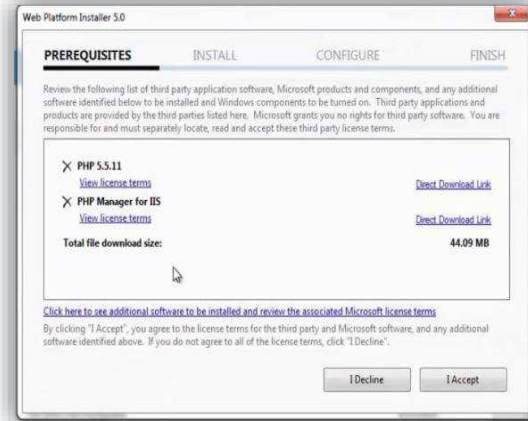
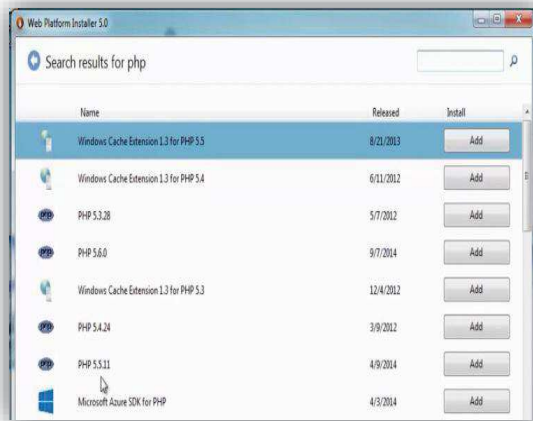
Install / Configure Microsoft Web Platform

- Go to Start Menu Search for IIS → Select IIS Manager
- IIS Manager and click web platform



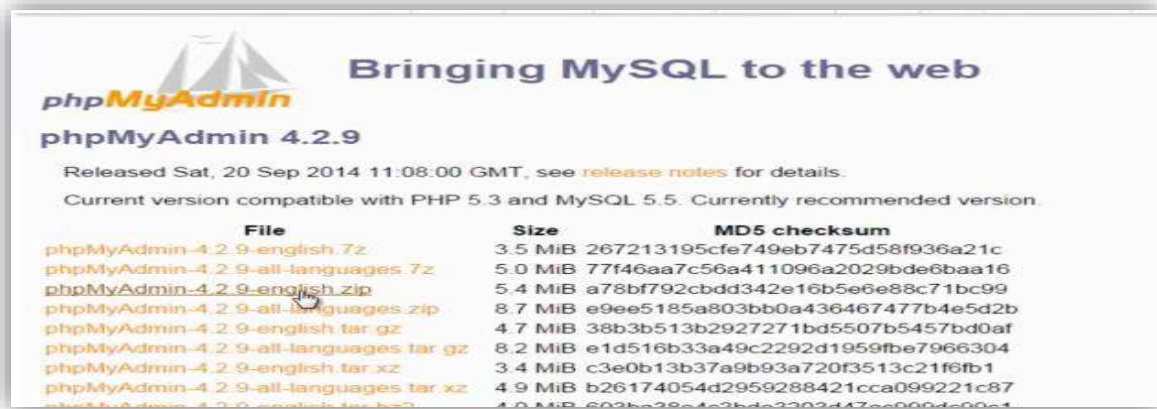
Search php

- Add PHP 5.5.11 and install
- Click I accept wait for finish then exit.



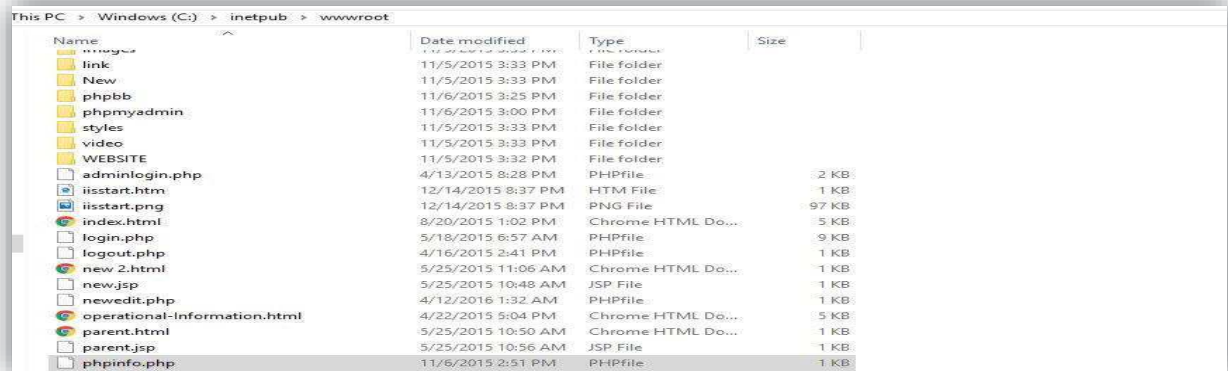
2. Installing phpMyAdmin

- We'll be installing phpMyAdmin as it's a GUI to managing the users database tables:
- Download the phpMyAdmin zip file
- Extract it to: C:\inetpub\wwwroot\phpmyadmin

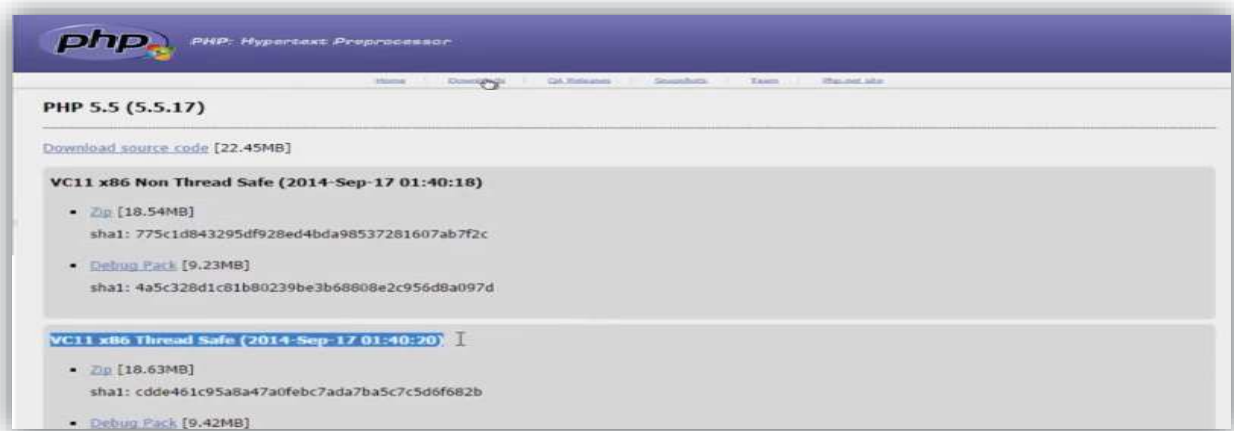


3. Install PHP

- First thing to do after you download and extract phpMyAdmin is place the extracted files in the appropriate directory inside your IIS web root so that IIS is able to access it.

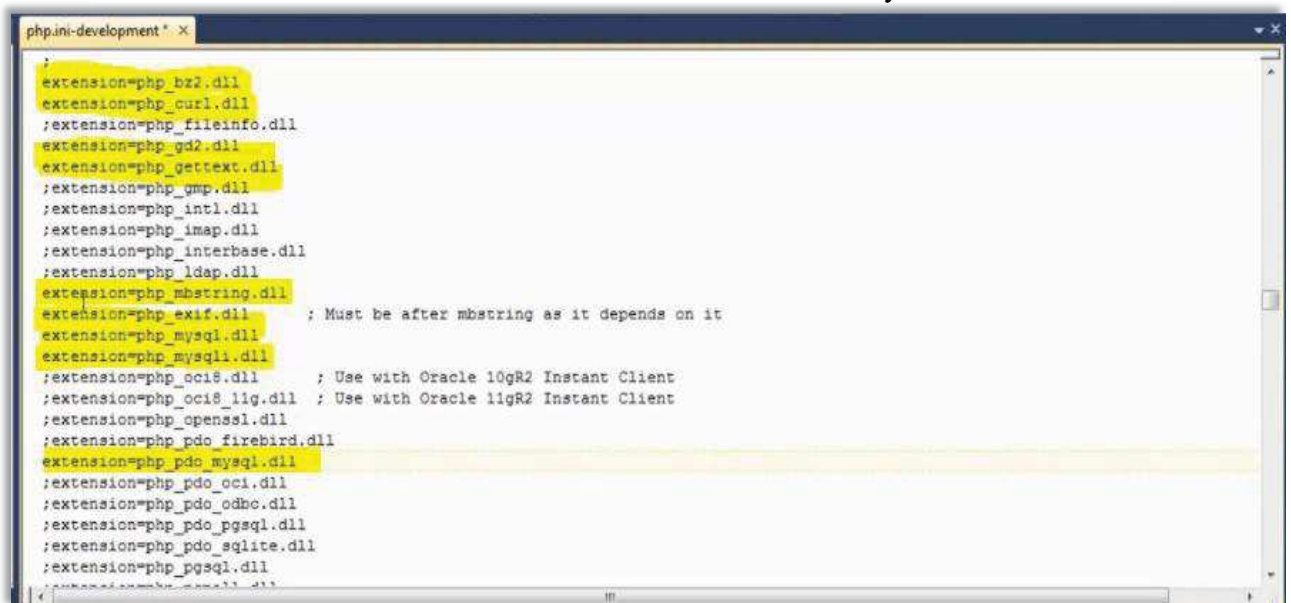


- You may wish to create a separate website for your phpMyAdmin installation, or simply add it as a sub directory or virtual directory under an existing website. Either way you'll need to make sure that the user account used by IIS to access your files has at least NTFS read permissions to all of your files once they are in place.
- Download the last version of PHP (5.x)



PHP Setting

- PhpMyAdmin uses several PHP extensions to perform its various functions. The extensions you'll need for phpMyAdmin are;
- MySQL (to connect to the MySQL server on my web hosting)
- MCrypt (highly recommended for performance when using the cookie authentication method, and actually required for 64-bit environments)
- MBString (used for multi-byte character support)
- GD2 (image creation and manipulation library)
- To enable these extensions open you php.ini file and navigate to the list of extensions and find these extension names.
- Simply remove the semi-colon (;) from that start, save the file and restart IIS to reload your PHP environment. These extensions should now be loaded into your PHP environment

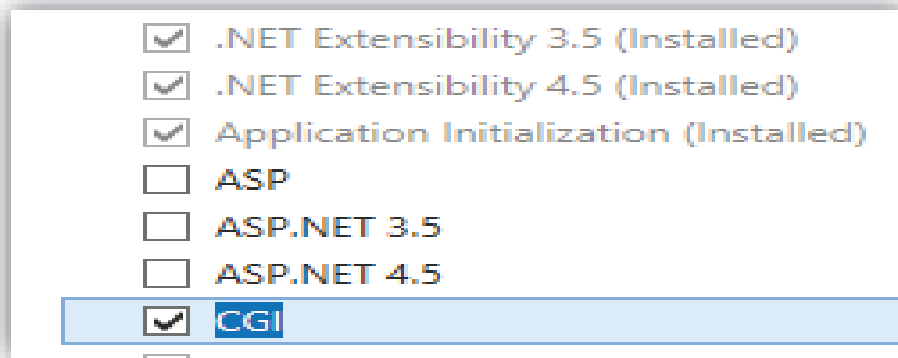


```
extension=php_bz2.dll
extension=php_curl.dll
;extension=php_fileinfo.dll
extension=php_gd2.dll
extension=php_gettext.dll
;extension=php_gmp.dll
;extension=php_intl.dll
;extension=php_imap.dll
;extension=php_interbase.dll
;extension=php_ldap.dll
extension=php_mbstring.dll
extension=php_exif.dll      ; Must be after mbstring as it depends on it
extension=php_mysql.dll
extension=php_mysqli.dll
;extension=php_oci8.dll      ; Use with Oracle 10gR2 Instant Client
;extension=php_oci8_11g.dll ; Use with Oracle 11gR2 Instant Client
;extension=php_openssl.dll
;extension=php_pdo_firebird.dll
extension=php_pdo_mysql.dll
;extension=php_pdo_oci.dll
;extension=php_pdo_odbc.dll
;extension=php_pdo_pgsql.dll
;extension=php_pdo_sqlite.dll
;extension=php_pgsql.dll
```

PHP Settings Windows Server 2012 R2

To use the FastCGI environment, you must first install the CGI role service. The installation process registers the Common Gateway Interface (CGI) role service in both the <globalModules> and <modules> elements. You do not need to perform any other steps to install the FastCGI environment.

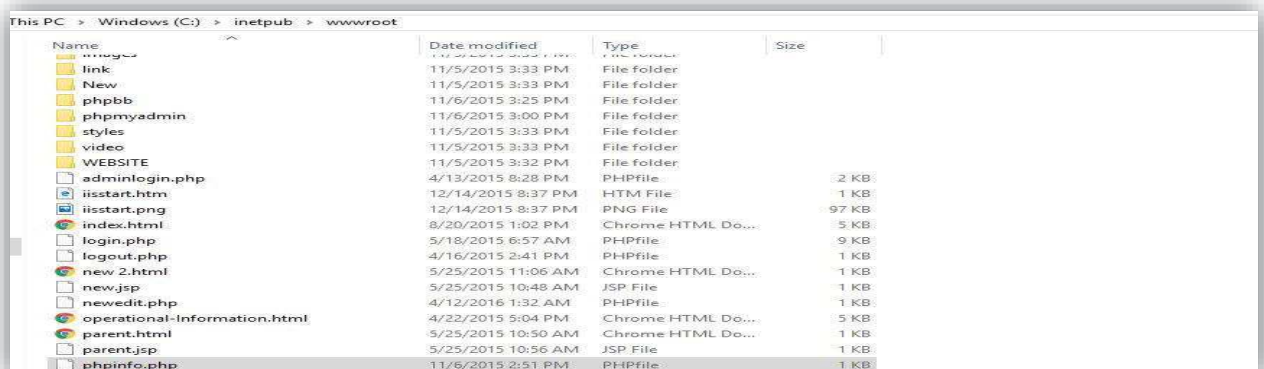
1. On the taskbar, click Server Manager.
2. In Server Manager, click the Manage menu, and then click Add Roles and Features.
3. In the Add Roles and Features wizard, click Next. Select the installation type and click Next. Select the destination server and click Next.
4. On the Server Roles page, expand Web Server (IIS), expand Web Server, expand Application Development, and then select CGI. Click Next.



5. On the Select Features page, click Next.
6. On the Confirm installation selections page, click Install.
7. On the Results page, click Close.

Create a PHPINFO.php page

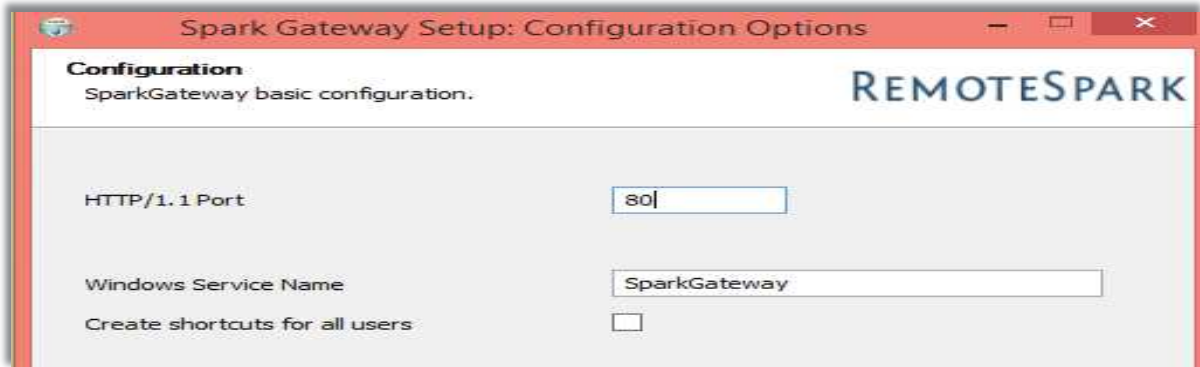
- To create a phpinfo file, open a plain text file (Notepad or Notepad ++), add the following lines `<?php phpinfo(); ?>`, and save: C:\inetpub\wwwroot and Filename: phpinfo.php



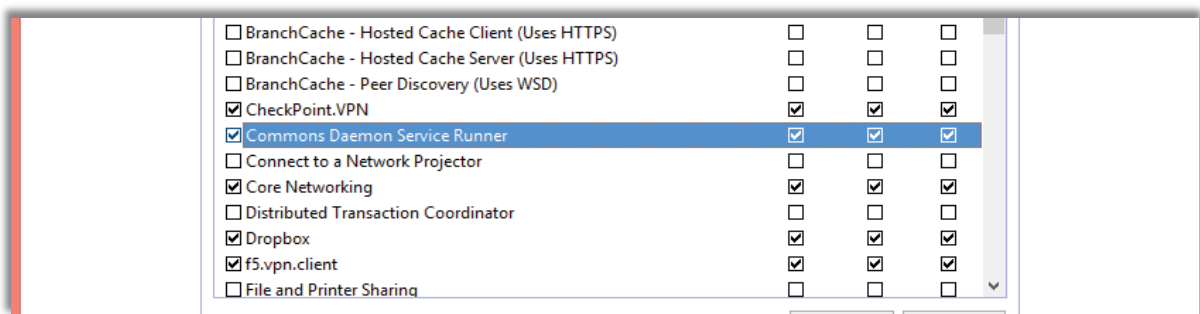
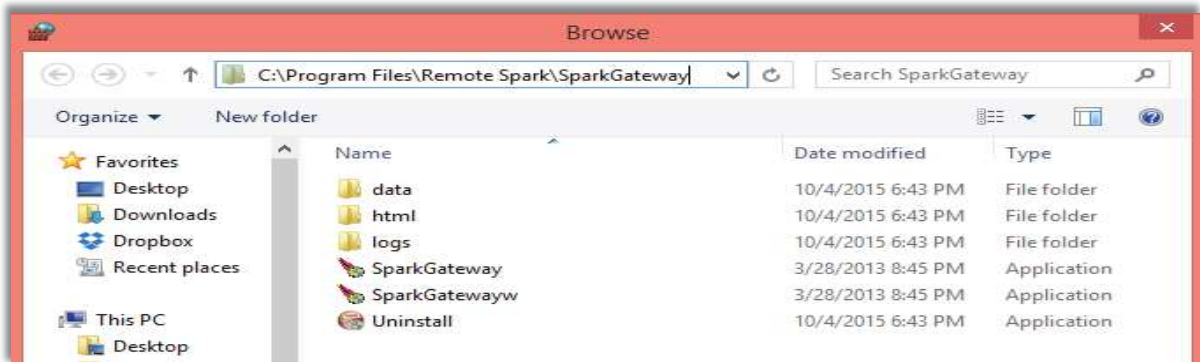
6.3.3 Gateway Installations

Gateway is a Java application installed on almost all operational systems. Web resources of Spark View are pure HTML and JavaScript, so it can be installed on Gateway.

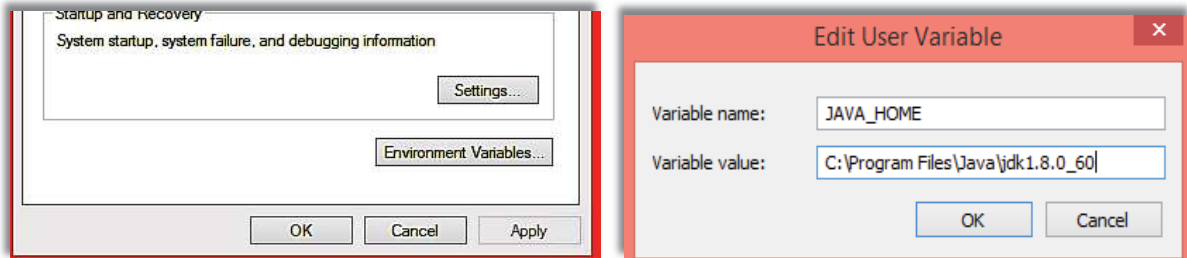
Download the Java 2 Standard Edition (J2SE) JDK, release version 1.6 or later from: <http://www.oracle.com/technetwork/java/javase/downloads/index.html> and install following the instructions and keep default setting only confirm HTTP/1.1 Port is 80.



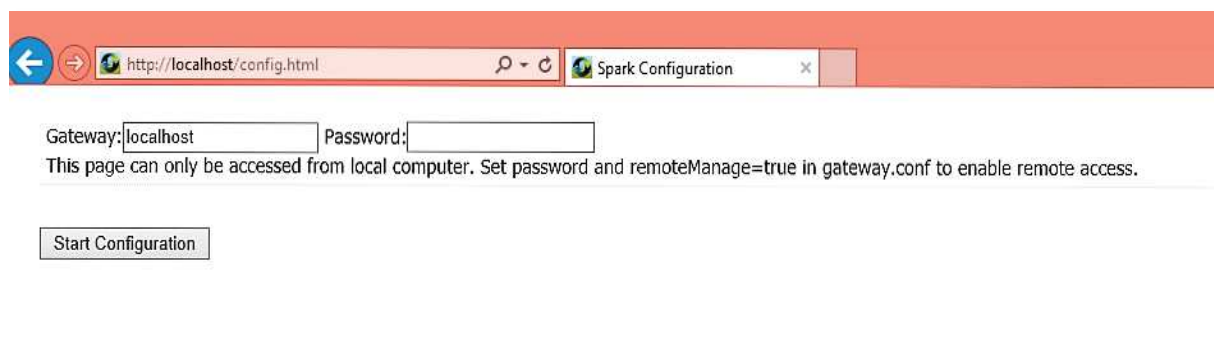
After installation go to Firewall setting and create exceptions for Spark gateway as follows
Go to Firewall setting>Allow an app or feature through Windows Firewall>Allow another app and locate Spark gateway and allow permission as follows



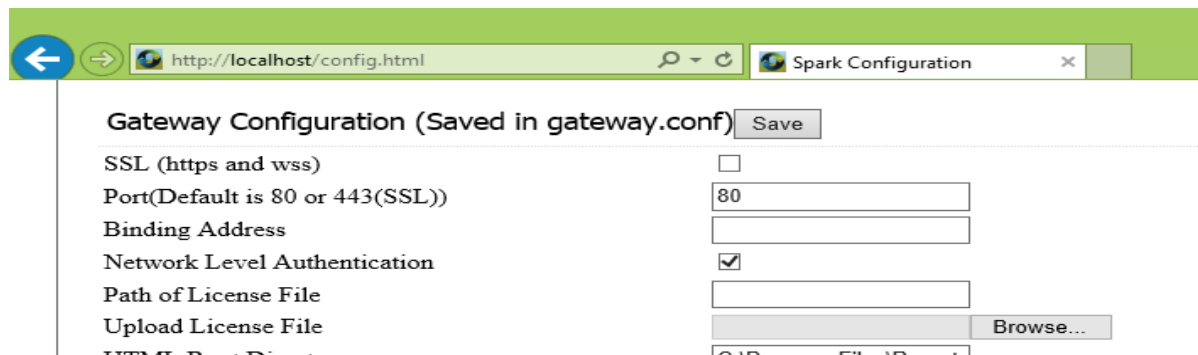
Now, go to System properties>Advanced system setting>Environment variables and introduces a new variable name JAVA_HOME and set value as shown below.



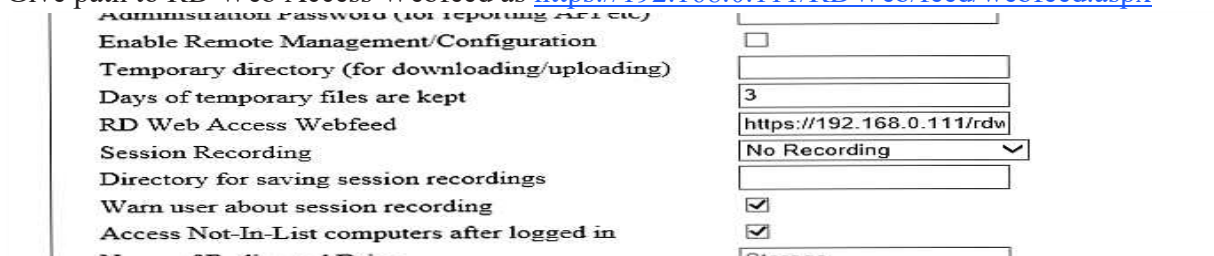
Then to configure gateway write in browser <http://localhost/config.html> and start configuration



Check Network Level Authentication

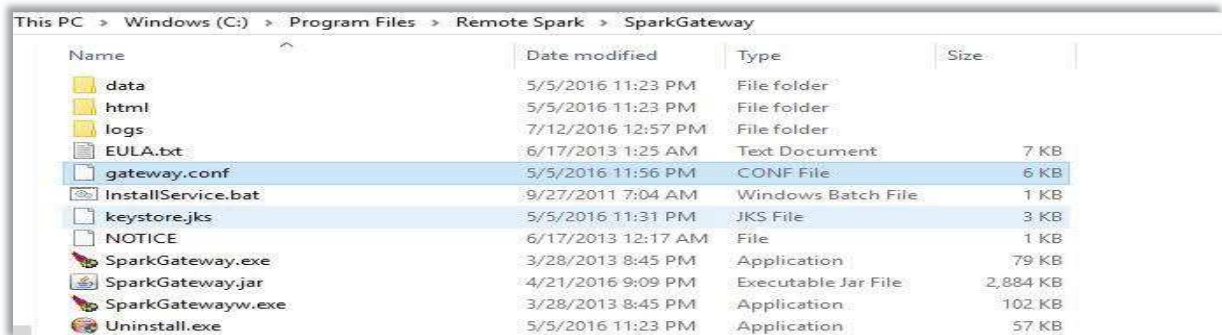


Give path to RD Web Access Webfeed as <https://192.168.0.111/RDWeb/feed/webfeed.aspx>



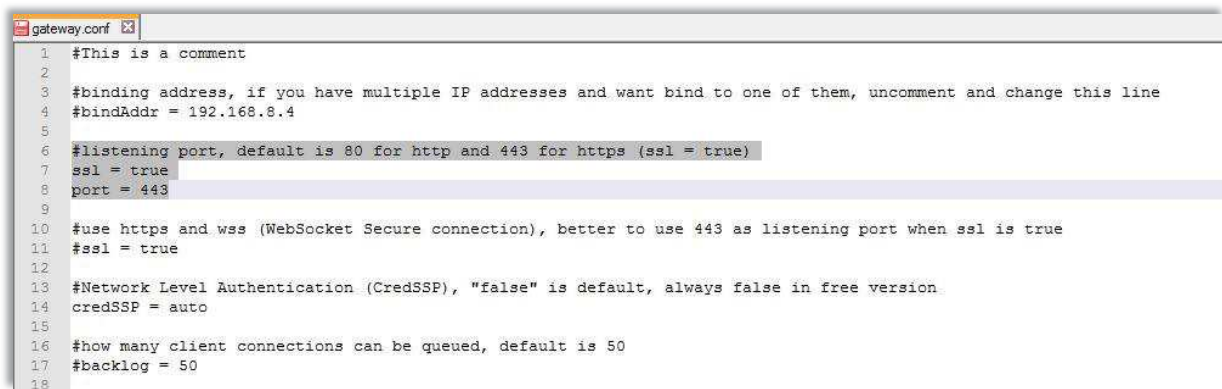
HTTPS and WSS (WebSocket Secure Connection)

Recommended to enable HTTPS and WSS. There is a self-signed certificate (keystore.jks) in the installation directory.



Name	Date modified	Type	Size
data	5/5/2016 11:23 PM	File folder	
html	5/5/2016 11:23 PM	File folder	
logs	7/12/2016 12:57 PM	File folder	
EULA.txt	6/17/2013 1:25 AM	Text Document	7 KB
gateway.conf	5/5/2016 11:56 PM	CONF File	6 KB
InstallService.bat	9/27/2011 7:04 AM	Windows Batch File	1 KB
keystore.jks	5/5/2016 11:31 PM	JKS File	3 KB
NOTICE	6/17/2013 12:17 AM	File	1 KB
SparkGateway.exe	3/28/2013 8:45 PM	Application	79 KB
SparkGateway.jar	4/21/2016 9:09 PM	Executable Jar File	2,884 KB
SparkGatewayw.exe	3/28/2013 8:45 PM	Application	102 KB
Uninstall.exe	5/5/2016 11:23 PM	Application	57 KB

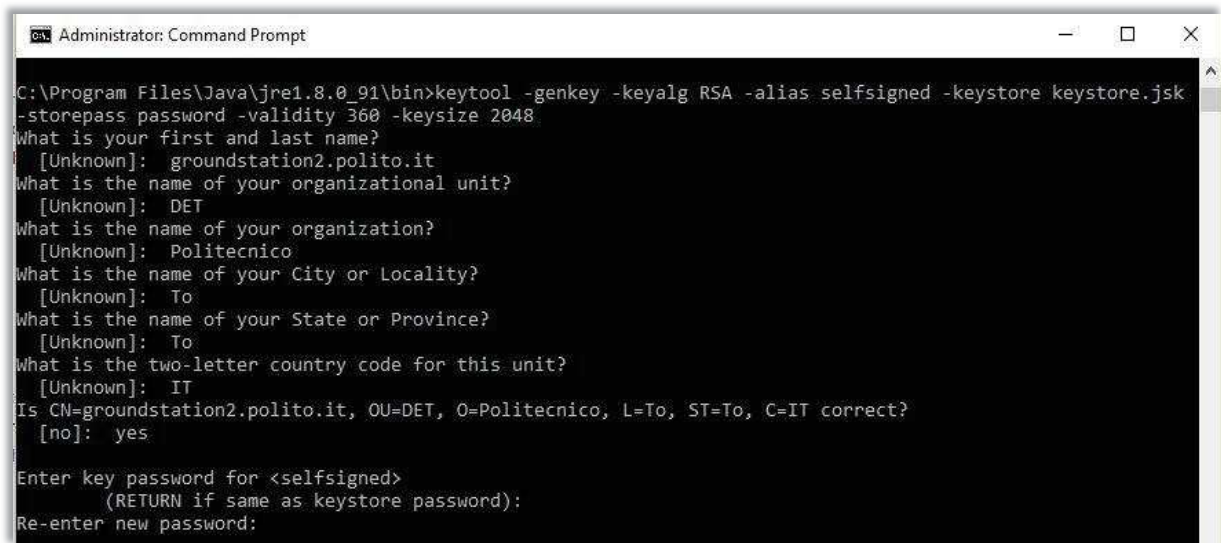
Set `ssl = true` in `gateway.conf` file.



```
1 #This is a comment
2
3 #binding address, if you have multiple IP addresses and want bind to one of them, uncomment and change this line
4 #bindAddr = 192.168.8.4
5
6 #listening port, default is 80 for http and 443 for https (ssl = true)
7 ssl = true
8 port = 443
9
10 #use https and wss (WebSocket Secure connection), better to use 443 as listening port when ssl is true
11 #ssl = true
12
13 #Network Level Authentication (CredSSP), "false" is default, always false in free version
14 credSSP = auto
15
16 #how many client connections can be queued, default is 50
17 #backlog = 50
18
```

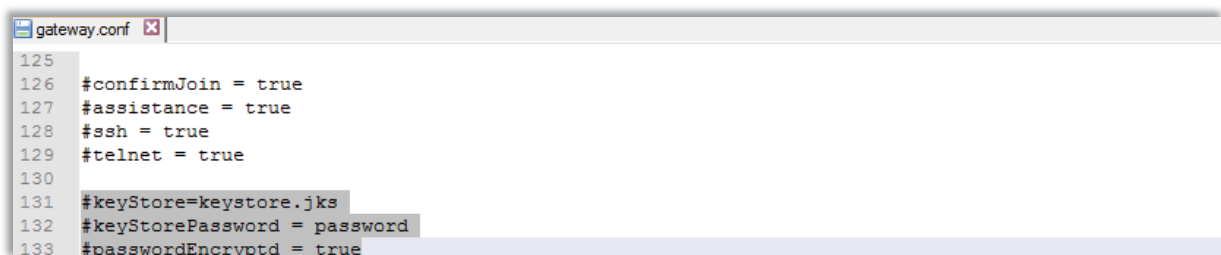
Import your SSL certificate to a Java keystore.jks,

- Generate a Self Signed Certificate using Java Keytool.
- Open the command (cmd.exe) console on whatever operating system you are using and navigate to the directory where keytool.exe is located (usually where the JRE is located, e.g. C:\Program Files\Java\jre6\bin on Windows machines).
 - 1.Run the following command (where validity is the number of days before the certificate will expire): keytool -genkey -keyalg RSA -alias selfsigned -keystore keystore.jks -storepass password -validity 360 -keysize 2048
 2. Fill in the prompts for your organization information. When it asks for your first and last name, enter the domain name of the server that users will be entering to connect to your application (e.g.groundstation2.polito.it)



```
Administrator: Command Prompt
C:\Program Files\Java\jre1.8.0_91\bin>keytool -genkey -keyalg RSA -alias selfsigned -keystore keystore.jks
-storepass password -validity 360 -keysize 2048
What is your first and last name?
[Unknown]: groundstation2.polito.it
What is the name of your organizational unit?
[Unknown]: DET
What is the name of your organization?
[Unknown]: Politecnico
What is the name of your City or Locality?
[Unknown]: To
What is the name of your State or Province?
[Unknown]: To
What is the two-letter country code for this unit?
[Unknown]: IT
Is CN=groundstation2.polito.it, OU=DET, O=Politecnico, L=To, ST=To, C=IT correct?
[no]: yes
Enter key password for <selfsigned>
(RETURN if same as keystore password):
Re-enter new password:
```

Set up keyStore and keyStorePassword in C:\Program Files\Remote Spark\SparkGateway



```
gateway.conf
125
126 #confirmJoin = true
127 #assistance = true
128 #ssh = true
129 #telnet = true
130
131 #keyStore=keystore.jks
132 #keyStorePassword = password
133 #passwordEncryptd = true
```

And restart gateway. This completes the installation.

6.4 Security Matters

Security is level of protection from harmful incident. It applies to all vulnerable and valuable assets like a person, device, dwelling, community, nation or organization. There can be a lot of definitions of security depending upon scenario of protection and harm.

6.4.1 Security: a hot issue

Today, security is a very hot issue as there are bad guys everywhere in every field or era who are ready to steal, disturb, modify, delete and disrupt valuable assets of peoples. So peoples need security almost all the time.

Everybody requires security while working on computer so any kind of attack should not happen, talking to someone so none other should listen except concerned one, sending mail so none should read except the addressed person, eating so food should not be harmful and so on.

Here I will explain a few types of security that relates to project then later I will discuss how security matters been taken to guarantee secure communication, data protection and avoidance to unauthorized access of resources and assets.

6.4.2 Security types

There are many types and categories of security in the this huge world of assets but some specific related to field of Information Technology are

6.4.2.1 Computer Security

Computer security, also known as cybersecurity or IT security, is the protection of information systems from theft or damage to the hardware, the software and to the information on them, as well as from disruption or misdirection of the services they provide. It includes controlling physical access to the hardware, as well as protecting against harm that may come via network access, data and code injection and due to malpractice by operators whether intentional, accidental or due to them being tricked into deviating from secure procedures.

Computer security covers all the processes and mechanisms by which digital equipment, information and services are protected from unintended or unauthorized access, change or destruction and the process of applying security measures to ensure confidentiality, integrity, and availability of data both in transit and at rest.

6.4.2.2 Information Security

Information security, sometimes shortened to InfoSec, is the practice of defending information from unauthorized access, use, disclosure, disruption, modification, perusal, inspection, recording or destruction. It is a general term that can be used regardless of the form the data may take electronic or physical.

Key features of information security are

Confidentiality

In information security, confidentiality "is the property, that information is not made available or disclosed to unauthorized individuals, entities, or processes.

Integrity

In information security, data integrity means maintaining and assuring the accuracy and completeness of data over its entire life-cycle. This means that data cannot be modified in an unauthorized or undetected manner. This is not the same thing as referential integrity in databases, although it can be viewed as a special case of consistency as understood in the classic ACID model of transaction processing. Information security systems typically provide message integrity in addition to data confidentiality.

Availability

For any information system to serve its purpose, the information must be available when it is needed. This means that the computing systems used to store and process the information, the security controls used to protect it, and the communication channels used to access it must be functioning correctly. High availability systems aim to remain available at all times, preventing service disruptions due to power outages, hardware failures, and system upgrades. Ensuring availability also involves preventing denial-of-service attacks, such as a flood of incoming messages to the target system essentially forcing it to shut down.

Non-repudiation

In law, non-repudiation implies one's intention to fulfill their obligations to a contract. It also implies that one party of a transaction cannot deny having received a transaction nor can the other party deny having sent a transaction.

6.4.2.3 Internet Security

Internet security is a branch of computer security specifically related to the Internet, often involving browser security but also network security on a more general level as it applies to other applications or operating systems on a whole. Its objective is to establish rules and measures to use against attacks over the Internet.

The Internet represents an insecure channel for exchanging information leading to a high risk of intrusion or fraud, such as phishing. Different methods are used to protect the transfer of data, including encryption.

Network layer security

TCP/IP protocols may be secured with cryptographic methods and security protocols. These protocols include Secure Sockets Layer (SSL), succeeded by Transport Layer Security (TLS) for web traffic, Pretty Good Privacy (PGP) for email, and IPsec for the network layer security.

6.4.2.4 Network Security

Network security consists of the policies adopted to prevent and monitor authorized access, misuse, modification or denial of a computer network and network-accessible resources. Network security involves the authorization of access to data in a network controlled by the network administrator. Users choose or are assigned an ID and password or other authenticating information that allows them access to information and programs within their authority.

Network security covers a variety of computer networks, both public and private. Networks can be private, such as within a company, and others which might be open to public access. Network security is involved in organizations, enterprises, and other types of institutions.

It secures the network, as well as protecting and overseeing operations being done. The most common and simple way of protecting a network resource is by assigning it a unique name and a corresponding password.

Concept of Network Security

Network security starts with authenticating, commonly with a username and a password. Since this requires just one detail authenticating the user name and password, this is known as one-factor authentication. With two-factor authentication, user is asked security token also and with three-factor authentication, user is asked for fingerprint or retinal scan.

Once authenticated, a firewall enforces access policies such as what services are allowed to be accessed by the network users. Though effective to prevent unauthorized access, this component may fail to check potentially harmful content such as computer worms or Trojans being transmitted over the network. Anti-virus software or an intrusion prevention system (IPS) that helps to detect and inhibit the action of such malware.

Communication between two hosts using a network may be encrypted to maintain privacy.

6.4.2.5 Data Security

Data security means protecting data, such as a database, from destructive forces and unwanted actions of unauthorized users. As I have database to store user credentials and information so to protect data I am using encryption method to store passwords and other information. There are many techniques some are described below.

Disk encryption

Disk encryption refers to encryption technology that encrypts data on a hard disk drive. Disk encryption typically takes form in either software or hardware. Disk encryption is often referred to as on-the-fly encryption (OTFE) or transparent encryption.

Backups

Backups are used to ensure data which is lost can be recovered from another source. It is considered essential to keep a backup of any data in most industries and the process is recommended for any files of importance to a user.

Data masking

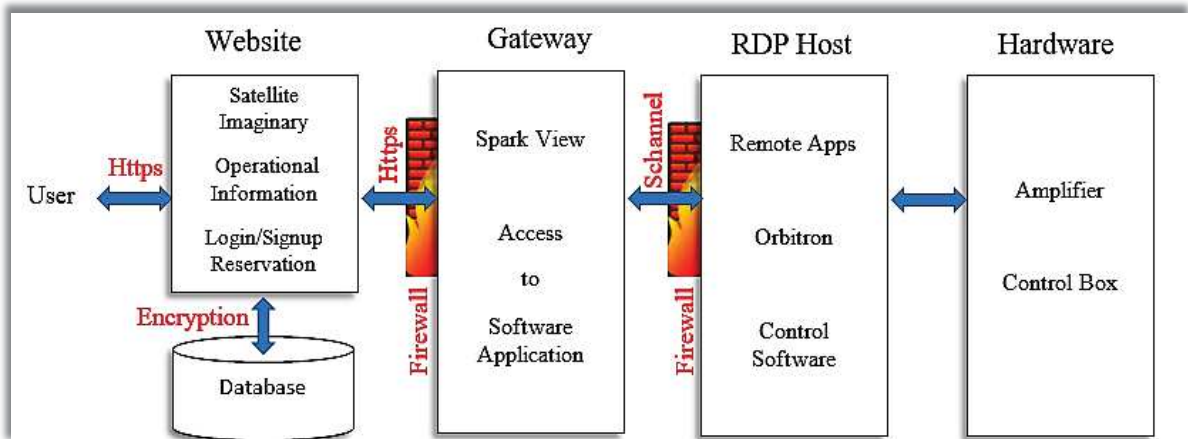
Data masking of structured data is the process of obscuring (masking) specific data within a database table or cell to ensure that data security is maintained and sensitive information is not exposed to unauthorized personnel. This may include masking the data from users (for example so banking customer representatives can only see the last 4 digits of a customer's national identity number), developers (who need real production data to test new software releases but should not be able to see sensitive financial data), outsourcing vendors, etc.

Data erasure

Data erasure is a method of software-based overwriting that completely destroys all electronic data residing on a hard drive or other digital media to ensure that no sensitive data is leaked when an asset is retired or reused.

6.4.3 Implementations

This section of security implementations describes possible vulnerabilities, threats and attacks with countermeasures taken to avoid any harmful act. As System Architecture is given by following diagram that includes a Website, Gateway, RDP Host and Controller Hardware.



So security requirements include

6.4.3.1 Physical protection of Assets

Physical protection means Computers and other Hardware must not be in approach of anybody else except authorized persons so that none can damage these resources physically, steal some components or make them unavailable by power failure or disconnecting them.

Strong authentication through username and password so that none can break and login to gateway or RDP host directly and destroy software apps or any other harm to data stored.

To obtain physical protection assets must be in a place where none is allowed to enter and access RDP Host and other hardware but authorized persons only.

6.4.3.2 Firewall

Firewall is a network security system that monitors and controls the incoming and outgoing network traffic based on predetermined security rules. A firewall typically establishes a barrier between a trusted, secure internal network and another outside network, such as the Internet, that is assumed to not be secure or trusted. Firewalls are often categorized as

- Network firewalls
- host-based firewalls

Network firewalls are a software appliance running on general purpose hardware or hardware based firewall computer appliances that filter traffic between two or more networks. Host-based

firewalls provide a layer of software on one host that controls network traffic in and out of that single machine.

6.4.3.3 Secure Communication Channel

I have two computers in domain nsat.local one is Gateway and other is RDP host there must be secure channel communication between these systems.

In a Windows domain environment, a secure channel provides a secure communication path between a workstation or member server and a domain controller (DC) in the same domain

- Domain Controllers in the same domain
- Domain Controllers in different domains

A secure channel always involves a DC. Secure channel is like an enabler of secure communication between machines and their trusted authority in the same domain, and between the trusted authorities of different domains. But I am using it for same domain as I have a single domain with one machine and one DC.

Here, secure channel means providing authentication of the requestor and confidentiality, integrity and data-authentication services for the data sent across the channel.

Secure channel exploits usage of Transport Layer Security (TLS), Secure Socket Layer (SSL) and Private Communication technology (PCT).

Secure Socket Layer (SSL)

SSL is predecessor of TLS and both work similarly and use same methods of encryption also provide same security features. TLS is enhanced version of SSL.

Transport Layer Security (TLS)

Transport Layer Security (TLS) is a protocol that ensures privacy between communicating applications and their users on the Internet. When a server and client communicate, TLS ensures that no third party may eavesdrop or tamper with any message. TLS is the successor to the Secure Sockets Layer (SSL). TLS is composed of two layers

- TLS Record Protocol
- TLS Handshake Protocol

The TLS Record Protocol provides connection security with some encryption method such as the Data Encryption Standard (DES). The TLS Record Protocol can also be used without encryption. The TLS Handshake Protocol allows the server and client to authenticate each other and to negotiate an encryption algorithm and cryptographic keys before data is exchanged.

Private Communication technology (PCT)

Private Communications Technology (PCT) 1.0 was a protocol developed by Microsoft in the mid-1990s. PCT was designed to address security flaws in version 2.0 of Netscape's Secure Sockets Layer protocol and to force Netscape to hand control of the then-proprietary SSL protocol to an open standards body. PCT is not used now a days.

6.4.3.4 Web Security

Web application security is a branch of Information Security that deals specifically with security of websites, web applications and web services. I am using SSL certificates to make website secure.

HTTPS

HTTPS also known as HTTP over TLS, HTTP over SSL and HTTP Secure is a protocol for secure communication over a computer network which is widely used on the Internet. HTTPS consists of communication over Hypertext Transfer Protocol (HTTP) within a connection encrypted by Transport Layer Security, Secure Sockets Layer. The main motivation for HTTPS is authentication of the visited website and to protect the privacy and integrity of the exchanged data.

In its popular deployment on the internet, HTTPS provides authentication of the website and associated web server with which one is communicating, which protects against man-in-the-middle attacks. Additionally, it provides bidirectional encryption of communications between a client and server, which protects against eavesdropping and tampering with and/or forging the contents of the communication. In practice, this provides a reasonable guarantee that one is communicating with precisely the website that one intended to communicate and ensuring that the contents of communications between the user and site cannot be read or forged by any third party.

6.4.3.5 Database Security

It has already been described with some techniques to keep data safe. As we have a database and its security has been explained in section 6.4.2.5.

That concludes this chapter.

Chapter 7

7 System Specifications and Guideline (User Manual)

This section is more focused on system specifications, features and working capabilities in terms of services provided to users.

7.1 System Specifications

System Architecture is already described above that shows complete working procedure, here I will describe requirements and features of this project.

Website

- Nanosatellites Information
- Satellite Imaginary
- Operational Information
- User Registration System
- User's Personal Information
- Server Booking System
- Secure Communication
- Complete Database
- Complete User Guideline
- Admin Panel

Server 1 (Groundstation RDP Host)

- Intel® Core™2 Duo Desktop CPU
- 3 Gigabyte of RAM
- 250 Gigabyte of Hard Drive
- CD/DVD RW Drive
- Installed with Microsoft Windows Server 2012R2
- Domain Controller
- Active Directory Domain Services
- Web Server (IIS)
- Software Apps (Orbitron etc.)
- User Authentication
- Hardware Controller (like Amplifier, Antennas etc.)

Server 2 (Gateway)

- Intel® Core™2 Duo Desktop CPU
- 2 Gigabyte of RAM
- 500 Gigabyte of Hard Drive
- CD/DVD RW Drive
- Installed with Microsoft Windows 7
- Work in domain Network
- Gateway (SparkView)

- Access to Software Apps
- Secure Communication between User and RDP Host

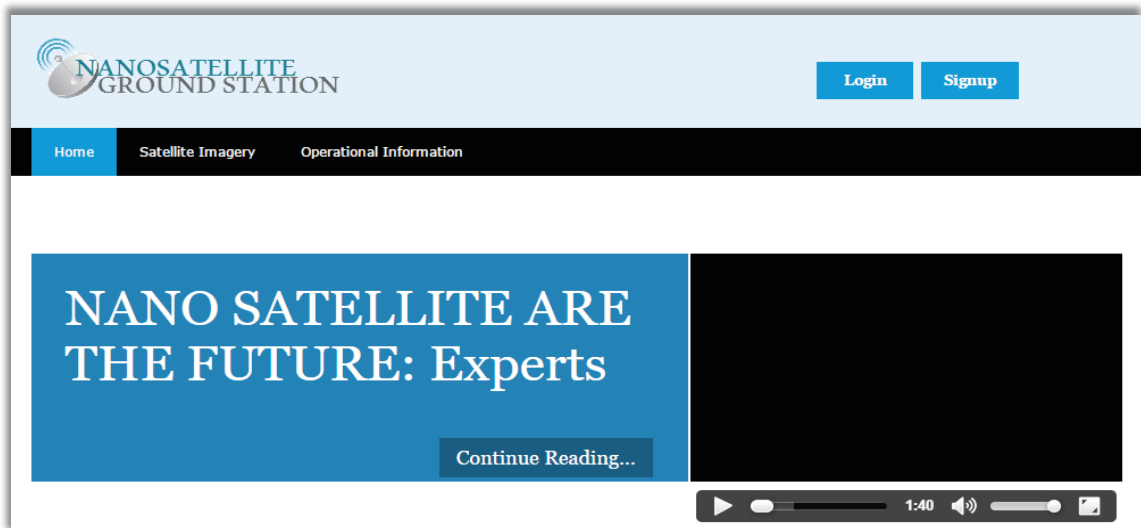
7.2 User Guideline

User guideline or user manual is complete instructional code that a user have to follow to make benefit of this system. There are some very important instruction which must be followed otherwise user might lose his work that will result in time wastage for him and for other users as well. Following is a complete user guide instruction manual.

1. *Visit website*
2. *Signup/Register on website*
3. *Login to website*
4. *Reserve a timeslot*
5. *Login to Server*
6. *Use your Software product(s)*
7. *Save your work*
8. *Download to your Computer*
9. *Logout from Server*

1. *Visit website*

Visit website page at groundstation.polito.it and have a look at the contents about Nanosatellites and much information is available.



2. *Signup/Register on website*

Website home page has a Login Signup link as shown above in step 1. Follow this tab to register yourself as a user or Login if already registered. Enter your First name Last name, Email id and Password according to the format for every information you enter and also provide with each and everything asked during the registration process.



The 'Sign Up' form is a vertical stack of five light blue input fields with black borders. The first four fields are labeled 'First name', 'Last name', 'Email', and 'New password' respectively. Below these fields is a solid blue button with the text 'Sign Up' in white.

Follow the conditions while you input your credentials. For example

- a) First and Last names can be alphanumeric and can contain letters (a-z) and numbers (0-9) and can't contain an equal sign (=), brackets (<,>), plus sign (+), period (.) or any other symbols. Names must contain minimum length of 5 characters.
- b) Passwords can contain any combination of ASCII characters and must contain a minimum length of 8 characters.
- c) Email id must have email format like @ sign and valid domain name like .com etc.

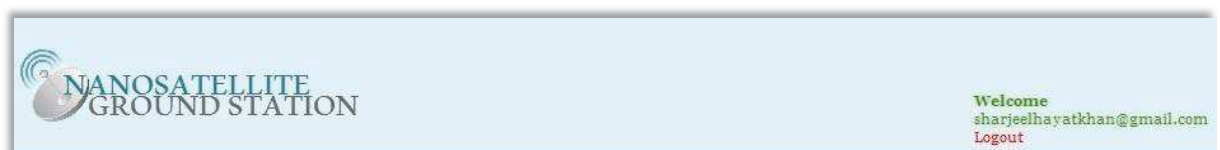
3. *Login to website*

Once you have registered on website, you can login to with your credentials used to register on website.



The 'Login' form is a vertical stack of two light blue input fields with black borders. The first field is labeled 'Email' and the second is labeled 'Password'. Below these fields are two solid blue buttons labeled 'User' and 'Admin'. At the bottom of the form is a link that says 'Forgot your password?'.

It will take you to your page (user page) as shown below.



This is specific page for every user where he can find his personal information and also some more specific informative and operational data about satellites and their controls and information about Groundstation. This page has a booking tab that allows him to reserve a timeslot on server if he wants to work on Groundstation. On this page user also have a current status of reservations already made by him and other users as well so that he can chose a different timeslot while making his timeslot reservation.

Your Bookings				
Date	Time	You	Session	Delete User
2016-07-12	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel kk	Delete
2016-07-14	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel sh	Delete
2016-07-16	20:00:00	sharjeelhayatkhan@gmail.com	sharjeel ds	Delete

All Bookings			
Date	User Id	Session	Time
2016-07-12	sharjeelhayatkhan@gmail.com	sharjeel kk	20:00:00
2016-07-14	sharjeelhayatkhan@gmail.com	sharjeel sh	20:00:00
2016-07-16	sharjeelhayatkhan@gmail.com	sharjeel ds	20:00:00

4. Reserve a timeslot

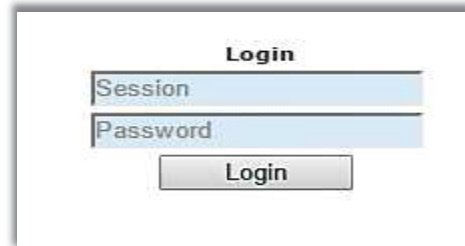
User page has a tab for booking his timeslot to work on Groundstation. Here user should write a session name and password (same or different from the password for login to website), select date and time. For this purpose he must follow the conditions given below

- Session name can be alphanumeric and can contain letters (a-z) and numbers (0-9) and can't contain an equal sign (=), brackets (<,>), plus sign (+), period (.) or any other symbols. It must contain minimum length of 5 characters and maximum 10 characters.
- Password can contain any combination of ASCII characters and must contain a minimum length of 8 characters.
- Date and time must be current or later. When date is current date user must select current at least current or later hour as he cannot reserve the past hour or date.

Ground Station	
Booking	
Session name	
Password	
Year ▼	Mon ▼ Day ▼
Time ▼	Book

5. **Login to Server**

After user has reserved his timeslot the reservations information is updated automatically and he can see his reservation is shown in the table. From this page he can login to server (Groundstation) providing his credentials entered during the reservation procedure.



Once he logged in his reservation credentials are automatically made invalid and he is directed to Groundstation where he can use software application of his choice. As timeslot has length of 60 minutes it will automatically end his session on time expiration he must complete and save his work and download to his personal computer before his session ends. He must reserve again if he wants to use server in future.

6. **Use your Software product**

Software products available to user are Orbitron and Control box depending upon his type. *General user* doesn't need to reserve time slot on server as he has enough information on his page and website. *Standard user* will need to reserve a timeslot if he needs more detailed information like satellite position, path and time to reach a specific location and weather information so he will have access to Orbitron only, as it efficiently provides above described information. *Controlling user* will have access to Orbitron and Control box he can do all operations including control satellites position and working responsibilities etc. *Administrator* has full access to each and everything he can even modify software applications and their control and also he can cancel reservations of users. He has complete access to everything involved in this system.

7. **Save your work**

As described above user must save his work before his session ends automatically. SparkView provides this facility. As user logs in to server user disk is created automatically to keep his current session and when he saves any file like picture or any other data, it is saved on that disk. In case user cannot save and download his work to his computer or device he is using before his session ends he will lose all of his work and it cannot be undone again and he will need to reserve a timeslot in the future and complete his work again and save and download it as explained in next step 8.

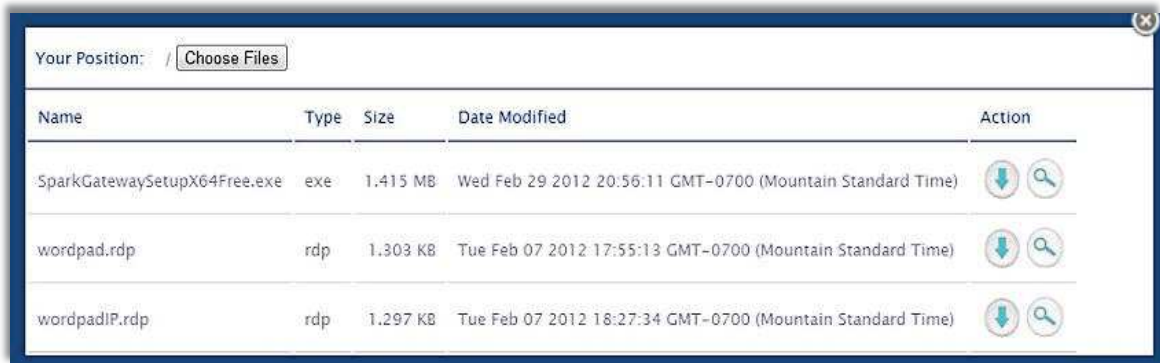
8. **Download to your Computer**

User saves his work on the temporarily disk on server created for his current session. He uploads his data to SparkView and then downloads to his own computer or device as shown below.






Choose files or drag files to your remote desktop (anywhere except the cloud icon) after logged in. Click the cloud icon on the top middle of you screen to check the uploading process.



To download file, Click the cloud icon, a file browser dialog is displayed. You can enter a folder or select a file to download. You can also drag a file to your desktop directly if you are using Chrome.



The screenshot shows a file browser window with a title bar and a close button. The window contains a table with the following data:

Name	Type	Size	Date Modified	Action
SparkGatewaySetupX64Free.exe	exe	1.415 MB	Wed Feb 29 2012 20:56:11 GMT-0700 (Mountain Standard Time)	 
wordpad.rdp	rdp	1.303 KB	Tue Feb 07 2012 17:55:13 GMT-0700 (Mountain Standard Time)	 
wordpadIP.rdp	rdp	1.297 KB	Tue Feb 07 2012 18:27:34 GMT-0700 (Mountain Standard Time)	 

9. Logout from Server

After user completed all the procedure explained above he must logout or his session will end automatically and he will be logged out from website. He will need to login again to website to access his page.

This completes the guideline instructions to work on the system.

Chapter 8

8 Conclusions and Future Improvising

This chapter describes final specifications focusing on final results requirements in the form of system functionalities which were supposed to be done. It also improvises some forehead improvements which can enhance system capabilities in terms of working efficiency, balanced and better usage of resources and hence better convenient services for users.

8.1 Conclusions

Initially, it looked very difficult and challenging to achieve the goal but later I was successful to find some basic solution then getting improved day by day it concluded to final stage and in a good shape. Finally it is good solution. As listed in problem statement there are some key points listed below

- Availability of resources to end users
- Authenticated users to avoid unauthorized access
- Limited control on resources to keep them safe
- Access to provided software products only
- Reservation of timeslot before or on time (if available)
- No access before or after reserved timeslot
- Secure communication between user and resources

Conclusions show that I was able to keep all key points users can access the resources in a proper way and also they have limited access he can only run software apps and cannot do anything else like modification or setting configurations.

I took security measures to make sure of authenticated access to resources and software apps and he can only access allowed apps.

Main key point is timeslot reservation and access during reserved timeslot that works efficiently. User cannot login to Groundstation before or after his reserved timeslot to access his apps. Website takes good care of booking system and works great.

And final key point is a secure communication between user and Groundstation that is done with secure channel and website works on https protocol that authenticates the communication is secure and is with original server and avoid attacks like shadow server or man-in-the-middle.

Finally project concludes to a good solution to problem statement and works according to it.

8.2 Future Improvising

There is always a scope of some more work in any task done. I tried my best and achieved the required goal of the project. I have been very successful to make it complete. There are some improvements that can be implanted to make this setup more useful, reliable and user friendly.

Website is very simple and an important part of this project, that can be improved very much. One can put more useful information and improve contents to make it more informative. There can be added multi-dimensional figures and videos that will definitely improve graphics and looks giving more beautiful interface to users. User registration system can be improved in terms of email confirmation, password reset through cell number and many other login options can be defined.

Timeslot Booking system at the moment does not allow same session name for more than one user even for more than one sessions for same user in case he wants to reserve more than one timeslot. It can be improved to a more intelligent reservation system. There can also be made a forum to have discussions on topics related to satellites and other suggestion from users to make this system more useful and user-friendly.

This project can be enhanced to connect to more than one Ground stations and multiuser working can be implemented. If there will be more than one systems available to work on it will be possible to allow more than one users working simultaneously.

Spark View has many other useful features that can be utilized for online video conferences and data sharing so that people can join a virtual sessions to get deep knowledge about satellite and communications.

Finally, this project has much potential and can be improved and enhanced in many aspects and it can be a source of valuable studies in this field of satellite communication.

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Annexure A

Satellite Ground Station

Technical Manual

Contents

1. General	description
.....	2
2. GENSO	Requirements
.....	3
3. Ground Station overview	
3.1 Conceptual	scheme
.....	4
3.2 List of	devices
.....	5
3.3 Cables and	length
.....	5
3.4 Rack	layout
.....	5
4. Control devices	
4.1 Control Box	
4.1.1 General description and conceptual scheme	7
4.1.2 Block Diagram	8
4.1.3 RF connection detail	9
4.2 Control Board	
4.2.1 Control Board block diagram	10
4.2.2 PTT signals	11
4.2.3 Table of in/out bits	11
4.2.4 RF routing paths	12
4.2.5 RF and AC switch table	13
4.2.6 Schematic Diagrams and pin out	14
4.2.7 Internal RF Switches	17
4.2.8 Internal Power Switches	17
4.2.9 Front Panel and LEDs	18
4.2.10 MIC connector	19
4.2.11 Status LEDs	20
4.3 Rear Panel	
.....	21
4.4 S-Band Box	
4.4.1 General description	23

4.4.2 Block diagram	24
4.4.3 S-Band box control board schematic diagram	25
4.5 Control Box Software	26
5. Document list, datasheet, changes	28
6. Operating manual	
6.1 Quick Guide (local use)	30
6.2 How to create a new software	31

1. General description

The Politecnico di Torino Satellite Ground Station is a radio communication system, able to communicate with orbiting satellites in the assigned Radio Amateur Satellite Service bands.

The ground station is hardware and software compatible with the GENSO specifications.

The ground station is composed by two separate antenna systems, one for VHF/UHF and the other for S-band (2400 MHz); one rack containing the electronic and radio communication equipment and one PC for station control and communication with users, running the GENSO application.

The specifications of the system are:

VHF Antenna system:

2 crossed yagi, 10+10 el. Array gain = 17 dBi, RHCP polarization.

LNA, NF 0,9dB. Gain 20 dB

Receiver/transmitter: ICOM IC-910H, RF power 100W

Estimated EIRP: +36dBW

UHF Antenna system:

4 crossed yagi, 18+18 el. Array gain = 22 dBi, RHCP polarization.

LNA, NF 0,9 dB. Gain 20 dB

Receiver/transmitter: ICOM IC-910H, RF power 70W

Estimated EIRP: +39 dBW

S-band antenna system:

3m gridded parabolic reflector, F/D 0,3, G= 35dBi. RHCP polarization, patch feed adapted to the reflector.

Receiver/transmitter: 144/2400 MHz transverter plus LNA and PA. NF=0,4dB. TX power 25W. EIRP

Estimated EIRP: +48 dBW

Antenna rotors:

ALFA-SPID BIG RAS – 0,5° accuracy and resolution. Variable speed DC motors, microprocessor controlled.

Radio equipment:

ICOM IC-910H as primary transceiver, VHF/UHF. Used as exciter for the S-band transverter.

Baseband access: 28/30 MHz via two 28/144 and 28/432 MHz transverters.

Monitoring system: a Perseus SDR HF receiver monitors the 28 MHz IF.

Decoding:

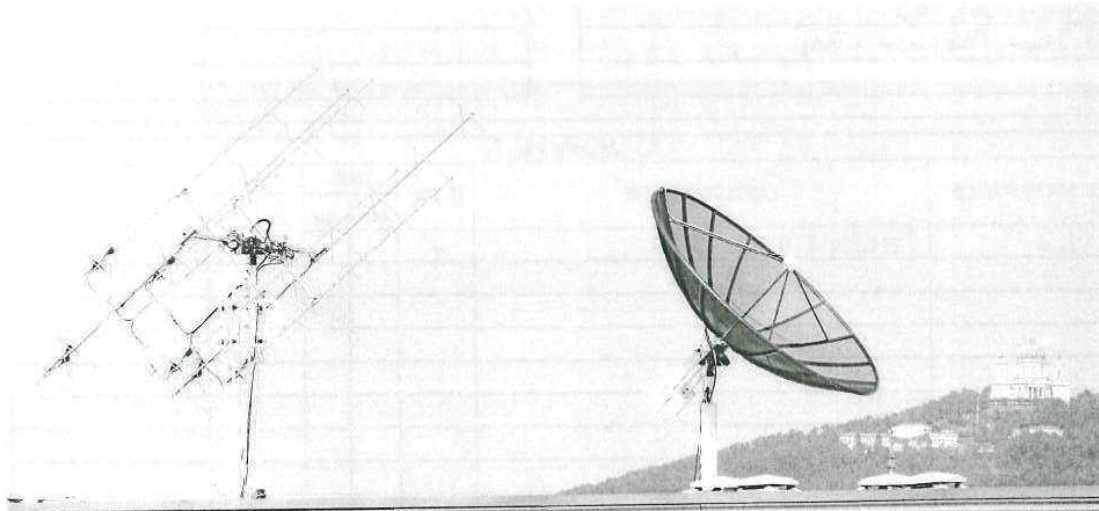
N-TG TNC7MULTI terminal node controller allows packet radio communications with digital satellites at 1200/9600/38400 Bd.

Control:

Pentium Dual-core PC under Windows XP executes the GENSO code for satellite tracking, communication and control. The PC is locally or remotely controlled via LAN.

Switching and interfacing:

A switchbox handles all interfacing and RF/DC/signal switching between equipments, under PC control.



Antennas of the Politecnico di Torino Satellite Ground Station

2. Requirements

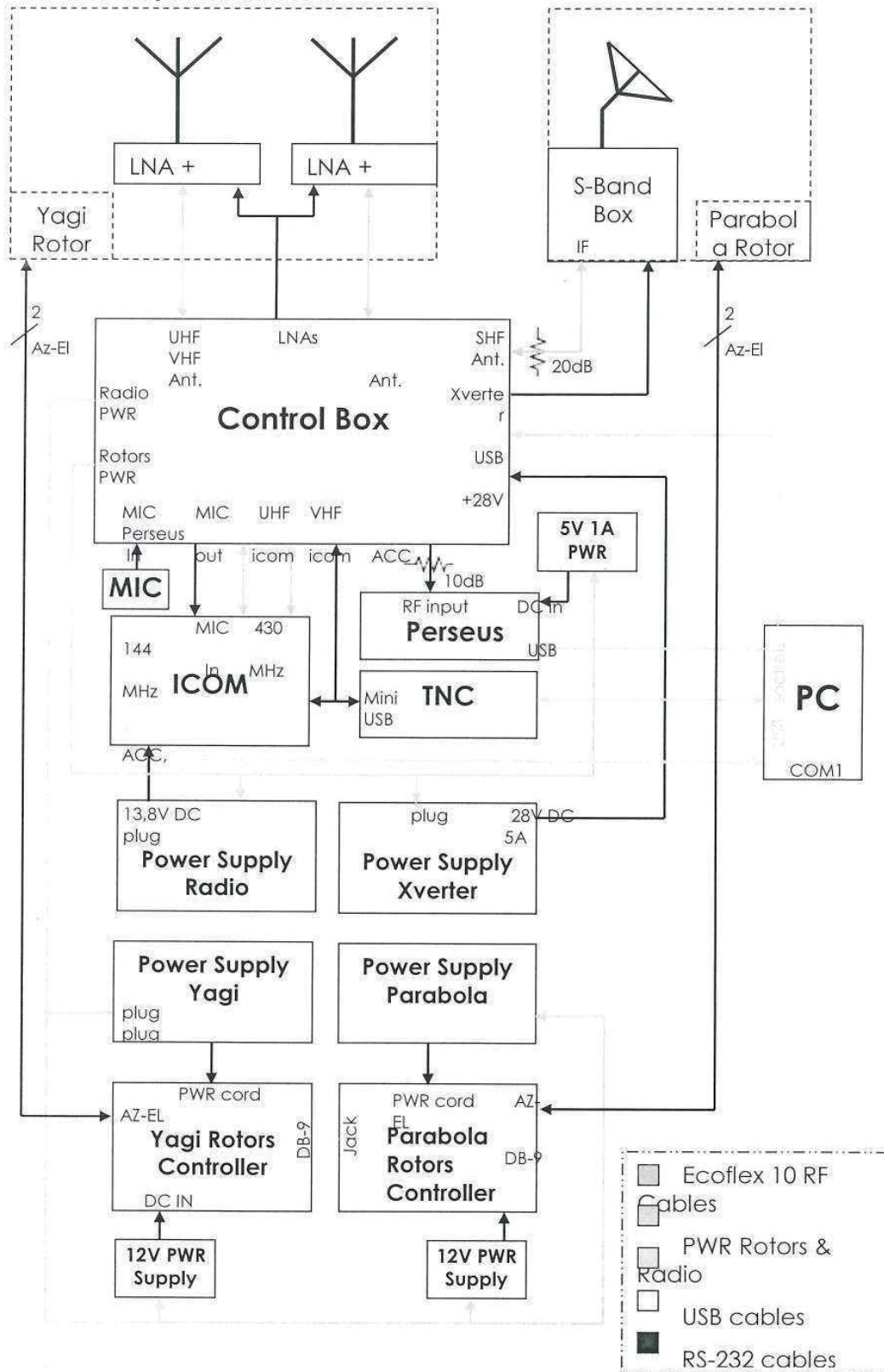
The ground station should comply to the GENSO standard, so must meet the following specifications:

- Controlled by a PC via USB cable
- Remote power control via USB
- RF signal routing between antennas, radio, auxiliary receiver and transceivers
- Software selection of operating bands (VHF, UHF, SHF)
- Operation in half-duplex or full duplex (VHF/UHF or UHF/SHF crossband)
- Visual display of selected signal paths and switch status to aid debug and operation
- Embedded diagnostics for power supply voltages and RF power
- Control of power supplies, internal and auxiliary (rotors, radio, etc)
- Auxiliary Transverters allow transmission/reception on all bands from an external IF transceiver (28-30 MHz IF)
- Signal routing (audio, PTT) between radio, TNC, microphone, and auxiliary Transverters

- management of PTT requests from all devices (microphone, TNC, Transverters)
- RX/TX switch timing for fail-safe operation
- Wideband RF channel monitoring of a selected band through "Perseus" SDR receiver
- Remote enabling of antenna LNAs

3. Ground Station Overview

3.1 Conceptual scheme



3.2 List of Devices.

- ✓ Yagi antenna for UHF Band: 22dBi gain, 4x 18+18 elements
- ✓ Yagi antenna for VHF Band: 17 dBi gain, 2x 10+10 elements
- ✓ Parabola antenna for S-Band: 35 dBi gain, 3 meters diameter
- ✓ Low Noise Amplifier for UHF: 20dB gain, 1,2dB NF
- ✓ Low Noise Amplifier for VHF: 20dB gain, 0,8dB NF
- ✓ Low Noise Amplifier for S-Band: 16dB gain, 0,4dB NF
- ✓ Alfa Spid Rotor for both Yagi antennas
- ✓ Alfa Spid Rotor for parabola
- ✓ S-Band Box
- ✓ Control box
- ✓ Radio: ICOM IC-910H
- ✓ TNC 7 multi USB TNC
- ✓ Perseus SDR RX 0-30MHz, 2 MS/s
- ✓ Velleman Power supply 13,8V / 30A (radio)
- ✓ 3 x ATEN Power supply 0-30V / 0-10A (transverter and rotors)
- ✓ 2 x Alfa Spid Rotor controller
- ✓ 2 x power supply 12V / 350mA
- ✓ PC with Microsoft Windows XP-pro

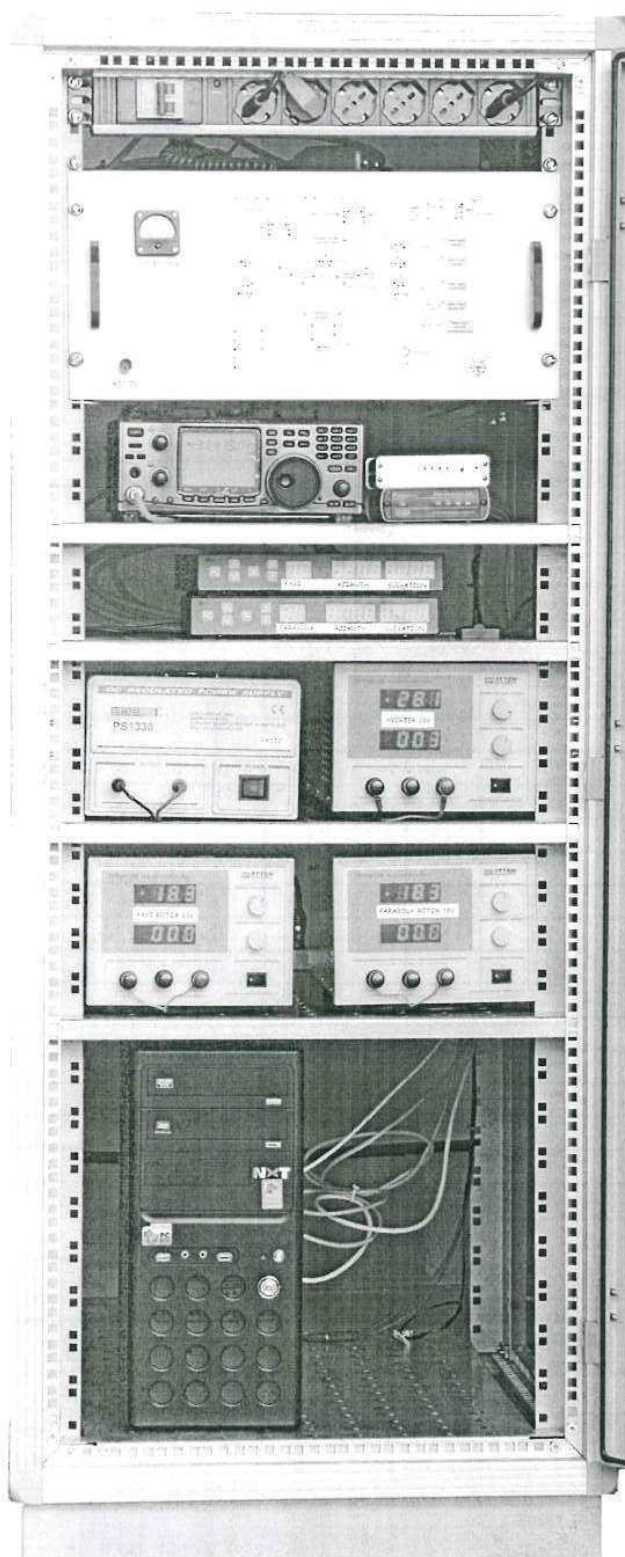
3.3 Cables and lengths.

- ✓ VHF RF feeder: 25m ECOFLEX 10 (50 Ω , attenuation @144MHz \approx 1,2 dB)
- ✓ 3 short ECOFLEX 10 cables for connection between combiner, LNA and VHF yagi antenna
- ✓ UHF RF feeder: 25m ECOFLEX 10 (50 Ω , attenuation @432MHz \approx 2,2 dB)
- ✓ 5 short ECOFLEX 10 cables for connection between combiner, LNA and UHF yagi antenna
- ✓ S-Band RF feeder: 27m ECOFLEX 10 (50 Ω , attenuation @144MHz \approx 1,3 dB)
- ✓ 1 Short ECOFLEX 15 cable for connection between TX S-Band Box and Parabola
- ✓ 1 Short ECOFLEX 10 cable for connection between Parabola and RX S-Band Box
- ✓ 2 x 25m four wire cables with shielding for Yagi's rotor
- ✓ 25m four wire cable with shielding for supply LNAs
- ✓ 2 x 27m four wire cables with shielding for Parabola's rotor
- ✓ 27m four wire cable with shielding for S-Band Transverter connection
- ✓ 2 x 25m UTP free cables

3.4 Rack layout

The rack is installed under the roof in the nearest secure place. It contains the power supplies, Radio, TNC, Perseus, Rotors controller, Control Box and PC. The connection between the various device inside the rack are descript in the conceptual scheme reported over there.

The final layout of the rack is reported in the next page.



Main switch / Mains plug
Logo and Station Identifier

Control Box

Radio, TNC, Perseus

Yagi rotor controller
Parabola rotor controller

Radio and Transverter power
supplies

Rotor power supplies

PC

4. Control Devices.

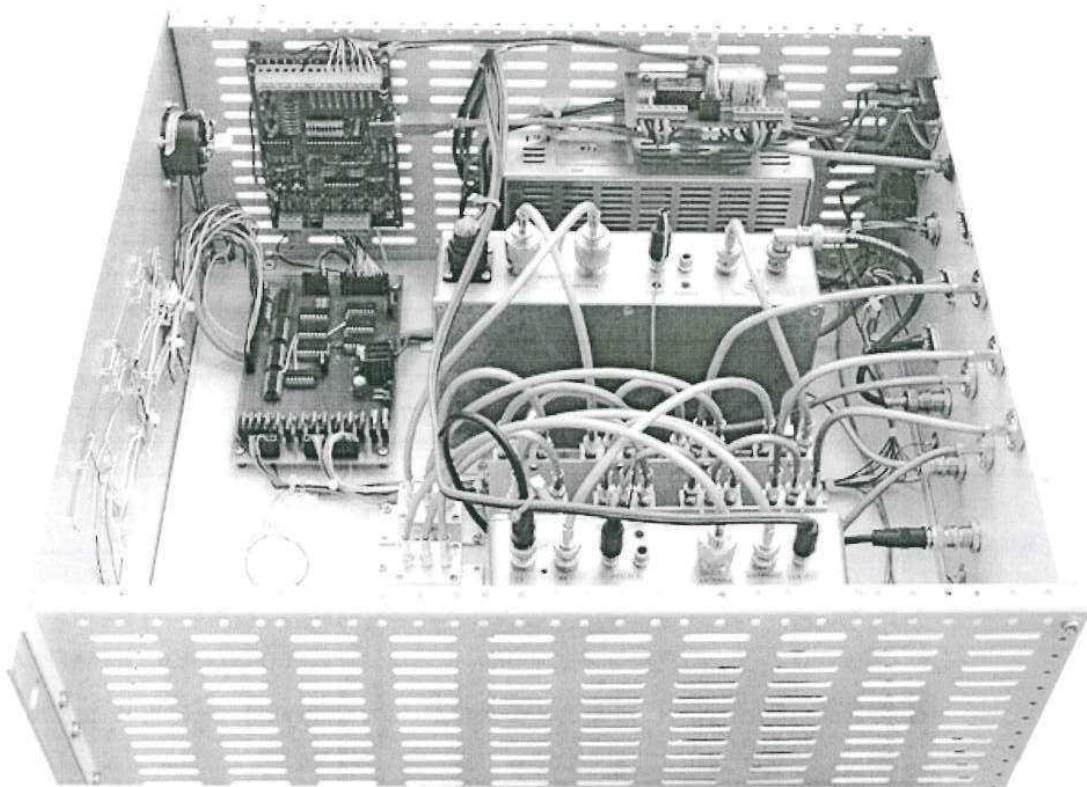
4.1 Control Box.

4.1.1 – Description

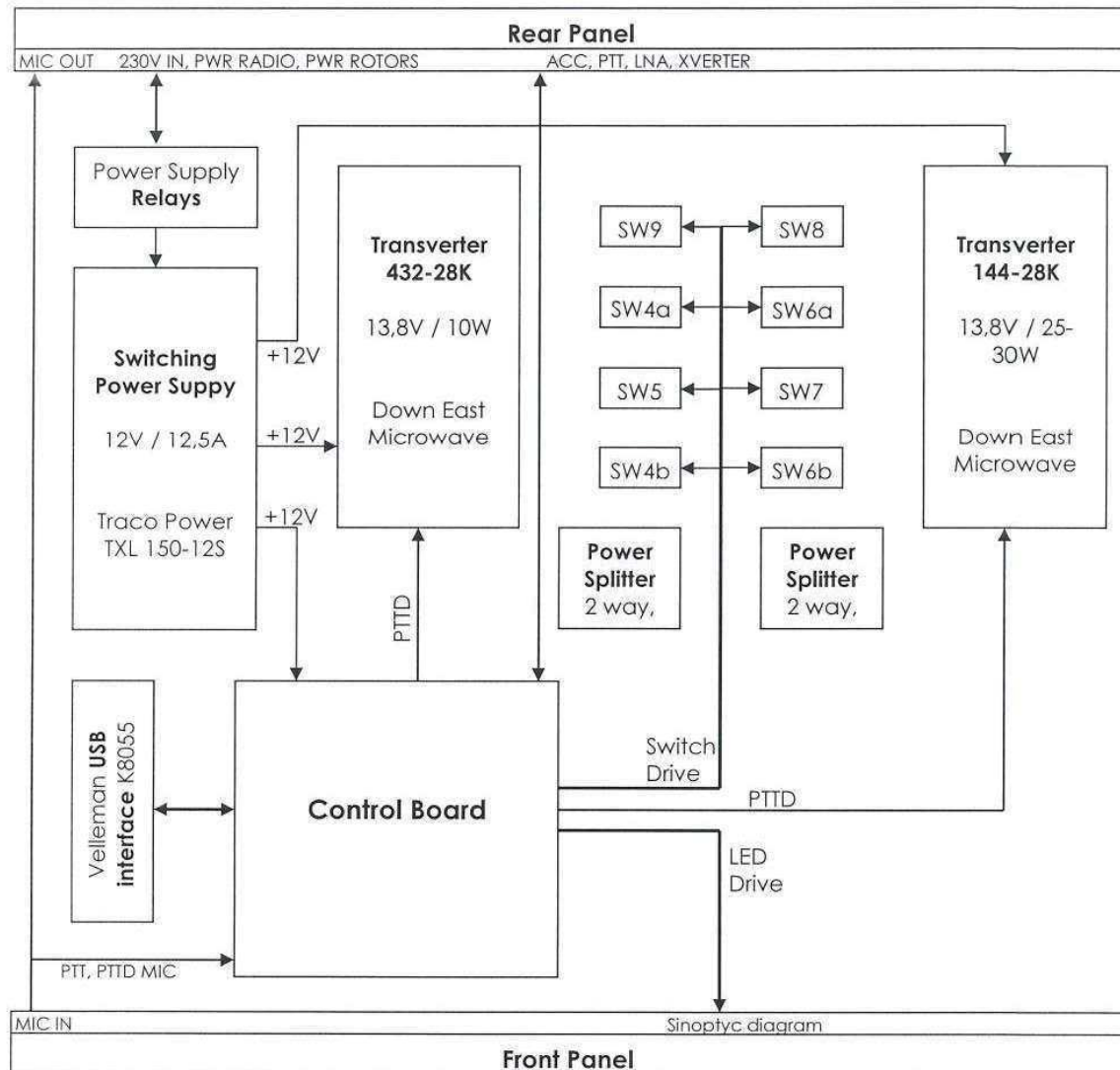
The Control Box contains the following functions:

- PC interface via USB
- Power supply control for itself and all external power supplies
- RF and control signal switching between sources
- RF signal conditioning (splitters, attenuators)
- HF/VHF and HF/UHF transverters
- Radio and TNC interfacing
- Signal sequencing
- Visual status indications
- Diagnostic and metering

Physically all is contained in a rack-mount enclosure, 5HE units high.

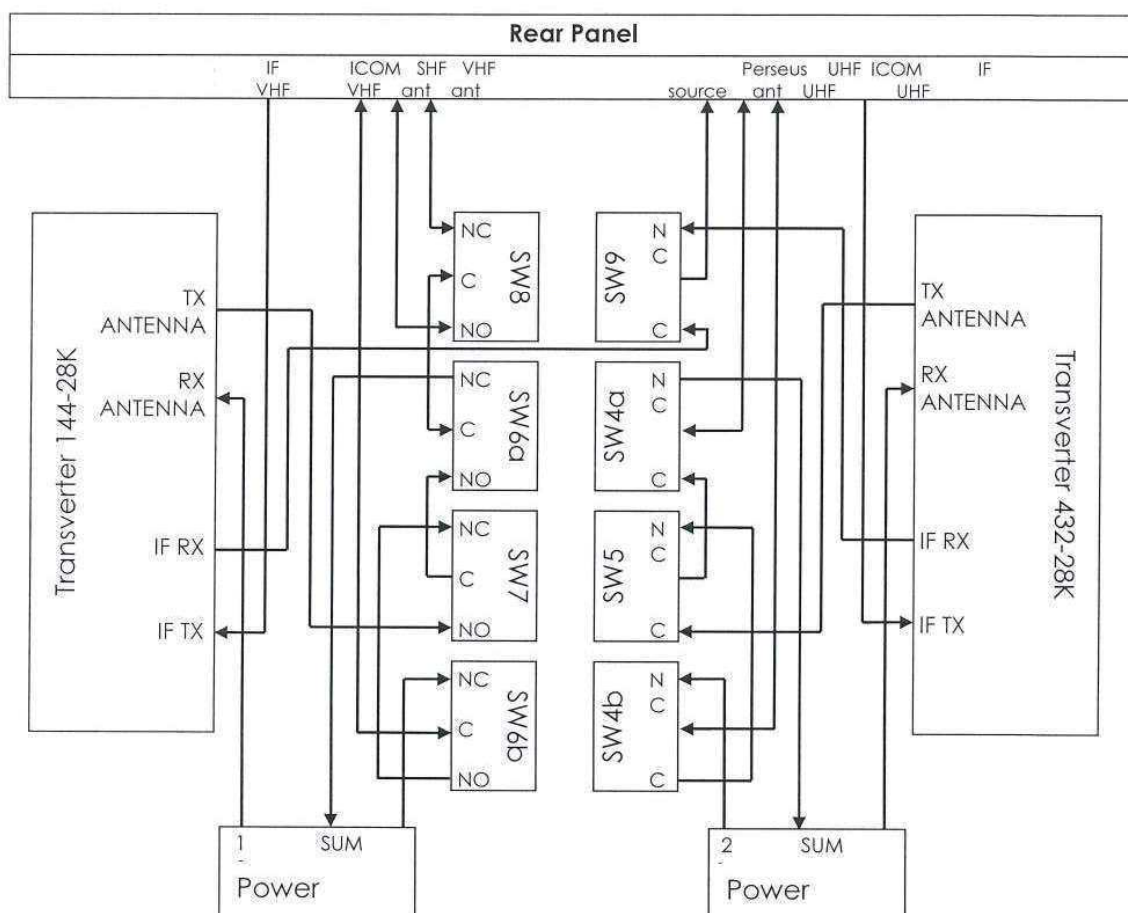


4.1.2 – Block diagram



4.1.3 – RF Connections Detail

Detail of interconnections between internal switches, transverters and power splitters. The connections are done with RG-142 cables; all switches and power splitters have SMA-type connectors, the antennas have N-type connectors except for 144-28k TX which have BNC-type connectors as all IF cables.

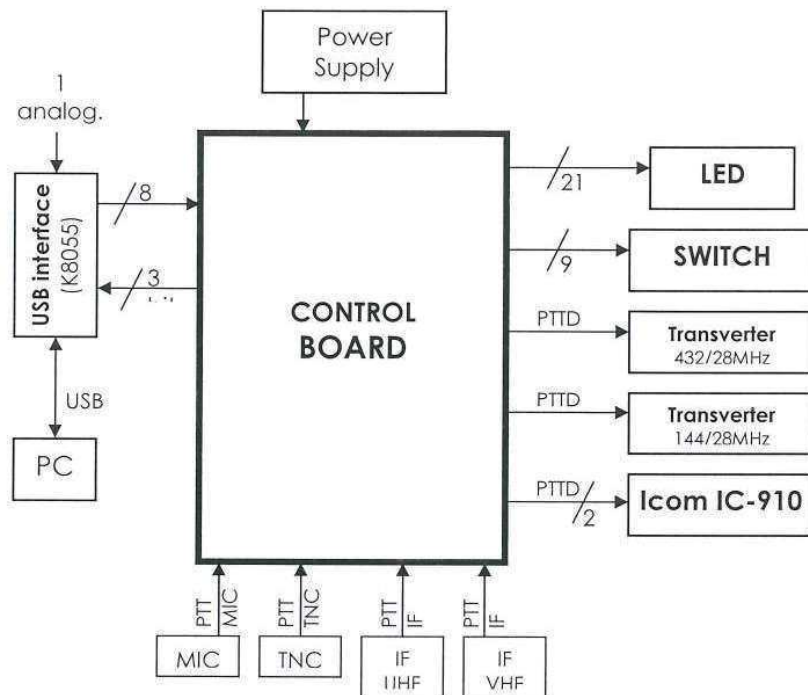


Type of used Cables:

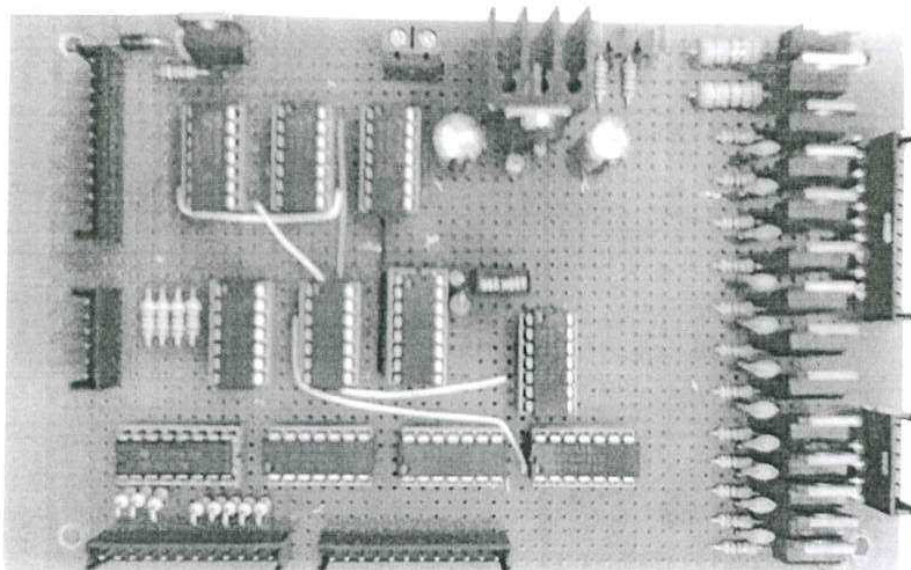
- ✓ 9 SMA-SMA cables
- ✓ 3 SMA-BNC cables
- ✓ 3 SMA-N male cables
- ✓ 5 SMA-N female cables
- ✓ 2 BNC-BNC cables

4.2 Control Board

4.2.1 – Control Board block diagram



This Control Board has been realized on a Eurocard IC pattern with wired logic C-Mos type (74HCxx family). All relays and PTTD signals are controlled by Darlington transistors.



4.2.2 – PTT Signals.

There are specific signals that allow transmission from a connected source, called PTT ("push to talk"). After receiving a PTT request, the control board set the RF switches in the correct way and after a 120 ms delay (variable by a potentiometer) enables the correct source (radio or transverter) for transmission. The delay allows all RF relay to switch without RF applied.

The available PTT sources are:

MIC	Microphone
TNC	Device for digital transmission in packages
IF	Other external source for UHF band
IF	Other external source for VHF band

The MIC and TNC PTT signals, through the control board, generate a PTTD (Delayed PTT) command towards the radio. In the same way, the IF PTT signals generates a PTTD command towards the corresponding Transverters. When a device receives the PTTD signal, it may begin to transmit.

4.2.3 – Table of input/output Bits.

To realize Genso's requirements, the control board must be controlled by remote users, so a PC connection is necessary. To control the various functions an USB interface board (Velleman USB Interface Board K8055) with 8 digital output (Q1 to Q8), 5 digital input (I1 to I5) and 2 analogical input (A1, A2) has been used.

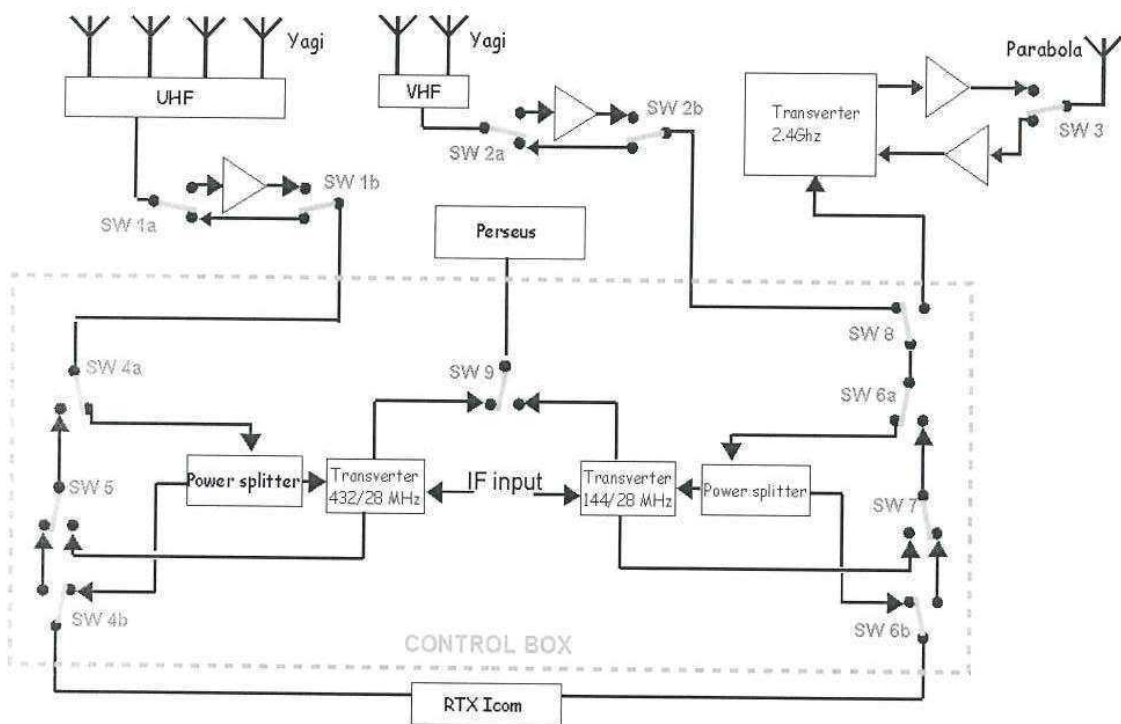
This interface provides 1 byte (8 bits) as output (Q1-Q8):

Q1	Bit 0	Switch box Power ON	1: Switch ON the system 0: Switch OFF the system
Q2	Bit 1	Rotors Power ON	1: Switch ON the supply of the rotors 0: Switch OFF the supply of the rotors
Q3 Q4	Bit 2 Bit 3	Transmission Band select	00: Transmission disable (all switches locked in receive-mode) 01: Preselect the UHF band 10: Preselect the VHF band 11: Preselect the SHF band
Q5	Bit 4	V/SHF RX select	1: S-band antenna routed to the VHF radio port through the S-band transverter 0: VHF band antenna routed to the VHF radio port
Q6	Bit 5	Perseus RF source	1: Perseus monitors V/SHF band (according to bit 4) 0: Perseus monitors UHF band
Q7	Bit 6	LNA enable	1: LNAs power enabled while in reception 0: LNAs are disabled
Q8	Bit 7	Not Used	Reserved for future expansion

The digital inputs of this board are additionally used as a feedback to control the status of power on radio and power on rotors; instead of this, the analogical inputs are used to measure the S-Band transmission power.

I1	Feedback Power on control box and radio	1: Power OFF 0: Power ON
I2	Feedback Power on rotors	1: Power OFF 0: Power ON
A2	Measure of S-Band transmission power	DAC from 0 to 255

4.2.4 – RF routing paths



This same image is printed on the switch box front panel. LEDs are placed near each switch, and indicate the current active RF path.

4.2.5 – RF and AC Switch table.

There are nine RF switches (SW1-SW9) and two AC power relays to be controlled. Some are double relays (2PDT) like the LNA switches, but are commanded together and indicated as a single relay for simplicity.

SW1	1: Inserts the UHF band antenna LNAs (ONLY for receiving) 0: Excludes the UHF band antenna LNAs (usually used in transmission)
SW2	1: Inserts the VHF band antenna LNAs (ONLY for receiving) 0: Excludes the VHF band antenna LNAs (usually used in transmission)
SW3	1: S-band Transmission 0: S-band Reception
SW4	1: VHF transmit path
SW5	1: UHF transmit path from IF source (RL6 MUST be '0')
SW6	1: VHF transmit path
SW7	1: VHF transmit path from IF source (RL6 MUST be '0')
SW8	1: S-band path (RX and TX) 0: VHF path
SW9	1: Perseus on VHF or S-band, according to RL8 0: Perseus on UHF
SWP1	1: Power supply ON (+12V/+28V) 0: Power supply OFF
SWP2	1: Power supply rotors ON 0: Power supply rotors OFF

The transistors used to control all switches are low-side drive, except for SW1 and SW2, used to power LNAs, which have an high-side drive transistor (+12V).

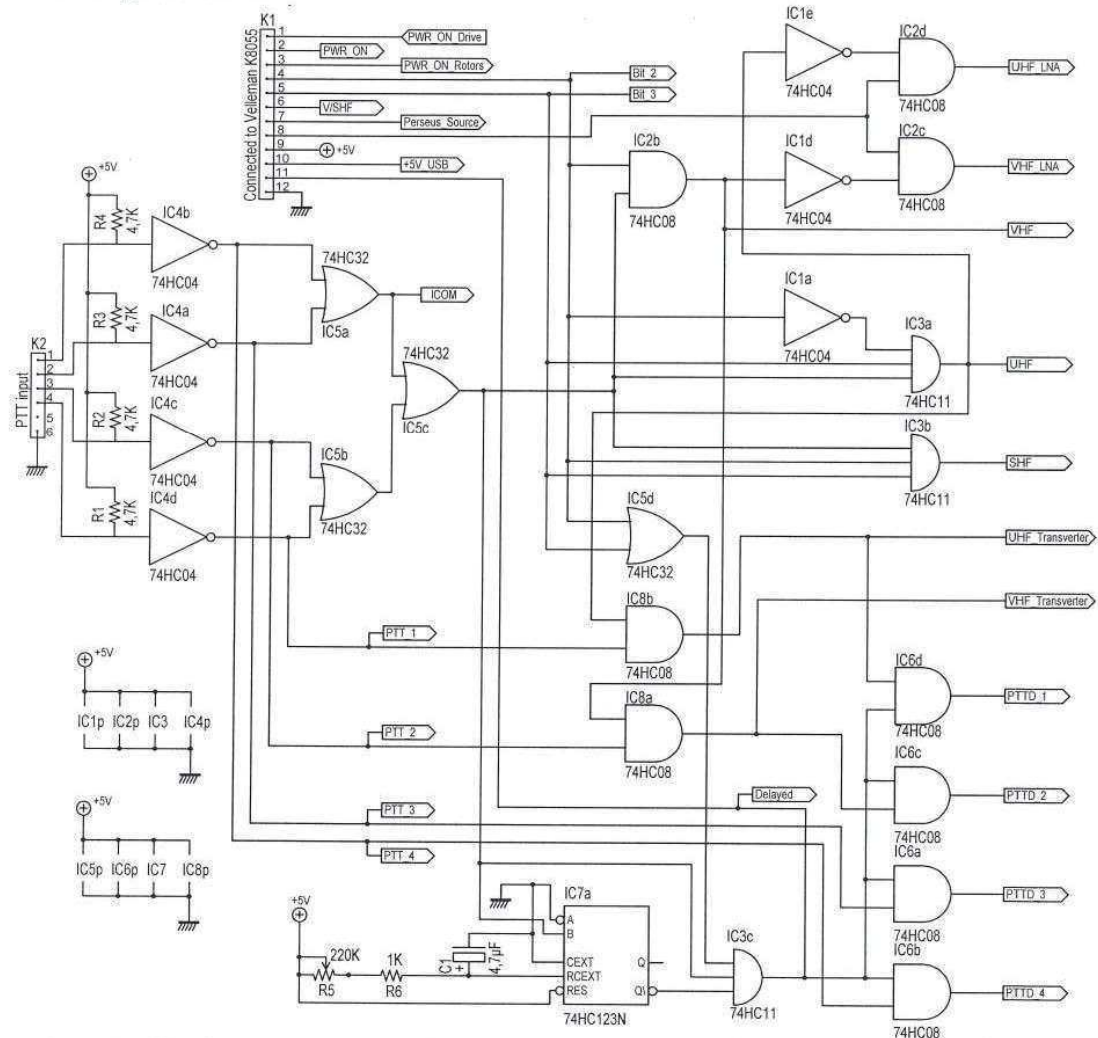
The LNAs for UHF and VHF Band have internal switches: those switches are reported in the general scheme with the name SW1a and SW1b for UHF LNA's, SW2a and SW2b for VHF LNA's.

SW3 signal is not directly connected to switch 3: it pass trough the Board present on S-Band Box.

To manage the LEDs on the panel, the control board has twenty-one output lines to drive LEDs. Each switch is associated to two LEDs; this means that only one LED, of the two associated to a switch, can be fed at the same time.

4.2.6 – Schematic Diagrams and Pin Out.

- Logical section



Connector K1: (to Vellman K8055)

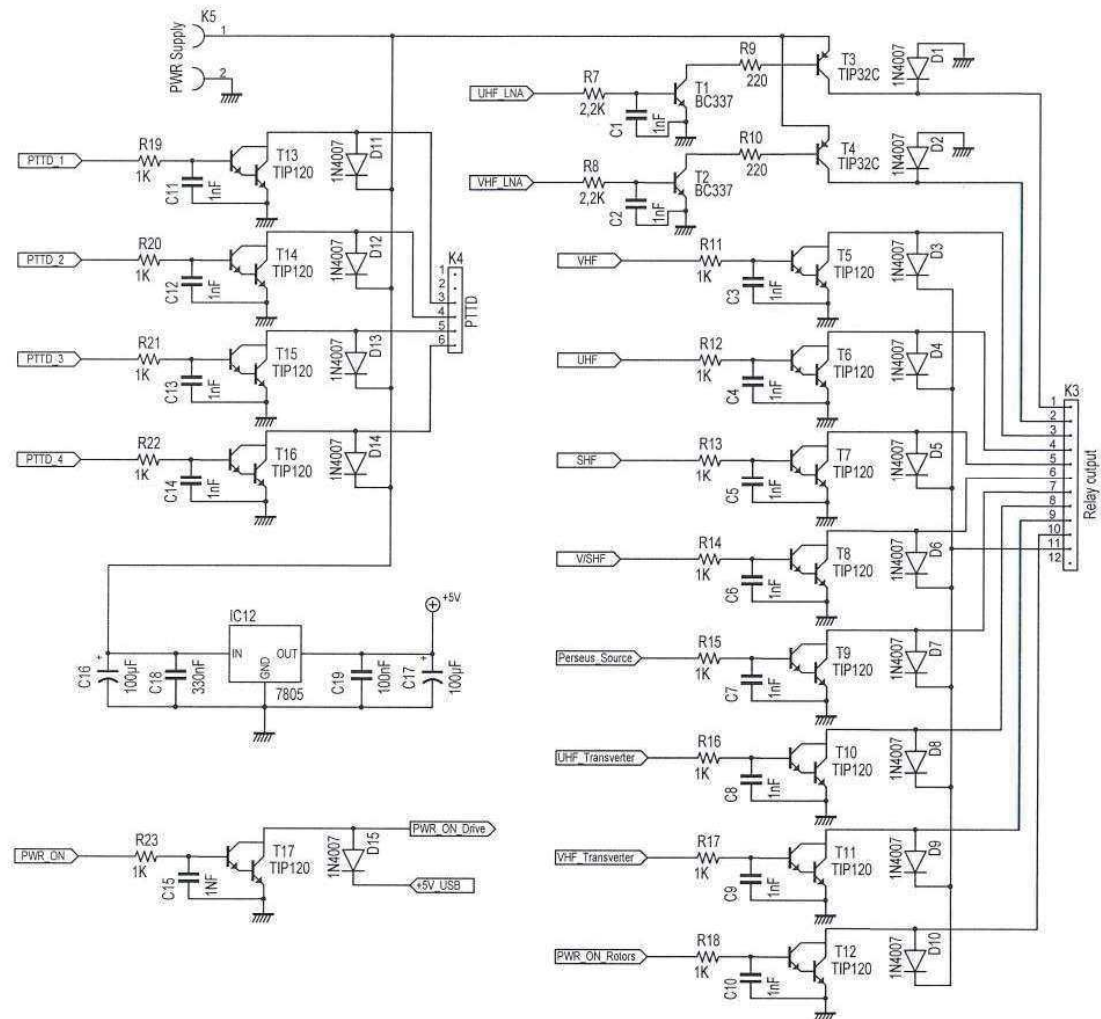
Pin	Function
1	Power On Relay Drive
2	Bit 0: Power On
3	Bit 1: Power On Rotors
4	Bit 2: Tx Band Select
5	Bit 3: Tx Band Select
6	Bit 4: V/S HF RX select
7	Bit 5 : Perseus source
8	Bit 6: LNAs enable
9	+5V Board Supply
10	+5V USB clamp
11	Delayed Time (related to PTT)

Connector K2: (PTT inputs)

12	GND
----	-----

Pin	Function
1	PTT MIC (active low)
2	PTT TNC (active low)
3	PTT IF VHF (active low)
4	PTT IF UHF (active low)
5	Not connected
6	GND

- Power supply section and Switch drive section.



Connector K3:

Pin	Function
1	+12V SW1
2	+12V SW2
3	SW6 Drive
4	SW4 Drive
5	SW3 Drive
6	SW8 Drive
7	SW9 Drive
8	SW5 Drive
9	SW7 Drive
10	Relay Rotors ON Drive
11	+28V Clamp
12	Not connected

Connector K4:

Pin	Function
1	Not connected
2	Not connected
3	PTTD IF UHF (active low)
4	PTTD IF VHF (active low)
5	PTTD TNC (active low)
6	PTTD MIC (active low)

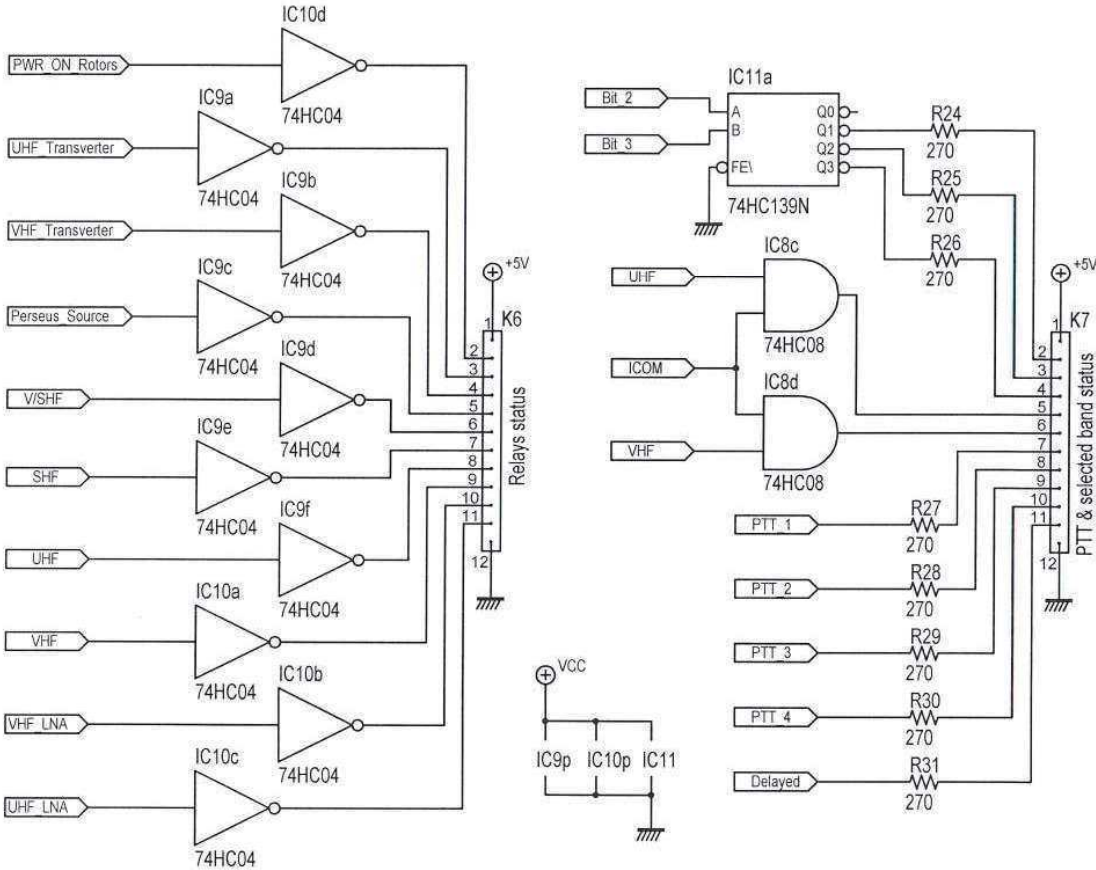
Connector K5:

Pin	Function
1	Power supply +12V
2	Power supply GND

The K3 connector provides outputs on the various switches that control the signal routing with a maximum current of 400 mA. The CLAMP pin must be connected to the positive voltage that supplies the switches.

The K4 connector provides the PTTD signals to the devices that are enabled to transmit.

- **LEDs drive section.**



Connector K6:

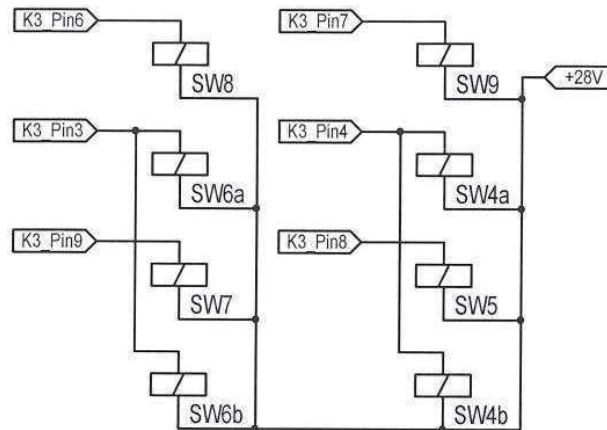
Pin	Function
1	+5V D.C. (LEDs Supply)
2	Status of Power ON Rotors
3	Status of SW5
4	Status of SW7
5	Status of SW9
6	Status of SW8
7	Status of SW3
8	Status of SW4
9	Status of SW6
10	Status of SW1
11	Status of SW2
12	GND

Connector K7:

Pin	Function
1	+5V D.C. (LEDs Supply)
2	Band Selected UHF
3	Band Selected VHF
4	Band Selected SHF
5	ICOM transmission to UHF
6	ICOM transmission to S/VHF
7	Status PTT of MIC
8	Status PTT of TNC
9	Status PTT Transverter S/VHF
10	Status PTT Transverter UHF
11	Status PTT Delayed
12	GND

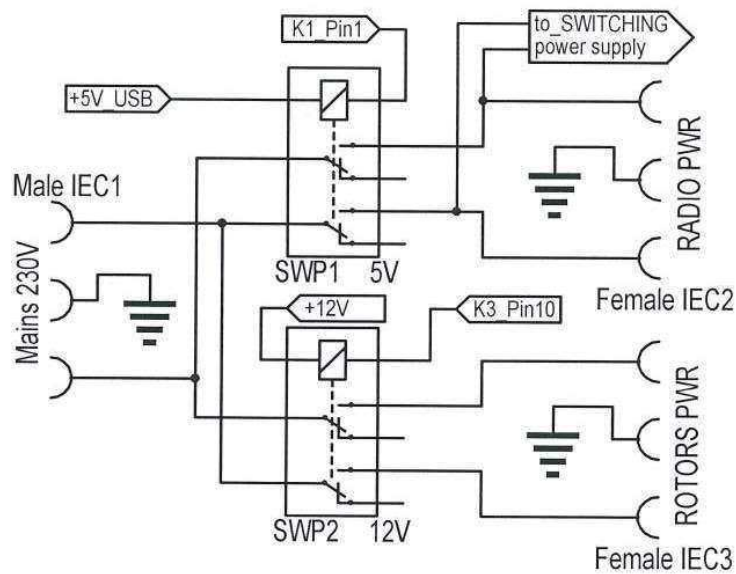
4.2.7 – Internal RF Switches.

The circuit diagram of all RF switches present in the control box is reported below.



The RF connections of those switches are reported in the Switches General scheme in the previous section. These switches are powered with +28V provided by an external power supply through a male 4-pins chassis connector in the rear panel of the Control Box.

4.2.8 – Internal Power Switches.

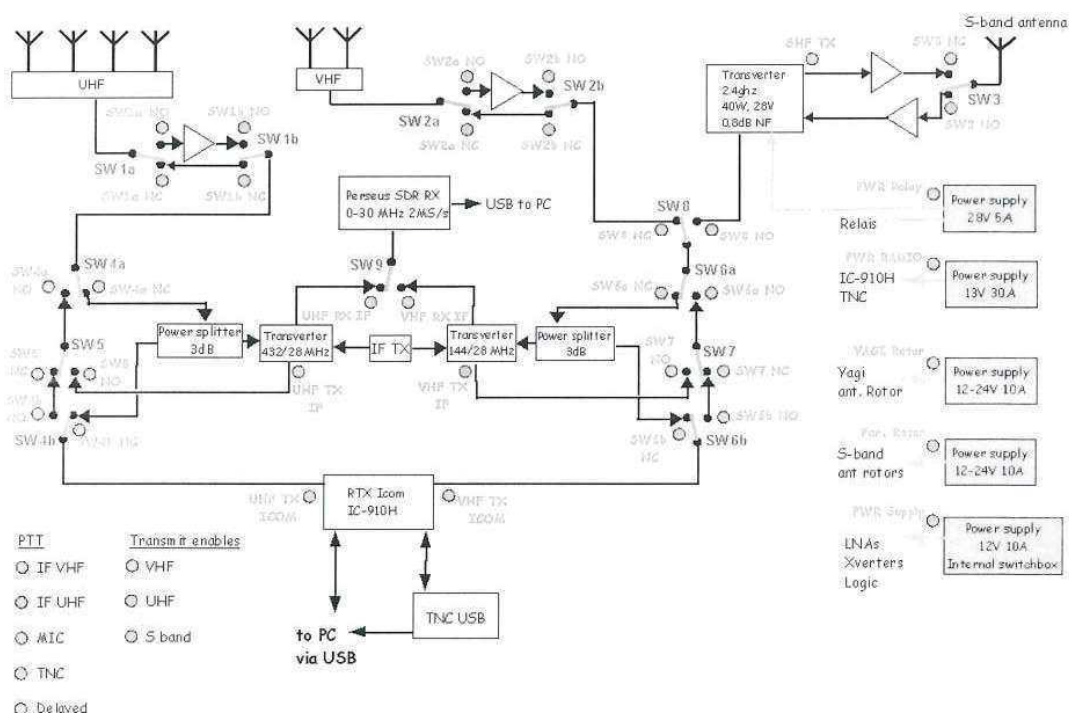


These two relays are soldered to a small board; they are connected to 230V mains power and to two pins of the Control Board. In accordance with signals from Control

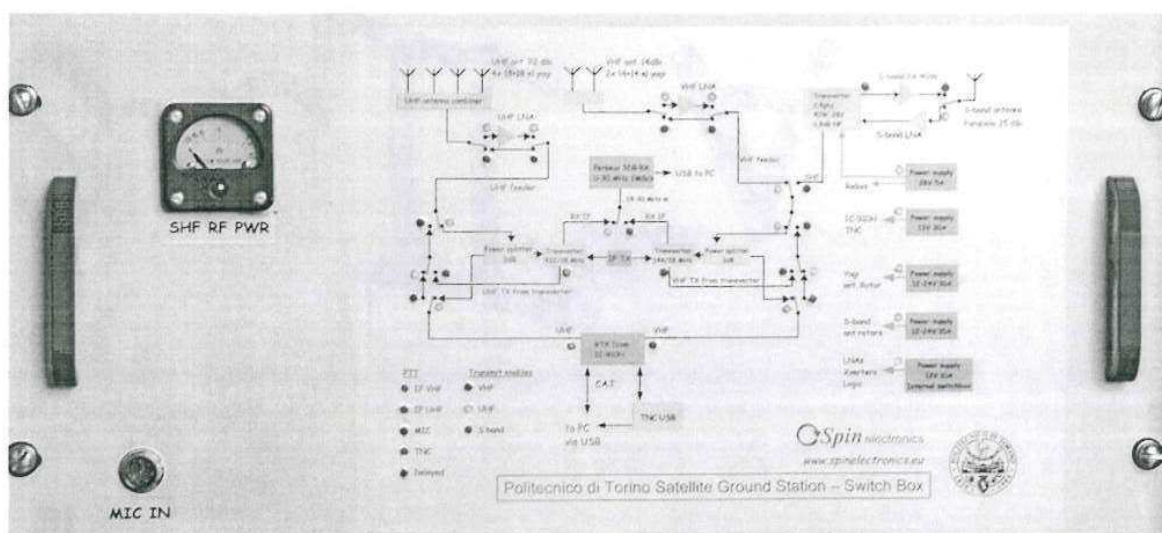
Board, SWP1 powers the internal switching power supply and the external power supply of the Icom. In the same way, SWP2 powers the two rotor power supplies.

4.2.9 – Front Panel and LEDs.

On the control box front panel there is a scheme of the entire systems with LEDs displaying the status of the switches, to allow an easy visualization of the signal routing.



This scheme appears in front of the Control Box; the one reported here has in additions the names of the leds (in red) and the names of the switches (in gray) to simplify the understanding.



In addition to switch status, other LEDs are associated to:

- four PTT signals (from microphone, TNC, and the two transverters)
- delayed PTT active
- radio UHF and VHF transmit function
- Transmit enables for each band
- Power supply (primary power applied)

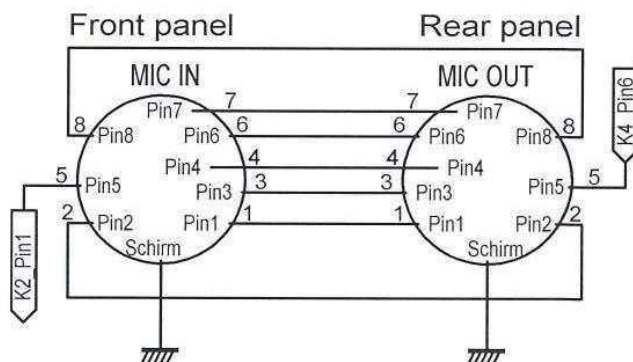
In the left side of the frontal panel there is also an analog meter indicating S-Band transmission power. The RF S-band power information is also measured by an ADC channel on the Velleman USB controller board, and is available to the operator. The nominal output power of 25W appears as 0dB on the meter and 70% on the ADC scale.

4.2.10 – MIC connector

A connector for Microphone input is provided on the front panel. The MIC input carries the PTT request that is processed by the Control Board and send back to the connector in the rear panel, for further connection with the radio. The scheme of MIC signals is reported below.

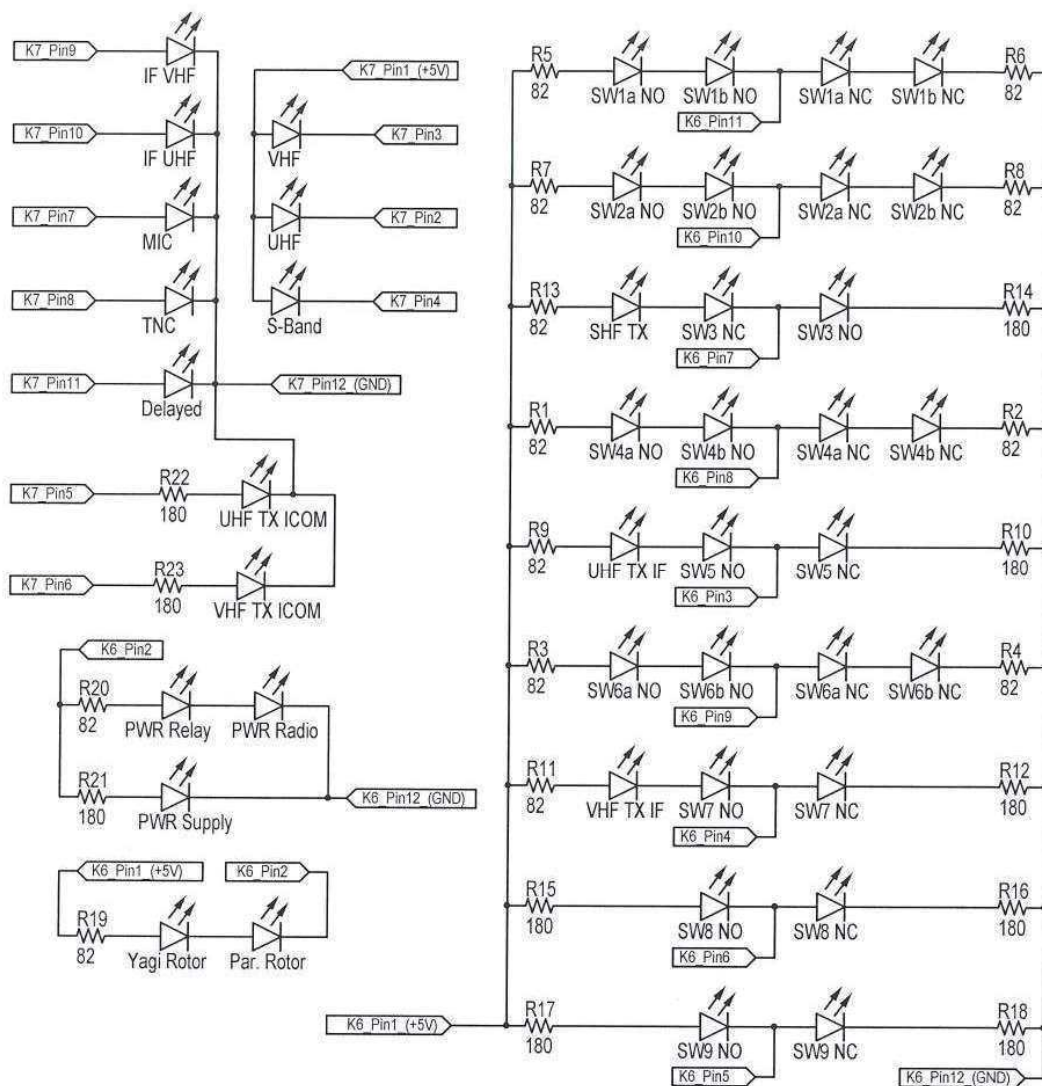
MIC OUT and MIC IN pin out:

Pin 1	MIC (microphone input)
Pin 2	+8V (max 10mA)
Pin 3	MIC U/D (freq. Up/Down)
Pin 4	SQLS (squench switch)
Pin 5	PTT
Pin 6	GND (PTT ground)
Pin 7	GND (Microphone ground)
Pin 8	AF OUT



4.2.11 – Status LEDs

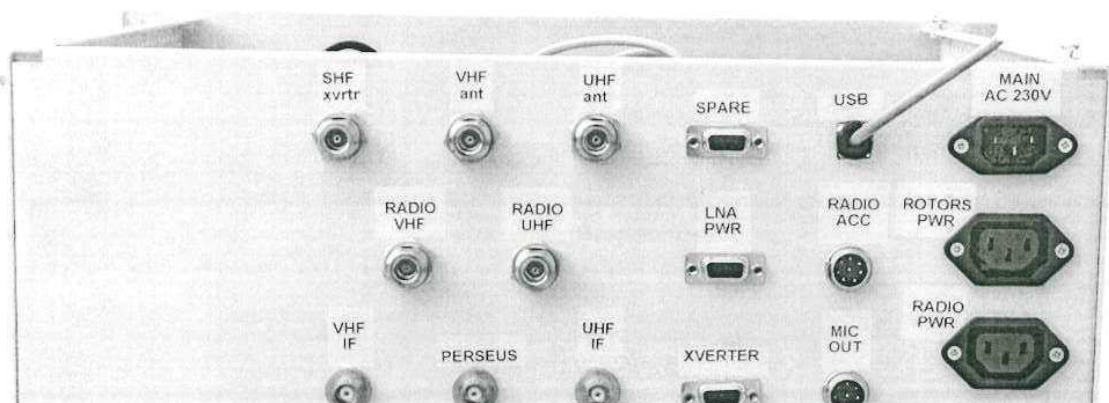
The LEDs are positioned on the holes made in the front panel, they are connected as visualized in the scheme below. The resistors and the connection wires to the control board are soldered directly to LEDs pins in the back of the panel.



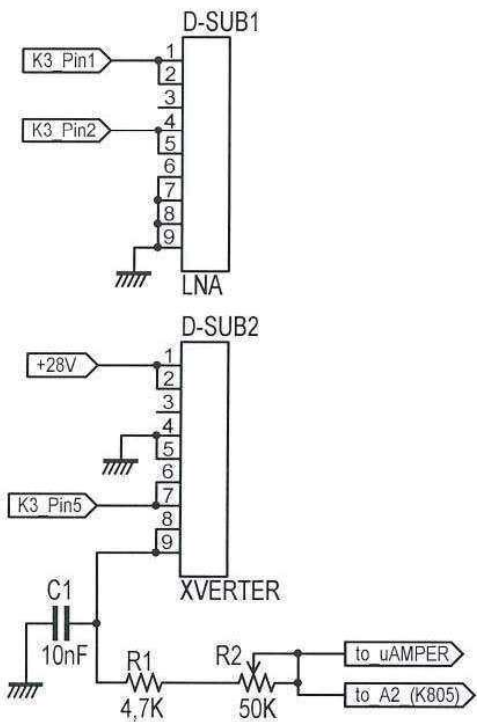
4.3 – Rear Panel

All connections, except for MIC input, are on the rear panel of the Control Box .
The connectors are identified by printed labels.

Label	Connector type	Function	From/To
MAIN AC 230V	Male IEC	General power supply	From mains plug
ROTORS PWR	Female IEC	Rotors power supply	To rotors multiple socket
RADIO PWR	Female IEC	Radio power supply	To radio multiple socket
+28V DC IN	Male 4 pin chassis	Transverter and internal RF relays power supply	From external power supply +28V / 5A
LNA PWR	Female D-SUB 9	LNAs power supply	To LNAs of Yagi antennas
XVERTER	Female D-SUB 9	S-Band box power supply	To S-Band box
USB	USB cable	USB connection	To PC
MIC OUT	Male 8 pin chassis	Output MIC signals	To ICOM
RADIO ACC	Male 8 pin chassis	ICOM data	To ICOM
VHF ant	Female N	VHF RF feeder	Yagi VHF antenna
UHF ant	Female N	UHF RF feeder	Yagi UHF antenna
SHF xvrtr	Female N	S-band RF feeder	S-Band Box
RADIO VHF	Female N	144MHz antenna connector	ICOM
RADIO UHF	Female N	430MHz antenna connector	ICOM
VHF IF	Female BNC	IF input for transverter	Not connected
UHF IF	Female BNC	IF input for transverter	Not connected
PERSEUS	Female BNC	IF signals output	To Perseus
VHF IF PTT	Female BNC	PTT request	Not connected
UHF IF PTT	Female BNC	PTT request	Not connected
SPARE	Female D-SUB 9	None	Not connected



Rear Panel connectors pin out

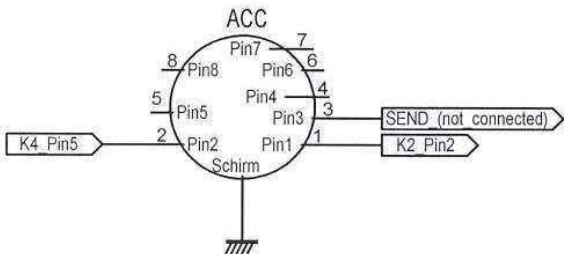


LNA PWR:

Pin 1	+12 V UHF LNA Power supply
Pin 2	
Pin 3	Not used
Pin 4	+12 V VHF LNA Power supply
Pin 5	
Pin 6	GND
Pin 7	
Pin 8	GND
Pin 9	

S-band Transverter:

Pin 1	+28 V S-box power supply
Pin 2	
Pin 3	Not used
Pin 4	GND
Pin 5	
Pin 6	S-Band Transmission
Pin 7	
Pin 8	RF measure
Pin 9	



ACC:

Pin 1	PTT in from TNC
Pin 2	TNC PTTD out to ICOM
Pin 3	Send (ICOM transmission status)
Pin 4	Not used
Pin 5	Not used
Pin 6	Not used
Pin 7	Not used
Pin 8	Not used

4.4 S-Band Box.

4.4.1 – General Description

A 144-146 -> 2400-2402 MHz transverter allows operation in the radioamateur satellite S-band.

The transverter is associated to a 25W PA (KU PA 2345) and a low-noise preamplifier.

The preamplifier and the front switching relay (SW3) are mounted at the parabolic reflector focus point, just at the rear of the feed. All other equipment is contained in a weather protected box at the base of the parabolic reflector mount.

The box also contains a control board powered from +28V, a terminal block to allow connection with external devices and a considerable heat sink with fan for PA and voltage regulator cooling .

The Board provides power (+12V) for LNA (MKU LNA 231 AH) and the switch SW3, and has two LEDs indicating +28V and PTT presence.

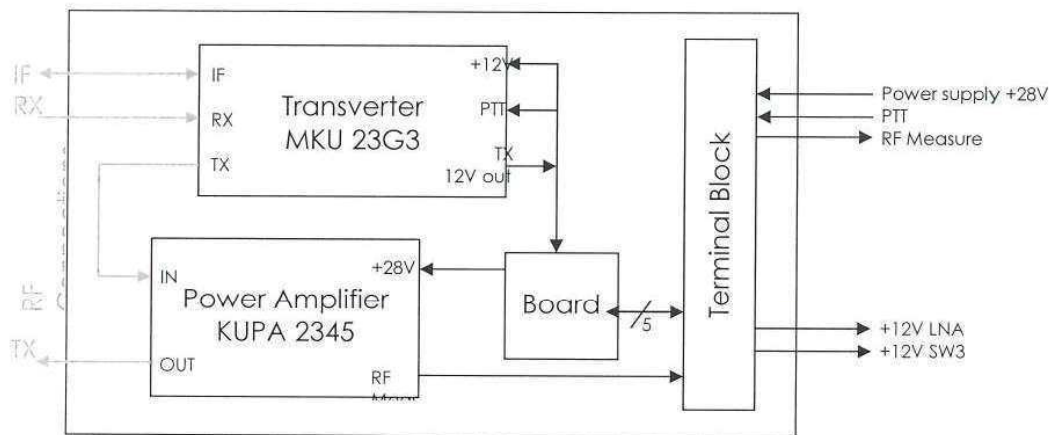
The transverter is always powered with +12V provided by the LM7812 present on the board, instead, the PA is only powered when the board receive a transmission request; in this situation the board provide also the switch-off of both LNA and SW3.

The transverter has an oven-stabilized crystal oscillator, and may be feed by an external, high accuracy 10 MHz signal if desired (not provided).

The PA RF measurement signal, proportional to the RF output power, is feed back to the main control box.

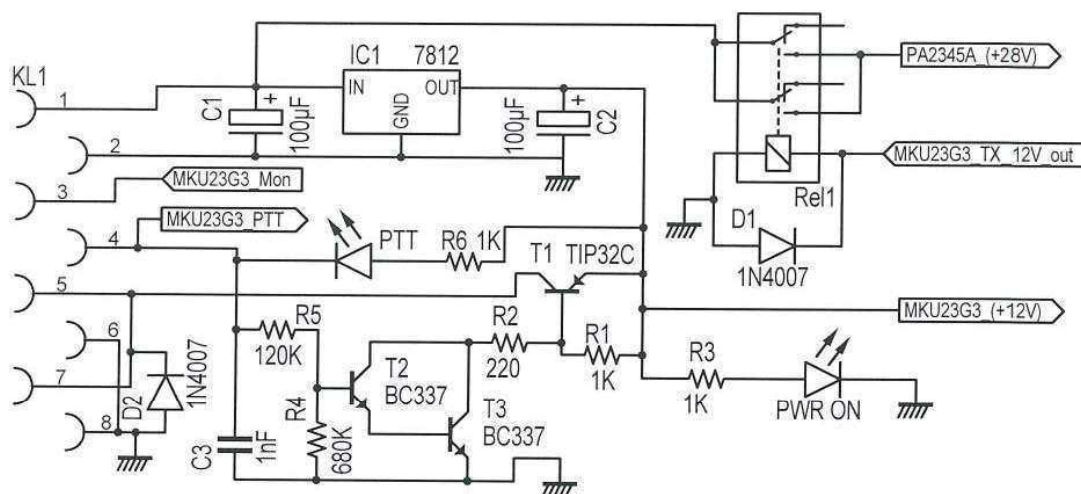
(foto)

4.4.2 – Block diagram of the S-band transverter box



(foto)

4.4.3 – S-band transverter box control board schematic diagram.



The labels present in this scheme are wires soldered between the board and corresponding devices.

Pin Out KL1

Screw 1	Input Power supply +28V	From Switch Box
Screw 2	Input Power supply GND	From Switch Box
Screw 3	RF measure of PA	To Switch Box
Screw 4	PTT	From Switch Box
Screw 5	Output Power supply +12V	To MKU LNA 231 AH
Screw 6	Output Power supply GND	To MKU LNA 231 AH
Screw 7	Output Power supply +12V	To SW3 +
Screw 8	Output Power supply GND	To SW3 -

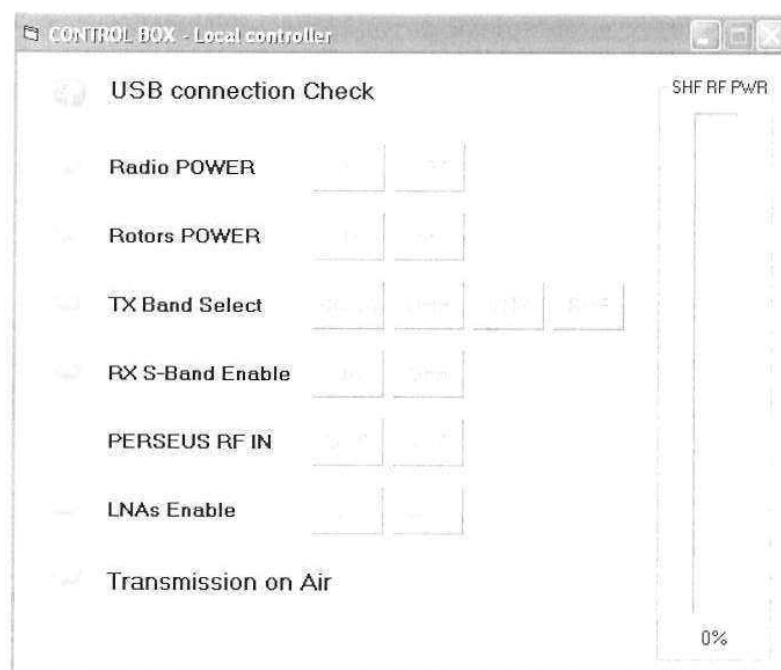
4.5 Control Box Software.

A controller software, written in Visual Basic, has been written to debug, test and manage the control box. The software communicates through the USB Interface and sets the switches present in the ground station. An operator feedback of the switch status is given.

This software sets seven output bits on the K8055 board as per "Table of Input Bits" in section 4.1.

The program shows a window with some buttons and icons.

At launch the program searches for the appropriate USB connection. While the control board is not detected, all icons are displayed in red, buttons are disabled and the user can't do any operation.



When the USB is detected, a green icon appears near the USB connection check and the user may activate Radio Power Supply and Rotors Power Supply.

The red annunciators change to green to confirm the power status of the switch box.

By default the system powers on in reception mode both on UHF and VHF band. The TX band is not selected, and LNAs are not enabled.

To receive and transmit S-Band signals, it is necessary to click on "RX S-Band Enable"; VHF operation is not possible if Rx S-Band is selected, but the UHF system may operate in full duplex.

To transmit it's necessary to select the "TX Band" (obviously isn't possible set as transmission band the SHF one if "RX S-Band Enable" is OFF); this choice enables the appropriate TX path. The RF relays will switch when one of the PTT signals is applied.

The "Perseus RF IN" command selects on which signal path the Perseus RX is connected (UHF or VHF/S-Band). Perseus and the transverters are always on, and may be used to monitor the other radio transmitter, since some RF signal leaks from the relays, and is available for further demodulation.

The UHF/VHF LNAs are off at switch on; usually they have to be on for successful communication. Switch them off only to check for possible receiver overload due to near strong signals.

The "Transmission on air" icon indicates the PTT status. A green icon means an active transmission.

The SHF RF PWR bar indicates the measured RF power at the output of the SHF transverter. 70% means 25W RF. The same signal is applied to the analog meter on the front panel.

When the program is terminated all the Ground Station is turned OFF.

5. Document list, equipment data sheets, changes, modification notes

Yagi antennas

datasheet	images
datasheet\yagis.pdf	various\yagi picture.pdf
datasheet\xyagi.pdf	various\Yagi support.pdf
datasheet\anpass.pdf	

Parabola

datasheet	images
datasheet\parabola.pdf	various\Par support.pdf
datasheet\feed.pdf	

UHF & VHF LNAs (SP 7000)

datasheet	changes
datasheet\LNA_ds.pdf	Bypassed internal switching delay to allow fast RX/TX switching (bridge between pins 1-7 of the NE555). Added an input HPF to the UHF LNA to avoid saturation when transmitting in VHF, due to mutual antenna coupling. See changes\Elsie1.pdf and changes\Elsie2.pdf for more info.
various\LNA_instruction.pdf	

S-Band LNA (MKU LNA 231)

datasheet	schematic
datasheet\kuhne_lna.pdf	schematics\MKU LNA 231.pdf

S-Band PA (KU PA 2345)

datasheet	images
datasheet\KU PA 2345.pdf	images\kupa2345a.JPG

S-Band Transverter (MKU 23G3)

datasheet	schematic	images
datasheet\MKU 23G3.pdf	schematics\mku23g3_sch1.jpg schematics\mku23g3_sch2.jpg	images\mku23g3.jpg , images\mku23g3-2.jpg , images\mku23g3-3.jpg

Velleman Power supply (Radio)

datasheet	changes	images
datasheet\ps1330_man.pdf	Added internal fan for improved cooling	images\ps1330.jpg

ATTEN Power supply TPR3010 (Rotors and Xverter)

datasheet
datasheet\TPR series.pdf

TNC 7 multi

manual
datasheet\TNC7_multi.pdf

Perseus

manual	images
datasheet\perseus_man.pdf	images\perseus.gif

RF Cables 150-12)

datasheet
datasheet\Ecoflex10.pdf
datasheet\Ecoflex15.pdf

TRACO POWER Switching power supply (TXL

datasheet
datasheet\TP_switching.pdf

Alfa Spid Rotors Controller

Datasheet & schematics	changes
datasheet\Rot Controller.pdf	Microprocessor power supply has been separated from the motor power supply, and feed by an external, clean, SMPS.
schematics\RC_logic.pdf	Power supply cable added to the remote control port to allow radio-command control.
schematics\RC_pwr.pdf	RS232C "RX DATA" signal is brought in parallel to the two controllers to allow parallel operation via a single serial interface.

ICOM IC-910H

manual	images
datasheet\IC-910H IM.pdf	images\lc910h.jpg

Relcom RF switches

Datasheet
datasheet\switches.jpg

Down East Microwave 144-28k Transverter

Datasheet and schematic	changes
datasheet\144-28N.pdf	IF and RF RX and TX ports have been brought to separate connectors, to allow external RF switching. Installed cooling fans, activated during TX only.

Down East Microwave 432-28k Transverter

Datasheet and schematic	changes
datasheet\432-28.pdf	IF and RF RX and TX ports have been brought to

	separate connectors, to allow external RF switching. Installed cooling fans, activated during TX only. The LO switch (404 or 407 MHz oscillator) cannot be operated, if not opening the switch box; by default, the 407 MHz LO is used (28 MHz -> 435 MHz conversion)
--	---

Power Splitter

Datasheet schematic	and	changes
datasheet\ZESC-2-11.pdf		Added four fast switching Si diodes in series/antiparallel on the port connected to the ICOM radio, to protect the devices from excessive RF power in case of erroneous operation.

Velleman USB Interface Board

Datasheet schematic	&	changes
datasheet\K8055.pdf		The integrated circuit ULN2803 (IC4 on the scheme) was removed and replaced with eight jumpers which connect pins 1-18, 2-17, 3-16, 4-15, 5-14, 6-13, 7-12, 8-11.

6. Operating Manual.

6.1 – Quick Guide (local use)

Switch on the PC, wait for the start-up of the SO and do the log-in.
Open the "Control Box.exe" executable (there is a link on the main desktop).
Wait until the icon near the USB check become green: now it is possible turn ON the ground station clicking the only button enabled (Radio Power ON).

Rotors

Enabling the Rotors Power ON, the rotors controller are turned on and they display current azimuth and elevation of Yagi and Parabola antennas. Usually the rotors should be in auto-mode (an "A" is visible on the left display) to be controlled by remote user or PC software.

The orientation of antennas are possible by manual settings of the controller (pushing the F button until the left display is clear) or via software.

For manual use, it is possible change the azimuth position pushing on the left/right arrows and change the elevation position pushing on the up/down arrows. In this case take care to not press the S button or the system can loss the real position of antennas.

Transmission

If no band is selected the "None" button are disable. In this case any PTT request are ignored, but warning: NEVER PRESS the Icom transmission button or the system takes damages. It is a good practice, before starting the transmission, check the Icom TX power.

To transmit it is necessary select a band in the "TX Band Select" choice. If it is necessary a S-Band transmission, before select the band, note that "RX S-Band enable" must be set ON, in the same way if it is necessary a VHF band transmission, the "RX S-Band enable" must be OFF. It is possible transmit with Microphone or TNC (the other option aren't yet used).

In any case the forbidden operation are disabled (the buttons became disabled).

Reception

In normal status, the Ground Station receive signals both from UHF and VHF Yagi; it is possible receive S-Band signal, clicking the "ON" button "RX S-Band enable". After setting this button, to receive again VHF Band it is necessary set it "OFF".

Perseus

To select which signals are processed by Perseus, choice the correct band by clicking the relative button. Remember that to view and/or record the received signals the Perseus software must be opened. For further information see Perseus Manual.

LNAs enable

In reception it is recommended use LNAs. If the LNAs are off and the quality of signal are low, try to power on them by clicking the pertinent button.

Transmission on air

While transmission, the Red symbols near this label, becomes green.

Switch OFF

It is a good practice switch off the Radio and the Rotors with the correct buttons before close the program. A Fatal Terminate of the program may cause a malfunction on the led and switches until the program's restart.

6.2 – How to create a new software for this GS.

First of all the USB cable of the Control box must be connected to a PC. To drive the Control Box it is necessary send via USB 7 bit to the Control Board; to due this remember that the USB Velleman interface need some Dynamic Link Library (DLL) to be controlled via software.

MSB							LSB
--	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Output bit layout

Power on

- To supply the Radio, set bit 0.
- To supply the Rotors, set bit 1.

If the first bit isn't set all other bit are ignored, so remember to set it first and ever. After setting the first bit, the Ground Station is able to receive UHF and VHF signals coming from Yagi antennas.

Now it is possible select:

Transmission band select

- If any transmission is requested, clear bit 2 and bit 3.
In this case all PTT request are ignored.
- To transmit on UHF Band, clear bit 2 and set bit 3.
In this case the PTT request cause a break of UHF reception to allow the transmission.
It is however possible receive in VHF or S-Band.
- To transmit on VHF Band, set bit 2, clear bit 3 and set bit 4.
Remember that in this case bit 4 MUST be set for safety use.
- To transmit on S-Band, set bit 2 and bit 3 and clear bit 4.
Remember that in this case bit 4 MUST be clear for safety use.

If any transmission is in pending bit2, bit3 and bit4 shouldn't be modifiable to avoid data loss and physical damage to the system.

Receive band select

- To allow reception in VHF Band, clear bit 4.
- To allow reception in S-Band, set bit 4.

Your program should have a control on bit 4: if cleared S-Band transmission should be forbidden; if setted VHF transmission should be forbidden.

Use of Perseus

- To allow the analyzing of UHF band, clear bit 5
- To allow the analyzing of VHF band, set bit 5

Perseus is always able to analyze signal on a selected band if this one is set in reception mode. Any transmission on the same band cause a break in the analysis.

Use of LNAs

- To power up and use both LNAs set bit 6.
- To disable both LNAs clear bit 6.

It is not necessary use LNAs for reception. LNAs are NOT used for transmission. If a LNA is enable before or during transmission, is automatically turned off by Control Board.

Input bit layout.

The Velleman Board has 5 digital input bit and 2 analog input. Only 3 digital in and 1 analogue in are used for the Ground Station monitoring.

MSB							LSB
--	--	--	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Power on check

- Bit 0 set means that the Ground Station is powered OFF.
- Bit 0 clear means that the Ground Station is powered ON.

Rotors on check

- Bit 1 set means that the rotors are powered OFF.
- Bit 1 clear means that the rotors are powered ON.

This bit is not really the status of rotors, but it's only a check on the status of the digital output of Velleman board's Q2.

Transmission check

- Bit 2 set means no transmission.
- Bit 2 clear means a transmission on air.

This bit is connected to the PTTD signal which is generated after a PTT request (it is the same signal which enable a transmission).

Analogue level conversion

This byte represents the conversion trough a DAC of the analog input (A2) of the Velleman Board, that is connected to RF power of S-Band transmission.