Ocean Structures and Materials
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Module - 4
Lecture - 2
Structural health monitoring

Welcome to the second lecture module four on Ocean Structures and Materials. In this lecture, we will talk about structural health monitoring and its application aspects to offshore structures.

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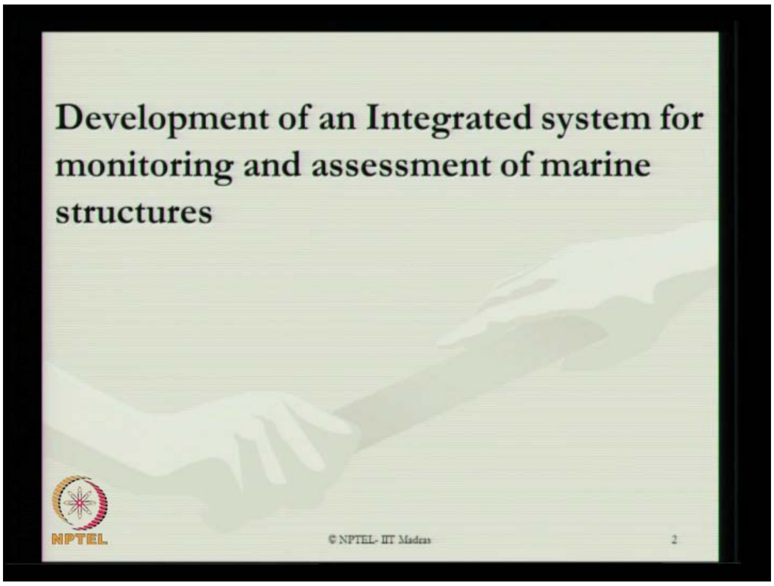

Let us in detail discuss, the development of an integrated system for monitoring and assessment of marine structures. Before we understand the details of wireless sensor networking and deploying structural health monitoring schemes on marine structures and other examples, let us look at the necessity why we should do this.

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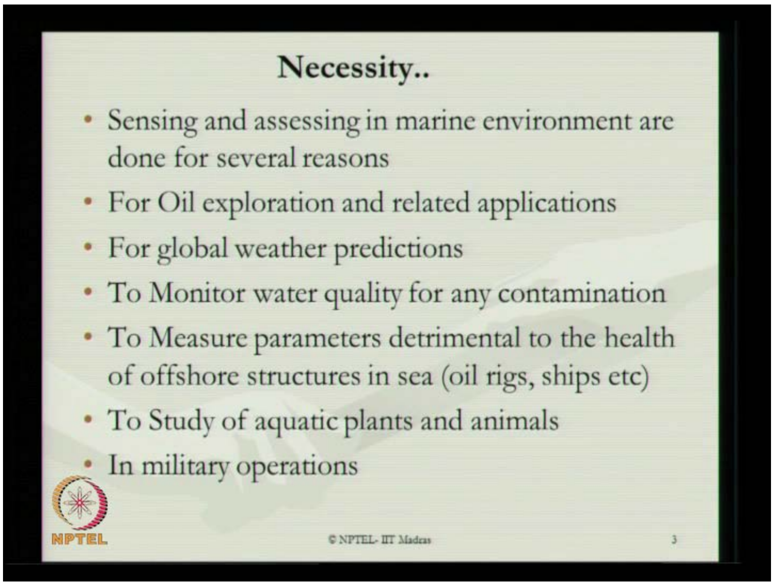

Sensing and assessing in marine environment are done for several reasons. For oil exploration and related applications; for global weather predictions; to monitor water quality for any contamination happen; to measure parameters detrimental to the health of offshore structures in sea, for example, oilrigs, ships etcetera. To study aquatic plants and animals and off course used in military operations.

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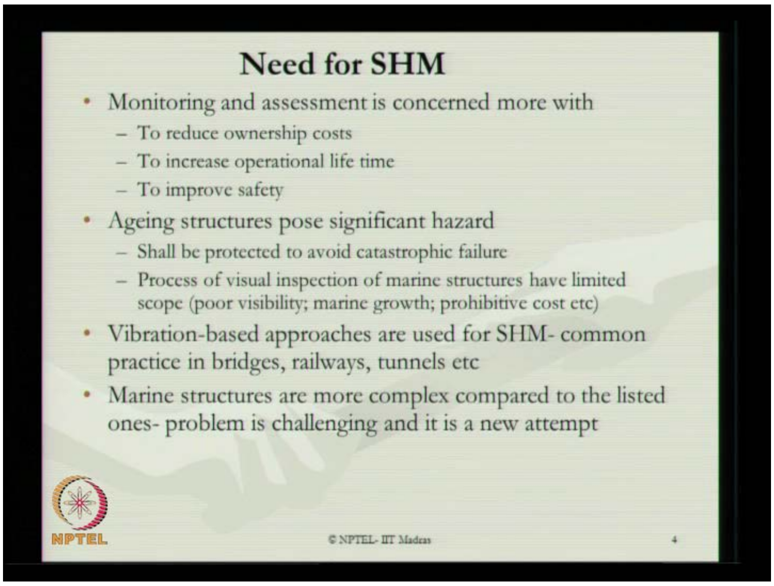

If we look at the need for structural health monitoring which is abbreviated as SHM, for monitoring and assessment is concerned, it is more connected with reduction of ownership costs, to increase operational lifetime, and of course, most importantly to improve safety and operability of the platforms. If we look at ageing structures, which pose a significant hazard then they can be protected to avoid catastrophic failure, if they are assessed in advance. Process of visual inspection of marine structures has limited scope as we discussed in the last lecture. The reasons are due to poor visibility, marine growth and prohibitive cost. Vibration based approaches are also used and becoming increasingly common for structural health monitoring scheme. And they are generally practiced broadly in bridges, railways and tunnels. Marine structures are complex when compared to the listed ones, of course, therefore, the problem is more challenging and it will be a new attempt and search front in marine structure design.

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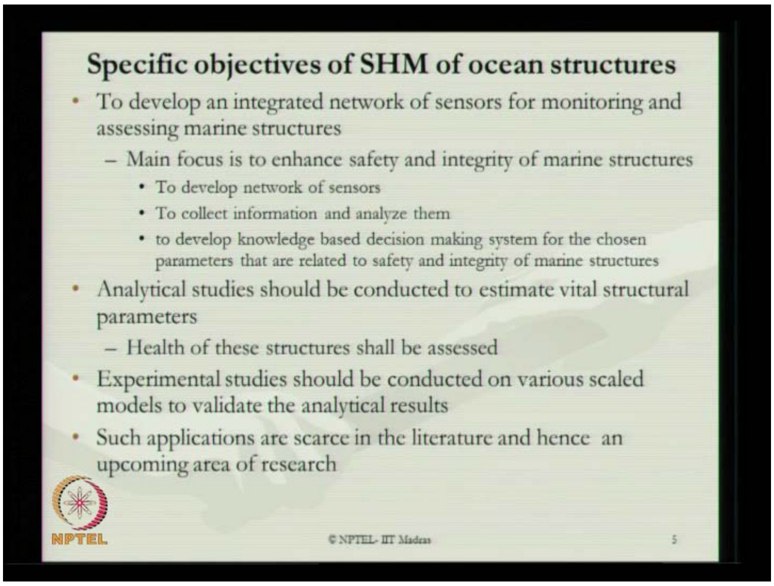

If we look at the specific objectives of SHM applied to ocean structures, there is a need to develop an integrated network of sensors for monitoring and assessing marine structures. The main focus should be to enhance safety and integrity of marine structures. In this network, we should say I should be able to develop network of sensors, to collect information, and subsequently analyze this information to develop knowledge based decision making system for the chosen parameters that are related to safety and integrity of the structural system.

Analytical studies are also important and they should be carried out to estimate the vital structural parameters, which are related to assessing of health of the structures.

Experimental studies are also important and they should be conducted on various scaled models to validate the analytical results what we see for assessing the health of structures. Such applications are gentlemen, they are very scarce in literature and hence it has got an upcoming area of research.

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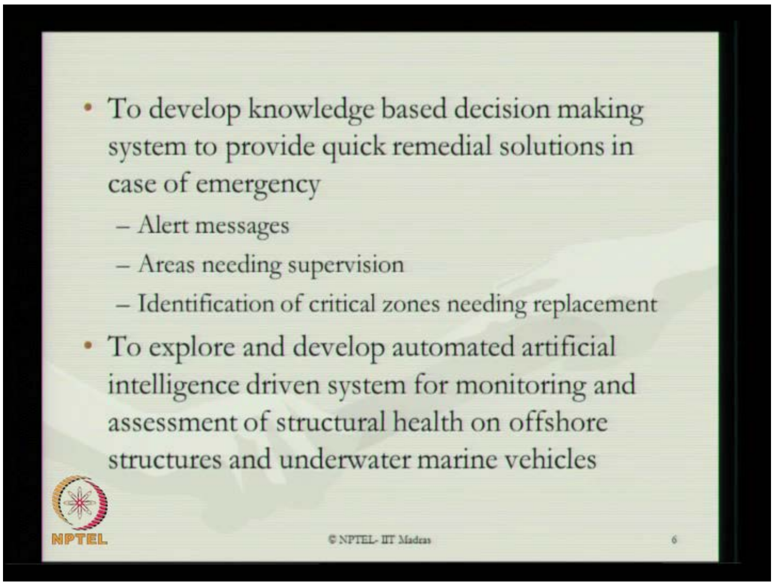

To develop knowledge based decision-making system and to provide quick remedial solutions in case of emergency, we should generate alert messages, and therefore areas needing supervision should be highlighted. Identification of critical zones needing replacement should be an outcome of these kinds of studies. They are also important to explore and develop automated artificial intelligence driven systems for monitoring and assessment of health of structures and underwater marine vehicles.

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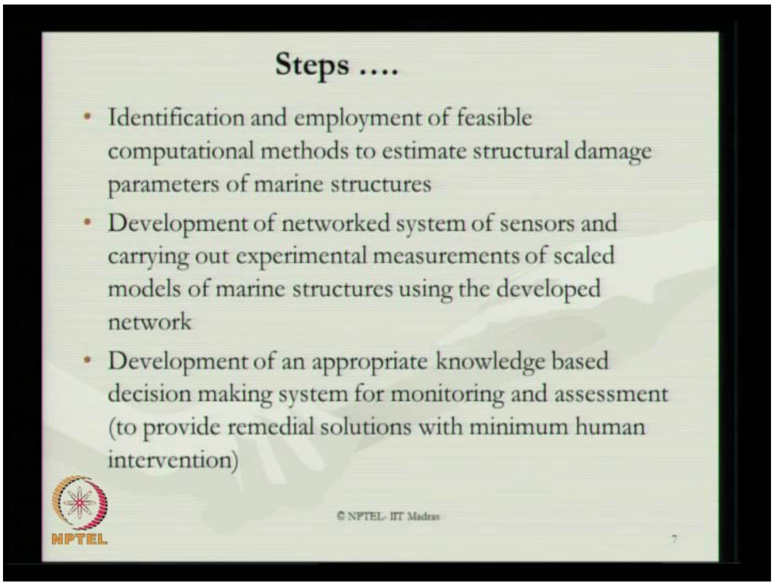

Lets us now look at the steps involved in development of SHM applied to marine structures. Identification and employment of feasible computational methods to estimate structural damage parameters of marine structures, development of networked systems of sensors and carrying out experimental measurements of scaled models on marine structures using the developed network. Development of an appropriate knowledge based decision-making system for monitoring and assessment, because this is very important to provide remedial solutions with minimum human intervention.

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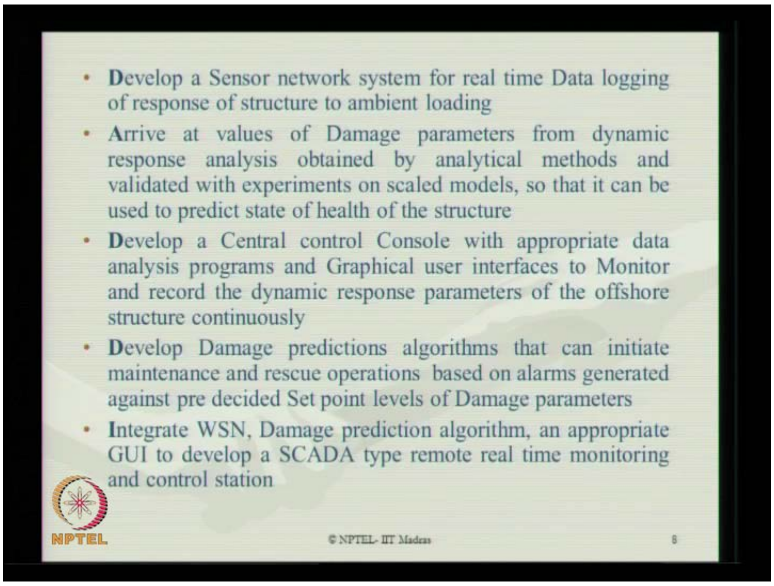

So, the first step could be to develop a sensor network system for real time data logging of response of structural to ambient loading. Then arrive at values of damage parameters from dynamic response analysis obtained by analytical techniques and then they are subsequently validated with experiments on scaled models, so that these values can be used to predict the state of health of an existing structure. Then develop a central control console with appropriate data analysis programs and graphical user interface to monitor and record, the dynamic response parameters of the offshore structures continuously.

To develop damage predictions algorithms that can initiate maintenance and rescue operation based on alarms generated during pre decided set point levels of damage parameters. For example, if one is able to estimate and establish the damage parameters, and one can design development of SMS and alarm based on these damage parameters then they can play a very important role in establishing and safety during operation of offshore platform. Then off course to generate and integrate wireless sensor networking, damage prediction algorithm and appropriate graphic user interface must be develop using what we called a SCADA type remote real time monitoring and control station techniques.

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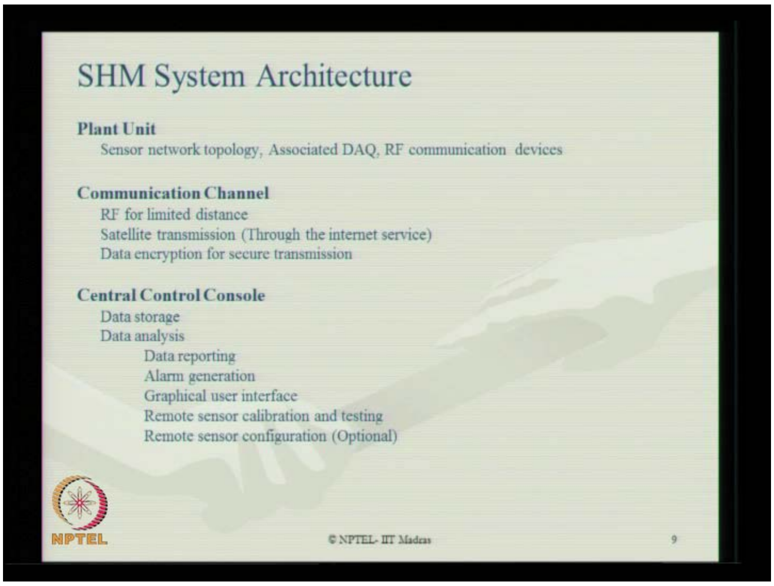

If we look at the SHM system architecture, which is a very important design and development, it should have a plant unit. The plant unit should consider and consist of sensor network topology, associated data actuation system, RF communication devices.

If you look at the communication channel, they must have RF for limited distance. Then of course, if the distance is very large then one must used satellite transmission through the internet and intra net services. Data encryption is also to be done for secure transformation. If we look at the central control console then it should have data storage; it must have data analysis capabilities for data reporting and alarm generation and graphical user interface development and of course, to generate sensor calibration and testing possibilities. Remote sensor configuration though it is optional, it is becoming very important recent advancement of SHM system architecture.

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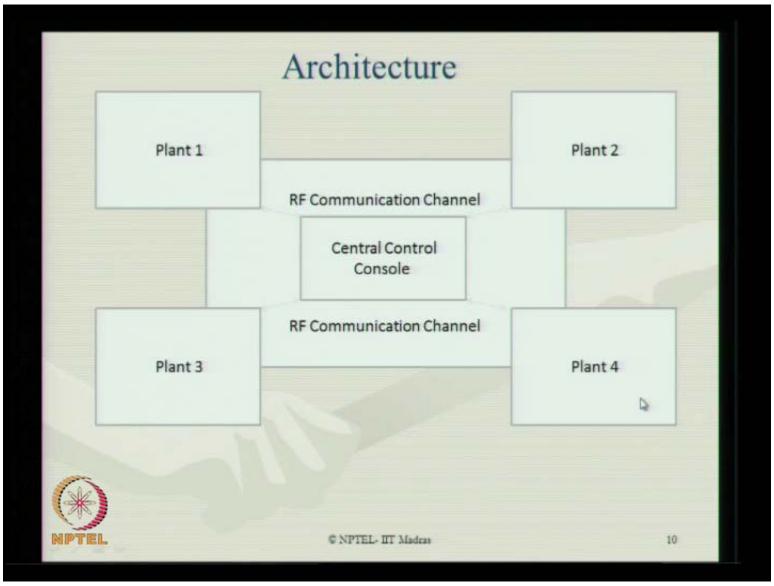

Now this is the layout of the architecture, for example, if you got couple of offshore plants located in closer vicinity, because generally you see the drilling units are always located to the closer vicinity for the central well. So, I got production platform, operational platform, drilling units as plant 1, 2, 3 and 4, I must connect them using a SHM architecture is what we call as RF communication channel. Then I must have a central control console, which can then connect these plants using radio frequency communication channels.

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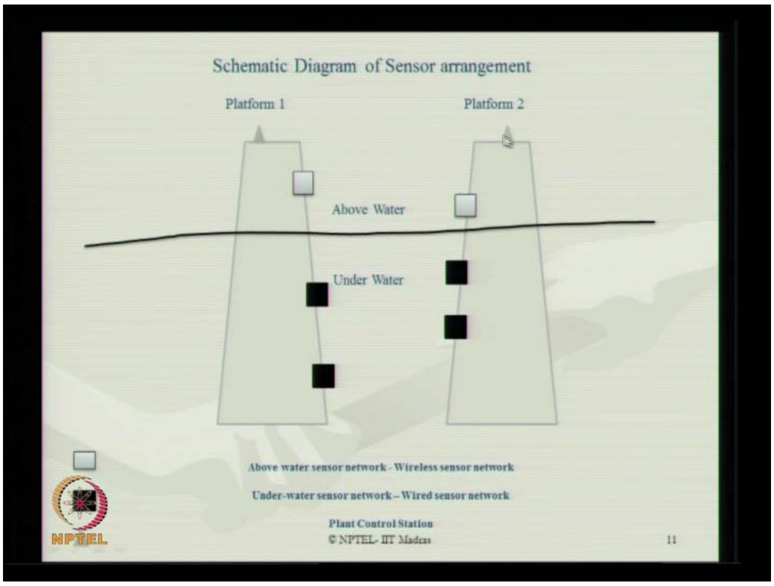

The schematic diagram of sensor arrangement shown in the picture here, for example, I have got two platforms, some of the sensors must be located in the water and some of them of course above water and these are the platform local control station which islocated much above the water level.

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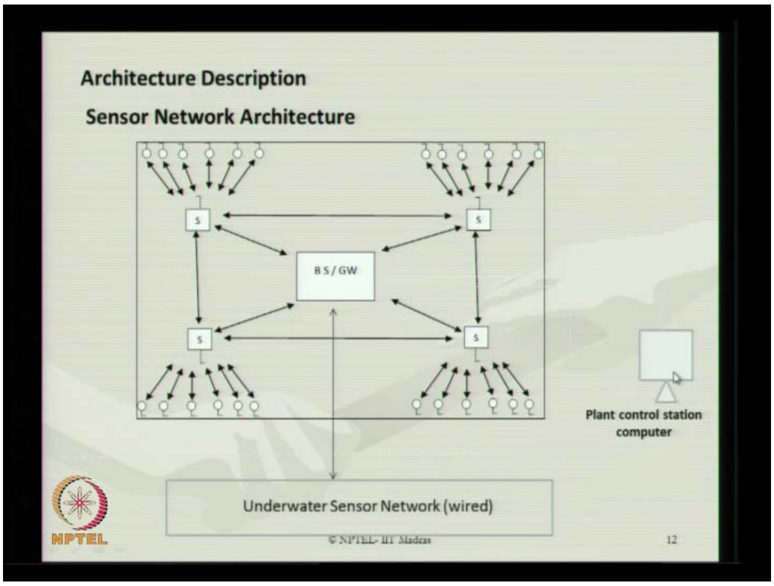

Now the architectural descriptions are shown in the picture here. The sensor network architecture should have the underwater sensor network which is generally done with wires, and above water are generally done with wireless sensor networking. All of them have been connected together using RF communication to the plant control station, the computer control which is localized for a specific plant.

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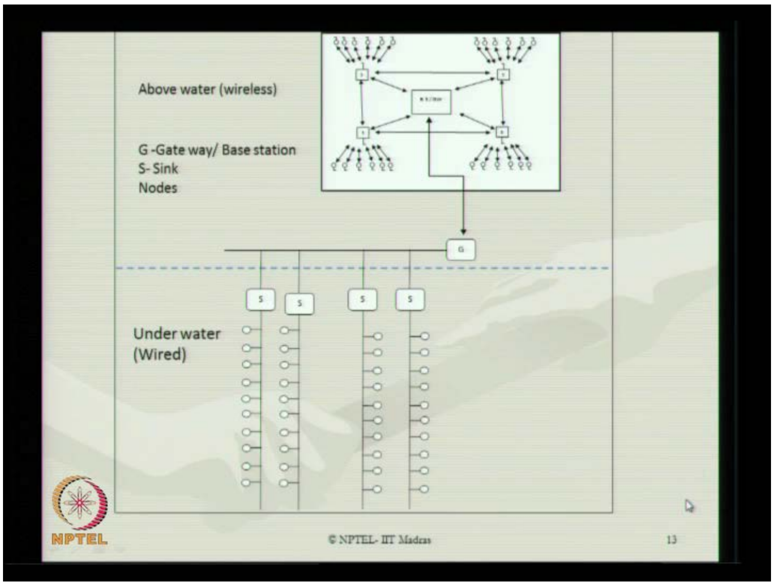

The above water sensors will be essentially a wireless, and the underwater sensors essentially will be wired. Both of them should be connected by using a gateway what we call as a base station or a gate way station. And of course, I must use different sinks which are locally connecting all the nodes to the sink and from the sink they are connected and communicated to the gateway.

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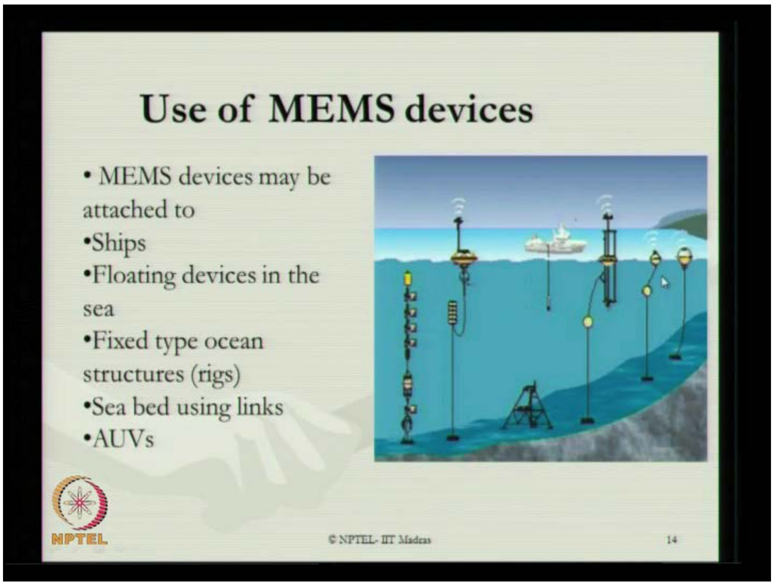

You can also use MEMS devices for marine applications. Let us quickly look at what are the possible uses of MEMS devices in SHM. MEMS devices may be attached to ships, floating devices in the sea fixed type ocean structures, for example, drilling rigs and seabed using links and off course in underwater-automated vehicles.

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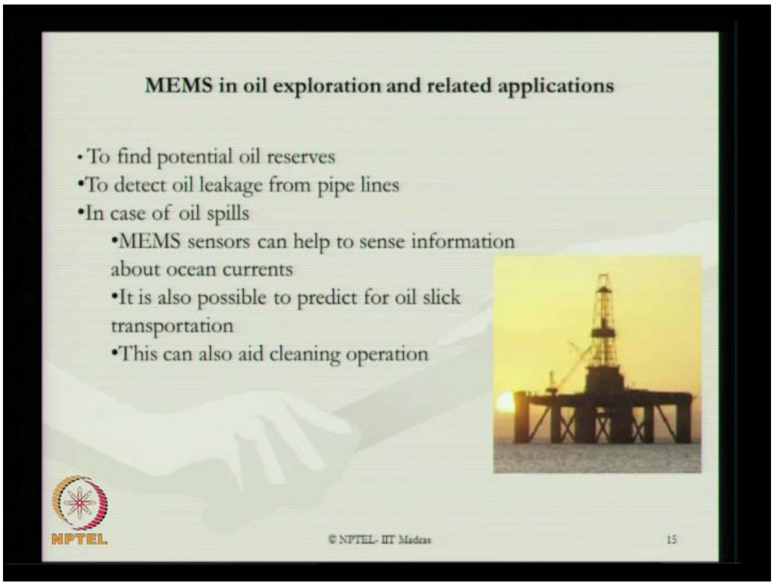

MEMS are widely used in oil exploration and related application is essentially to find potential oil reserves. It detects oil leakage from pipelines in case of oil spills. MEMS sensor can help to sense information about the ocean currents therefore, you can prevent the further spreading of oil spill from the local area to the global surface. It is also possible to predict for oil slick transportation, it is very important an uncontrollable problem in case of oil spill accident this can also aid cleaning operation very large extent.

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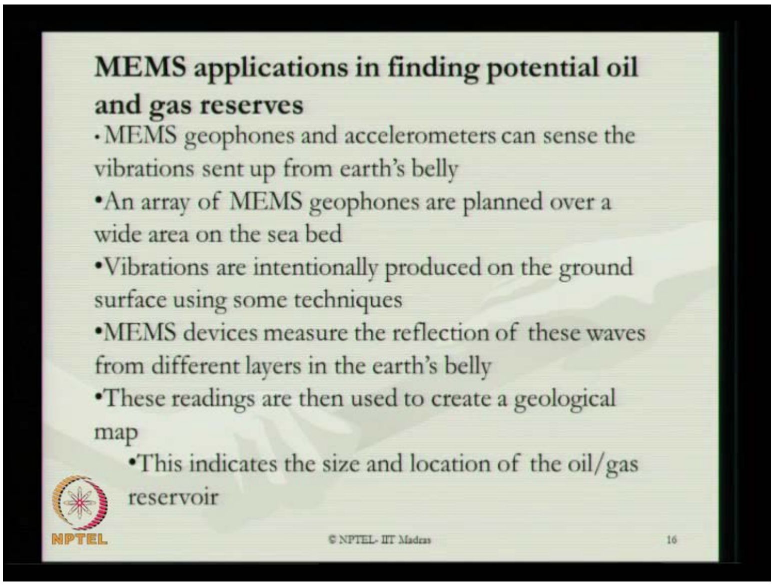

MEMS applications are finding increasing values in potential oil and gas reserves identification. MEMS geophones and accelerometers can sense the vibrations sent by the earth's belly. An array of MEMS geophones are planned over a wide area on the sea bed. Vibrations are intentionally produced on the ground surface using some techniques, and MEMS devices measure the reflection of these waves from different layers in the earth's belly. And these readings are then used to create a geological mapping, which indicates the size, location and availability an oil and gas reservoirs which are recent advancements using MEMS application to identify the oil reserves in sea bed.

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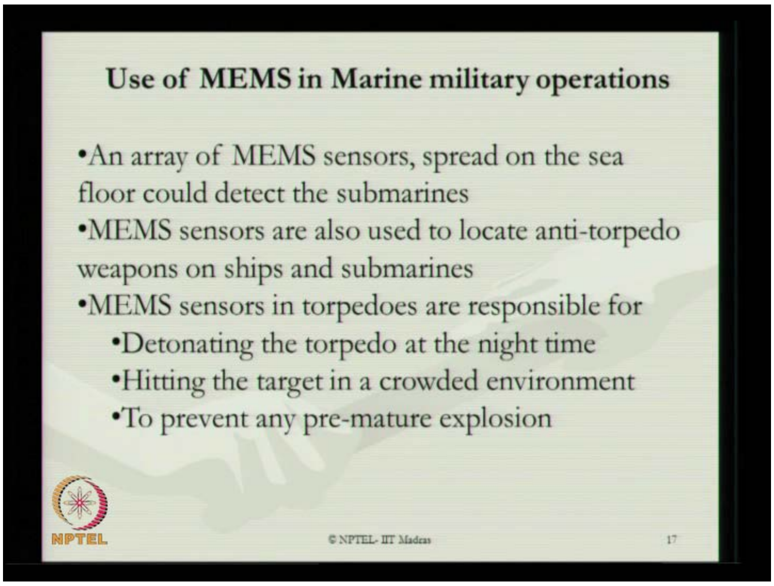

We can also use MEMS very widely in marine military operations. An array of MEMS sensor is spread on the sea floor which can detect the submarine approaching your specific segment of strategic importance. MEMS sensor are also used to locate anti-torpedo weapons on ships and submarines. MEMS sensors in torpedo are essentially responsible for detonating the torpedo at the night; time hitting the target in a crowded environment and off course to prevent any pre-mature explosion.

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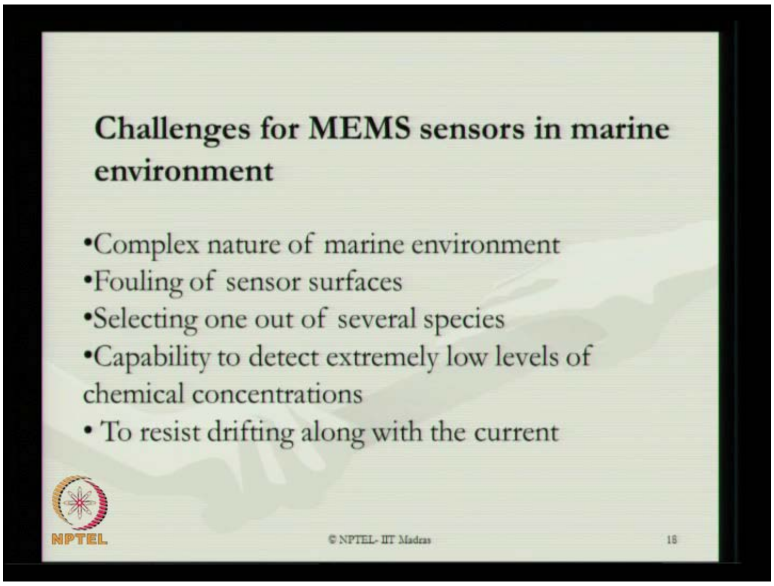

There are some challenges associated with MEMS sensor when deploy in marine environment that say the complex nature of marine environment:. The fouling of sensor surfaces, selection of outlet of several species, capabilities to detect extremely low levels of chemical concentrations, which arise from marine pollution, and of course resist drifting of the sensor along with the current.

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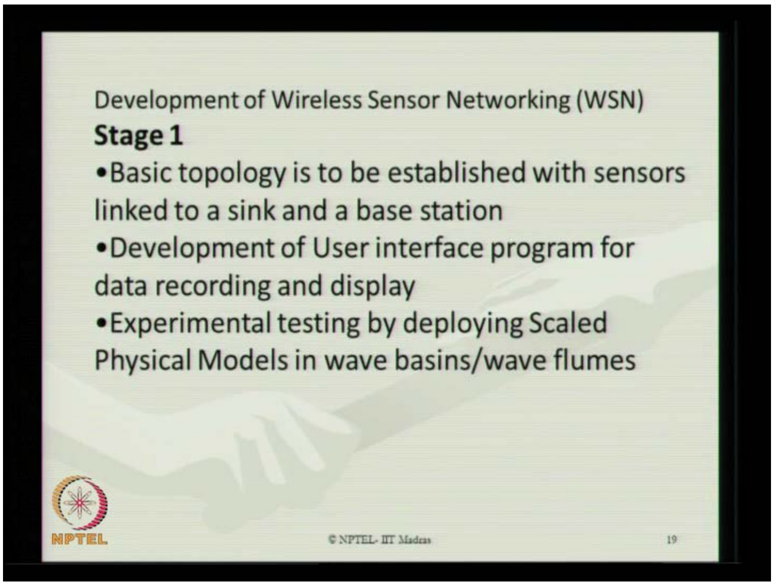

Let us now look at different stages involved in development of wireless sensor networking, which is a very common application in marine environment. The stage one we develop a basic topology, which is to be established with sensors linked to a sink and the base station. The development of user interface program for data recording and display is also the part of the stage one, and off course one must consider conducting experimental testing on deploying scaled models in wave basins and in wave flumes to assert times whether the establish specific topology is properly activated an efficiently design.

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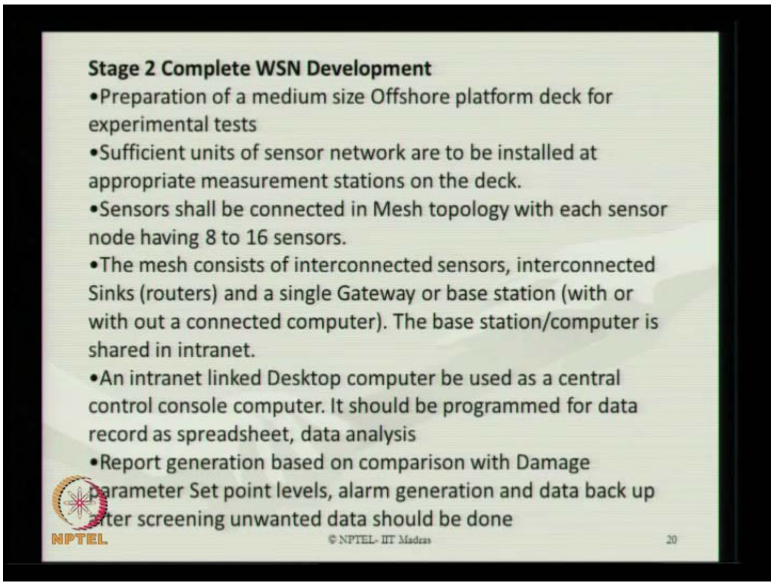

Once stage one is completed, in stage two - one can think of complete wireless sensor networking development. In this stage preparation of a medium size offshore platform deck is very important for conducting experimental test. Sufficient units of sensor networks are to be installed at appropriate measurement stations on the deck. Sensors then shall be connected in what we called a mesh topology with each sensor having node form 8 to 16 sensors. The mesh consists of inter connecting sensors, interconnected sinks which are called as routers and single gateway or base station; it can be with or without connected to the computer. The base station is then shared in the intranet. An intranet linked desktop computers is generally used as central control console. It should be programmed for data recording in the form of spreadsheet and data analysis. The report generation shall be based on comparison with the damage parameter set point levels, which are established based on the experimental studies conducted on the deck in stage two itself.

Then one can think of generating alarm generation and data back up after screening unwanted data, which are wide noise produce during measurement techniques.

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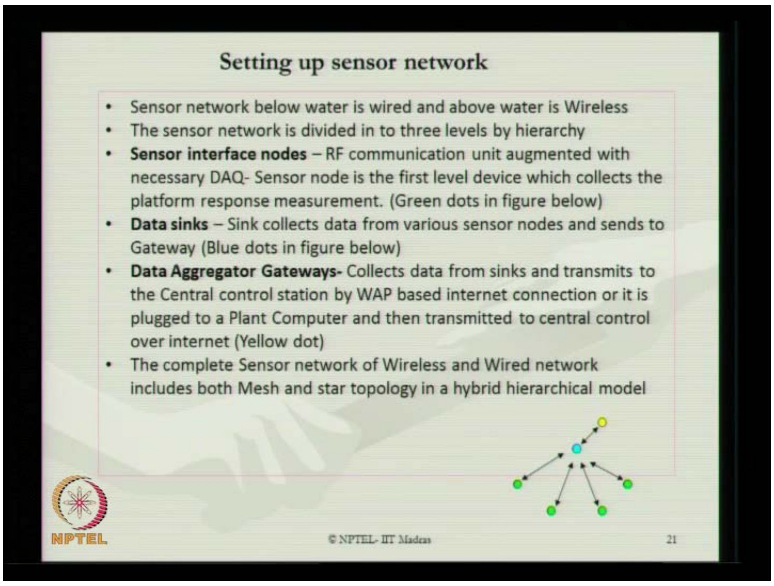

If you think of setting up a sensor network for wireless sensor networking for marine structures then the sensor network below water is wired preferably an above water is generally kept wireless. The sensor network is divided into three levels by hierarchy; the sensors interface nodes which are generally done with RF communication unit augmented with necessary data actuation units. The sensor node is the first level device which collects the platform response measurements. Now in this picture shown here, these are all the sensor interface nodes which are S mark which are actually used to collect the data from the platform. Once the data is collected then the establishment what we called data sinks.

The sinks collect the data from various sensor nodes and senses it to the gateway. Now the blue point what you see here are what we called as data sinks, these data sinks collect data from the zone sensor interface nodes which are already located on the platform or on the deck at different places. Once the sinks receives the data then the third level is data aggregated gateway, these collect data from the sinks and further transmits these data to the central control station by WAP based internet connection or it is plugged to a plant computer. The complete sensor network of wireless and wired networking includes both mesh and star topology in a hybrid hierarchical model.

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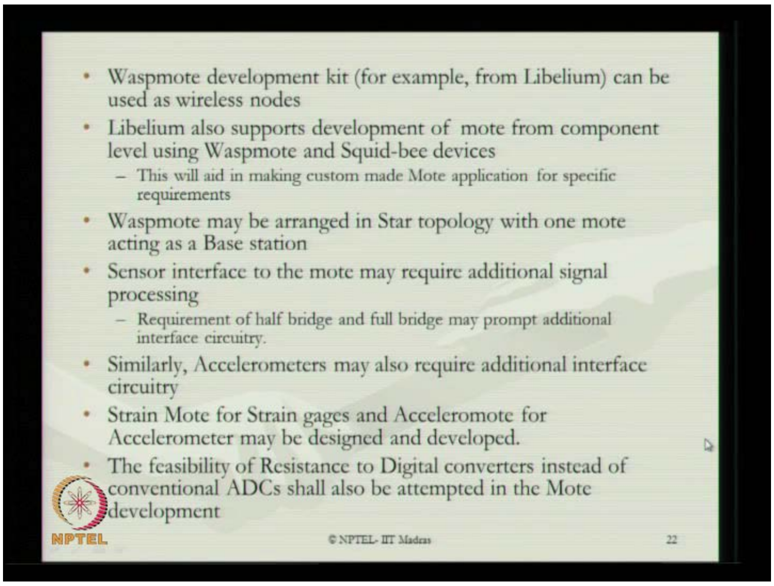

Under this frame, we are what is called wasp mote development kit. For example, the typical kit is developed libelium USA, which can used as an wireless nodes. Libelium also support development of mote from component level using wasp mote and squid-bee devices. This will aid in making the custom-made waspmote or mote application for specific requirements. Waspmote may be arranged in star topology with one mote acting as a base station.

The sensor interface to the mote may require additional signal processing which can be develop of half bridge and half bridge may prompt additional interface circuitry as well. Similarly, accelerometer can also require additional interface circuits. The strain mote is generally used for strain gages and acceleromote generally used for accelerometer should be designed and develop which can compatible with WSN network which has been used for the measurement. The feasibility of resistance to digital converters should be think of instead of conventional ADC should be attempted in the mote development stage itself.

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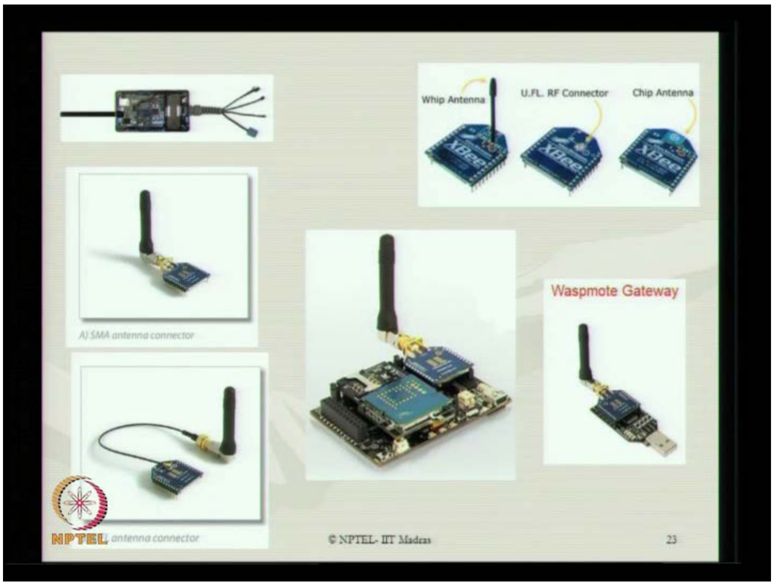

These are some the interesting antennas which are used by libelium, which is SMA antenna connector which can also be used as whip antennas RF connectors and chip antennas. This the typical waspmote gateway which has got the receiver which can receives signal from the sinks and also directly from the sensor. The whole assembly of the sink on the gateway with a receiver looks like this, which can be housed in the metal box which can be protected from external damage.

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This is how a specific network of different sinks and connectors are being used and that becomes my network of all these wireless sensor networking as you see in this picture.

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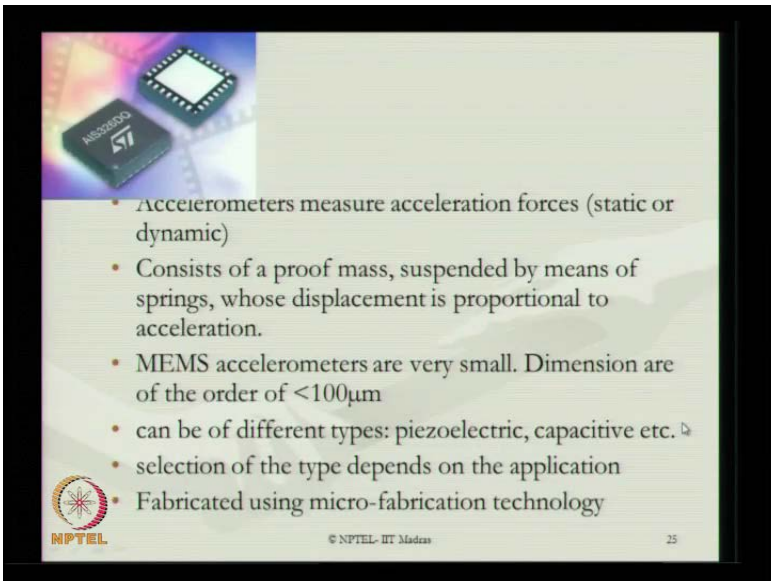

We also talk about MEMS accelerometers. Accelerometers are generally used for measuring acceleration forces; it can be static or it can be dynamic in nature. It consists of a proof of mass suspended by means of spring, whose displacement is made proportional to the acceleration of the body. MEMS accelerometer are very commonly used, because they are very small in size and the dimension are very thin to the order of less than 100 mu m. Can be used of different types piezoelectric and capacitive types selection of type off course depends on the application. They are also used and fabricated using micro fabrication technology.

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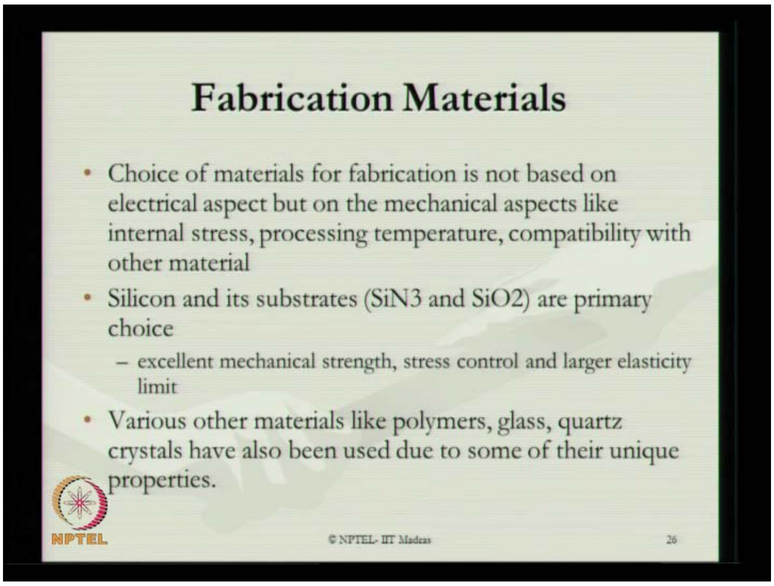

Different materials are used for fabrication. Choice of materials for fabrication is not based on electrical aspect, but all on the mechanical aspects like development and measurements of internal stress processing temperature and compatibility with other material with which they are have been used. The common material which have been used for manufacturing MEMS accelerometer are silicon and its substrates, because they are excellent mechanical strength and stress control strategies and we gone large elasticity limits. Various other materials are also used like polymers, glass, quartz crystal are also been used because of their uniqueness properties.

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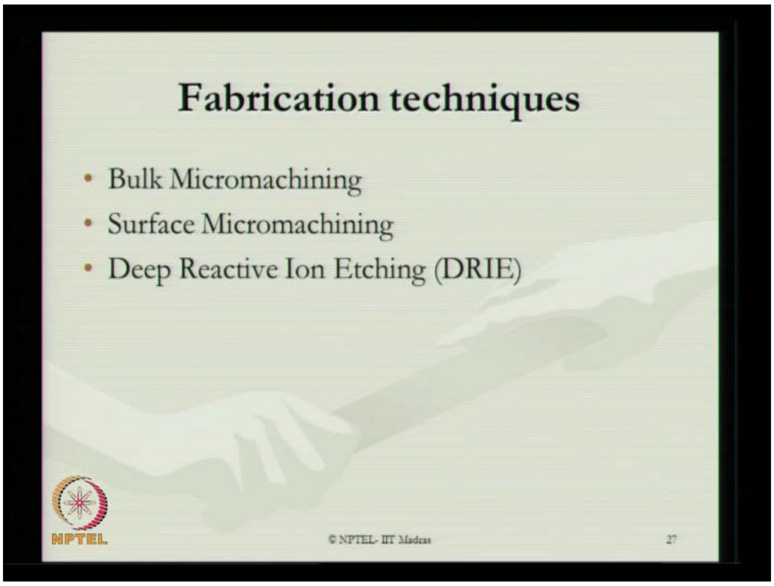

There are different techniques of fabrication, bulk micromachining, surface micromachining and deep reactive ion etching which is the very recent development in manufacturing and fabricating MEMS accelerometer, which is called dry technique.

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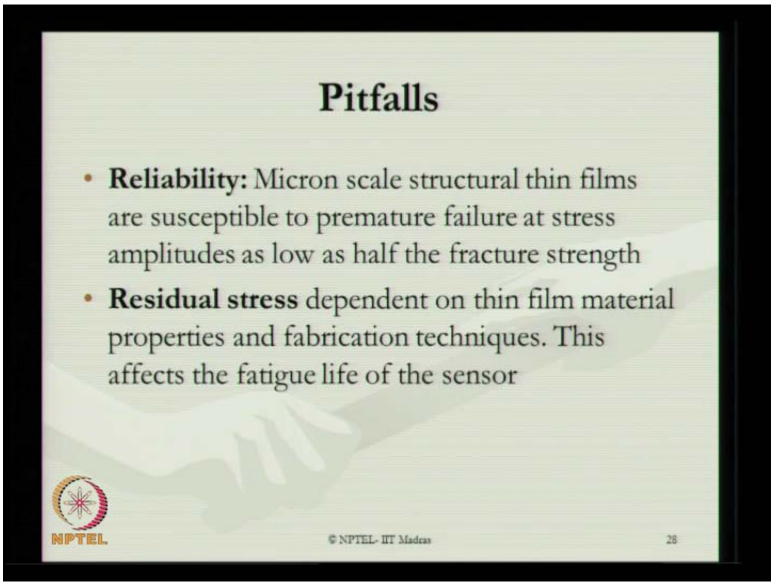

There are of course certain pitfalls in these using MEMS accelerometer. Reliability and residual stress developments are two segments which has got series pitfalls. Micron scale structural thin films are susceptible to premature failure, and therefore, reliability levels are lesser compared to the fracture strength. Residual stress dependence on thin film material, properties and fabrication techniques, which also in important pitfalls using MEMS accelerometer.

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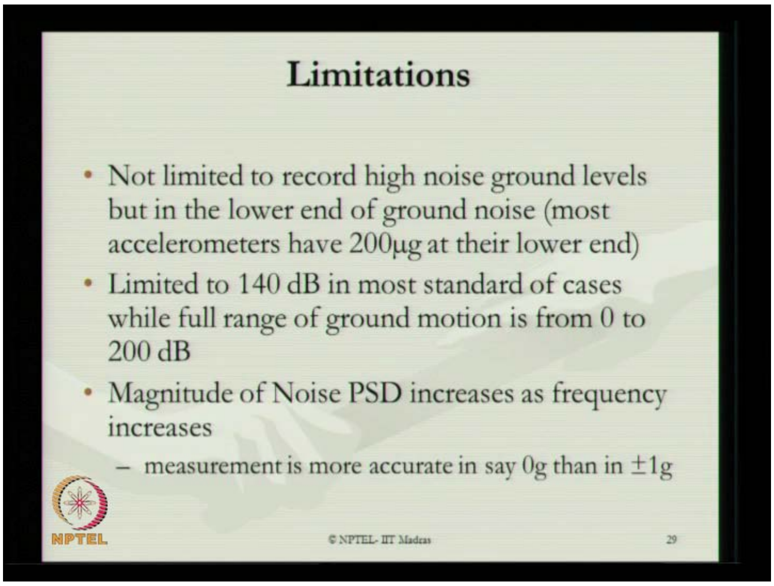

Of course, there are series limitations, not limited to the record high noise ground levels, but in the lower end of ground noise also there is a problem. They are limited to 140 decibel in most standard cases, while full range of ground motion is varying from 0 to 200 decibel. So, the magnitude of noise levels in terms of PSD increases as the frequency increases. Measurement is more accurate in the rays of 0 g less than in case of plus or minus 1 g.

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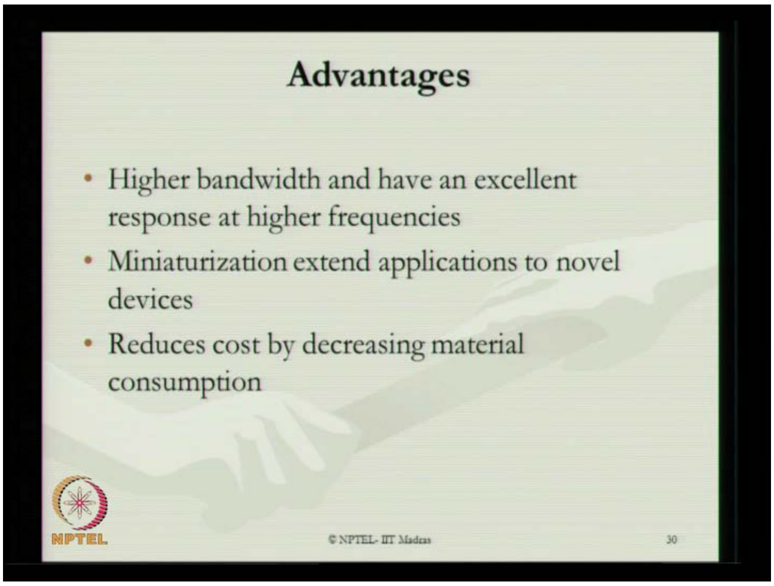

There are some advantages of these techniques, higher bandwidth and they have an excellent response at higher frequencies. They are very small in size, and they are extended application for novel devices. They are reduced cost by decreasing material consumption.

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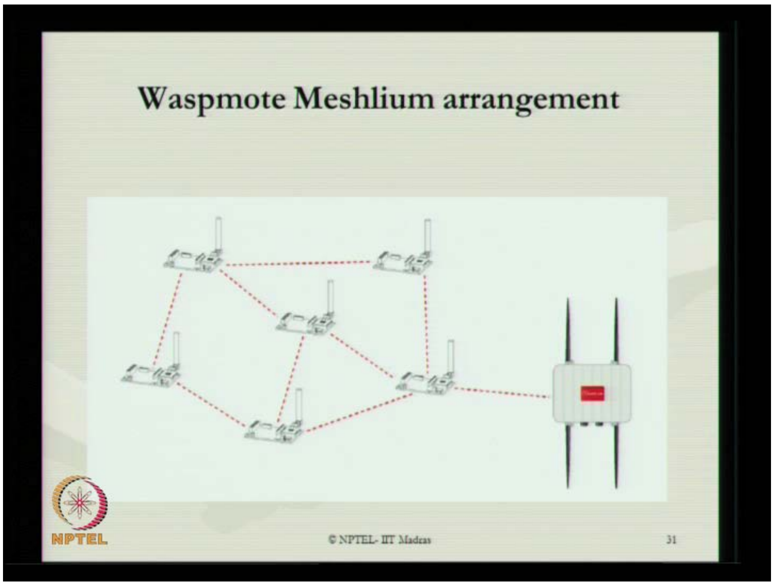

If we look at the waspmote meshlium arrangement, the picture shows interestingly different waspmote arrangement, which we called meshlium arrangement, which can be connected the central control console as you see in this picture.

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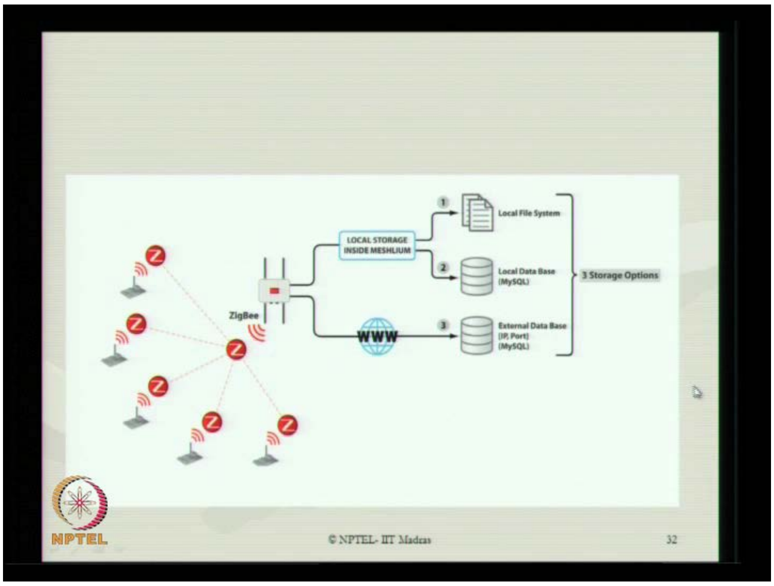

Now the interface of the gateway can be a zig bee gateway, it is a very common technique which is supported by libelium USA. The local storage inside the meshlium can be of two systems; one can be from the local file support system are can also have MySQL data base which can be used for local storage. Alternatively, one can use also internet which can create an external database, and therefore, we have three varieties of storage options whatever data collected from the central control console for further analysis of data, and this is connected to the network using what we called zig bee gateway.

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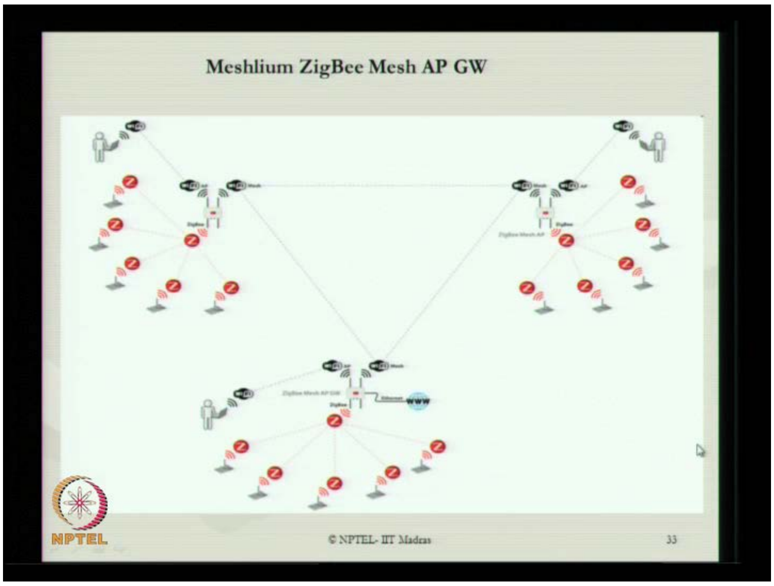

The meshlium zig bee mesh, therefore, comprises of interesting three different configurations which can be then further network for wider area of networking for a different platform located in a specific region or in country.

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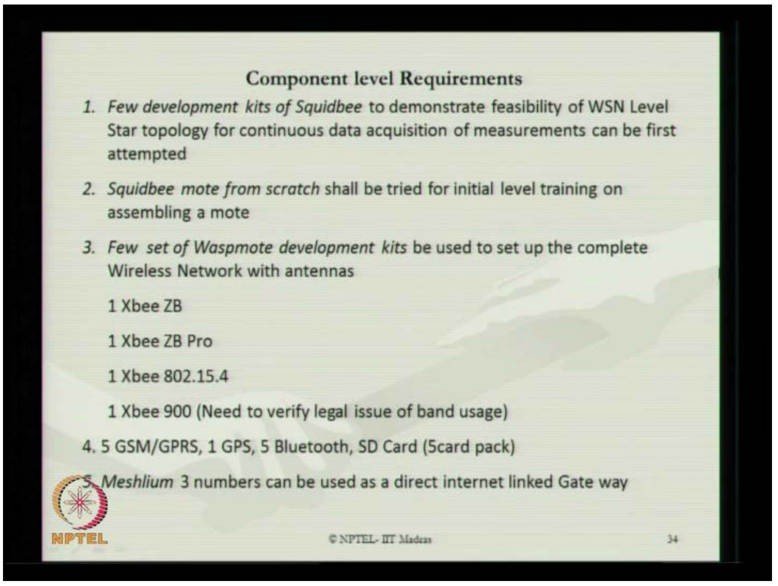

So, then let us look at the component level requirements which are generally done for WSN networking. Few development kits of squid bee are to be done to demonstrate feasibility of wireless sensor networking, level star topology for continuous data acquisition that should be first attempted squid bee mote from scratch should be try for initial level training on assembling a mote. Few set of waspmote development kits are then to be used to set up the complete WN with antennas. This can comprise of 1 Xbee ZB, 1 z b pro, 1 802 15 4 configuration Xbee, and 1 Xbee with 900 which can need to verify the legal issues of band usage. I can also use 5 minimum GPRS, 1 GPS, 5 Bluetooth devices, and one standard SD card for a single assembling. Meshlium therefore, consists of three members which can be used as a direct inter link linked gateway which can connect three different systems architecture global.

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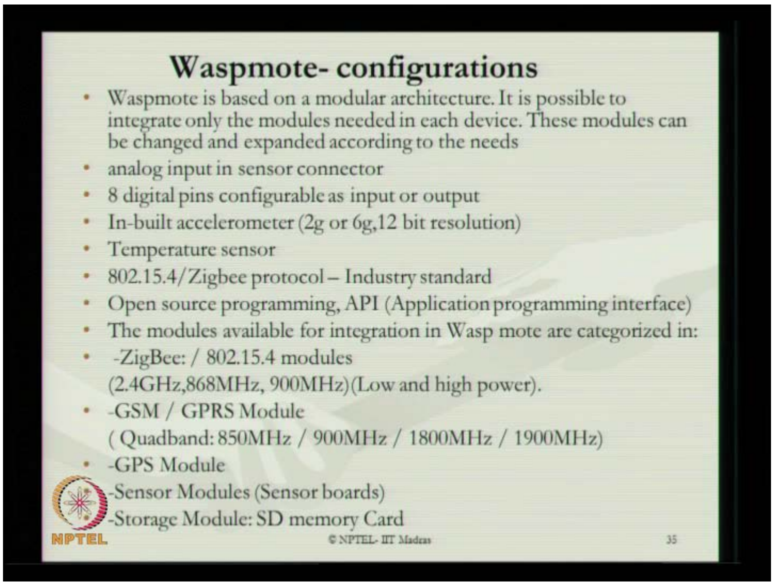

Let us look at the waspmote configurations in detail. Waspmote is based on a modular architecture; it is therefore, possible to integrate only the modules in the device. These modules can then be changed and expanded according to the needs which is seen as one of the highest versatility and one of the great advantage have using waspmote configuration for wireless sensor networking. The analog input in the sensor connector, it is got 8 digital pins configurable as input or output depending upon what are using the device as, it is got in built accelerometer which is having the capacity varying from 2 G or 6 G which is having 12 bit resolution. It is also has the temperature sensor; it has a zig bee protocols with industrial standard is what open source programming which is supported by application programming interface. The modules available for the integration or categorized in zigbee, GPRS module which is having a quad band which has got also a GPS module which is having a sensor module which we called a sensor boards and off course it contains a storage module within SD memory card.

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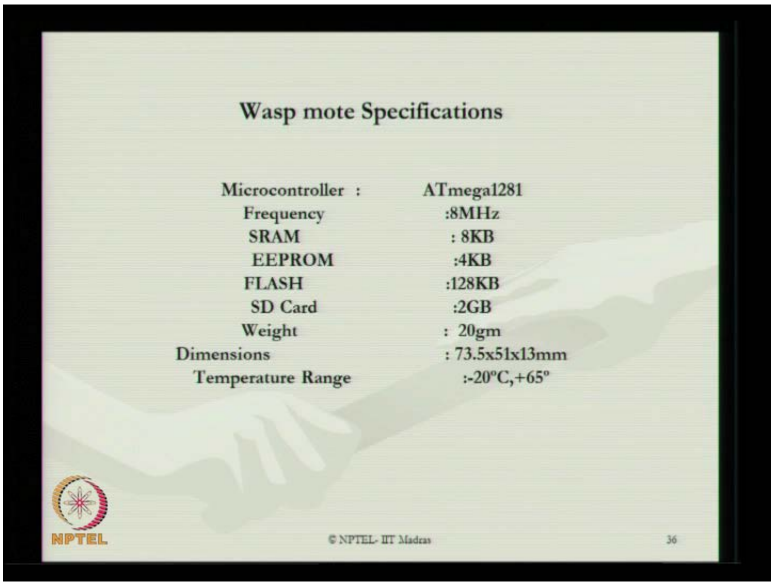

Therefore, in summary the waspmote specification has a microcontroller which is AT mega 1281, it operates frequency of 8 mega hertz; the S ram about 8 kilo bytes whereas, EEPROM is about four kilo bytes. The flash memory about 128 KB and SD card about 2 GB. And the above all its weight only 20 grams and the dimensions are only about 73 by 51 by 13 millimeter it can sustains a temperature range from minus 20 to plus 65 degree Celsius.

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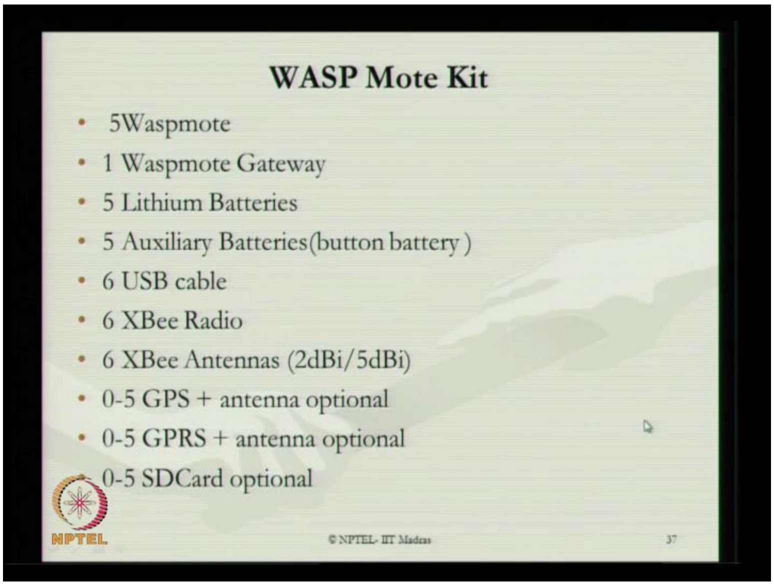

The wasp mote kit has developed and promoted by libelium USA has got 5 waspmote, one wasp mote gateway, 5 lithium batteries, 5 auxilium batteries which is an button battery, 6 USB Cables, 6 XBee radios 5 XBee antennas and 5 GPS and antenna optional and 5 GPRS and 5 SD card which is optional.

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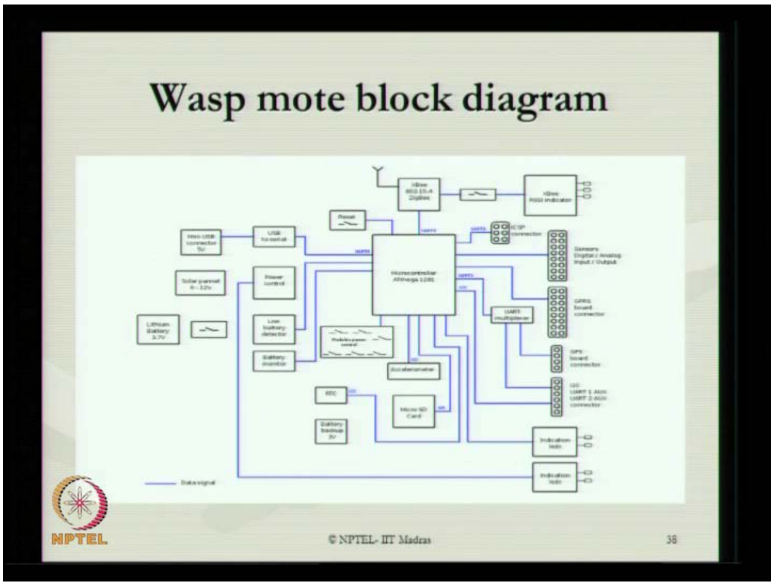

This is interesting waspmote block diagram which is also seen from the libelium website which you can see in the system architecture or the waspmote on the schedule the configuration in the previous slide.

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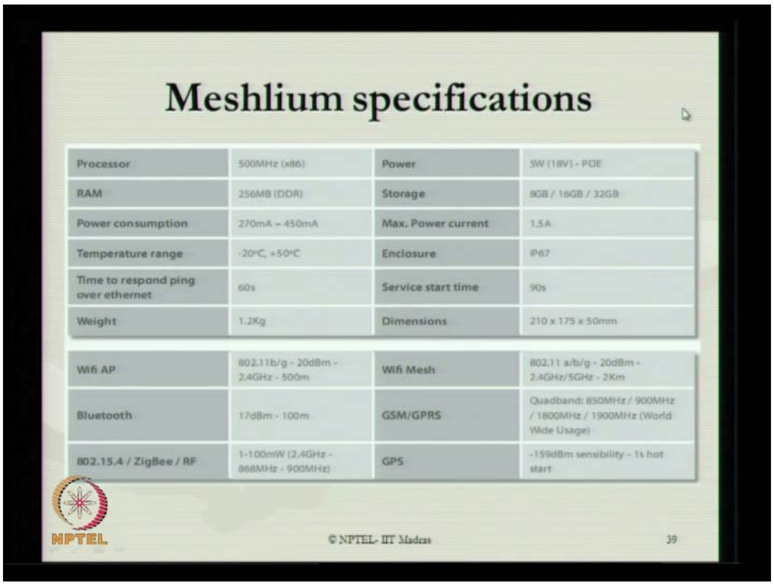

If we look at the meshlium specification which are adopted for WSN networking the processor consists of 500 mega hertz, and the power is essentially with watts the storage about varying from 8 GB to 32 GB the ram is about 256 MB. The power consumption varies from 270 to 450 milliamps. The maximum power current is required only 1.5 amperes; it can sustain a temperature range from minus 20 and plus 50 degree Celsius. It comes in a enclosure which is called specified as IP 67. It takes only 60 seconds to respond pinging over the Ethernet. The service start time is about ninety seconds. The whole Meshlium box weighs about 1.2 KG for the dimension of 200 and 10 by 175 by 50 millimeters. It is also have Wi-Fi enability with Bluetooth and off course with GPRS configuration as shown in this slide.

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Now when you talk about open source programming, the configuration software which meshlium advises, if meshlium includes a management software on its own to configure all required parameters through interesting graphics user interface. All communication interfaces like Wi-Fi, ZigBee, GPRS, Bluetooth etcetera shall be used to manage the storage of data once they are received. The operating system generally preferable is Linux and the configuration software is an open ware a typical front end GUI is what you see here which has been advised by libelium as such.

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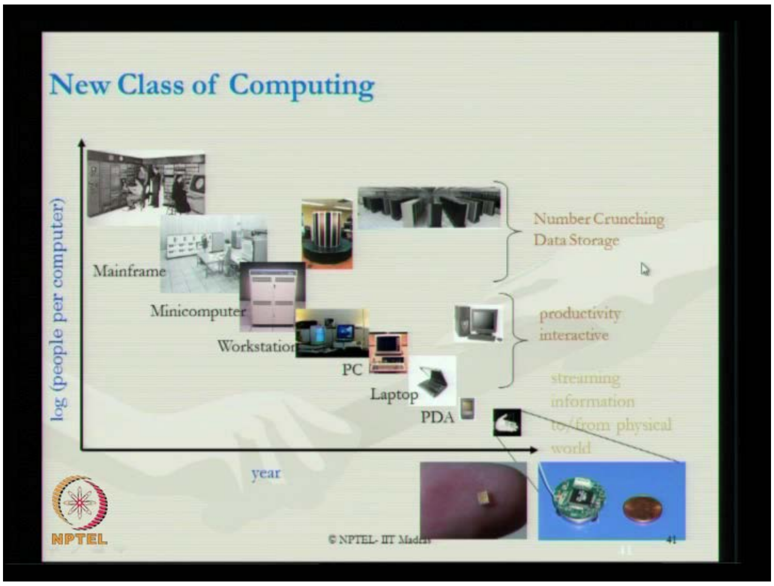

Now let us look at the new class of computing. Once they receive the data from the network how do we analyze the data. If we look at people per computer what I called logging in configuration varying from US, it move from mainframe to now many computer to work stations to PCS and now to the laptop. And now we also something called PDA. So, the class of computing they started varying from the main frames to laptop and PDA’s. Therefore, the chip order system architecture should be minimum possible as well as light as possible, which is sufficient enough to hold it in one form as you see in this photograph here. So, the interesting feature is I have a microchip which is very simple which can be hold in a thump of a human being. So, now, it is having a capability of recording data 24 into 7 continuously which can integrate minimum 5 waspmote configurations with meshlium linking. So, it is interactively productivity, the streaming information are all added advantages of new class of computing which required in the modern era.

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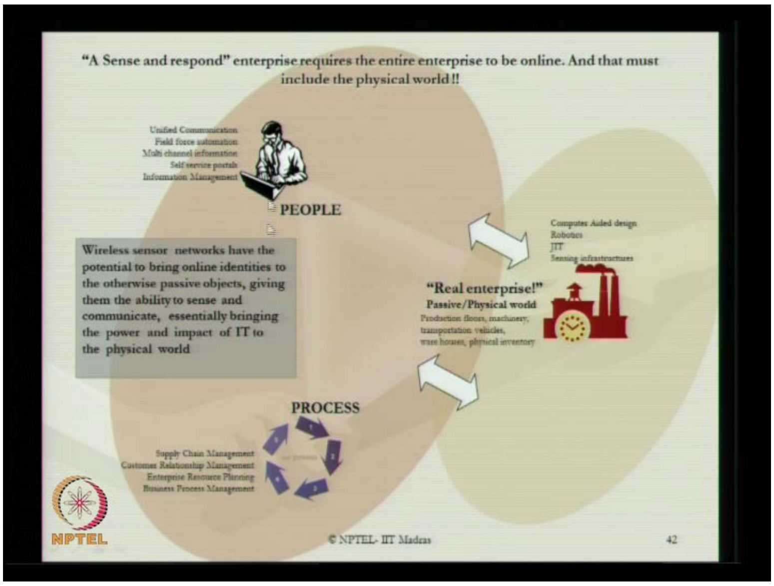

Now let us look at interestingly a sense and respond enterprise that requires entire enterprise to be online, because I want the whole platform remain online, when I want assess health of the platform. So, let us say there are three elements, for example, the people, the process and off course the real physical world. A typical enterprise can be defined us the combination of these three the people, the process and off course what we defining of the real enterprise, which is the physical infrastructure that is core to what the business does. The unified communication, field force automation, multichannel information, self-service portals and information management are all related to the people. Whereas talk about process they have supply chain management, customer relationship, enterprise resource planning, and business process planning which all come as the process. There are all integrated together to the computer aided design robotics and sensing information and infrastructure what I say as real physical world. For these can be connected using wireless sensor networking that is very important that is the focus what we want to do the in the near future.

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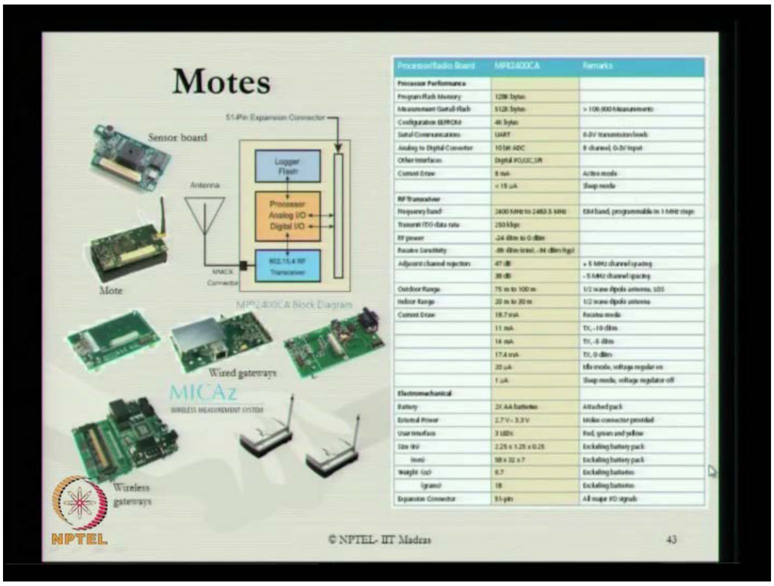

Now look at the motes which are used for system architecture there are different modes which are seen in the picture, sensor boards motes and the wireless gateways and wired gateways which are all forming the group of system architecture which can be used the configuration and a specification of these motes are available in this table.

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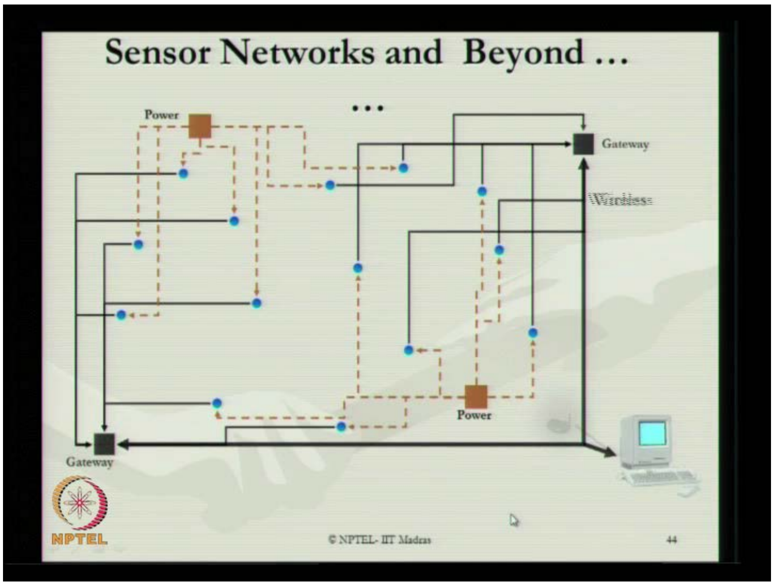

Now let us look at the sensor networking and an idea beyond this. Let say I want the power source at two locations, I got the gateway which is connecting one segment and the other segment of the platform, which are connected ultimately for my central control console which can be a PC or it can be a system through internet.

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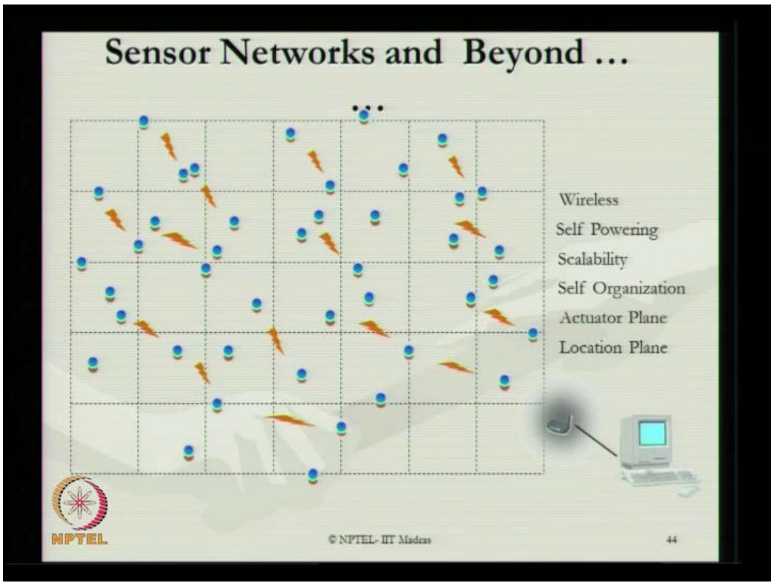

So, I can connectthem using a wireless, remove all the wire connectivity and a make complete control console receiving the signal through the wireless configuration. I can make the self power, I can even remove batteries in these sensor units, and I can make them self power. Subsequently can improve the scalability, I can even make each sinks subjected to different system architecture, where which they can receive signals from the adjacent units as well. Can also make them self organize, I can tune all of them, so that they all communicate successively in a chain and then they can be connected through a wasp mote network to my central control console what I call as self organization. I can also have an actuator plane; I can control them completely from a specific station which is connected using an wireless sensor networking. I can talk of the location plane where employee this central control console and do the control of all these data at one point of the time.

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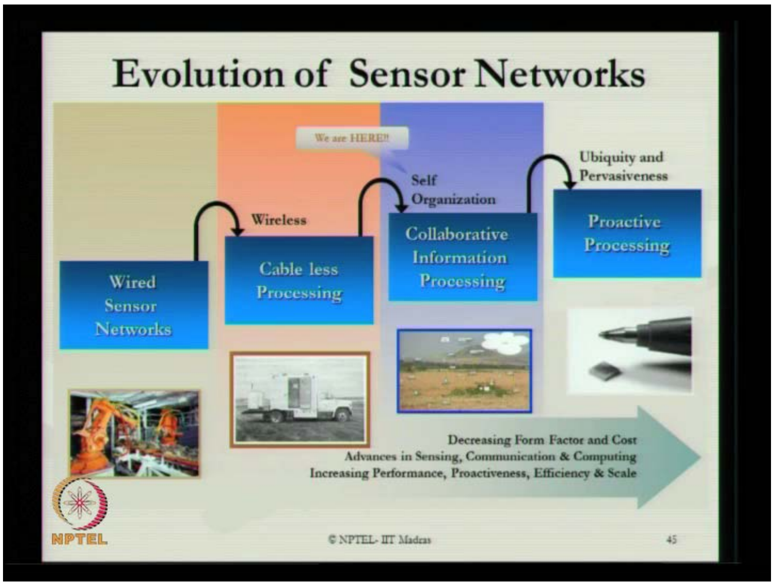

If you look at the evaluation of evolution of sensor networks, it is started with wired sensor network then people started using cable less processing what we called wireless. Then people are no moving to collaborative information processing which we called self-organization. Now in the present scenario, we are here whereas we should having an ability to make them proactive processing which the future networking of wireless sensor networking as applied to marine offshore structure .

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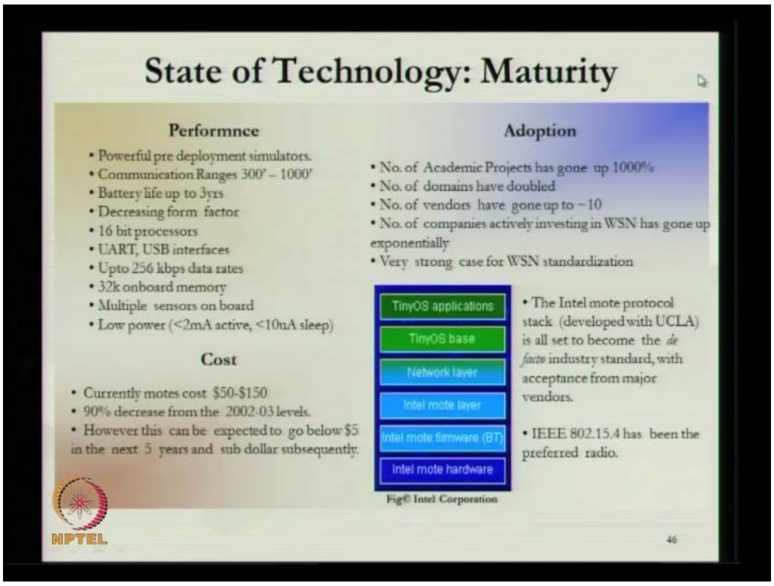

If we look at maturity state of our technology, look at the performance the cost and the adoption of these, they are not expensive in the initial stage and of course, a long run the benefit is very high.

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They have been applied an different location starting from buildings, mobile asset management, medical networking, security systems, offshore structure and industrial monitoring, environmental monitoring research in educational institution as well.

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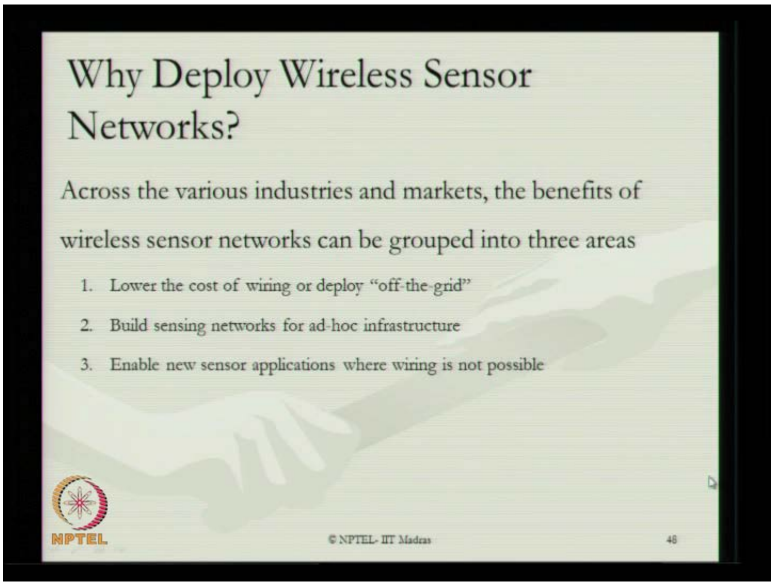

Now the fundamental question comes why to deploy wireless sensor network after understanding so many advantages. Across the various industries and markets the benefit of WSN are grouped in three areas. Lower the cost of wiring or deploy off-the-grid; build sensing networks and ad-hoc-infrastructure; enable new sensor application where wiring is not possible that's very important.

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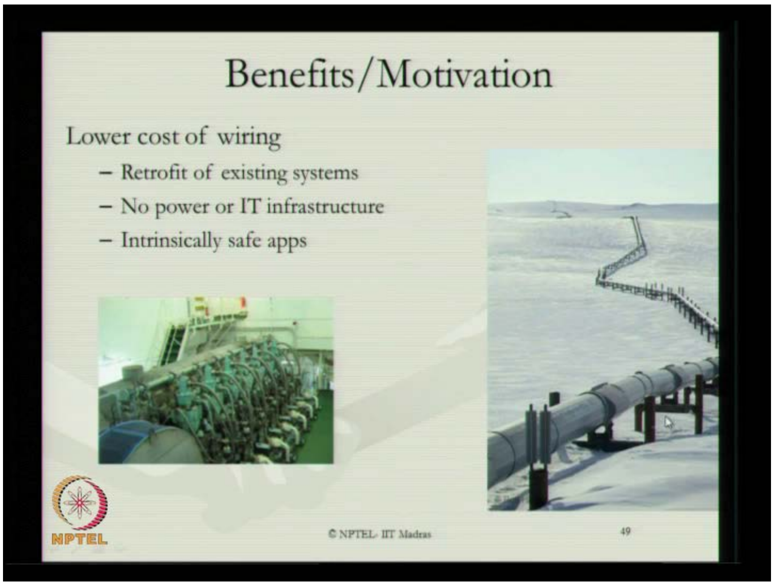

There are high benefits and motivation. Low cost of wiring because it can retrofit of existing system; no power or IT infrastructure; intrinsically safe application as you see in offshore pipelines is has been deploy the recent times.

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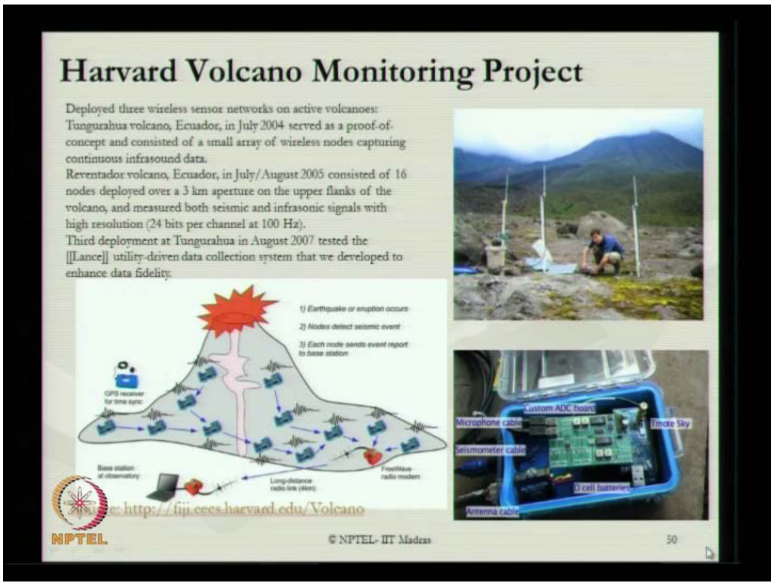

I can give some interesting case examples where Harvard volcano monitoring project is done, deploying three-sensor network on active volcanoes. The Ecuador in July 2004 served as proof of concept and consisted of a small array of wireless nodes as you see in this picture and this is the system architecture which has been deployed in this specific example.

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In Amrita university, the landslide-monitoring project is also carried out in Kerala using wireless sensor networking. You can see the source information as you see from here.

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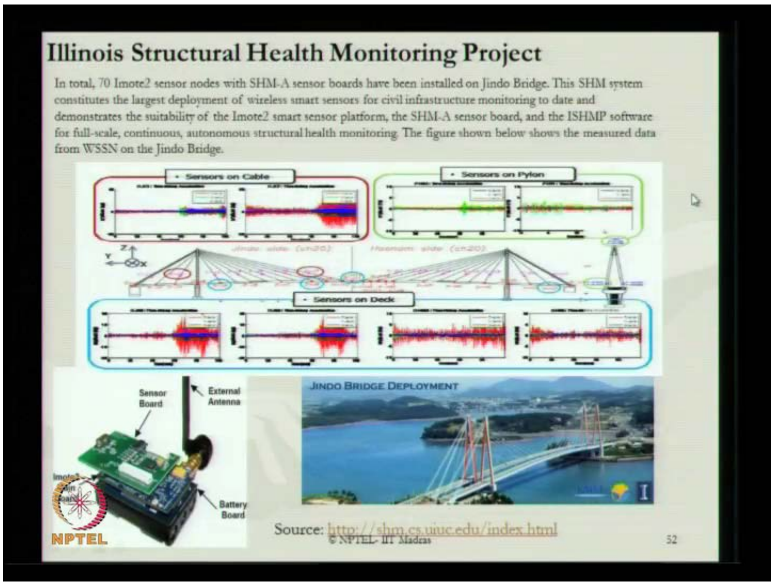

Illinois structural health monitoring project is also used this for developing health monitoring of Jindo bridge using structural health monitoring system. You can see on the left, a typical gateway which is housing a sensor board, external antenna, battery and Imote2, the main board is can be used for monitoring the Jindo bridge deployment in Illinois. The source is given in the website as you see in the bottom of the slide.

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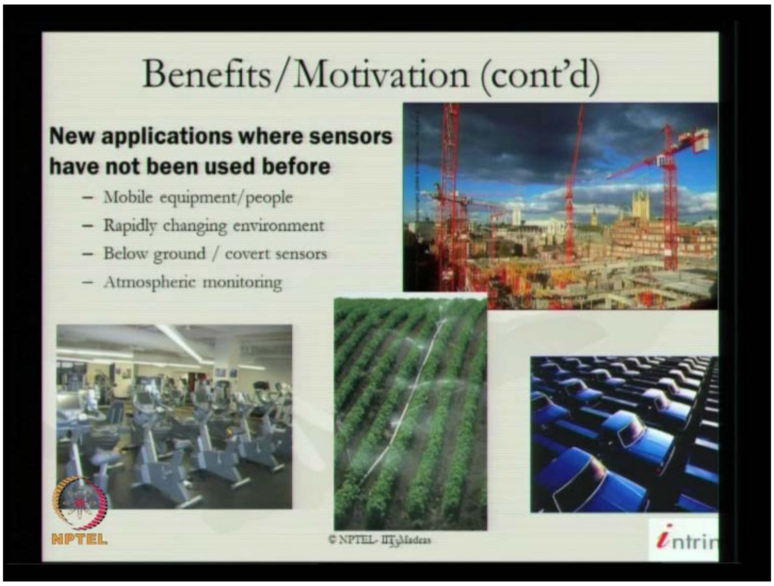

There are various benefit and motivation, which can be done. The new application where sensors have not been used or mobile equipments rapidly changing environment, they have been used underwater and power sensors and atmospheric monitoring, where wireless sensor networking has not been used intrinsic is a company in India located in Bangalore which works extensively on these kind of networking projects.

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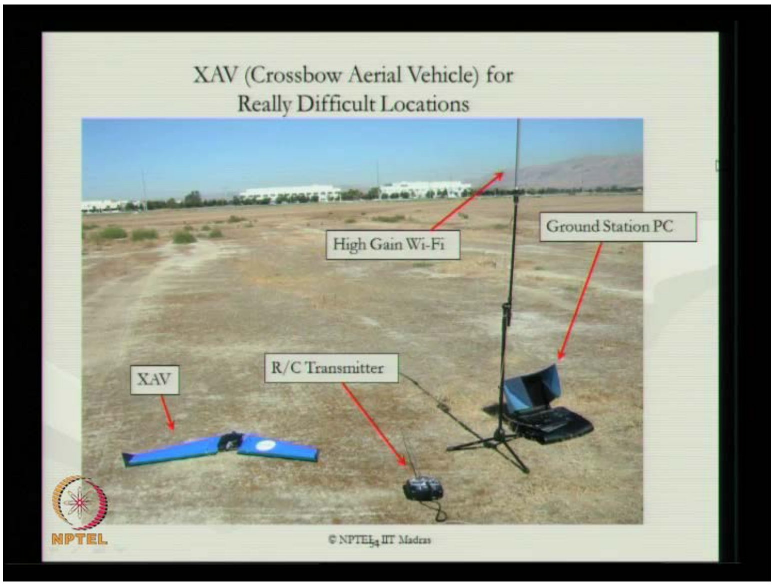

One can also used crossbow aerial vehicle, which is called XAV technique for really difficult location as you see in this picture. So, high gain Wi-Fi can receive from here, can communicate the ground station PC, one can use what we called RC transmitters are instated of that I can use what we called simply a crossbow aerial vehicle which can collect the data using any of advanced technique as you see in this picture here.

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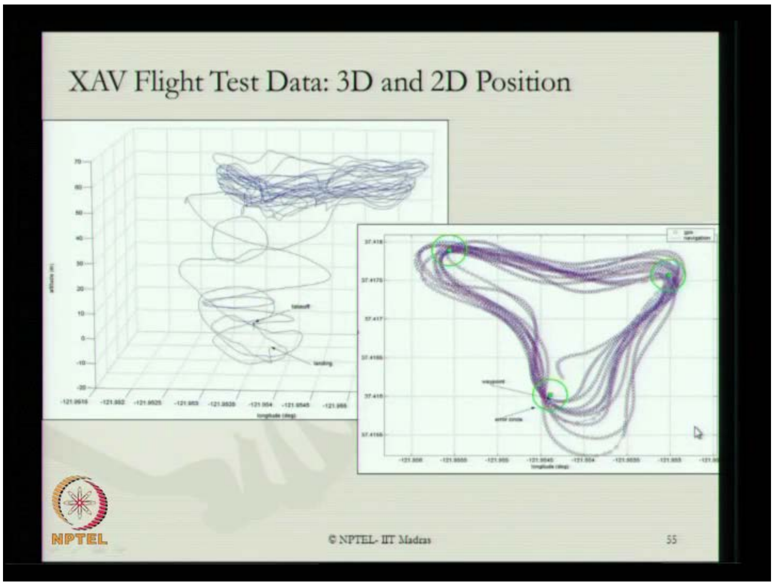

A typical tide data available for flight test data done on 3D and 2D positioning using an XAV flight is shown in this picture here.

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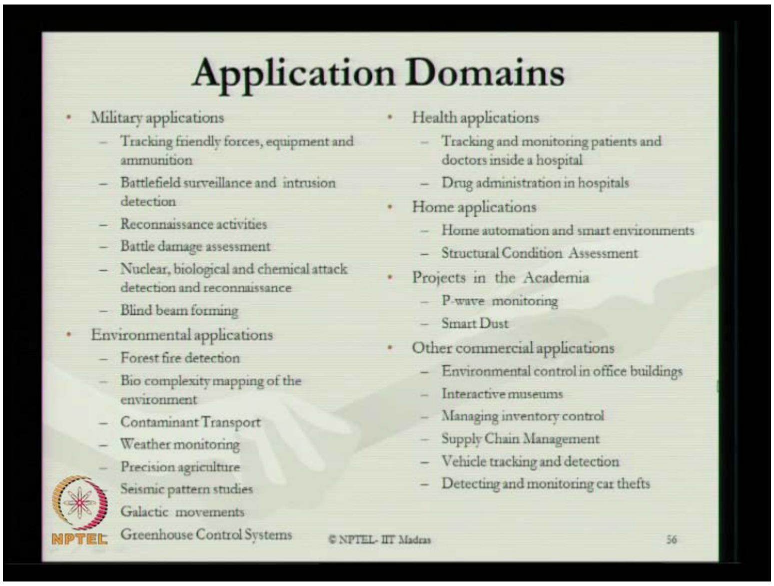

It got different application domains in military application, in environmental application, in health application, home application project in the academia and other commercial applications, we can use this methodology of wireless sensor networking in a larger interest.

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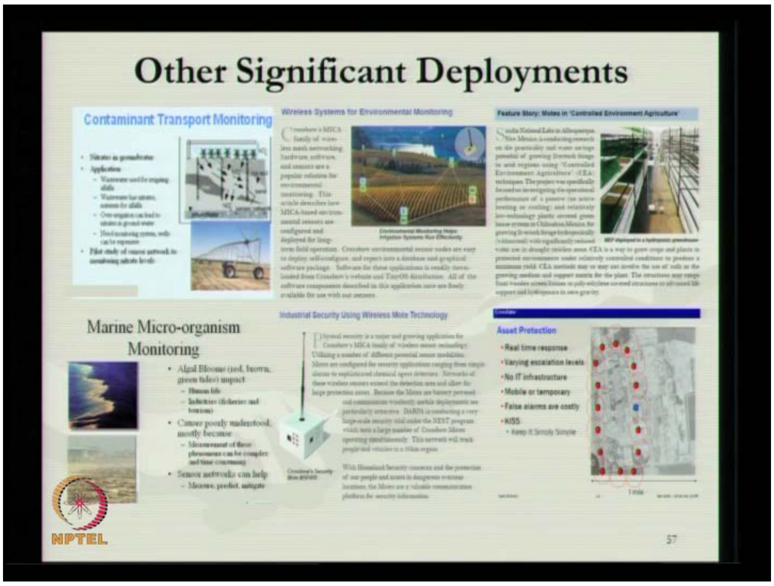

There are other significant deployments as see in this picture here. It can use for marine microorganism monitoring, can be used for industrial security, can be used for assert protection, can be used for control environment agriculture, can be also used for environmental monitoring, which is a very important task for in offshore structure and marine and costal production system.

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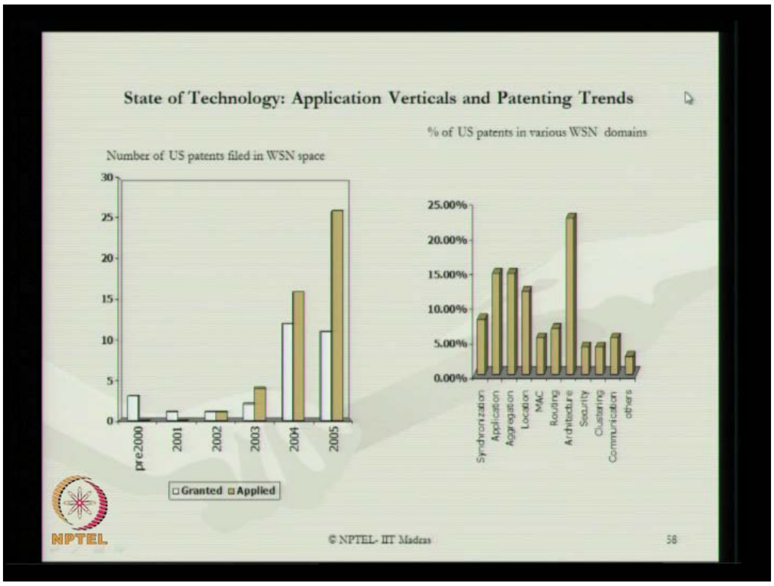

If we look at state of the technology in terms of patenting and research in US, the number of US patents fields in wireless sensor networking space is on the increasing side. Whereas if you look at percent US patents in various wireless sensor-networking domain, you can see different segment in application, location, map, routing you see the maximum is done on our system architecture developed for WSN is closely about 25 percent.

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There are different examples where WSN is deployed for creating intelligent solution- Industrial control and automation, proactive advertisements, dynamic space management, interactive display units, online vibration monitoring and user notification systems.

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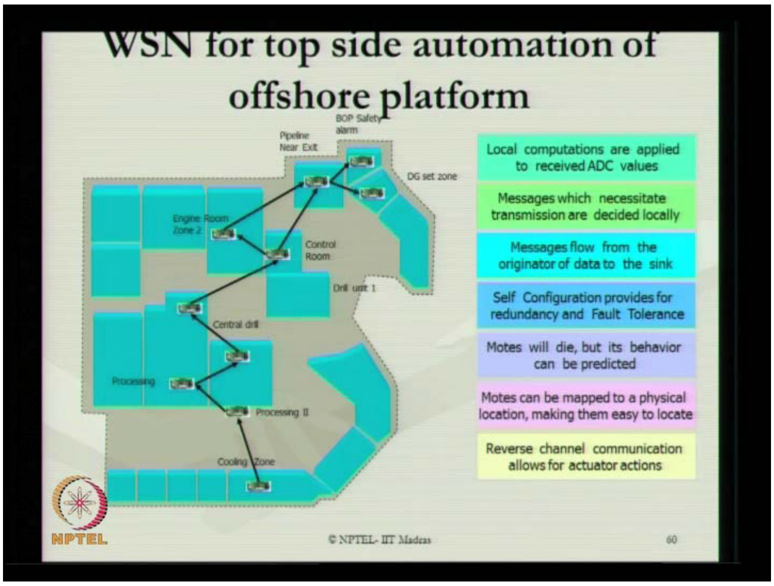

WSN for top side automation of offshore platform is a suggested model as you see in this picture here. I have got the BOP safety alarm here, pipeline near exit, DG set zone is what is marked here. The engine room zones here, the control room and the drilling units- the central drill unit here and the processing unit one and two and the cooling zone present here on the top side environment. Now local computation are applied to received the ADC value from different segments; once the pipeline engine room drill units and cooling zones are connected. Now by using WSN, the self-configuration provides for redundancy and fault tolerance is can improve safety. The motes will die; however, its behavior is off course can be predicted. The motes can be mapped to a physical location making them easy to locate where the actual failure is occurred. Once this can be done then reverse channel communication is possible, so that we can control the BOP safety alarm, and the control unit and the drilling segments from your cooling zones or from the central control station. Therefore, the operability and the safety can widely increase by applying WSN for top side automation than offshore platform.

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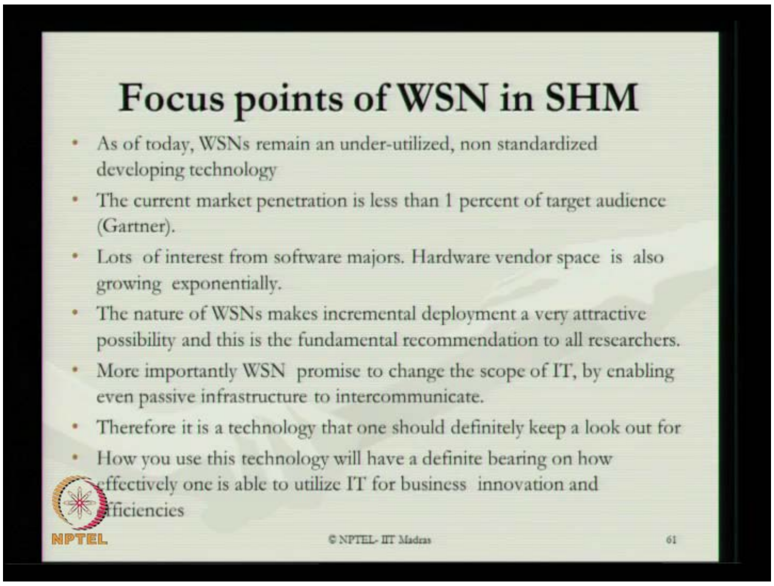

If you look at the focus points of WSN in SHM, as on today WSN remain asunder utilized non- standardized developing technology. The current market penetration less than one percent; lots of interest are available for software majors hardware vendor space is also growing exponentially. The nature of WSNs makes incremental deployment a very attractive possibility and this is the fundamental recommendation to all researchers through this lecture. More importantly WSN promises to change the scope of IT, by enabling even passive infrastructure to intercommunicate. Therefore, it is a technology that one should definitely keep a look out for. How you use this technology will have a definite bearing on how effectively one is able utilized IT for business innovation and efficiencies. Thank you very much. So, this lecture has given you interestingly a broad idea of using wireless sensor networking as applicable to general construction industry and specifically to offshore industry as well.

Thank you.