

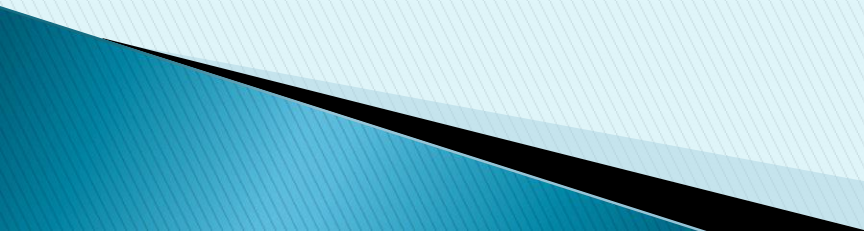


# **INFORMATION PROCESSING**

## **- A FUTURISTIC SCENARIO**

**Dr SK Shivakumar**  
**ISRO Satellite Centre**  
**Bangalore**

# **Agenda**

- **Introduction - Information Processing**
  - **Future Trends in Computing**
  - **Next Generation Space Systems**
  - **Information Processing-Space systems**
  - **Conclusions**
- 

# Earlier Predictions

- ▶ "I think there is a world market for may be five computers." –

IBM Chairman, Thomas Watson, 1943

- ▶ "There is no reason for any individual to have computer in his home." –

Ken Olsen, DEC CEO, 1977

- ▶ "640K ought to be enough for anybody."

Bill Gates, Microsoft Chairman, 1981

- ▶ "DOS will be with us forever."

Brad Silverberg, Microsoft VP, 1991

# **Introduction - Information Processing (IP)**

Information processing refers to the manipulation of digitized information by computers and other digital electronic equipment, known collectively as information technology (IT).

Information processing systems include business software, operating systems, computers, networks and mainframes. Whenever data needs to be transferred or operated upon in some way, this is referred to as information processing.

## **Need for Information Processing**

1. For Large amount of Data Processing: 1950s–1960s
2. Management Reporting: 1960s–1970s
3. Decision support: 1970s–1980s
4. Strategic and End User Support: 1980s–1990s
5. Global Internetworking: 1990s–2000s
6. All Aspects of Human Endeavour: Beyond 2000s

# **Applications of IP in Today's World**

## **1. Banking & Finance Sector**

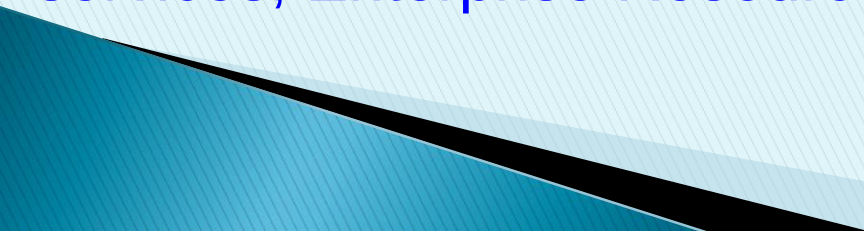
Transaction processing systems, Process control systems, Online banking & Trading, Office Automation systems, E-governance

## **2. Science & Technology Area**

Large Data processing, Decision Making & Analysis, real time decision making systems, Data Communication systems/Links

## **3. Manufacturing & Marketing Industries**

Production planning & Control, Management Information System, concurrent and collaborative engineering, Customer support services, Enterprise Resource planning



# Applications of IP in Today's World

## 4. Information Technology

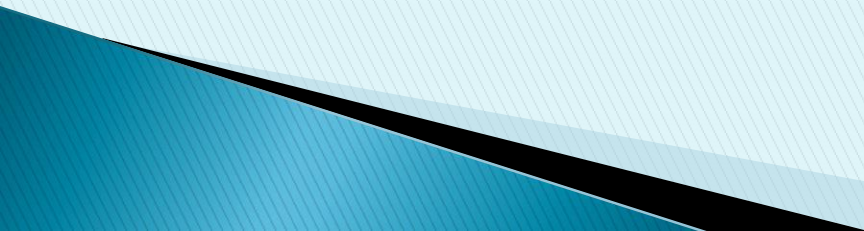
Data base services, Networking, Business solutions, Automation & Intelligent systems

## 5. Medical Engineering

Diagnosis, Supporting clinical decision making , Guiding Clinical practices, E-Health records maintenance

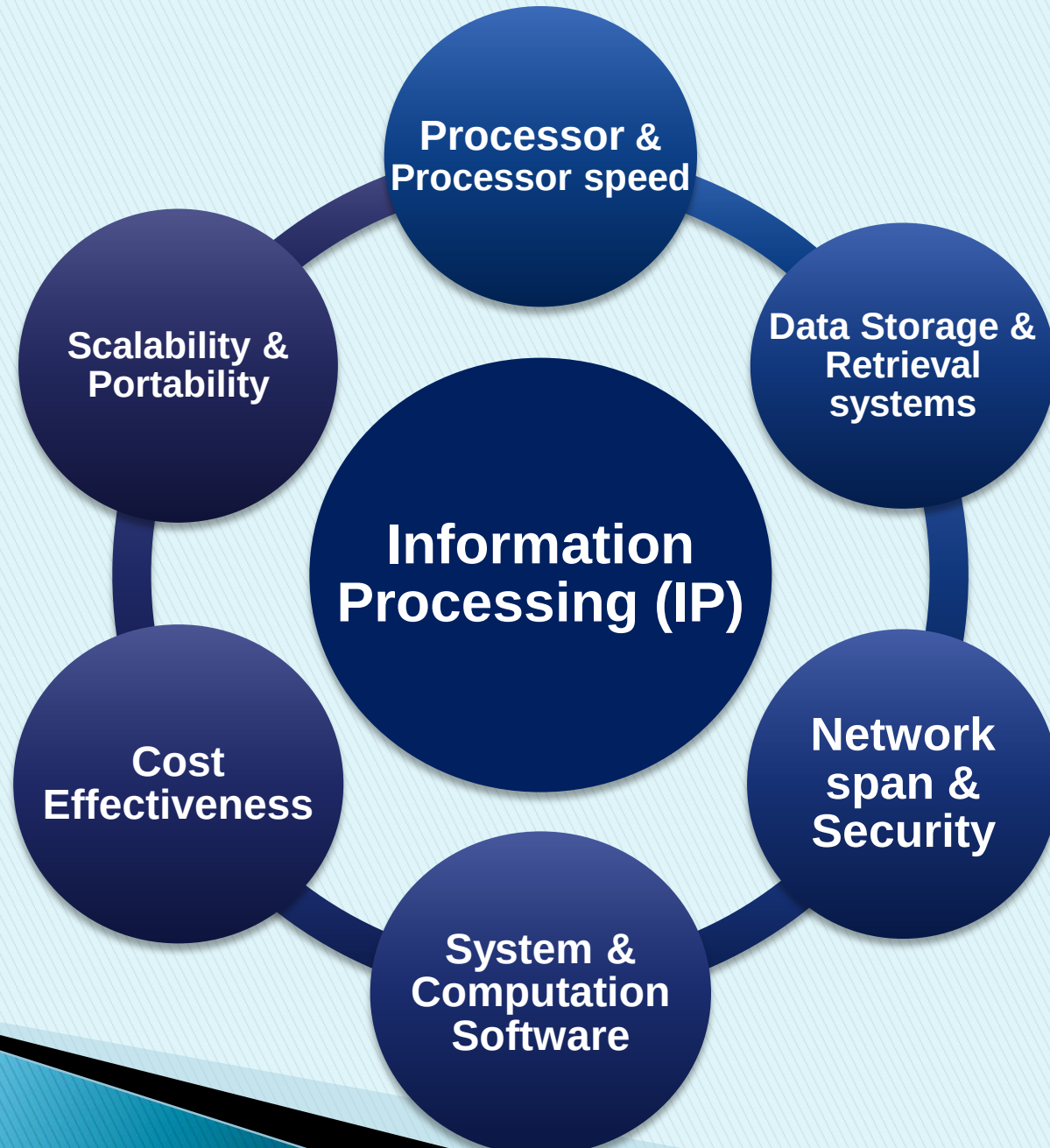
## 6. Military Applications

Image processing, Onboard computing, Decision support system, Navigation & Guidance systems, Expert systems

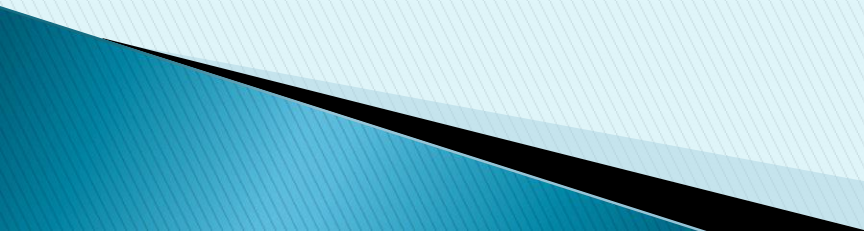




# Main features of IP systems



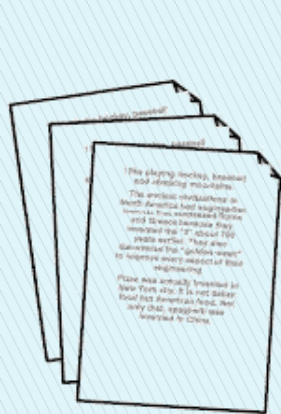
# **Future Trends in Computing**

- ▶ Mobile Cloud
  - ▶ Web of Things
  - ▶ 3D Printing
  - ▶ Smart & Connected Healthcare
  - ▶ Next Generation Networks (NGN)
- 



# Future Trends in Computing

## Information Sources



**Documents  
and Content**



**RFID, Meters  
and Other OT**



**Cloud Computing  
and Cloud Data**



**B2B**

**Social  
Computing**



**Mobile and  
Communications**



**Internal Applications,  
Email, More**

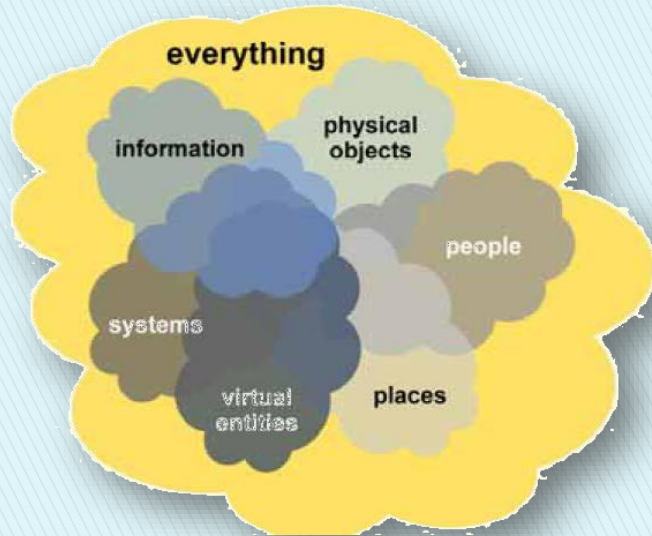
# Future Trends - Mobile Cloud



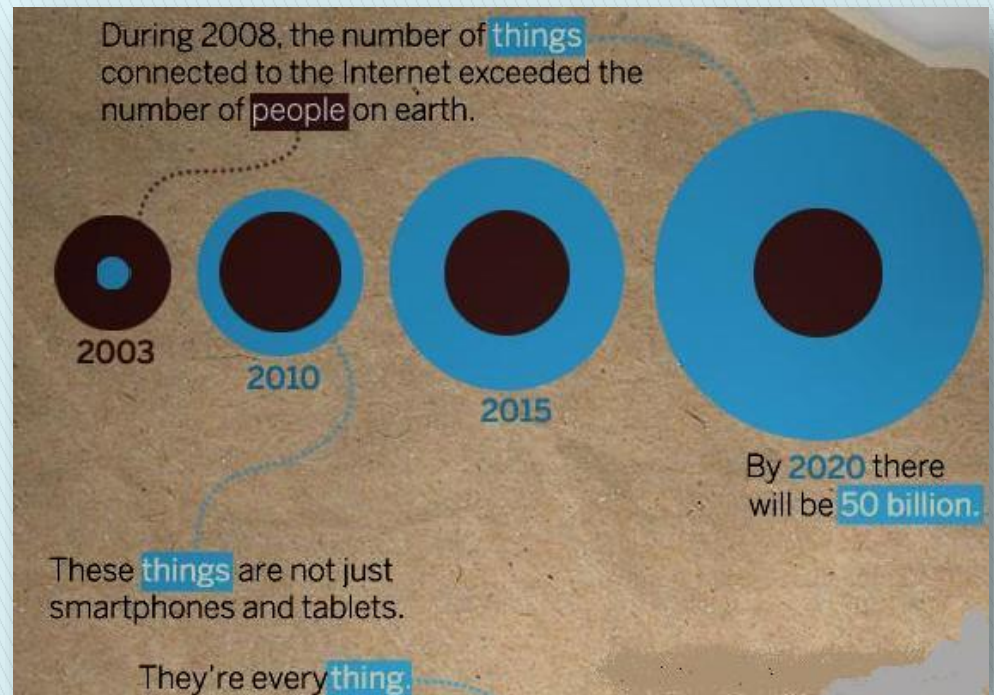
- ▶ Convergence of Mobile Devices & Cloud Computing
- ▶ Creation of new platform
- ▶ Potential for unlimited computing resources
- ▶ Overcomes limitation of mobile devices
  - *Memory, Compute Power, Battery Life*
- ▶ Data Processing and Storage outside of Mobile Devices
- ▶ Creation of “Third Platform”
  - *Data Synchronization, Reliability, Scalability*
  - *Leading to explosion of new services*



# Future Trends - Web of Things

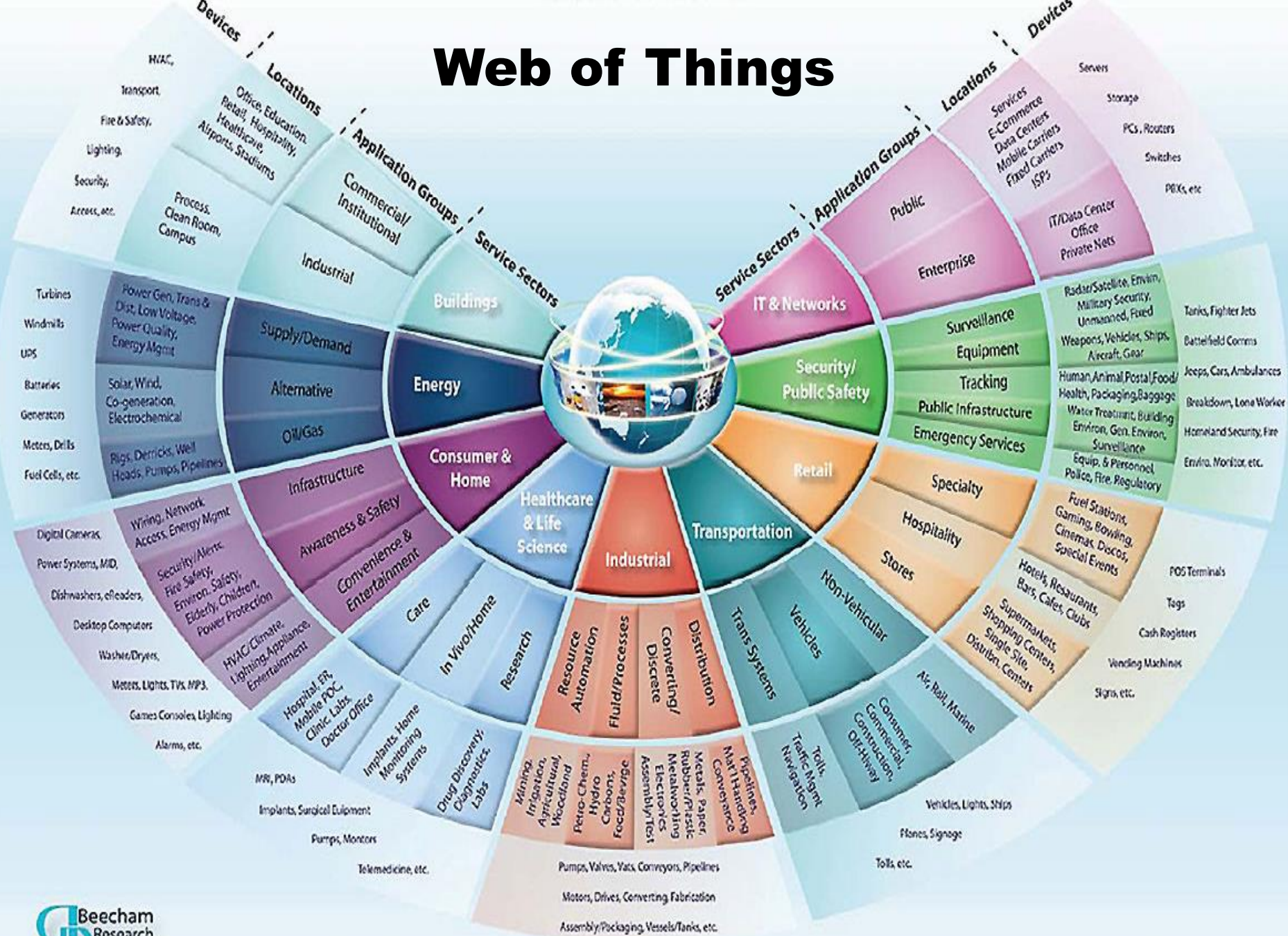


- ▶ Everything has URL
- ▶ Takes advantage of ability of mobile devices to observe & monitor environment
- ▶ Increases coordination between things in real world and their counterparts on the web



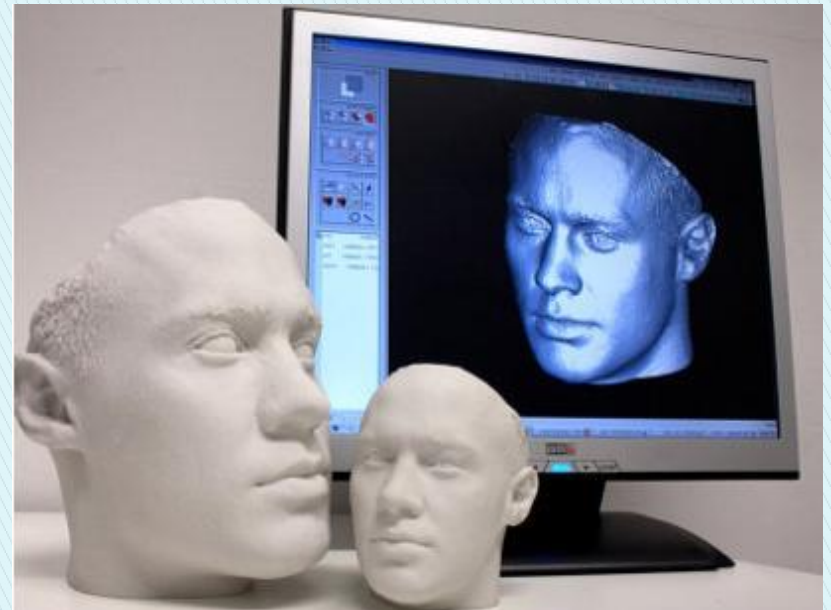


# Web of Things



# Future Trends - 3D Printing

- ▶ Digital Model can be printed into a Physical Object
- ▶ Additive manufacturing
- ▶ Fast, Inexpensive, Easy
- ▶ Wide applications
  - Auto parts, jewellery, prosthetics, firearms
  - Can be used to make objects on other planets or Moon using their soil





# Future Trends – Smart Healthcare



- ▶ Computing & information processing will play major role in individual & Social well being
- ▶ Collect, Process & Transform Healthcare Data into knowledge & Action
- ▶ Analyze data & Human responses
- ▶ Guide Implementation and Management of Therapies & Intervention

# **Future Trends - Next Generation Network (NGN)**

- ▶ The rising tides of big data, video & cloud computing is driving tremendous demand for networks that are
  - More efficient & Faster
- ▶ One network transports all information and services Voice, data & all kinds of media like audio, video
- ▶ NGN Communication Protocols
  - Packet-switched and uses IP at the network layer
  - The centre of the network is the IP multimedia service
  - Session Initiation Protocol (SIP) at application level



# Future Trends - Next Generation Network (NGN)



# Future Trends – Internet via MEO Satellites

- ▶ A constellation of MEO satellites using Ka-band payloads
- ▶ The network provides a combination of
  - Ubiquitous reach of satellite &
  - Speed of fiber through ground gateways
- ▶ To deliver satellite Internet & mobile backhaul services

## Middle-mile for Internet using MEO Satellites



# Future Trends – O3b : Other 3 billion N/W

## O3b's planned new system

O3b is planning a constellation of 16 satellites providing high-speed, low-cost Internet connectivity to emerging markets in Asia, Africa, Latin America and the Middle East. Activation of the system is scheduled for late 2010

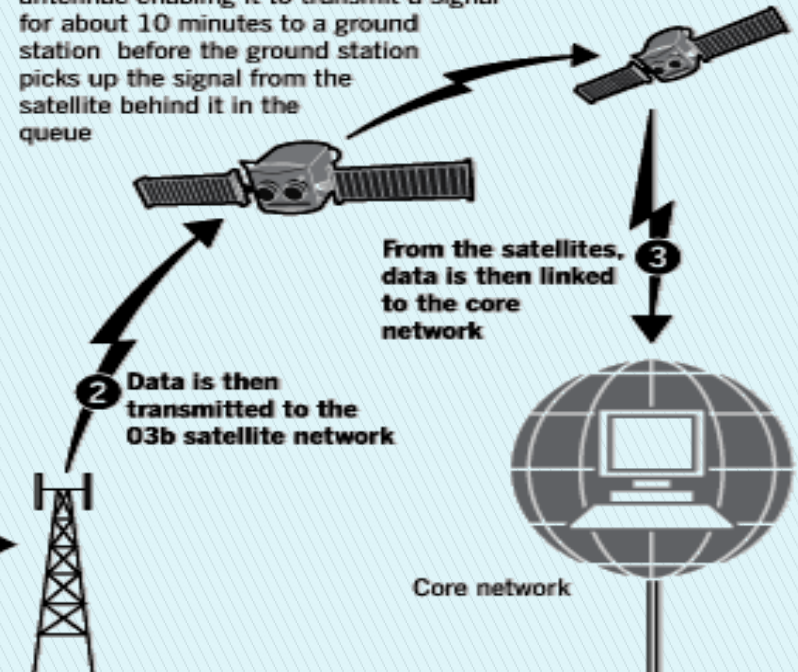
## The planned network coverage

The array of 16 satellites will be able to cover all points between 45 degrees north of the equator and 45 degrees south

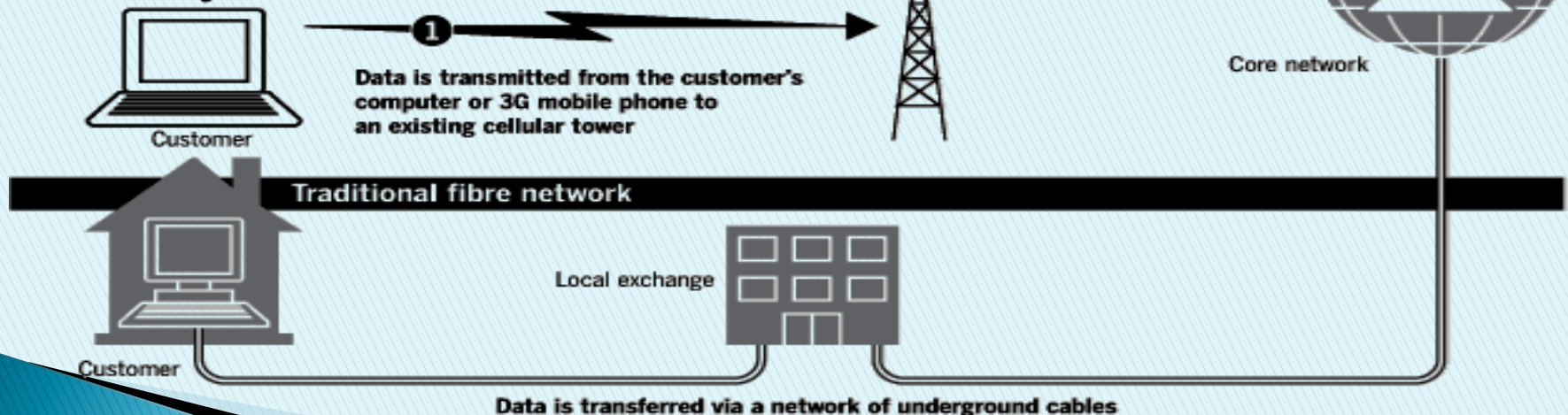


### Satellite

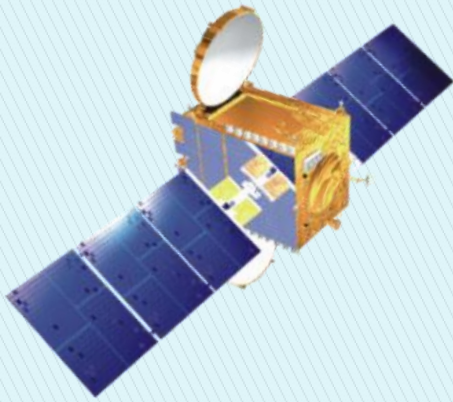
Launched into orbit, it has swivelling antennae enabling it to transmit a signal for about 10 minutes to a ground station before the ground station picks up the signal from the satellite behind it in the queue



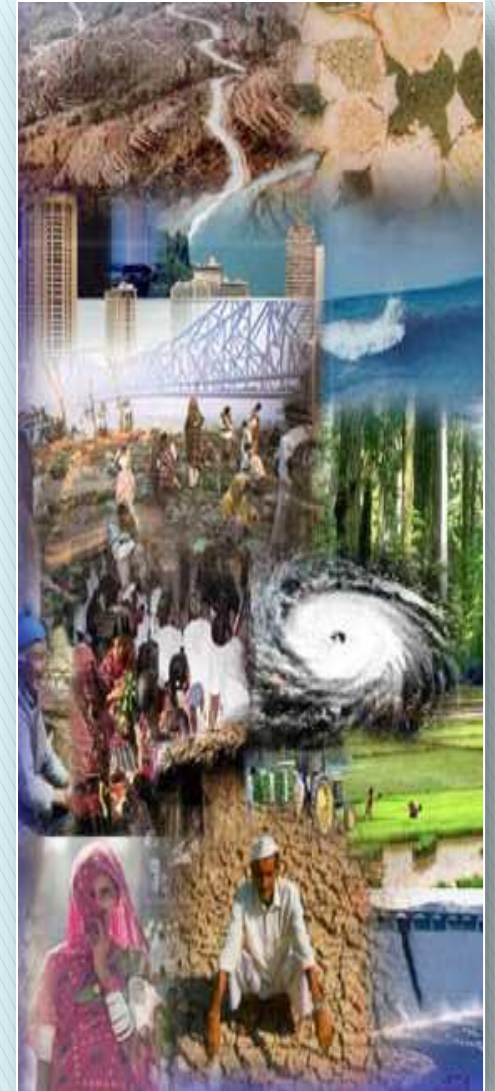
## How the system works







# Next Generation - SPACE Systems And Challenges





# SPACECRAFT PROGRAMME PROFILE 2016-2017 (22 s/c)

|                     | 2016 (12 s/c)                                                                                          |                                                                                                          |     |     |                                                                                                              |     |                                                                                                     |     |     |                                                                                                           |                                                                                                          |                                                                                                                 | 2017 (10 s/c)                                                                                                    |                                                                                                              |                                                                                                            |     |     |     |                                                                                                              |                                                                                                         |                                                                                                                  |                                                                                                              |                                                                                                              |     |
|---------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----|-----|--------------------------------------------------------------------------------------------------------------|-----|-----------------------------------------------------------------------------------------------------|-----|-----|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-----|-----|-----|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----|
|                     | JAN                                                                                                    | FEB                                                                                                      | MAR | APR | MAY                                                                                                          | JUN | JUL                                                                                                 | AUG | SEP | OCT                                                                                                       | NOV                                                                                                      | DEC                                                                                                             | JAN                                                                                                              | FEB                                                                                                          | MAR                                                                                                        | APR | MAY | JUN | JUL                                                                                                          | AUG                                                                                                     | SEP                                                                                                              | OCT                                                                                                          | NOV                                                                                                          | DEC |
| GEOSAT PROGRAMME    |                                                                                                        |                                                                                                          |     |     | <br>INSAT-3DR<br>GSLV Mk-II |     |                                                                                                     |     |     | <br>GSAT-9<br>GSLV Mk-II | <br>GSAT-17<br>PROCURED | <br>GSAT-19<br>GSLV MK-III D1 | <br>GSAT-19<br>GSLV MK-III D1 | <br>GSAT-7A<br>GSLV Mk-II |                                                                                                            |     |     |     | <br>GISAT-1<br>GSLV Mk-II |                                                                                                         | <br>GSAT-22<br>GSLV MK-III D2 |                                                                                                              | <br>INSAT-4AR<br>PROCURED |     |
| IRS & SSS PROGRAMME |                                                                                                        | <br>CARTOSAT-2C<br>PSLV |     |     | <br>SCATSAT-1<br>PSLV       |     | <br>RES-2A<br>PSLV |     |     |                                                                                                           | <br>EMISAT<br>PSLV      |                                                                                                                 |                                                                                                                  | <br>CARTOSAT-2D<br>PSLV   | <br>CARTOSAT-2E<br>PSLV |     |     |     |                                                                                                              | <br>MICROSAT<br>PSLV |                                                                                                                  | <br>CHANDRAYAAN-2<br>GSLV |                                                                                                              |     |
| NAVIGATION PROG.    | <br>IRNSS-1F<br>PSLV | <br>IRNSS-1G<br>PSLV  |     |     |                                                                                                              |     |                                                                                                     |     |     | <br>IRNSS-1H<br>PSLV   |                                                                                                          |                                                                                                                 |                                                                                                                  | <br>IRNSS-1I<br>PSLV    |                                                                                                            |     |     |     |                                                                                                              |                                                                                                         |                                                                                                                  |                                                                                                              |                                                                                                              |     |

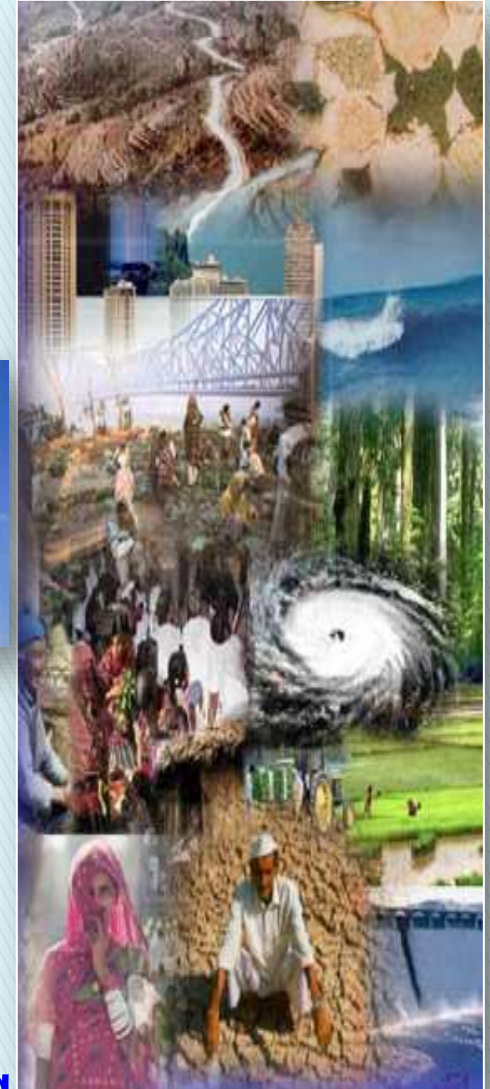
\* All dates indicated above are spacecraft readiness schedules

01<sup>st</sup> January , 2016

# SATELLITE APPLICATIONS : BENEFITS TO THE SOCIETY

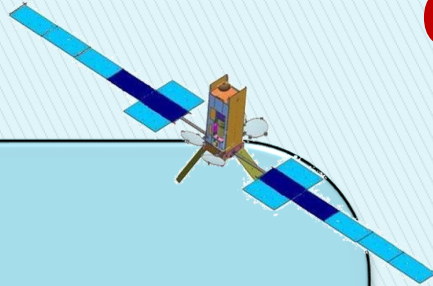
Satellites play a vital role in transforming the lives of human mankind. The benefits of satellites are tremendous in the areas of :

1. Agriculture
2. Energy & Environment
3. Infrastructure Planning
4. Water Resources
5. Developmental Planning
6. Communication
7. Navigation
8. Weather & Disaster Management
9. Health & Education
- 10.Space Science – Quest for Knowledge



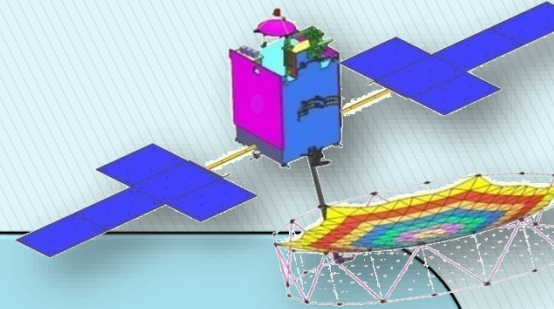
# COMMUNICATION PROGRAMME - CHALLENGING MISSIONS

## GSAT- 19



- 6 Ton Class
- **Power:** ~3.5KW
- **Payload** : 3 Ka-band, 2 Nor- C band & 1 MSS F/W & 1 MSS R/T
- **App:** Augmentation of Transponders in orbit for Communications services

## GSAT- 20

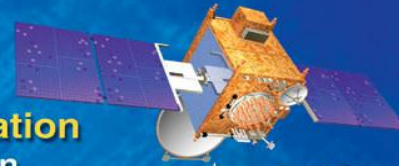


- 6 Ton Class
- **Power:** 7.8 KW
- **Payload** :35 Spot beams & 3 Wide beam F/W & R/T
- **App:** Augmentation of Transponders in orbit for Communications services



# GAGAN

GPS Aided Geo Augmented Navigation  
Indian Satellite Based Augmentation  
System



## ARCHITECTURE

GSAT-  
8,10 (GSAT/INSAT)  
(L1,L5)

GAGAN Coverage 82°E

GSAT-  
8,10 (GSAT/INSAT)  
(L1,L5)

GPS

GPS

GPS

INLUS

INRES

INMCC

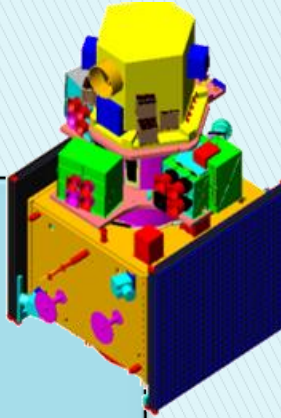
FIBRE OPTIC

- ★ Total Electron Content Station (TEC)
- Indian Reference Station (INRES)
- 📡 Indian Land Uplink Station (INLUS)
- 🏢 Indian Master Control Centre (INMCC)

Navigation - Air, Sea and Land, Positioning Applications, Survey, Image Correction, GIS, Timing, Surveillance/fleet monitoring

# REMOTE SENSING PROGRAMME-CHALLENGING MISSIONS

## RESOURCESAT-2A



**Standard IRS Bus**

**Payloads:**

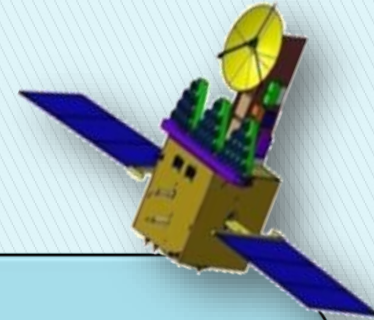
**LISS-4, LISS-3, AWIFS**

**Orbit : 817 Km SSPO**

**LT :10.30 AM**

**Applications: Resource applications**

## OCEANSAT-3



**Standard IRS Bus**

**Payloads:**

**13 band OCM, Ku-band SCAT, Sea Surface Temperature Monitor (SSTM)**

**Orbit: 720 Km SSPO**

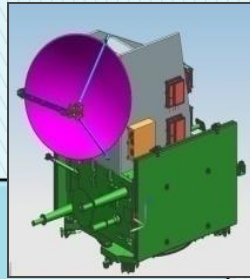
**Local Time:12.00 Noon**

**Applications: Oceanography**



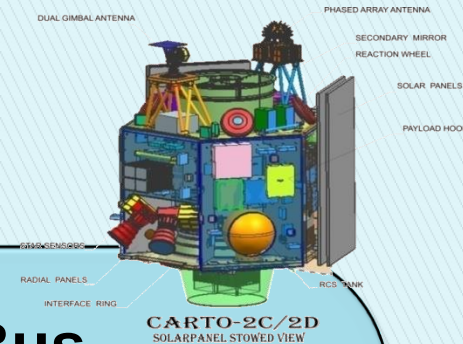
# REMOTE SENSING PROGRAMME-CHALLENGING MISSIONS

## SCATSAT-1



**Standard IMS-2 Bus**  
**Payloads:**  
**Scatterometer**  
**Orbit: 720 Km SSPO**  
**Mass: 360 Kg**  
**Power : 280W**  
**Applications:**  
**Oceanography**

## CARTOSAT-2C/2D/2E/2F



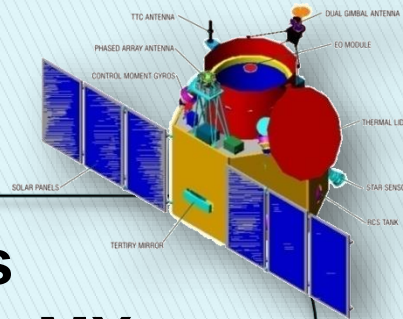
**Hexagonal Bus**  
**Payloads: PAN, MX**  
**Orbit: 500 Km SSPO**  
**Mass: 650 Kg**  
**Power : 1000W**  
**Applications: High Resolution**  
**Cartography with TDI Imaging**



# REMOTE SENSING PROGRAMME-CHALLENGING MISSIONS

## UPCOMING SATELLITE MISSIONS

### CARTOSAT-3



**Hexagonal Bus**

**Payloads: PAN, MX**

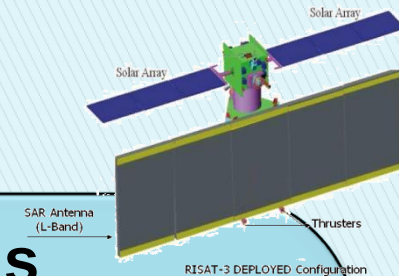
**Orbit: 450 Km SSPO**

**Mass: 1500 Kg**

**Power : 2000 W**

**Applications: Adv.  
High Resolution PAN &  
MX Camera & Hyper  
Spectral Imager for  
Cartography**

### RISAT-3



**Triangular Bus**

**Payloads: L-band SAR**

**Orbit: 536 Km SSPO**

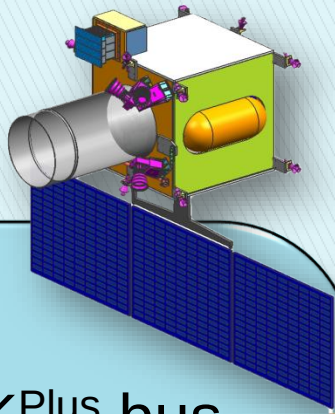
**Mass: 2530 Kg**

**Power : 4500 W**

**Applications: Multi  
resolution microwave  
imaging for natural  
resource management  
and other applications**

# REMOTE SENSING PROGRAMME-CHALLENGING MISSIONS

## GISAT



- Standard I-1K<sup>Plus</sup> bus
- **Power:** 920 W
- **Payload :** Multispectral Imager
- **App:** Geo Imaging satellite in Geostationary orbit with high temporal resolution

## INSAT-3DR/3DS



- **2.2 Ton Class**
- **Power:** 1.1 KW
- **Payload :** 6 Channel Imager & 19 Channel Sounder
- **App:** Advanced Meteorological services – Climate & Weather Forecasting

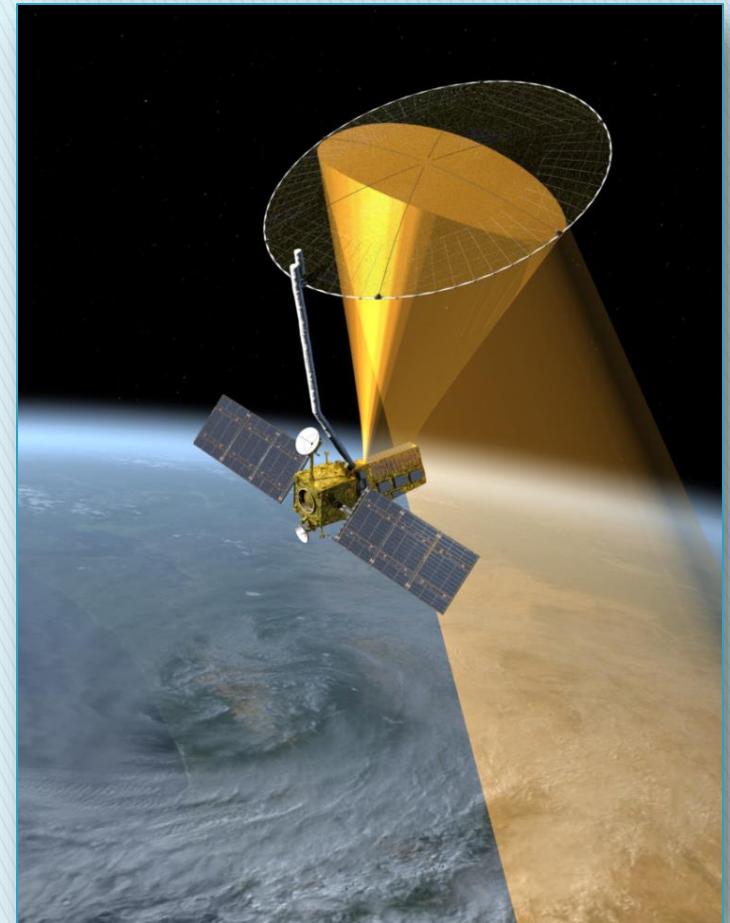
# REMOTE SENSING PROGRAMME-CHALLENGING MISSIONS

## NASA-ISRO SAR

A Global mission for monitoring Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI). It is a collaborative Mission between NASA/JPL & ISRO with World's First Dual Band (L & S) Synthetic Aperture Radar (SAR) for Earth Imaging.

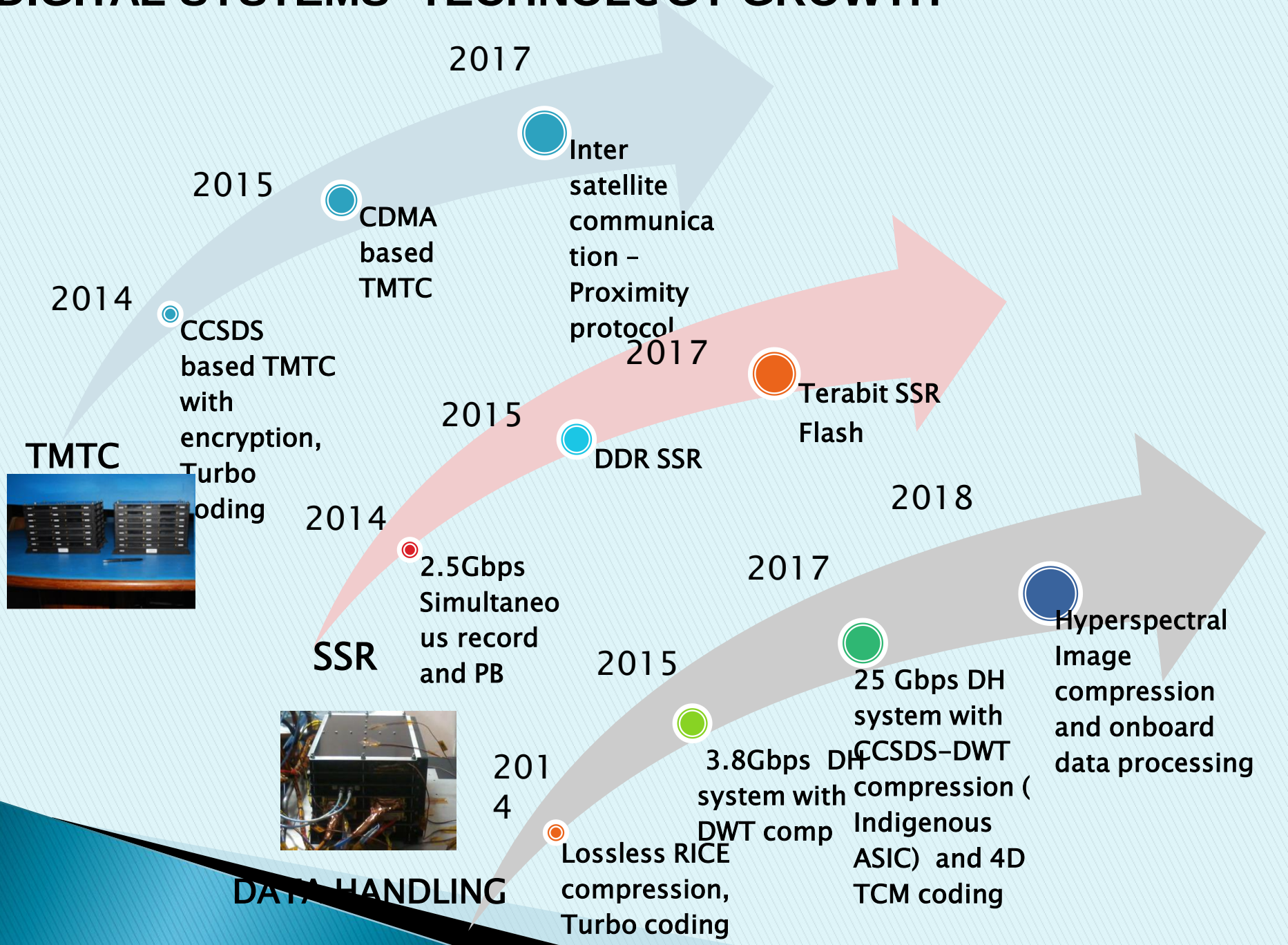
### **SALIENT FEATURES**

- New Sweep SAR Technology with large (12m) unfurlable reflector
- Payloads : L-Band SAR payload by NASA-JPL and S-Band SAR payload by ISRO-SAC
- Spacecraft Mainframe by ISRO-ISAC
- Launch: ISRO-GSLV
- Target Launch Date: 2019-20





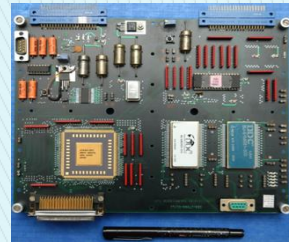
# DIGITAL SYSTEMS- TECHNOLOGY GROWTH



# CONTROL ELECTRONICS

## LEON 3 FT Processor based CPU Board for OBC/AOCE

- Proto Model Demonstrated. New chipset & software tools identified & under procurement
- Software modules under porting, testing of basic functions completed



## HX-1750 processor based CPU Board for OBC & AOCE

- Std AOCE design: SM card tested. QM under testing. FM under wiring. To be flown in GSAT-18,17
- AOCE V1/ OBC design: SM card under testing. To be flown from IRNSS-1H onwards & INSAT3DR/S



## IROVER Navigation Guidance & Control Electronics

- FPGA design completed, Modification with HX1750 CPU in progress. Software Development in progress



## Hall Effect Thruster 100

- Developmental model completed & tested for cumulative firing of 450Hrs. Thrust measured : 70 mN ; specific impulse: 1830 seconds

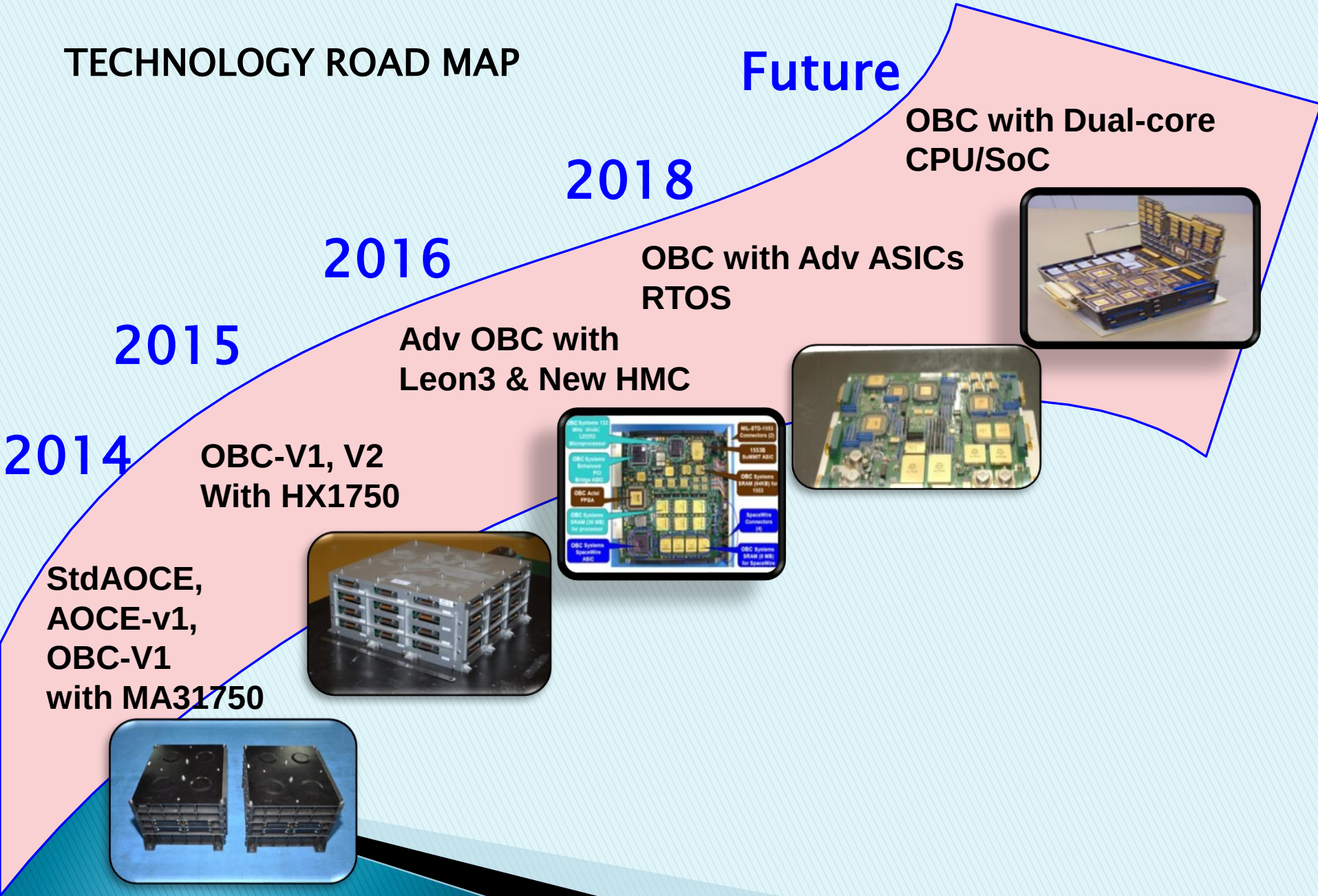


## Advanced OBC

- Design with OBC ASICs, FPGAs, New HMCs in progress

# CONTROL ELECTRONICS

## TECHNOLOGY ROAD MAP





# CONTROL DYNAMICS & SIMULATION

**Mars Orbiter Mission :** Thruster FDIR logic was successfully implemented. Demonstrated the autonomous LEB sequencer for all burns

**Cartosat-2C:** Autonomy features incorporated including autonomous acquisition till three axis stabilization, Magnetometer based rate estimation and damping during post- safe mode recovery

**Control Moment Gyros based AOCS for CARTOSAT-3:** Singularity avoidance and Steering algorithms completed

**SPADEX:** Relative Dynamics modeling simulation completed. Navigation Guidance & Controls along with autonomous docking sequence configuration is in progress

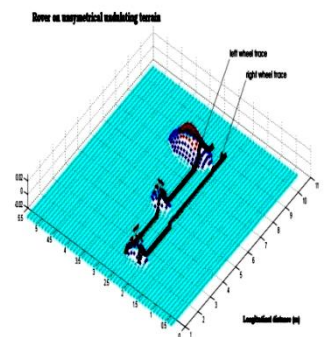
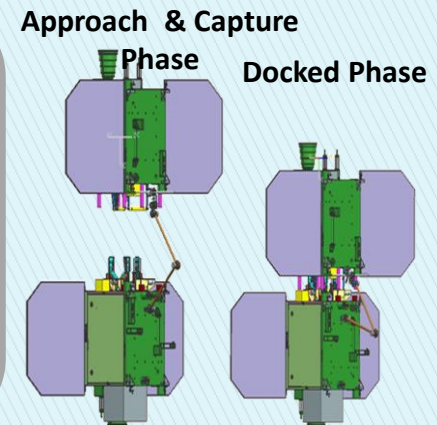
**Control & Simulation Studies on Docking with Robotic Arm**

Trajectory Generation for Robotic Arm (3D), Study of Impact Dynamics during Capture and Robot Control using Feedback Linearization completed

**Chandrayaan-2:** Developed Closed Loop Guidance algorithms for the terminal powered descent phase of Lander mission. Scheme for hazard avoidance through hovering maneuver designed

**Navigation, Guidance and Control for Planetary Rovers:**

Six wheel rover inverse kinematics analysis completed. Navigation and control using video data in progress



# COMMUNICATION SYSTEMS

## Indigenous 12-Channel SPS:

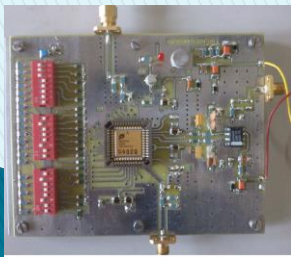
- Engineering Model Realized.
- First LEON-3 processor based system developed at ISAC.
- To be Flown from Resourcesat-2A onwards.



## Ku band TC Receiver for future GEO missions:

- 12.75 – 13.25 GHz & 13.75 – 14.5 GHz, Frequency settability :  $\approx 150$  Hz.
- Synthesizer based Local Oscillator module completed.

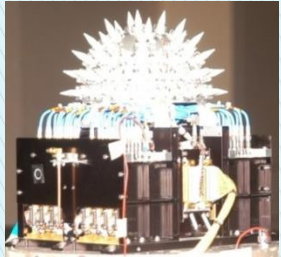
## S-Band Digital Coherent Receiver for LEO & deep space missions: Verification model in progress



## X-band Coherent Receiver for Deep Space:

- Synthesizer based Local Oscillator module completed.
- Preliminary design of 1st and 2nd Intermediate frequency amplifier stages completed.

# COMMUNICATION SYSTEMS

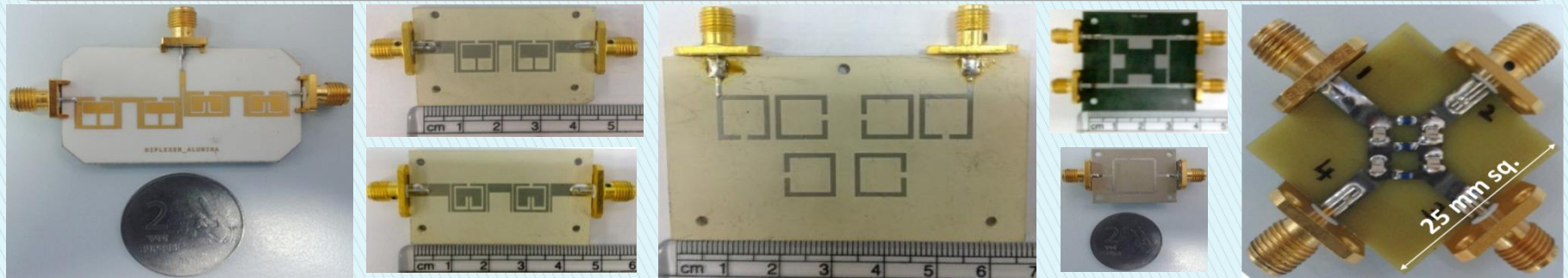


## Beam Steering Electronics For Cartosat-2C:

- **Single FPGA solution. 50% reduction in mass.**
- **Engineering Model tested successfully using RTAX-ProASIC Adapter**

## Miniaturized Planar Filters & Passive Systems:

**Developed for use in Transmitter and Receiver sub-systems of future IRS and GEOSAT missions**



## Dual Channel Waveguide Rotary Joint at Ka-band for CARTO-3/NISAR:

**Design verification model is under progress**



**High Power SSPA (50 Watts): To replace X band TWTAs for future missions.**  
**Test Evaluation board testing completed**



# Information processing - Space systems



# Mission & Onboard Software - Satellites

**Satellite Mission**

**Mission  
Software  
Elements**

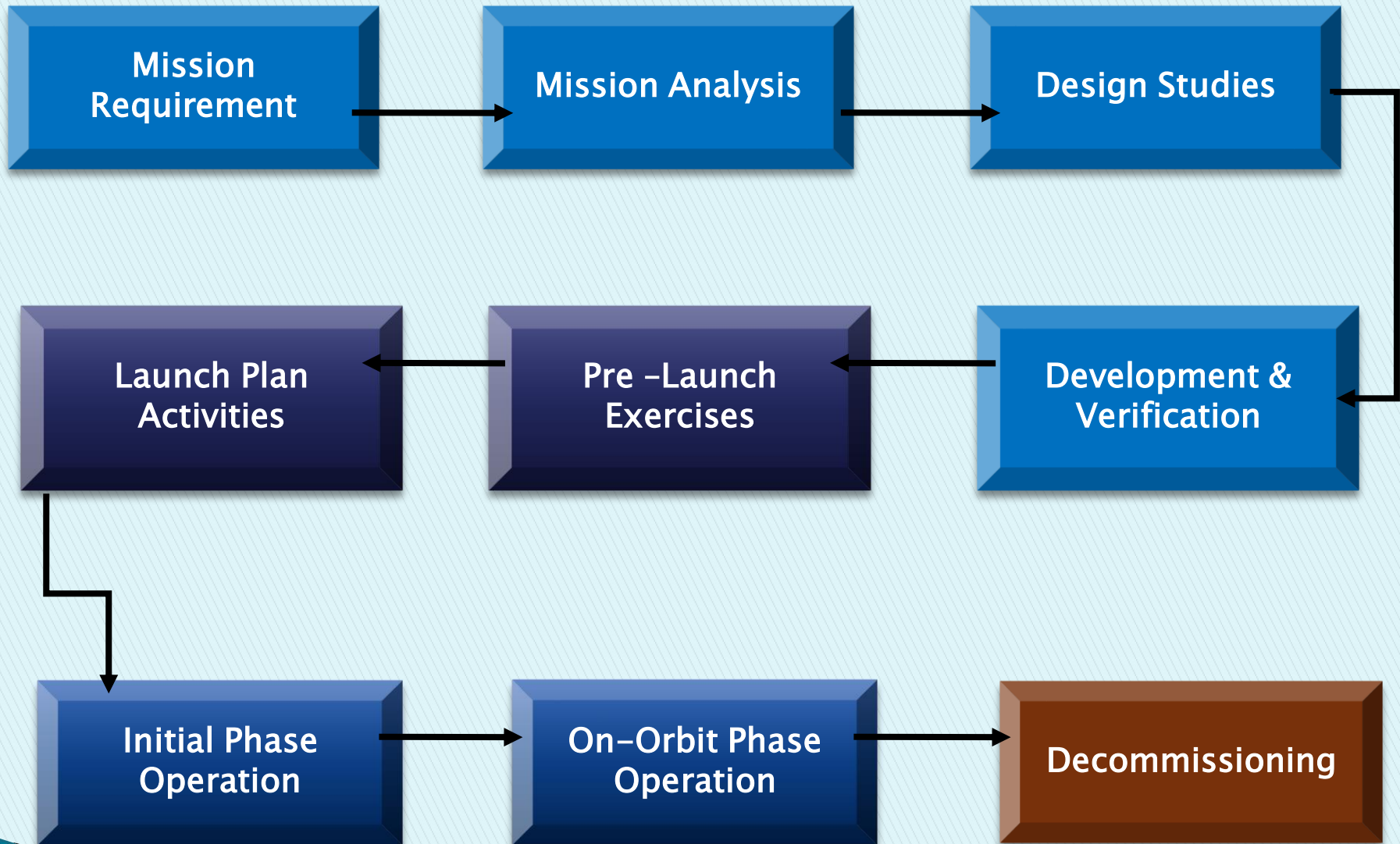
**Ground  
Segment**

**Payload Data  
Reception &  
Processing**

**Satellite Control  
Centre**

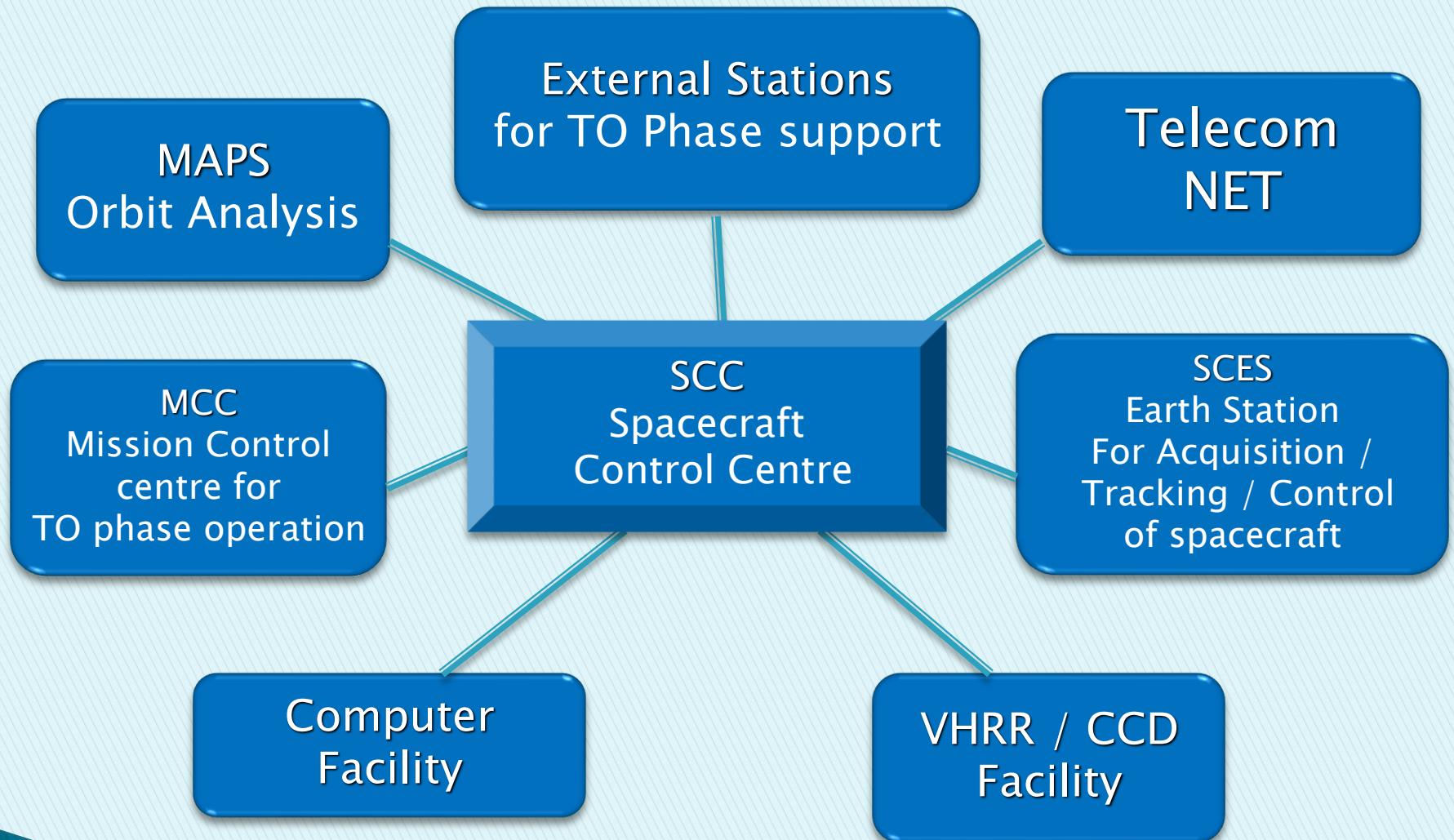
**Onboard  
Software**

# Information Processing – Satellite Mission

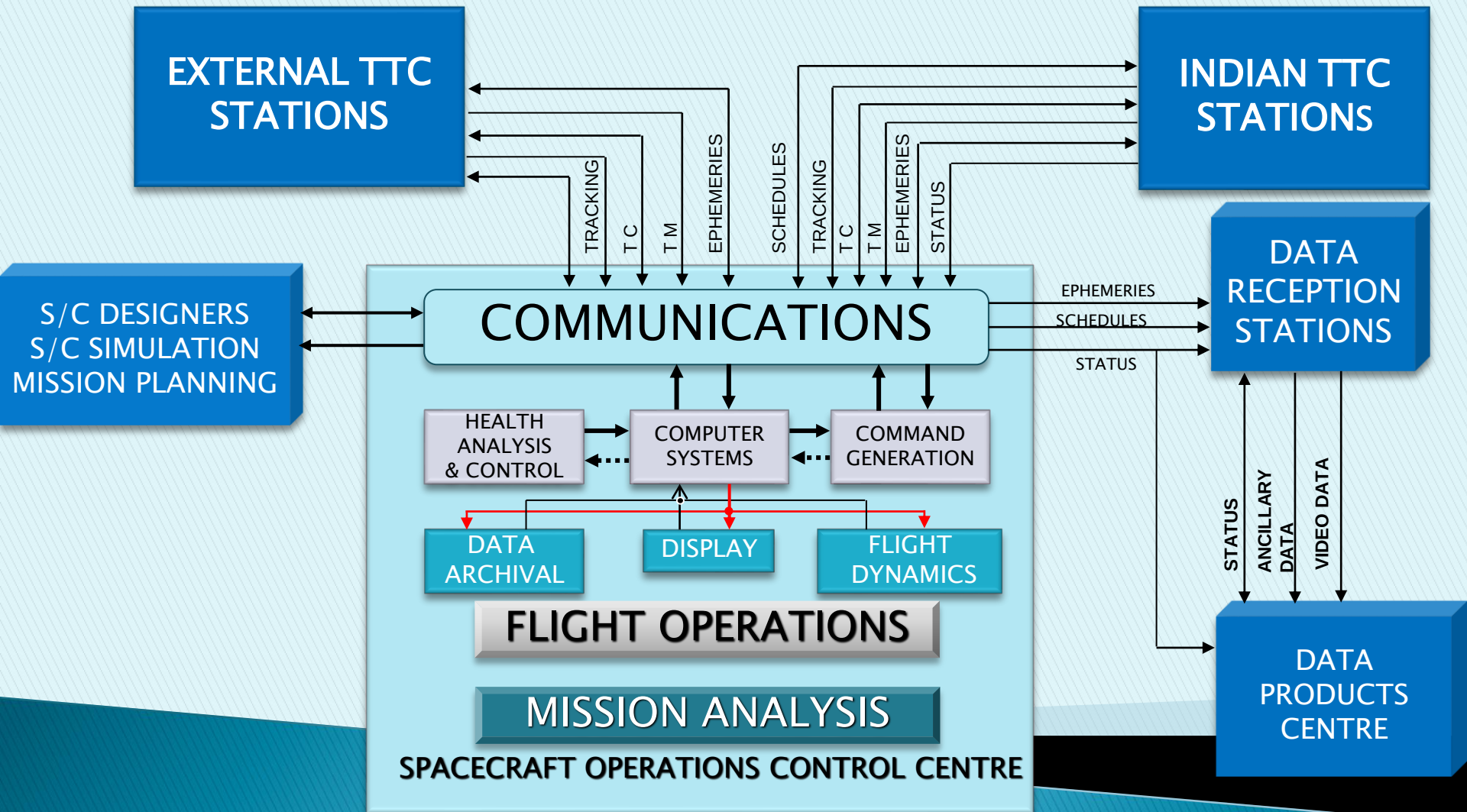




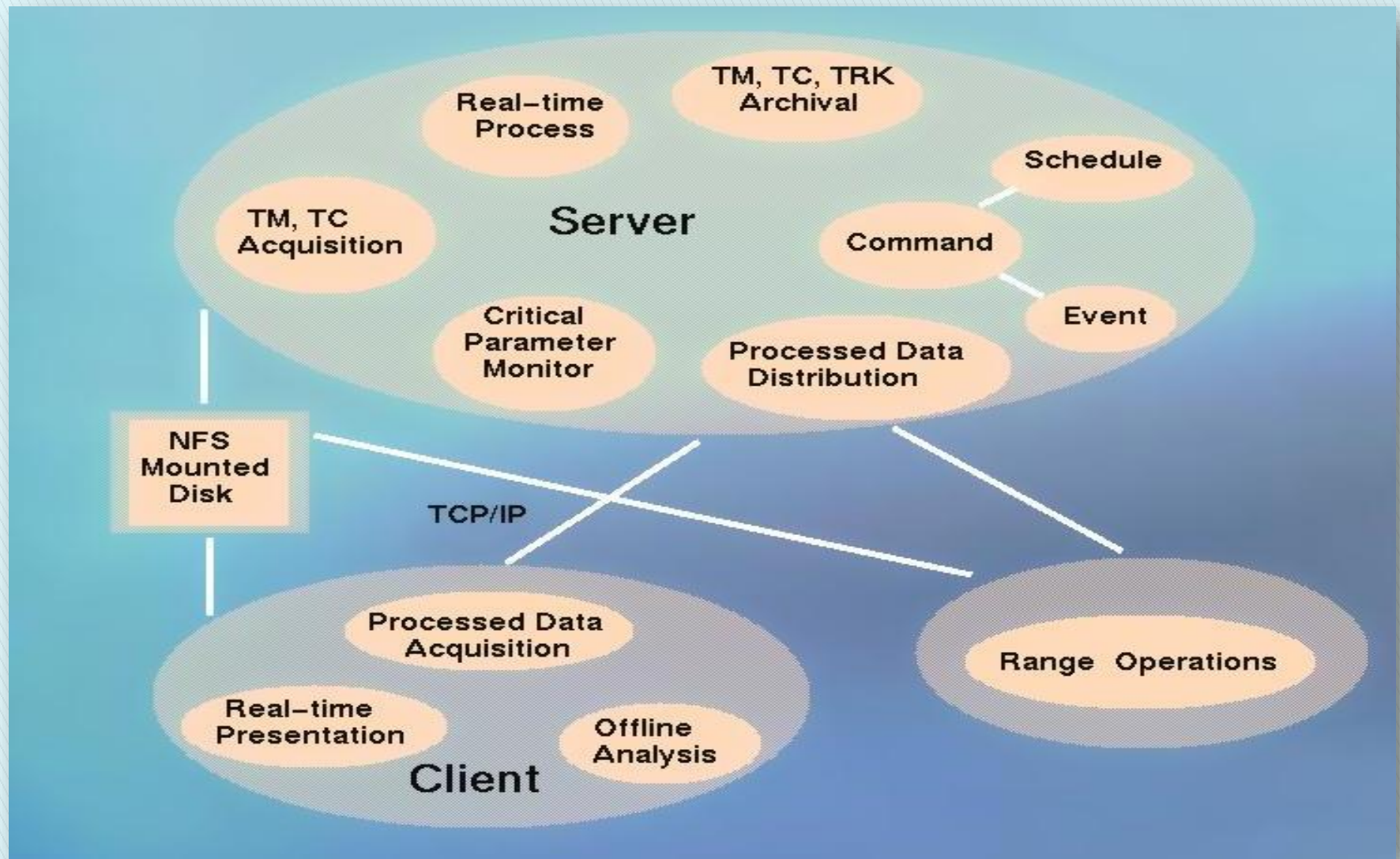
# Ground Segment - a Typical GEO Mission



# Ground Segment - a Typical LEO Mission

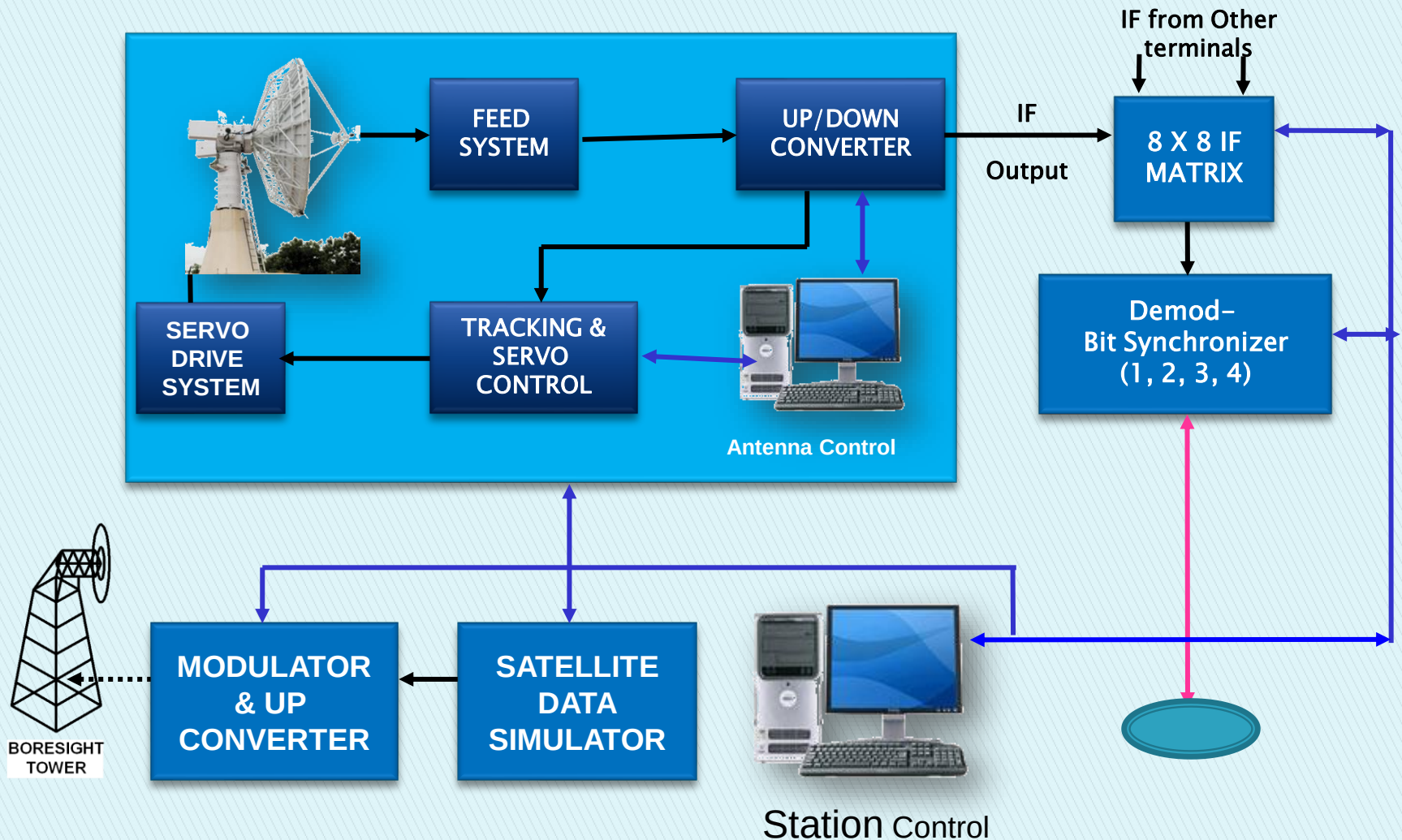


# Typical Satellite Control Centre



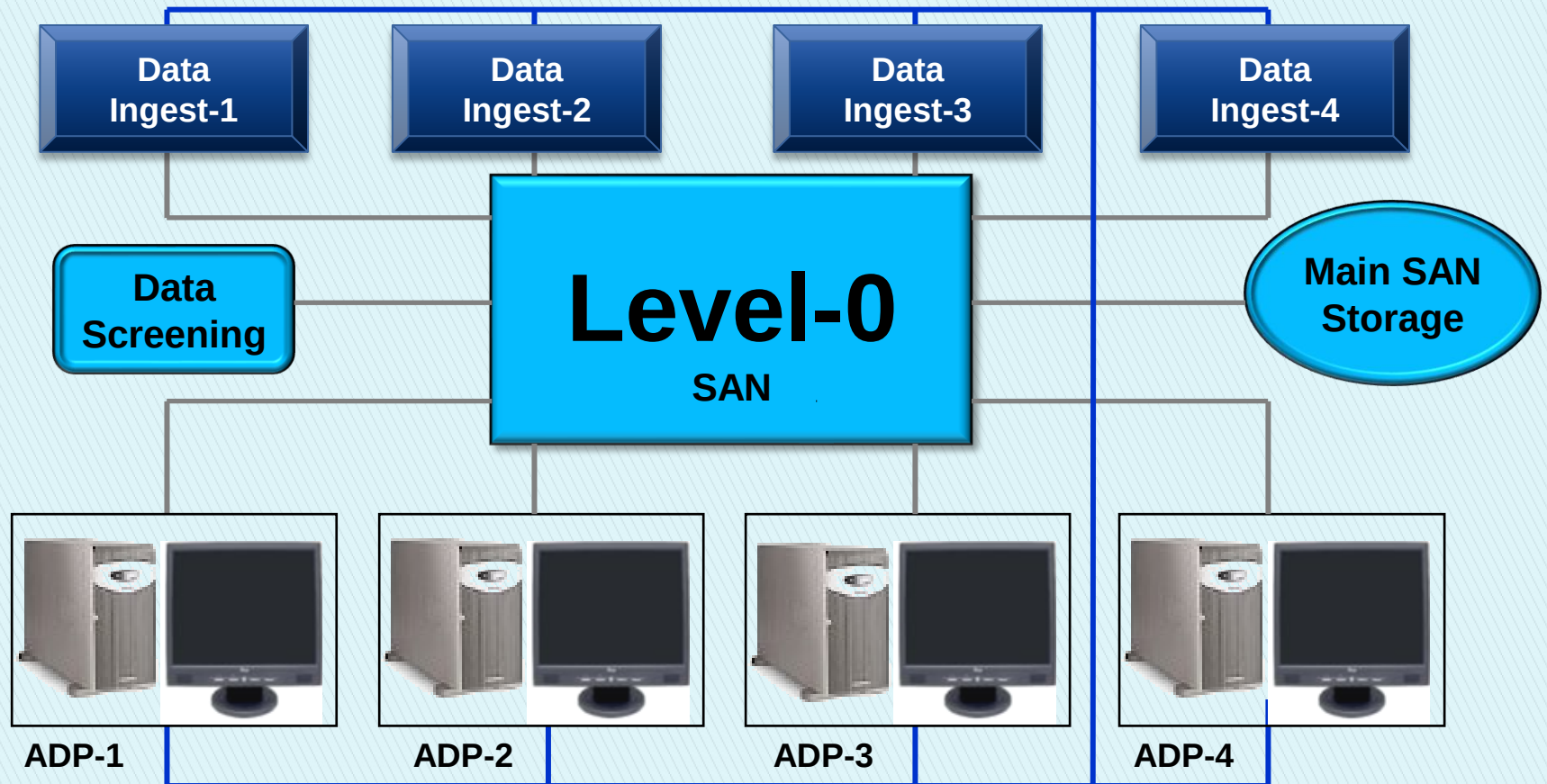


# Typical Payload Data Reception Centre



# Typical Data Processing Centre

GIGABIT ETHERNET



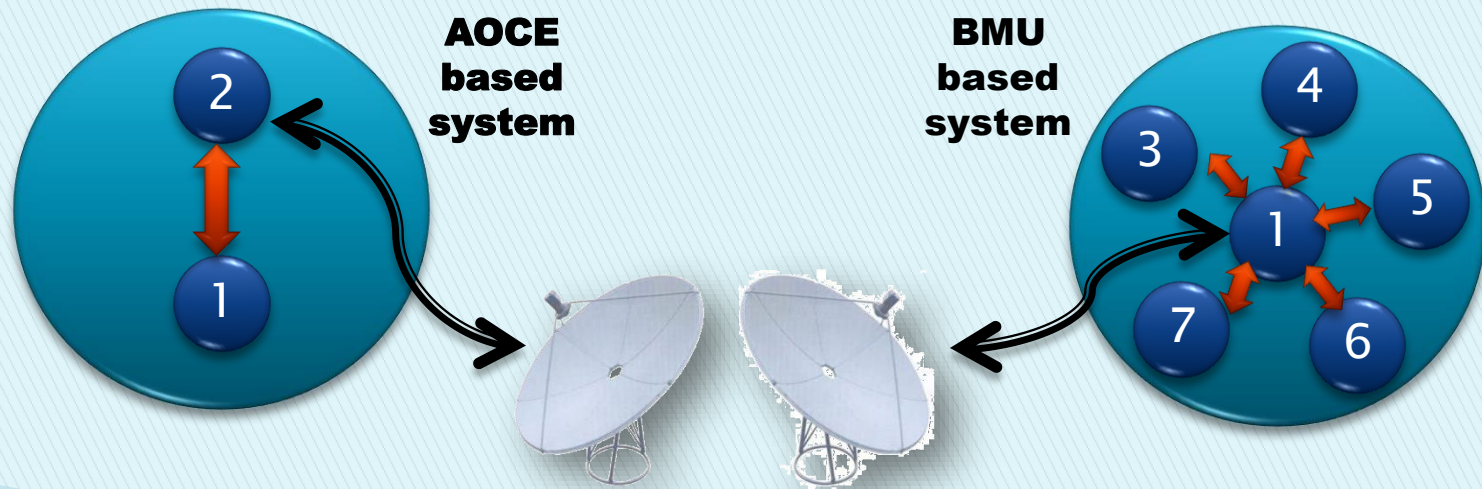
# Mission Software Elements

|                                                                              |                                                                                                 |
|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Spacecraft health Monitoring,<br>Analysis and Control<br>Software (SCHEMACS) | Data acquisition<br>Data processing<br>Data presentation<br>S/c commanding<br>Detailed analysis |
| Flight Dynamics software<br>(FDS)                                            | Orbit , Attitude<br>Maneuver, Planning                                                          |
| Spacecraft simulator                                                         | Simulation, Training                                                                            |
| Mission Planning and<br>Analysis                                             | Plans, Procedures<br>Anomalies                                                                  |
| Spacecraft Data Management                                                   | TM/TC/TRK data, Health<br>parameters, Anomalies,<br>Critical events                             |
| Payload Ancillary Data<br>Processing                                         | Orbit / attitude, Data quality, Health<br>parameters                                            |



# On Board software systems

| Sl no | Subsystem               | Platform           | Language                    |
|-------|-------------------------|--------------------|-----------------------------|
| 1     | Onboard computer        | MA31750            | Ada '83                     |
| 2     | Telecommand system      | 31750/RTX2010/8086 | Ada '83/Forth/8086 assembly |
| 3     | Base band data handling | RTX2010/8051       | Forth/ 8051 assembly        |
| 4     | Solid state recorder    | 8086               | 8086 assembly               |
| 5     | PAA                     | 8086               | 8086 assembly               |
| 6     | DGA                     | RTX2010            | Forth                       |
| 7     | SPS                     | 8051               | 8051 assembly               |



# Autonomy

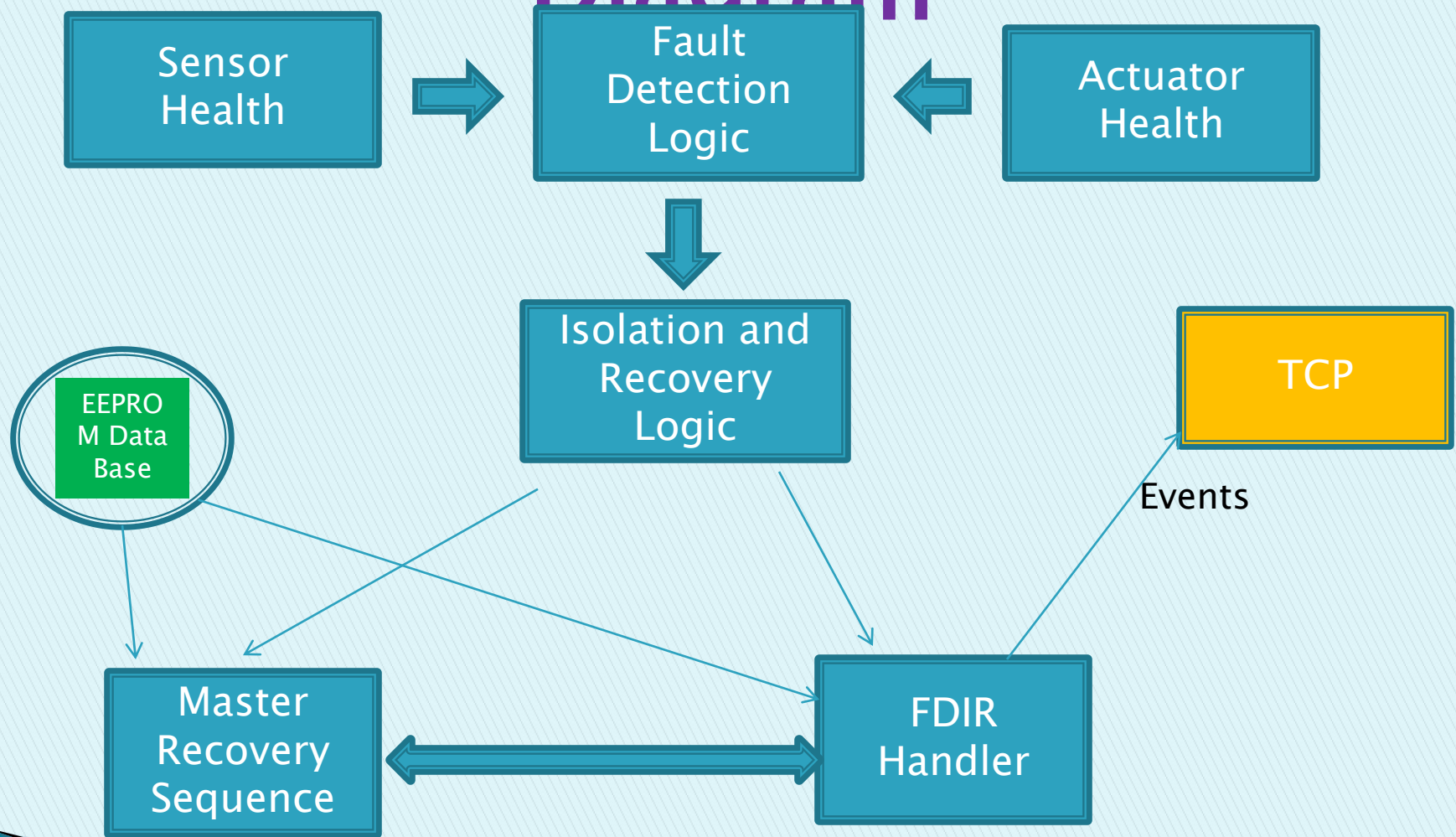
## ❑ Definition

- To Monitor health of AOCS systems continuously & take corrective actions to avoid Attitude loss
- Ensure Power Generation & communication towards earth and survive without ground intervention incase of any AOCS system failure

## ❑ Objective

- Onboard Autonomy is built for Failure Detection, Isolation & Reconfiguration(FDIR) and Master Recovery Sequencer (MRS) so that S/C recovers from failure automatically without ground intervention.
- Use available resources and achieve Earth pointing

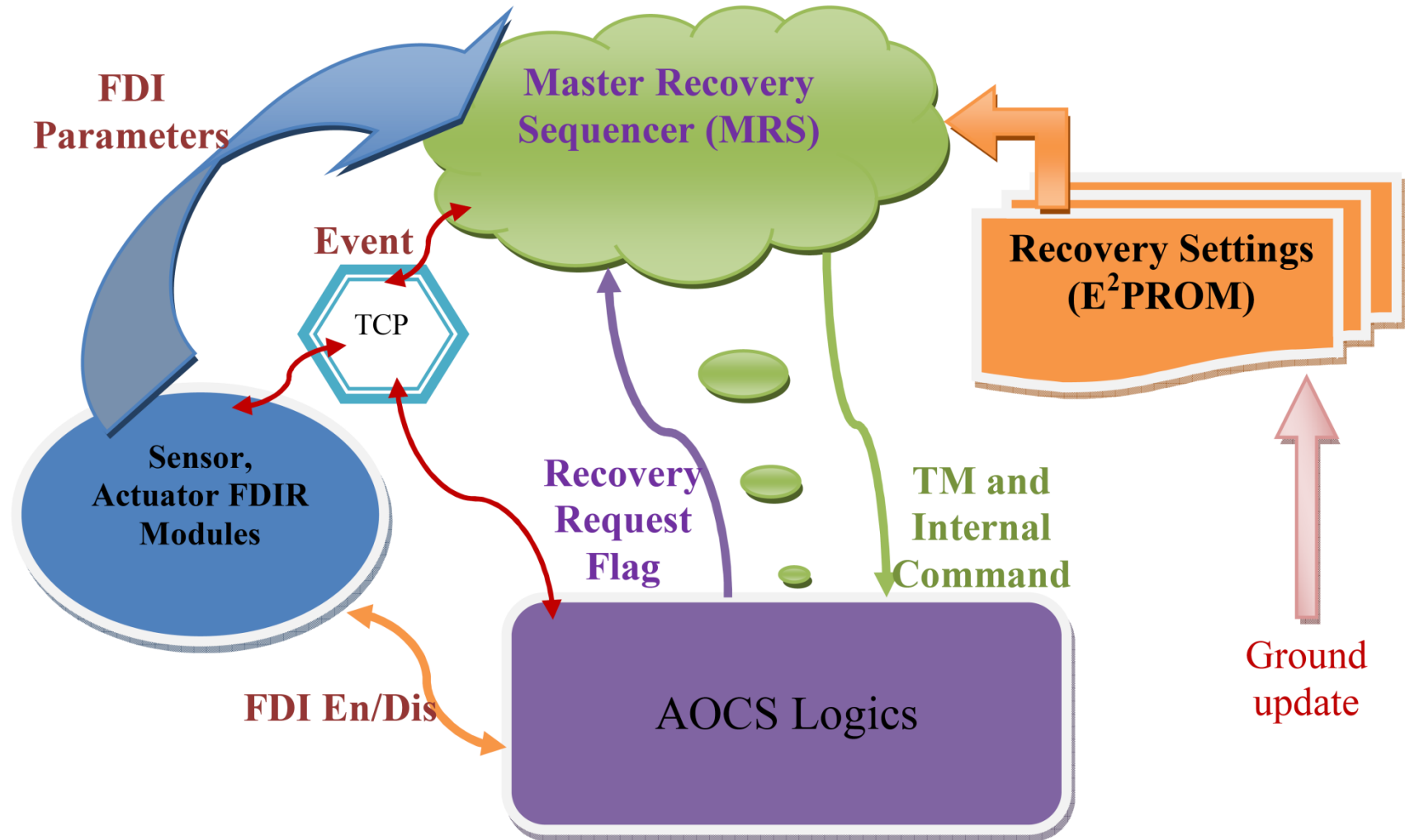
# Autonomy Context Diagram



# Master Recovery Sequencer (MRS)

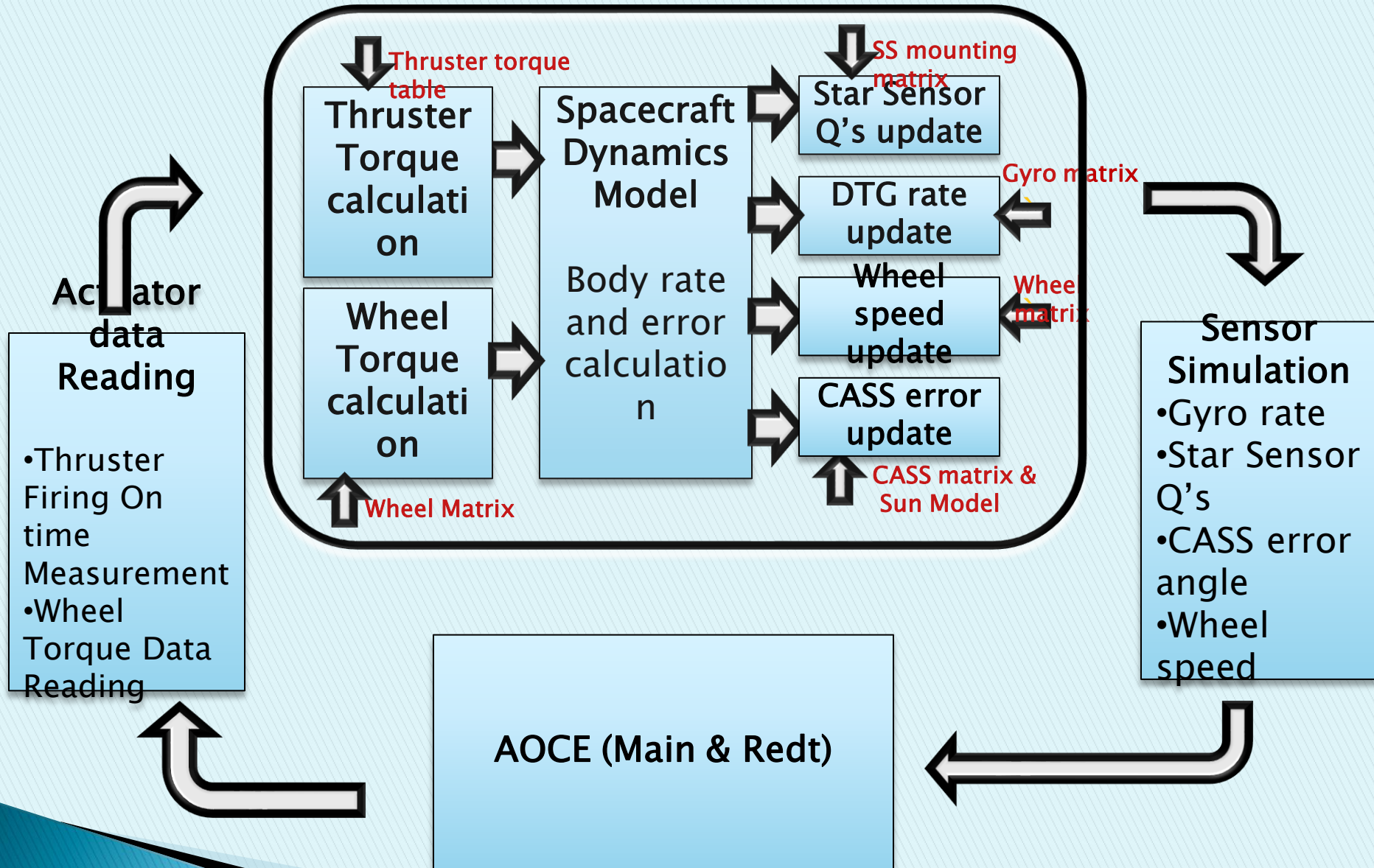


**On-board**

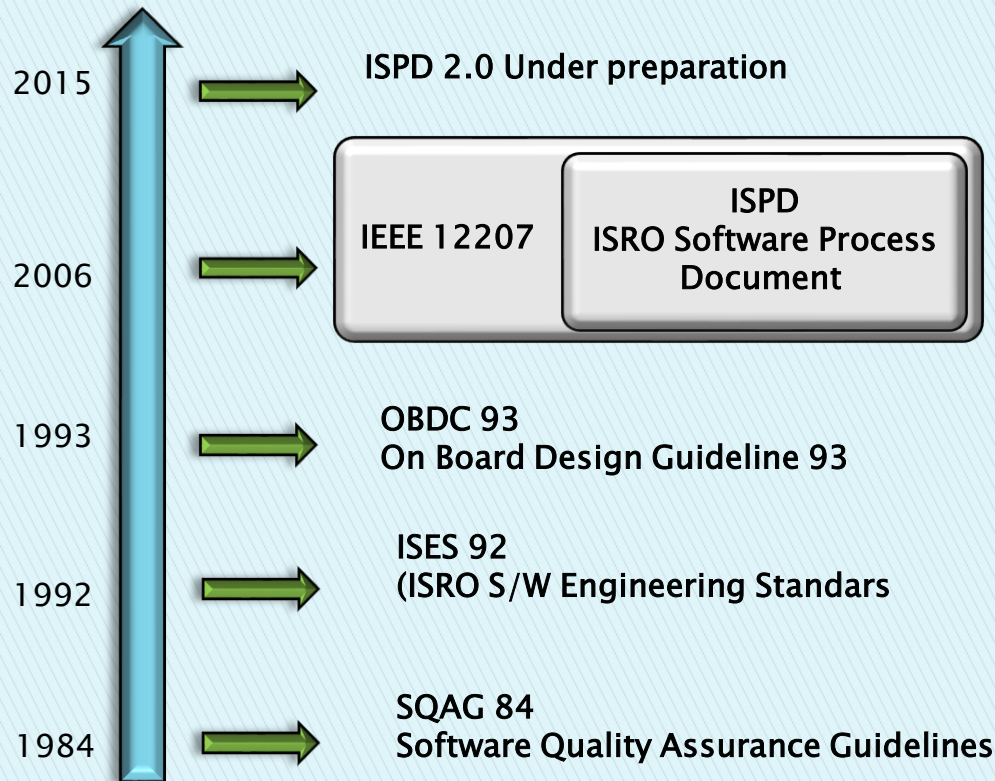




# Onboard In Loop Simulation(OILS)



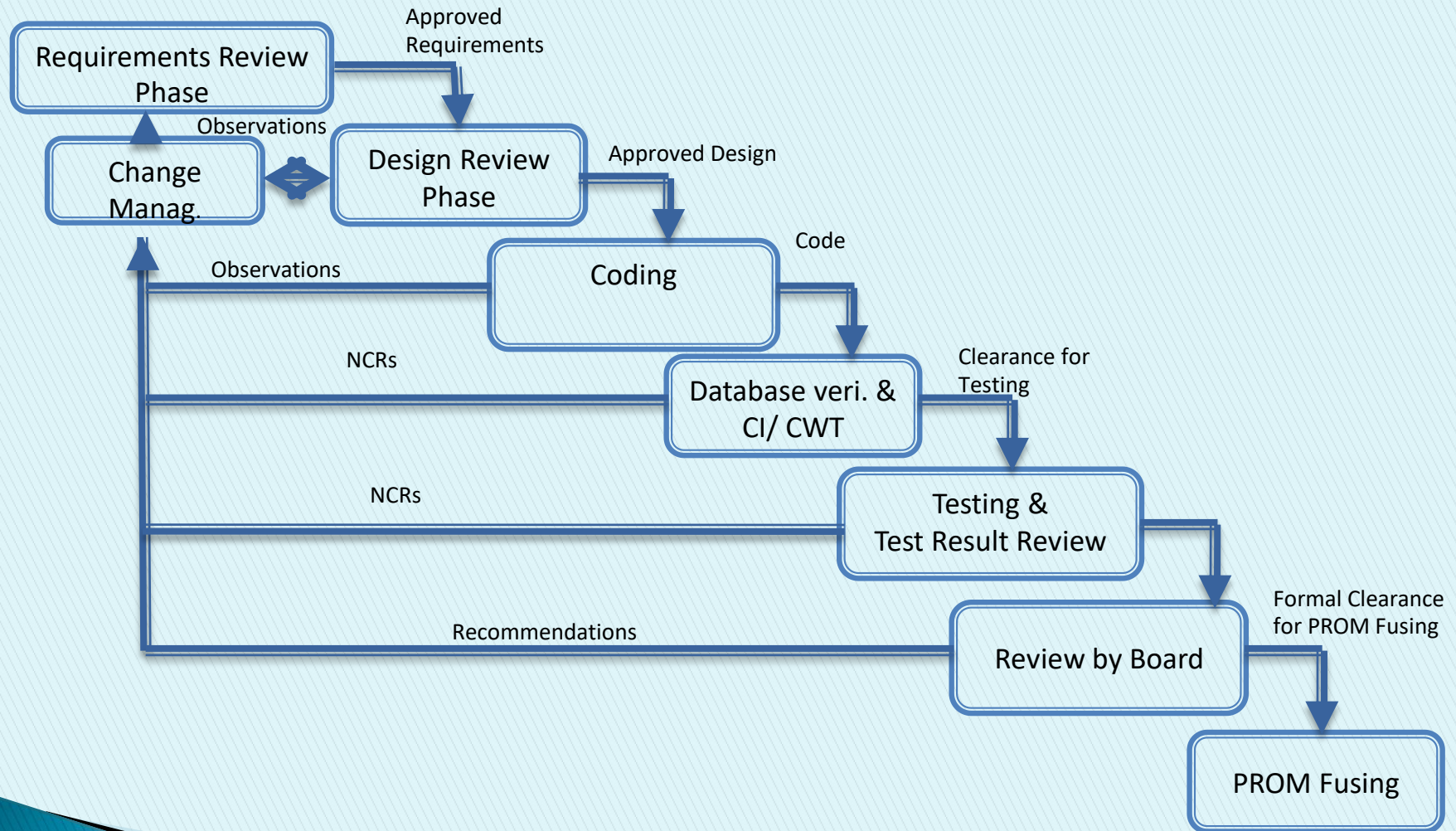
# ISRO Software Standards



# ISRO Software Process Document

- ISPD is an implementation guide of IEEE/EIA:12207 software framework
- It prescribes a set of processes and related plans, procedures, guidelines & templates
- It is applicable to all s/w activities in ISRO
- Software in ISRO is classified into
  - Onboard
  - Checkout and Simulation
  - Launch Support & Test Facilities
  - Information Services
  - Mission
  - Image Processing
  - Scientific

# On-board Software Development Life Cycle





# **Conclusions**

- ▶ **Today, Computer technology, Information processing and Information Technology has become indispensable in all walks of human life.**
- ▶ **It has transformed Space Engineers from being limited to be unlimited.**
- ▶ **Space Engineers tend to find solutions from nothing to everything through either Computer Hardware or Software.**
- ▶ **It has played a significant role in transforming the world from 'Nothing to Everything'. It has conquered time, distance & information access.**

**“Information technology and business are becoming inextricably interwoven. I don't think anybody can talk meaningfully about one without talking about the other.”**

**- Bill Gates**

# Thank you

