Network Centric Operations: The Role of Satellite Communications

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Abstract. Nowadays there are new common challenges and objectives for the Defence and Security communities: new forms of conflicts, new players, new tasks, augmented speed of technological innovation.

The NCO concept requires to implement the so called Network Enabled Capabilities (NEC): this means to better exploit the different assets (already operational or in acquisition) and to make them interoperable to allow an efficient information exchange for the interconnection of every node (People, Weapons, Sensor or C2) wherever located in the world. In this context, the SatCom segment (e.g. the Italian Sicral System), represents a valuable asset and the adequate solution to interconnect in a flexible manner the mentioned nodes.

Today, transparent repeaters, similar to the ones available on Sicrall satellite, are available, with some limitations in terms of network flexibility and traffic handling.

The paper proposes the adoption, in the near future, of the Processed EHF/KA Satellites (e.g. the Fidus Mission Satellite), and as long term solution, the Processed and IP Routing EHF/KA Satellites, to implement flexible network configurations as well as IP routing for maximum resource utilization; indeed the processing of the IP packets on board, as usually performed by IP routers on ground, allows to better support delay sensitive traffic and services.

1 Introduction and Aim

Plotting the future is always a taught duty, also because future is never waiting for you and none has a crystal ball to avoid mistakes.

Nevertheless this is what a General Directorate of Ministry of Defence has to manage, building it up consistently with plans made by NATO and allied nations, taking into account international threats.

In plotting the future, we look around, catching news in technology and seeing what others are doing, in order to identify the target and choose the road. The subject of this paper is the Network Centric Operations and the satellite role.

The evolution represents an historical characteristic, and nowadays the changes have characteristics of a revolution more than an evolution. The actual instability period should continue and could be identified as an "instable transient".

The current scenario represents a major modification of the old logic of the "cold war" with the counter position of two major assets; globalisation is nowadays a key word with a consequent revolution in the context of security concept.

The causes of such revolution are not of military nature, but have to be searched in the events that are changing the world and in their effects:

- The growing development gap between countries, that produces major differences in prospective and expectations.
- The technology proliferation, especially information technology, that leads to a "digital" division between those that have access to digital data and those that do not.
- The globalisation and the general growing information interconnection, that are levelling the world.
- Lastly, the loss of countries sovereign that evolves into two directions:
  - The first, positive, that tries to modify the sovereign characteristics of countries towards new kind of extra-national form of aggregation.
  - The second, negative, that leads to difficulties in governance with frequently dramatic consequences (such as ethnic-social-religious conflicts or terrorism).

These causes tend to form, on one side, an interconnected set (core) of countries (having access to technology) that are active part in the globalisation process and, on the other side, a residual "disconnected" and isolated part (gap), which have more and more the perception of possible opportunities but less and less the possibility to access them.

The first set includes: North America countries, European (founder and new) countries, Russia, China, India and Australia.

The residual part includes: the Balkans and Persian Gulf areas, a part of Asia, Korea, almost the entire Africa (with the exception of South Africa) the Centre-Western part of South America.

It can be noticed that it is just on the border between the core and gap areas that instability and crisis were more evident in the past. They are actually in progress and are most probably to turn up in the future.

This border goes through the European-Asiatic continent, crossing strategic areas of primary importance (due to the presence of energy sources) up to the Pacific Ocean, affecting important sites for the maritime trade (see Fig. 1).

Faced with the causes that determine the revolution of the scenario and the security globalisation, the courage to change drastically the security approach is needed.

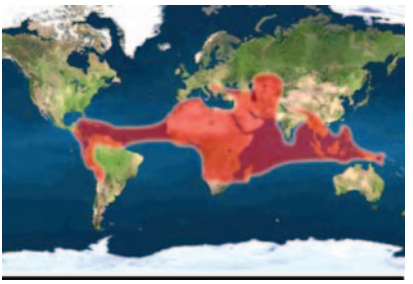

Fig. 1. World instability areas.

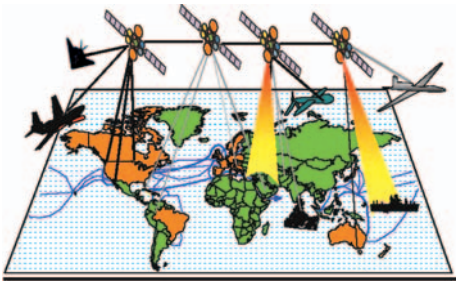

Fig. 2. Synergic utilization of resources, capacity, methodology and instruments, matching the World Instability Areas.

First of all, it has to be understood that the national government holds decreasing power in favour of an increasing support to the international organization for a multilateral approach.

Secondary, taking into account the characteristics of the risks, it has to be noticed that the security concept can be viewed as a continuum, where internal and external security are not separated.

Finally it shall be taken into account that the globalise security concept have to be considered in its more general mean, going over the classic geostrategic one.

The deduction of what has been said is that multilateralism and internal – external continuum, must be the founding elements for a new holistic approach, requiring a synergic development and utilization of capacity, methodology and instruments (see Fig. 2).

2 Requirements and Constraints

Nowadays there are new common challenges and objectives for Defence and Security communities: new forms of conflicts, new players, new tasks, augmented speed of technological innovation. The capability to conduct Network Centric Operations (NCO) is considered the most appropriate solution, to respond to the new challenges of the so called "Information Age" and the asymmetric conflicts.

The Network Centric Operations (NCO) concept requires to implement the so called Network Enabled Capabilities (NEC). In a first phase this means to put together different assets (already operational or in acquisition) and to make them interoperable to allow an efficient information exchange. NCO allows to distribute information only to "need to know" users and to delegate some decision to the very last and remote organizational entity (fighting users).

These assets are usually classified in three different segments: Finders (sensors), Deciders and Effectors, so making a 3D system (Detect-Decide-Destroy).

The **Finders** shall provide Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) information to the Deciders increasing the "situational awareness".

The **Deciders** at all levels shall be connected with the **Effectors** by mean of integrated Command and Control chain in order to speed up the sensor to operator cycle (3D Cycle) and to increase the mission effectiveness.

The space assets contribute to all these three segments and provide a very flexible service.

Furthermore in a secure framework environments three main requirements have to be highlighted:

- First of all the **bandwidth**, whose wideness cannot be chosen; it is simply required as much bandwidth as technology makes available, and without any differences among the needs of strategically, deployable or tactical network nor among physical layers. That means same bandwidth on fiber optics as well on satellite channels.
- The second requirement is the **IPv6 convergence**, as it seems to fit the multi-services scenarios, allowing effective use of unique interface for all users, to serve people and computers, communicating data and applications in national or multi-national operational environments. That means the development of new software, more collaborative applications and enabling the diffusion of Voice over IP, safe-guarding the quality of service in the meanwhile keeping on using the existing equipments and networks.
- Last but not least, there is a need for **node switching** which must be able to adapt channel to information, which means they should be aware of the semantic of data. As consequence an effective and shared tag information system has to be settled.

That is enough to understand what we are looking for: a really new kind of equipments, networks and systems, in which it will be impossible to distinguish between computing and communicating: even the crypto functions will be implemented in the same hardware and utilizing the same software which will replace the nowadays assets.

This kind of new assets (which will be the structure of the new world of information called "info-structure") will update what we use today and force us to revise the systems already in service in order to define the new programs.

The implementation approach for a NATO Network Enabling Capability (NNEC) is to build a Networking and Information Infrastructure as a "Federation of Systems" (FoS) in services in different nations. In this way it is not required a heavy NATO infrastructure. Assets from different countries will contribute for NII (Networking and Information Infrastructure) remaining under autonomous control of each nation. Of course this idea relays on trusted security and strong interoperability. In this context the IP protocol results to be the most suitable to interconnect heterogeneous networks and to support different services (telephony, multimedia services) by means of various physical layers.

3 Evolution, Not Revolution

The replacement of existing network is really a serious matter, since we don't have yet the new equipments we need, whereas operation are every day performed and no interruption is allowed.

Can you imagine how huge is to reengineer the set of sensors, decisors and actuators that must be in such an infrastructure?

How must they be changed? And what happens when we change one but not the others? Even more which should change first? And what about the improvement we look for?

And of course, there is a financial aspect that is not the least to be mentioned among the constraints.

To find out the correct answer for transforming while operating, Italy decided to have a national study done by Finmeccanica and to participate in conducting two international feasibility studies, one in NATO and the other in EU context.

4 The Italian Milsatcom Programme

As regards the Italian MILSATCOM Programme, in the following it will be described the architecture and some technical solutions implemented in the SICRAL Project and the standards that have been adopted in order to grant interoperability with Allied and Partner Nations.

4.1 "The Present": The SICRAL 1 Project – Operational Effectiveness

The need for a military satellite communication system arose, in Italy, around the end of the '80s. In a global scenario that rapidly evolved towards the radical changes that were characteristic to the end of the past century, the requirement for the capability to have real time access to the information became more and more pressing.

In the above scenario, the need for an adequate C3 instrument was self-evident. It had to be able to provide high levels of mobility, flexibility and deployability, and, at the same time, to be robust, jam-resistant, reliable and performing.

Considering that the national industry was already in possession of the adequate know-how and experience, it was considered that the time was ripe to provide the Italian Armed Forces with such a capability. As a result, the SICRAL 1 satellite was launched in 2001 and is now a reality (see Fig. 3).

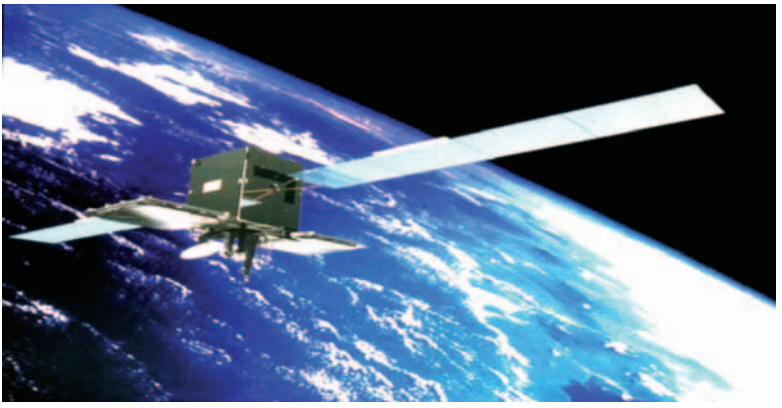

Fig. 3. SICRAL 1 satellite.

According to the military requirements, the primary mission of SICRAL is to provide communications for national Forces, both in real world operations and in exercises, in particular when forces are deployed abroad. That function can also be extended to allied or coalition forces involved in the same activities or for their national use.

In addition, it can provide communications in case of "Disaster Relief", when Armed Forces are called to intervene in areas where usual communication media are jeopardized by natural phenomena, such as an earthquake or a flood.

As a secondary mission, the system can integrate the infrastructural communication networks, enhancing their capacity and providing a gap filler capability in case of failure of the fixed networks.

The architecture was therefore designed as follows:

- A space segment, based on a spacecraft with a payload operating in UHF, SHF and EHF bands, fitted with anti-jamming Satellite Control systems;
- A ground segment based on:
  - Main Satellite Control Centre, protected against direct threats (Physical, electronic and nuclear) and configured to be easily improved, in order to perform multi-satellite control functions;
  - Network Management Centre, performing the configuration of satellite services, acting, at the same time, as entry point to terrestrial networks;
  - Back-up Satellite Control Centre;
  - User terminals: fixed, transportable and mobile;
  - An integrated logistic support component is completing the architecture.

The areas covered by the satellite change according to the band in use. UHF covers the totality of the visible hemisphere, which means from the east coast of the US and Brazil to the west coast of India, considering that the satellite's position is 16°2 longitude East.

SHF fixed coverage is directed to the main areas of interest, such as Europe, the Mediterranean and the Middle East, including the Red Sea and the Persian Gulf. A mobile SHF spot, which can be directed wherever required in the visible hemisphere, completes satellite fittings.

EHF coverage is limited to homeland and its proximities.

Ground terminals are, basically, of three different types: Fixed, Transportable and Mobile.

Transportable terminals are composed by two shelters (one is for power supply) and an antenna trailer. They can also be transported on aircraft and will operate in EHF and SHF bands.

Mobile terminals are smaller in size and in performance. However, some installations, such as SHF ship borne, can provide the same throughput of transportable terminals.

Such kind of equipments is installed on board ships (SHF and UHF), aircrafts and vehicles (UHF).

In addition, the flexibility of the system is provided by man-pack terminals, operating in SHF and in UHF.

The system was designed in compliance with international and military standards, as well as with NATO STANAGs.

4.2 "The Near Future": "SICRAL 1 B" & NATO SATCOM Post 2000

Italy is participating in the NATO SATCOM Post 2000 project, managed by the NATO C3 Agency acting as Host Nation on behalf of the Alliance, for which a national contribution has been integrated in a Consortium together with France and U.K., furnishing the required Capability in UHF and SHF through the provision of Allocated Capacity from their SICRAL, SYRACUSE and SKYNET satellites.

For such reason a new communication satellite called SICRAL 1B, to be launched in the year 2007, has been conceived. SICRAL 1B is also a bridge between SICRAL 1 and SICRAL 2, the satellite that will replace the SICRAL 1, which is expected to expire by 2011, at the end of its operational life. For the development of the 2nd SICRAL constellation satellite, SICRAL 1B, some consideration has been taken into account, such as the need to exploit the investments already made within SICRAL 1 project and the adoption of advanced technologies for flexible resource management.

The Italian Defence intends to develop a self–sustained, from the financial point of view, military SATCOM programme. The SICRAL 1 has some exceeding resources that are currently made available to foreign Forces involved in multi-national or allied operations and to allied Forces for their national use, producing some incomes.

With SICRAL 1B, it will be possible to greatly increase the income, satisfying the communication services required by NATO, in order to finance future development programmes, as SICRAL 2.

Moreover, the new satellite SICRAL 1B, will take advantage of an existing space-craft adapted to the new technical requirements, of the existing Italian Control and Management Centres (Master and Back-up) and of the existing management organ-ization and infrastructures.

The equipment has to comply with NATO STANAGs and requirements. For such purpose, anti-jamming and physical protection have to be taken into consideration in accordance with NATO requirements.

With Sicral1B therefore advantages and economics will be brought either to the National and to the NATO programmes.

The main technical characteristics of Sicral1B are the following:

- High number of possible connections;
- Interoperability with Allied users;
- Security of Satellite Control system;
- Security of communications and transmission.

The satellite is controlled by a fully redundant control system with 2 separate Control Centres. The TT&C *(Tracking, Telemetry and Control)* function is designed to operate in EHF during the nominal lifetime operations and in S-band during the launch, the LEOP *(Launch and Early Orbit Phase)* and the contingency lifetime periods. The Command function is encrypted.

The orbital position is scheduled at 11.8 degrees East.

4.3 "The Future": SICRAL 2

The effectiveness of SICRAL 1 demonstrated that SATCOM is an absolutely essential strategic asset.

However, even if outsourcing options might appear more cost-effective, it should be acknowledged that military requirements call for peculiar systems, which should be able to provide a high level of flexibility, which is currently not available on the market.

Two simple considerations may provide a better clarification of the concept:

- Communications for highly mobile users, such as ships, aircraft and small patrol units, can be provided only in UHF. However, UHF assets are not available on commercial markets, although they can be provided on military satellites;
- Communications between ships in Enduring Freedom Operation and Italy have been provided with a 1 Mbps trunk for ITS Garibaldi and with a dedicated 128 Kbps INMARSAT connection for the rest of the naval forces. The latter was obtained within one month from the request and turned out to be particularly expensive.

It is therefore necessary that the Armed Forces maintain or, better, increase their SATCOM capability, in order to ensure the coherent development of military capabilities.

It should also be mentioned that communication capabilities such as only a SATCOM system can provide, are a powerful force multiplier, not only because they allow the effective conduct of operations, but also, and more importantly, because they allow a better control of the crisis, thus representing a vital factor for the safety of forces deployed in the theatre. Taking into account the time necessary to design, develop and procure a new system, Italy has already started a feasibility study for the continuation of the programme, in order to launch a follow-on satellite, named SICRAL 2, not later than 2011.

With regard to EHF, the processed EHF is foreseen in the context of near term satellite missions (Athena/Fidus mission), as later on discussed.

5 The Italian Satellite Core Infrastructure

As already mentioned, the Network Centric Operations (NCO) concept requires to implement the Network Enabled Capabilities. The existing assets have to operate together for a well-organized information exchange and have to be configured to work efficiently with future resources.

The space assets is an important and unique assets to enable mobile communications in remote areas, as well as for providing imagery, navigation, precise position and weather information. The present and the future high performance capabilities of the satellite segment naturally brings to the integration in an overall NEC architecture.

There is one point that is never stressed enough: nowadays homeland defence and international security cannot be separated and must be guaranteed making full use

of all the available resources, both military and civilian. In this context the dual use characteristic of the assests becomes even more important.

Italy is fully committed in developing and exploiting space assets for Command and Control Intelligence, Surveillance, Target Acquisition and Reconnaissance (C4 ISTAR)

In this scenario the core of the Italian Satellite Infrastructure is useful to give an overview of both the already existent facilities and the planned developments for the near future of ground and space segment.

Regarding the ground segment the Italian Infrastructure is composed of "Communication Control Centre" and "Satellite Control System" placed in Vigna di Valle and a secondary "Satellite Control System" placed in Fucino.

Both the Communication Control Centre and the Satellite Control System exchange information with the NMAC (NATO Mission Access Centre) to monitor satellite resources assigned by every nation to the NATO mission.

Also shown are the Italian military terrestrial networks connected to the Satellite Communication Control Centre.

Regarding the space segment the present constellation is composed by Sicral 1 satellite. Skyplex and Leased Bentpipe transponders, on the other hand, have the functionality of backup/gapfillers.

The evolution of the present constellation foresees the introduction of:

- Sicral 1B satellite, planned to be launched in 2007
- Sicral 2 satellite, planned to be launched in 2011
- Athena/Fidus planned to be launched in 2011, supporting processing on board with DVB-RCS standard in EHF/Ka band.

6 Network Actually Connected to CGC SICRAL

Military terrestrial networks already connected to the SICRAL Control Centre (CGC) are listed below:

- RIFOR (Roma Area Joint-Forces Optical Network): with overall Data Rate of 620 Mbps
- RIFON (National Joint-Forces Optical Network)
- RNI (Joint-Forces Digital Network) based on:
  - A Radio Bridge National Backbone
  - Several Joint-Forces Local Networks connected to RNI
- DIFENET (Internet Defence)
- SOTRIN (Integrated Transmissions Subsystem)
- ROID (Integrated Operating Network for Defence)
  - Switched voice/data network
- RINAM (National Integrated Network, Air Force)

Sicral 1 Control Centre represents an interconnection node between satellite and the military terrestrial networks listed above. Moreover by means of a secure IP network connected to the Centre it is possible to manage satellite resources assigned to NATO from different sites in Europe.

7 C4I Systems Interconnected Via SatCom, to Support the NEC

A list of Command and Control Systems that would be a useful upgrading in NEC context, for the following C4I assets. For each asset the benefits of the integration with Sicral SatCom links is reported:

- **SIACCON** (Automatic Control and Command System for the Italian Army)
  - SatCom needs: could be useful to support the SiCCAM system interaction
- **SICCONA** (**National** Command and Control System)
  - SatCom needs: it shall integrate all military units and systems in various operative scenarios
- **ACCS** (Air Command and Control System)
  - Integrated Command and Control System for Air Forces
  - SatCom needs: it will interact with SICCAM, National/NATO systems (also Army and Air Force)
- **C4I Difesa** (High Command and Control System)
  - SatCom needs: requested meshed wide band links to C2I main systems
- **SiCCAM** (Air Force Command and Control System)
  - C2I System for avionic operations (on development phase)
  - It will include previously existent systems and it will interact with NATO ACCS (Air Command and Control System), ACE ACCIS (Allied Command Europe Automated Command and Control Information System) and other C2I national system.
  - SatCom needs: It could interact with SIACCON and National/NATO C2I systems
- **C2M** (Air Force Command and Control Mobile System)
  - Command and Control Mobile System of Italian Air Force operative since 1998 and now on optimization phase: further elements will be included such as MATRA and DCE
  - SatCom needs: it could be used to advantage Sicral mobile transportable SHF/UHF stations, particularly on theatre application
- **MIDS-**LVT (Multifunctional Information Distribution System-Low Volume Terminal)
  - Integrated system for tactical, identification and navigation information distribution, applicable with small dimension terminals according to STANAG 4175
  - SatCom needs: It could be integrated to Sicral Satellite System

8 Platforms Interconnected Via SatCom, to Support the NEC

In the following, the platforms that can be interconnected via SatCom to support the NEC are listed, for each one the benefits of the integration with Sicral SatCom links is reported:

- TETRA e TETRA-TAC TETRA-CAMPALE
  - short-range communication platforms
  - SatCom needs: Necessary an Access Point to Sicral System

- UAV PREDATOR, MIRACH 26, FALCO e NIBBIO
  - Unmanned Airbone Vehicle platforms for surveillance/reconnaissance operations
  - SatCom needs: high capacity satellite link
- EF2000
  - Combat aircraft
  - SatCom needs: Possible use of Sicral UHF terminal
- FUTURE SOLDIER
  - R&S program for the development of ITC future soldier equipments
  - Necessary an integration to C2I Network (SICCONA e SIACCON)
  - SatCom needs: Necessary wireless Access Point via SatCom (Man-pack UHF/EHF)
- NEW NAVAL UNITS
  - SatCom needs: new EHF/SHF/UHF terminals
- BMD (TBMD, NATO-BMD, ALT-BMD, THAAD)
  - Ballistic Missile Defense:
  - SatCom needs: meshed wide band links (with on board processing)

9 SatCom Requirements in the NEC Context

NEC allows to facilitate the interconnection of every nodes (People, Weapons, Sensor or C2) positioned in continental areas. In this context the SaTCom segment should represent an adequate solution to interconnect several nodes in the same network.

To reach this goal, it is possible to use three satellite payload solutions:

- Bentpipe (Transparent) Repeater
- Processing Repeater
- Processing and IP Routing Repeater

Nevertheless, today it is possible to use only Bentpipe Repeater, by means SICRAL 1 payload, that is characterized by fast connectivity to deployed forces in star topology. This system presents some limitations in term of network flexibility (point to point connection) and traffic priority handling.

10 Evolution Toward SatCom Processed Systems

As discussed above at present satellite communication mainly rely on transparent configurations, but the prospective and the service requirements for the near future scenario lead toward "processed" systems. In particular a Near Future Scenario (year 2011) is represented by the Processed EHF/Ka Satellite FIDUS, characterized by:

- Flexible network configuration by means point to point and meshed two ways connectivity for all network terminals
- Optimized satellite capacity management
- Small terminals with reduced power
- Optimal use of the satellite transmission power

A Long Term Scenario (year 2014) is represented by Processed and IP Routing EHF/Ka Satellite (SICRAL 3), that will have the same features of a "Processed EHF/Ka Satellite" and in addition:

- On Board IP Routing for maximum resource utilization, using the IP Protocol, as usually implemented in Internet
- Priority Policy for Delay Sensitive Services.

11 Implementation of NEC Requirements

NEC implementation requires that every node can exchange data with other nodes. Obviously with Transparent Satellite (Present Scenario) there are many limitations such as:

- Mainly Star network configuration (Hub centric) supported
- Meshed connectivity possible only by means of double hop between nodes
- No support of alternative IP routes, as regards the routing path.

On the other hand, "Processed and IP Routing Satellite" will provide several benefits; the major ones are: Possible use of both Star and Mesh (Figs. 4–5) communication network configuration

- Meshed connectivity by means of single hop between nodes; the meshed solution is the one that maximize the connectivity between nodes giving the opportunity to

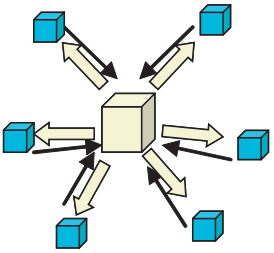

Fig. 4. Star topology.

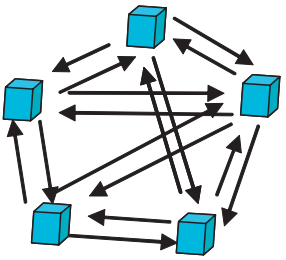

Fig. 5. Meshed topology.

every node to exchange data towards all other nodes, Network Operation Centre or Headquarter.
- On board IP routing, allowing more alternative IP routes (composed of terrestrial and satellite paths)
- The regenerative approach allows also an optimal use of the satellite transmitting power, avoiding noise, jammers, interference, intermodulation retransmission and signal unbalances.

Figure 6 shows a meshed network via processing and IP Routing satellite.

Other significant difference, between Transparent and Processed/IP Routing Satellites, consists in the dynamic bandwidth allocation, that allows different Information exchange profiles for every mission phase and for every node. Requirements concerning the information exchange are reported below:

- high capacity links (several Mbps)
- high level of asymmetry allowed (forward versus return link)
- end users easily upgradeable as Content Sources (bandwidth availability)

Using "Not Processed Satellite" there are the following limitations:

- Difficult Channel Bandwidth Adaptation (without IP priority processing)
- Long times for channel bandwidth adaptation (several double hop time intervals due to star communication)

"Processed and IP Routing Satellite" will carries several benefits in terms of Channel Bandwidth Adaptation:

- Dynamic Channel Bandwidth Allocation based on the IP priority scheme
- Improved Reactivity Time (about 300 ms. to modify the used bandwidth).

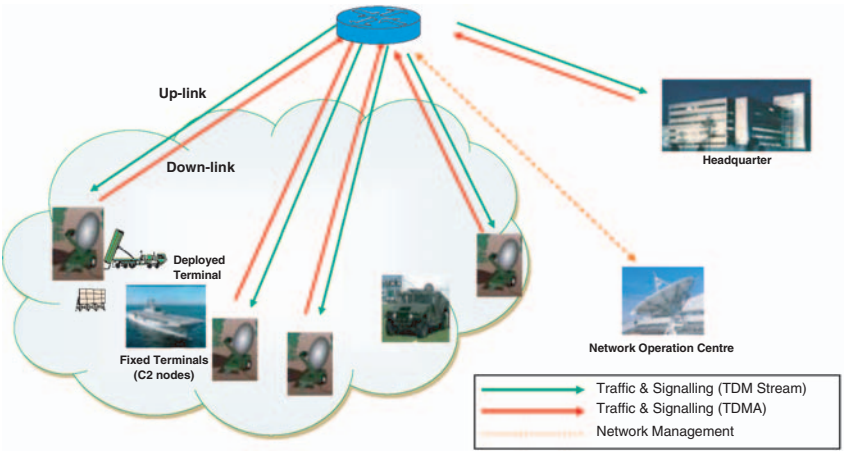

Fig. 6. Meshed network via processing and IP routing satellite.

Link robustness is an other important requirement for NEC. It is characterised by:

- Anti-jamming features, implemented by means of Spread Spectrum Modulations
- Backup bearers given by multiple routing paths
- Quality of Service (in terms of Delay), implemented with differentiated traffic handling (priority policy)

Using "Not Processed Satellite" there are the following limitations in terms of link robustness:

- Anti jamming capability reduction, caused to the absence of on board dispreading
- Low efficiency of capacity utilisation adopting multiple-routing paths
- Efficiency reduction for delay sensitive applications, due to the relevant round trip time delay (several double-hop time intervals needed in the star topology)

On the contrary, "Processed and IP Routing Satellite" guarantees link robustness as:

- High anti-jamming performance is obtained by means of On Board Spread Spectrum Dispreading
- Unwanted and jamming signals are blocked before transmission on the down link
- IP Routing in the sky is implemented, supporting more alternative IP routes (composed of terrestrial and satellite paths)
- Single hop round trip time ameliorates the TCP/IP performance and Quality of Service.

The service area for NEC should be related to a word wide coverage. In order to guarantee such a coverage, with the link dimensioning constraints (adopting very small aperture terminals), a multi Beam Antenna on board the satellite is needed.

In this case, adopting "Not Processed Satellite" there are limitations in terms of Beam to Beam connectivity, as the fixed frequency association scheme, between up and down link of different beams, is too rigid for NEC context. "Processed and IP Routing Satellite" instead will carry several benefits such as:

- Inter beam connectivity managed at IP Packet Routing level
- Inter beam connectivity implemented with single hop (minimum time delay).

12 On Board Processing and IP Traffic Routing

The IP-over-Satcom network target is to cope with the growing request for new Network Centric Infrastructures providing packet and circuit switched connections with flexible resource allocation on request by user. This process requires an on board routing, which *performs on the Satellite the same functionality, usually implemented within an Internet Terrestrial Router*:

- IP routing of the up linked IP packets toward downlink destination address (Address Field in Fig. 7)

- Priority policy to privilege Delay-Sensitive Traffic, for immediate transmission on the downlink (Priority Field in Fig. 7)

Figure 8 shows the conceptual scheme of the On board Processing with IP Traffic Routing with priority policy.

In the picture the service areas transmitting packets toward the satellite with three priority levels (High, Medium and Low) are shown, with three channel addresses (Ch1, Ch2 and Ch3). The on board processor manages each received IP packet and forwards it to the channel indicated in the IP header address field. Each IP Packet is stored in a Buffering Stage and Queue matched to its own level of priority. Finally, the priority server controls the output packets sequence, according to a delay sensitive traffic policy, privileging the high priority packets.

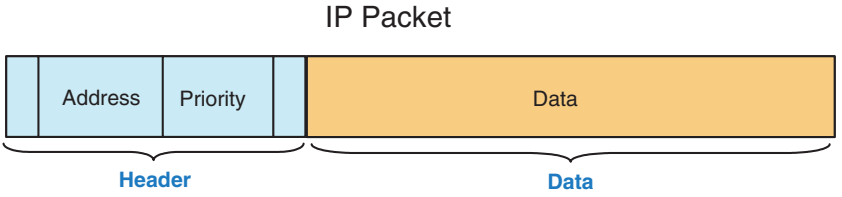

Fig. 7. IP packet.

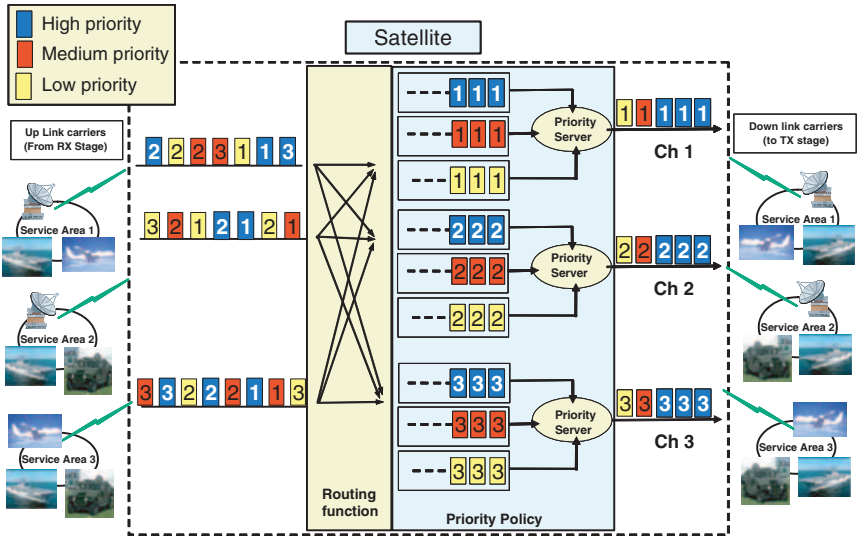

Fig. 8. On board processing and IP traffic routing.

13 Conclusions

The implementation of the Network Enabled Capabilities represents a challenge and an opportunity for technological innovation.

The aim is to make full use of the assets already in inventory following the "Transforming while operating" concept and, in this frame, the Italian SatCom Infrastructure, has been conceived to cope with such an evolving scenario.

NCO/NEC concept system leads to special communications requirements in terms of interconnectivity, flexibility, robustness, dynamic bandwidth assignment and coverage.

In particular the interoperability and interconnection issues, which represent the main obstacles in the path to a fully integrated Defence System, can be solved thanks to the IP based common protocol transport layer. Processing and IP Routing SatCom represents indeed the ideal solution to deploy NEC, although it requires to proceed with standardization agreements (at NATO level) and with a technology program for the relevant development activities.