A Cost Efficient Space Communication Architecture for Multiparty Enterprise Age of Space Exploration

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Outline

- **Introduction**
- **A Multi-party Enterprise Model for Space Explorations**
- **A Multi-party Communication Architecture of Future Space Explorations**
- **Cost-efficiency of the Space Communication Architecture**
- **Conclusion**

Introduction

- One main aspect of future space explorations is being multiparty.
- We describe a multi-party enterprise model for future space explorations.
- Next, we present the multi-party communication architecture for these future explorations.

The Multi-Party Enterprise Model

- Future space exploration will be operated and administered by multiple national and industrial parties.

- This will cover various mission exploration phases that includes:
  - Planning
  - Launching
  - Deployment
  - Operation & Administration

- There is a strong trend towards privatizing the space organization.

- This will lead to new space age, where new generation of commercial space industries will appear [1].

The Multi-Party Enterprise Model

- This model integrates four industrial groups:

1. Instrumentation
3. Deployment
5. Experimentation
7. Communications.

The Multi-Party Enterprise Model

- Enabling such commercial space applications in future would require the existence of a multi industrial party enterprise model.

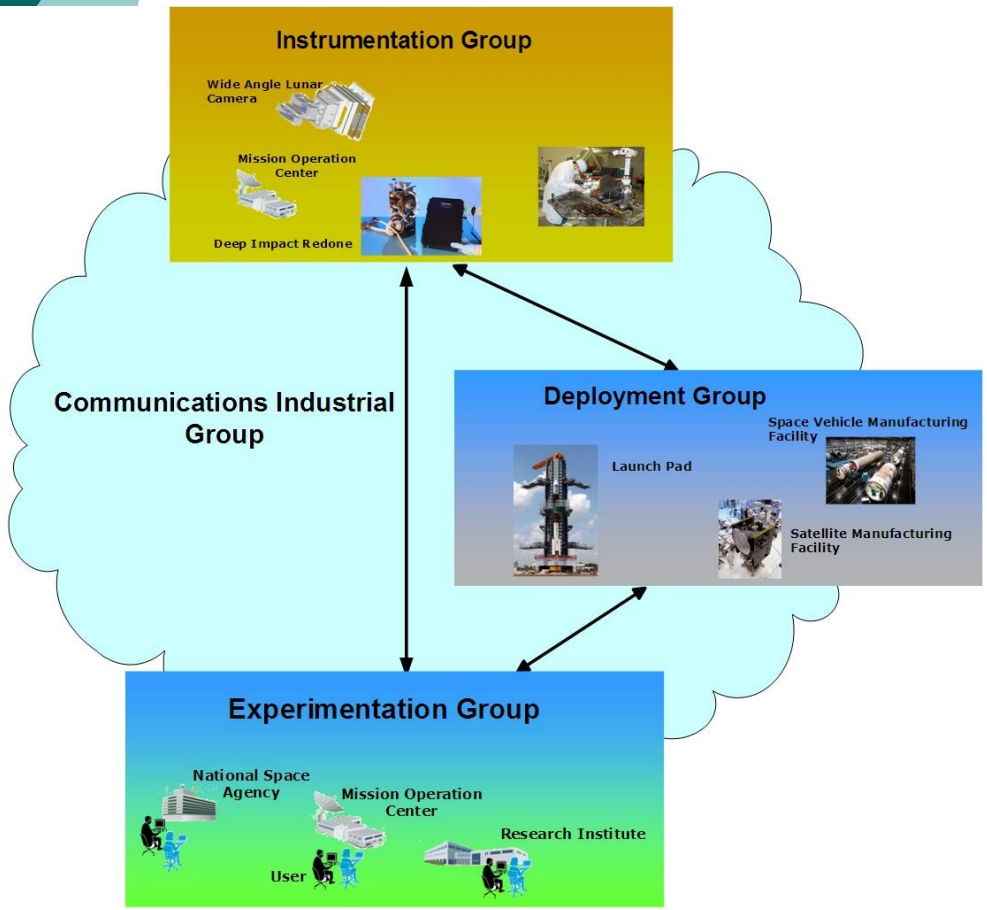


Figure 1:The Multi-Party Space Exploration Model

The Multi-Party Enterprise Model Communication Group

- Represents the network infrastructure that provides inter-group connectivity during the various exploration phases.
- Comprises the national, commercial and research organization that build, administer and operate Space communication networks.
- The services provided by this group are reachable at three geographical zones [1]:
  - Earth
  - Orbital (Near Space)
  - Deep space

The Multi-Party Enterprise Model Communication Group

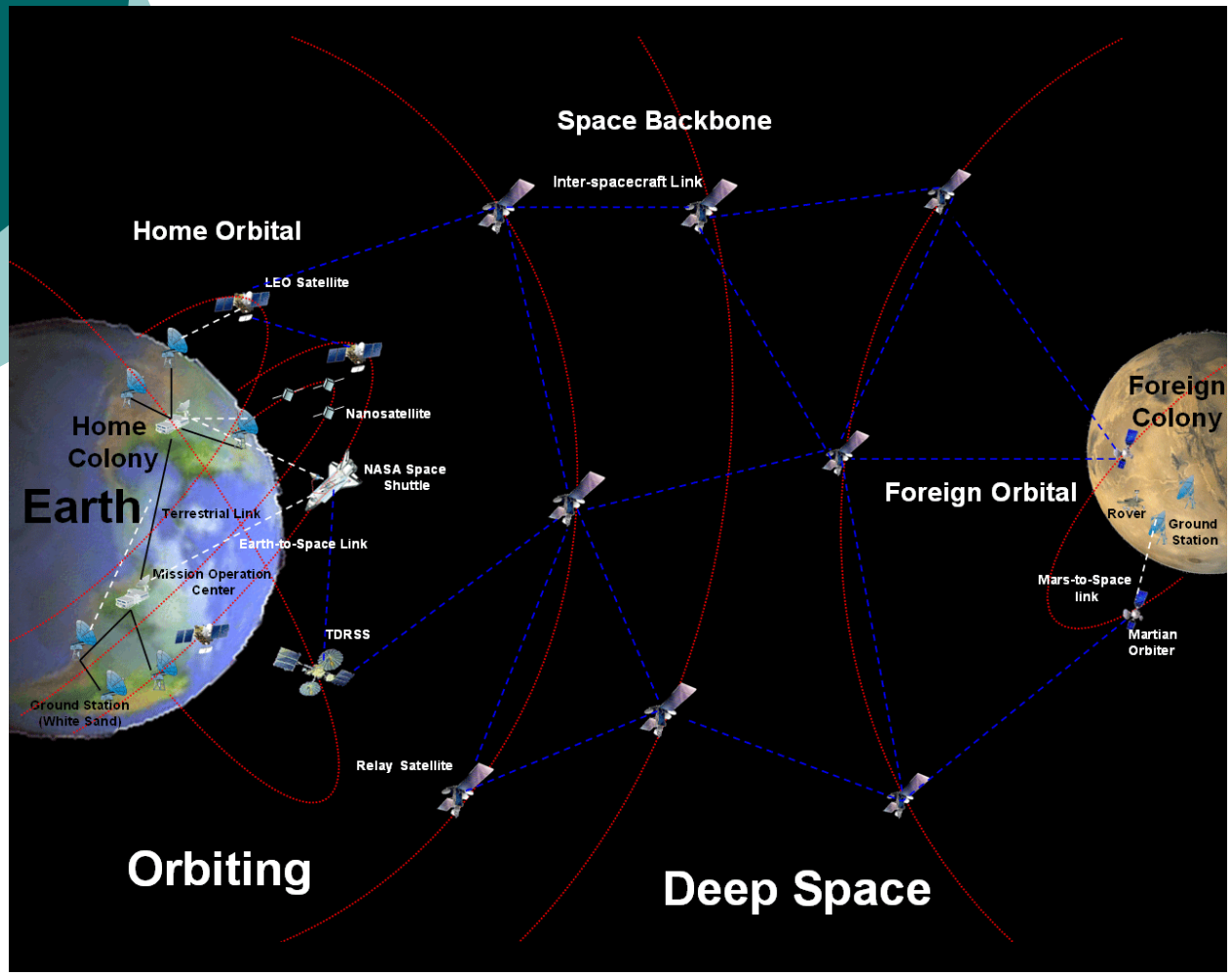


Figure 2: The Communication Group

The Multi-Party Space Communication Architecture

- We Describe the communication Architecture serving the presented multi-party model.
- We only consider the experimentation, instrumentation and communication groups.
- The concept of Multi-party space exploration is described from the communication architecture perspective.
- We elaborate three groups of end-to-end communication within this architecture:
  - Experimenter-to-Experimenter (**E2E**)
  - Instrument-to-Instrument (**I2I**)
  - Experimenter-to-Instrument (**E2I**)

The Single-Party Space Exploration Concept

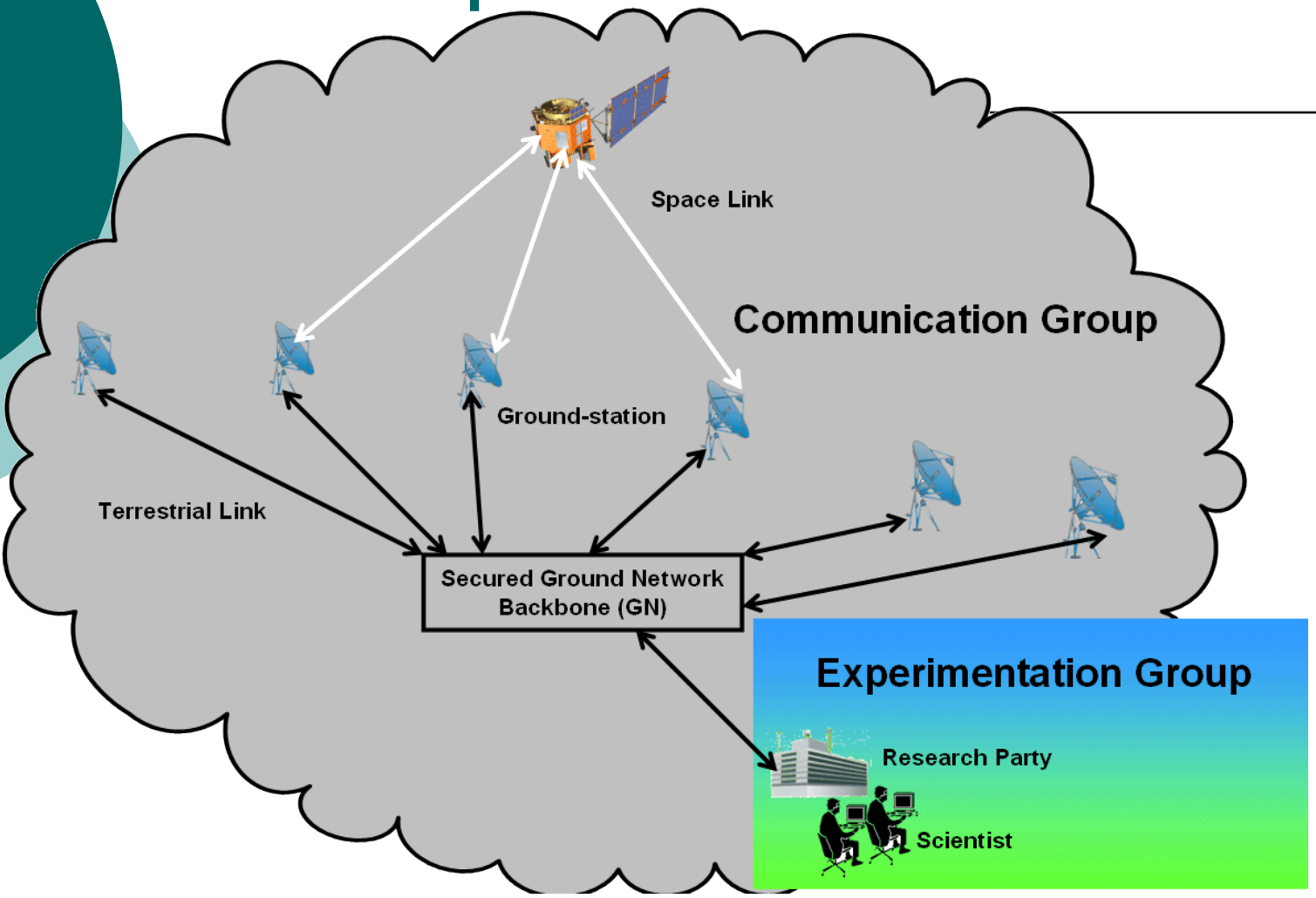


Figure 3: The Single-Party Space Exploration

Multi-Party Space Exploration Concept

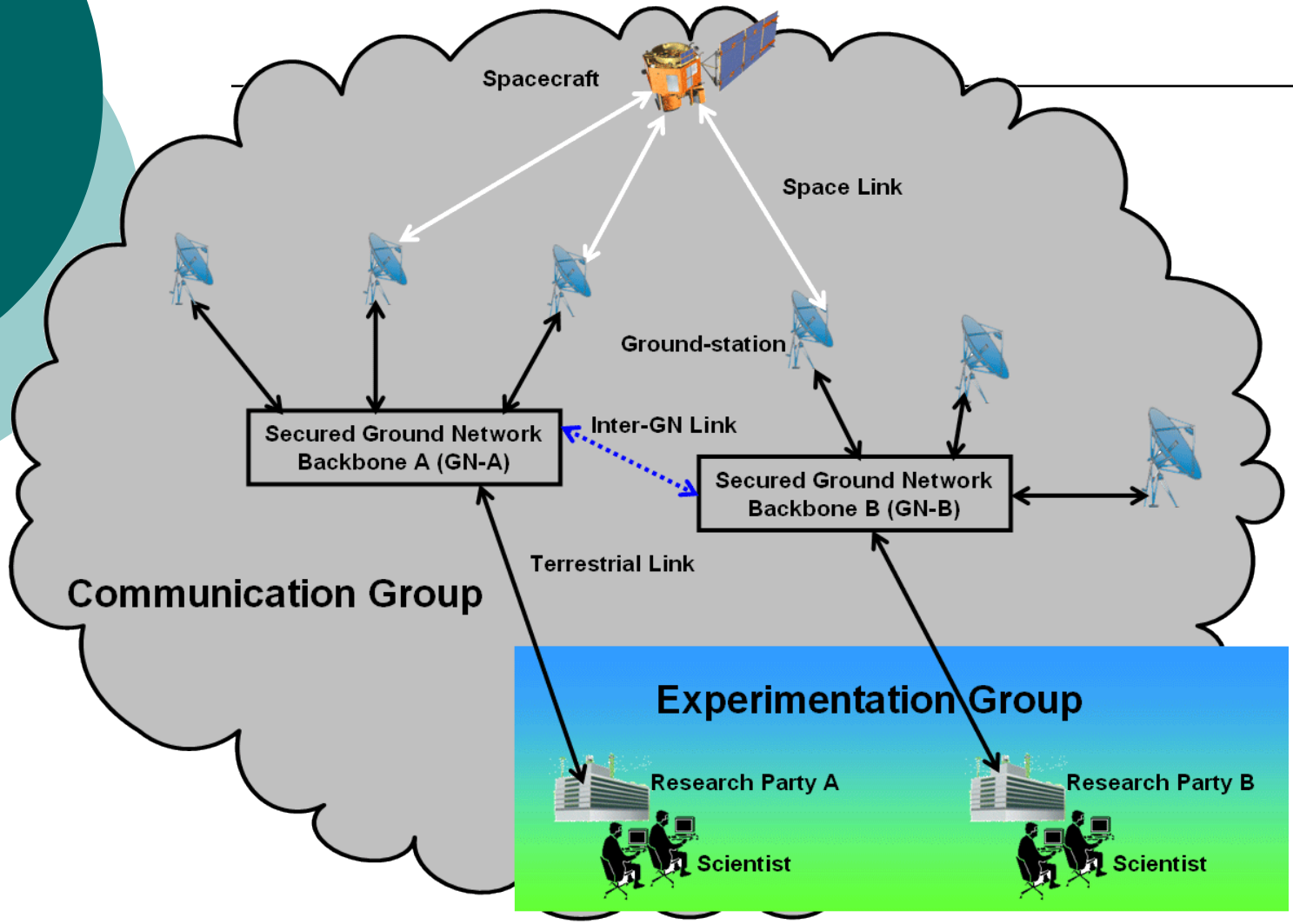


Figure 4: The Multi-Party Space Exploration

Communication-Centric Instrument Representation

- Space Experiment conducted on an instrument reserves some or all of its computational and communicational resources.
- We represent a scientific instrument deployed onboard spacecraft or inside a planetary outpost as a black box performing three types of functionality:
  - Scientific experiment
  - Data storage and processing
  - Communication
- An instrument performs its functionality in terms of three types of hardware entry points
  - Ports
  - Streams
  - Sockets

Communication-Centric Instrument Representation

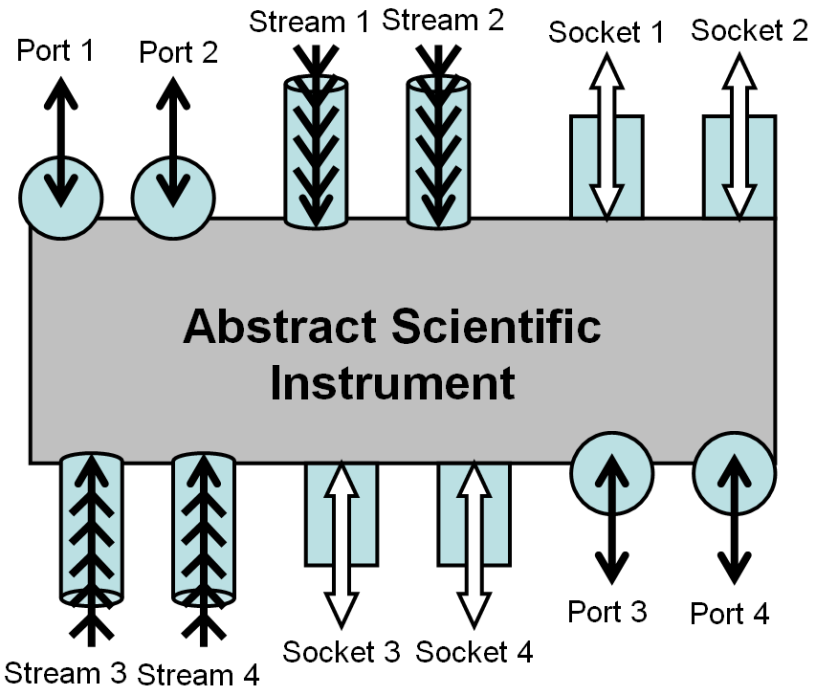


Figure 5: Communication-centric representation of scientific instrument

Type	Usage	Data
Port	Instrument control, configuration, data storage	Signal, raw data (textual, numerical, imagery and equisetic)
Stream	Data Acquisition and Communication	Continuous data (Video and Audio)
Socket	Communication	Signal, raw data, multimedia

Table 1: Data port types

Communication-Centric Instrument Representation

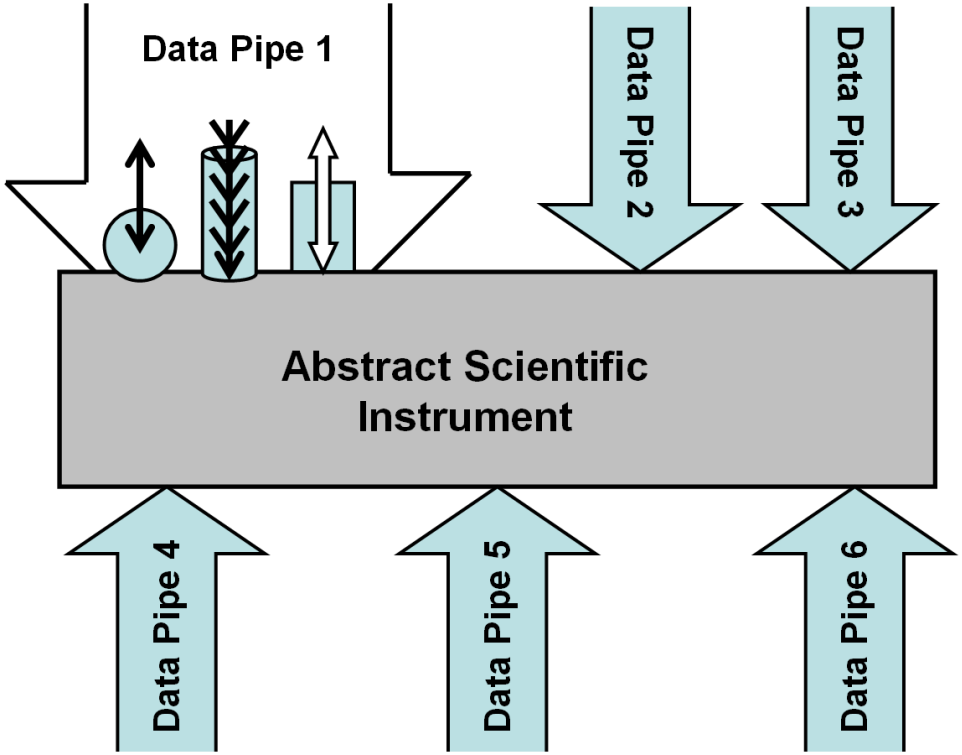
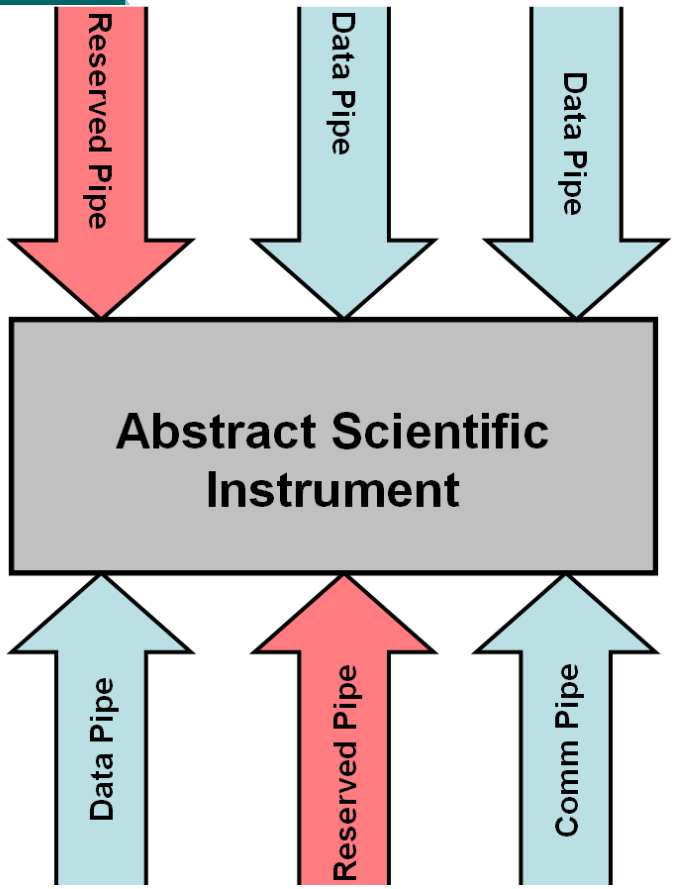


Figure 6: The data pipe bundling

- **A data pipe bundles one or more ports, streams and sockets.**

- **Data pipes enables users (Experimenters) to reserve instrument resources for a specific period of time.**

Communication-Centric Instrument Representation



- One of more data pipes can be reserved by instrument vendor for maintenance and housekeeping purposes.

- Inter-instrument communication within the onboard LAN can be implemented by one or more data pipes.

Figure 7: Reserved data pipe concept

Experimenter-to-Experimenter (E2E)

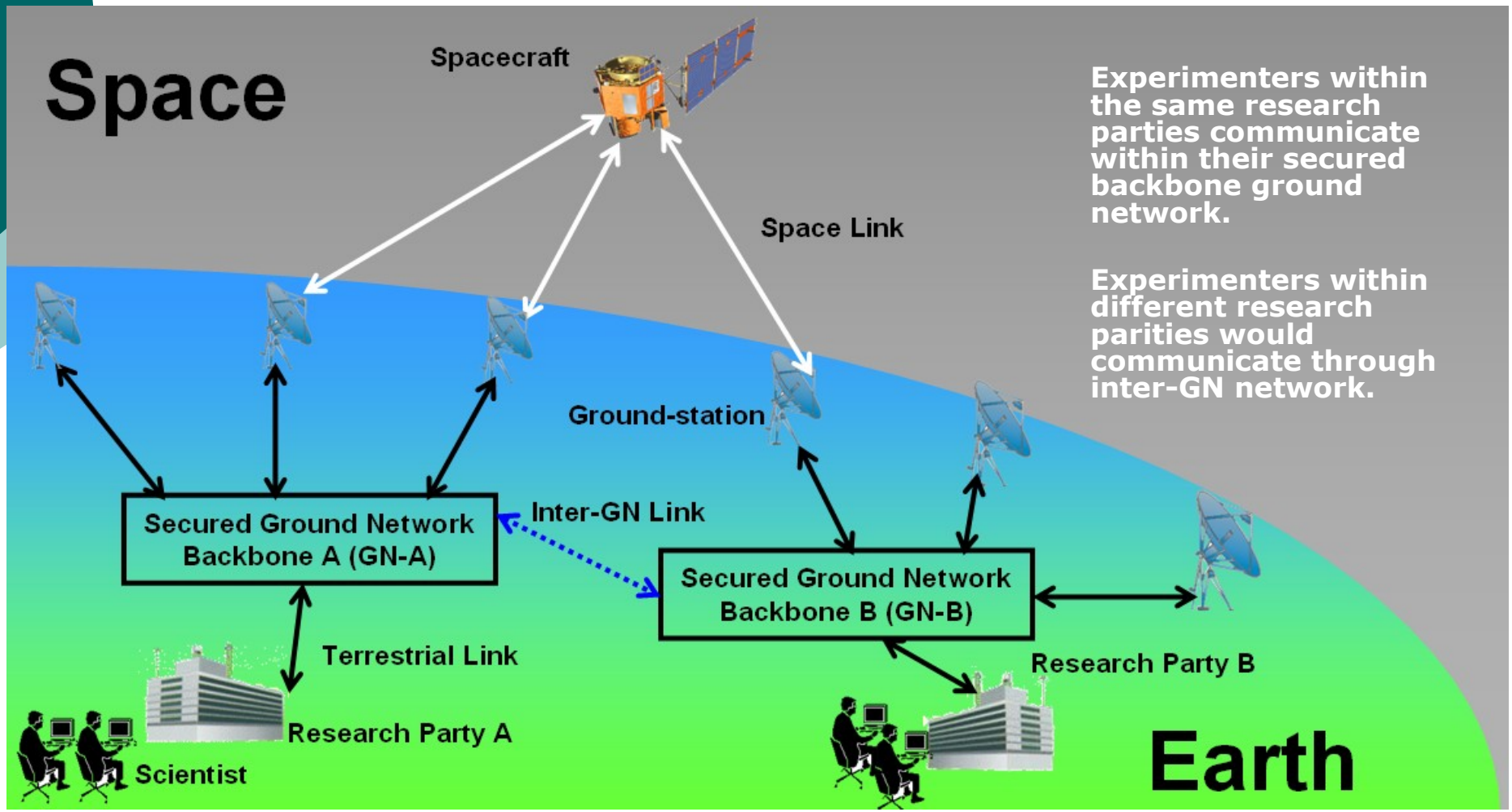


Figure 8: E2E communication

Instrument-to-Instrument (I2I)

- In future space exploration, experiments may involve more that a single instrument deployed onboard spacecraft.
- These instruments may exploit a sort of data dependency requiring inter-instrument communication.
- We described four scenarios of Instrument-to-Instrument Communication.

Instrument-to-Instrument (I2I)

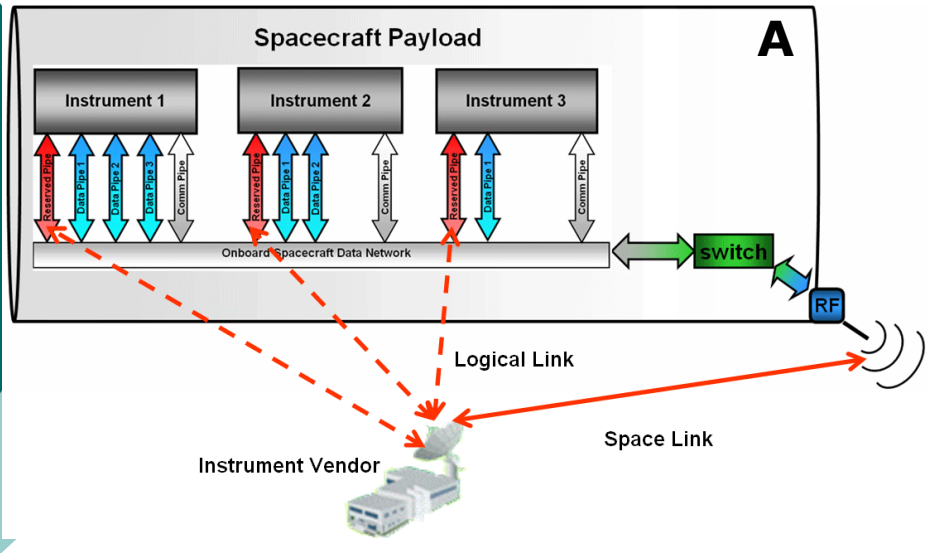
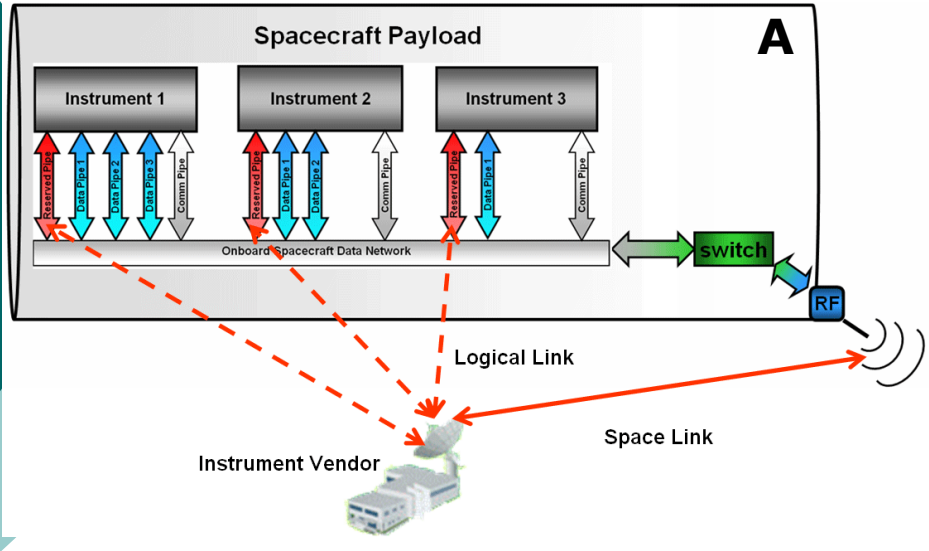


Figure 8: I2I communication

Instrument-to-Instrument (I2I)



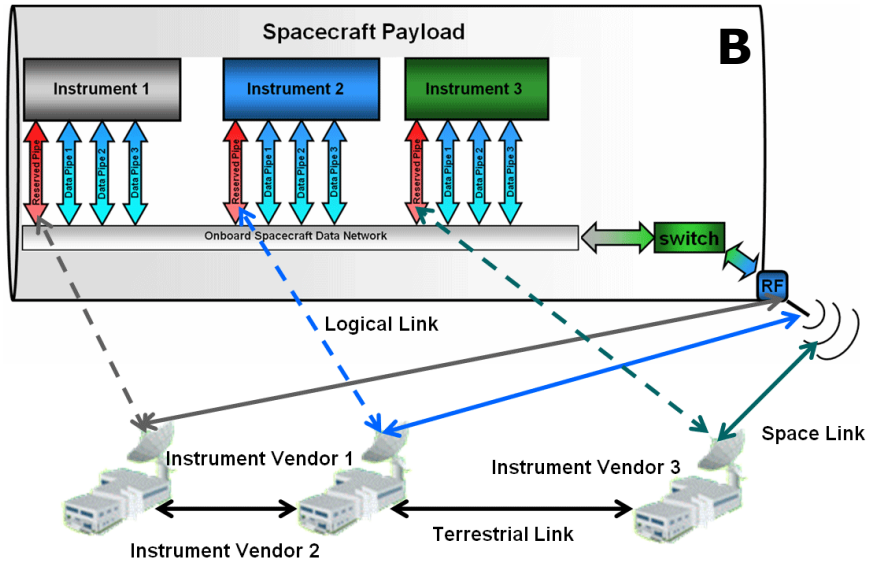
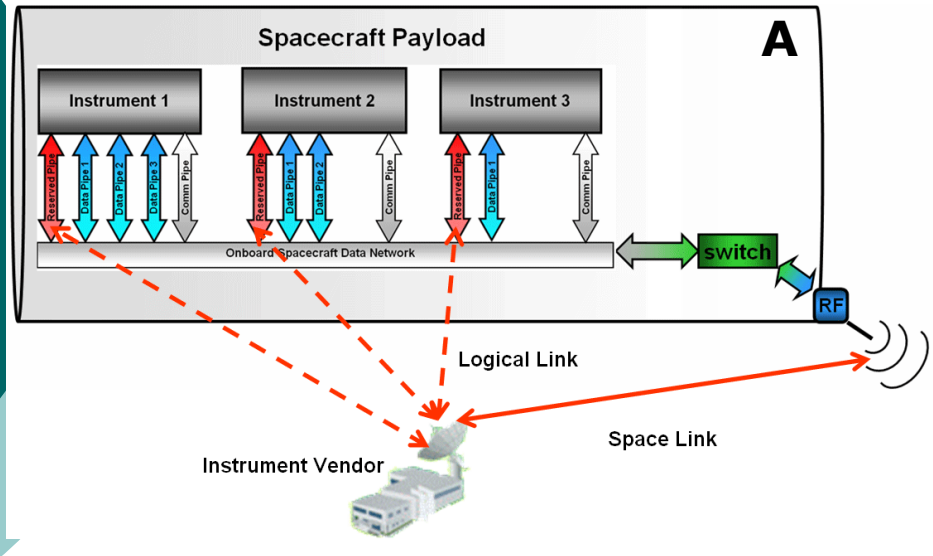
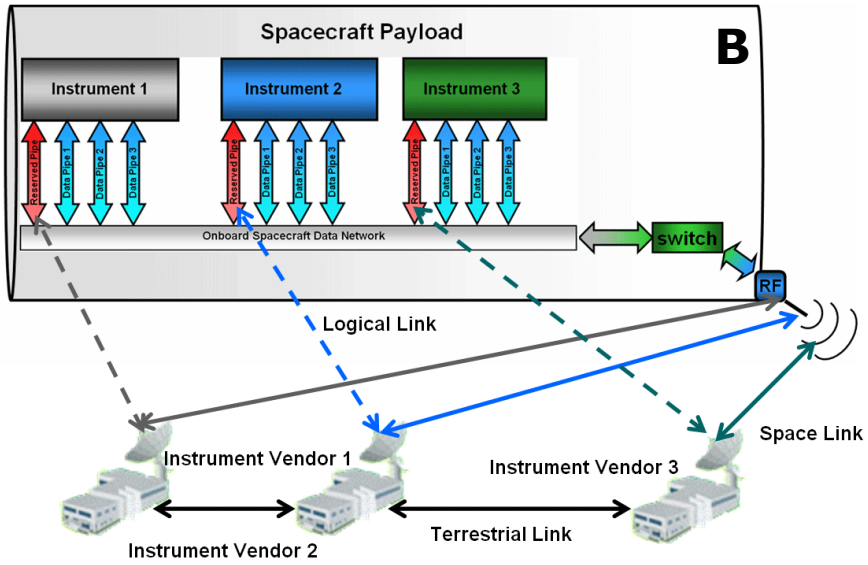


Figure 8: I2I communication

Instrument-to-Instrument (I2I)





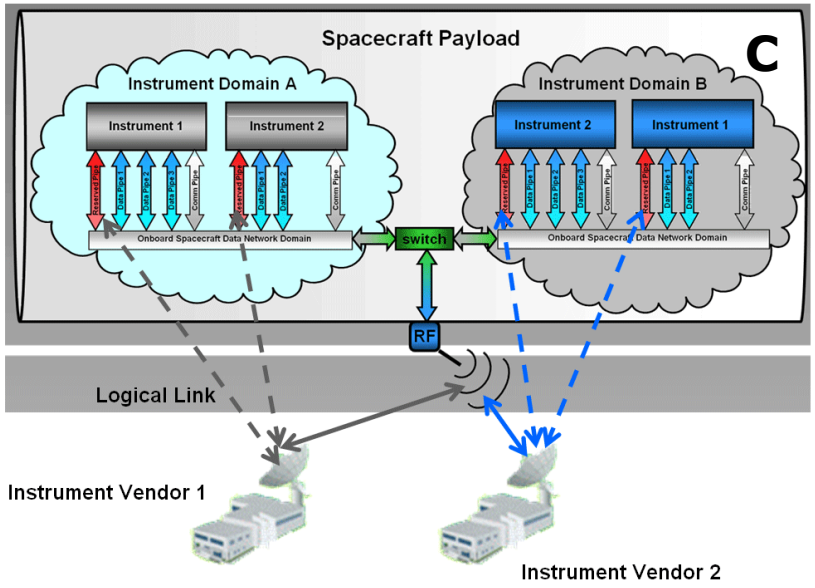


Figure 8: I2I communication

Instrument-to-Instrument (I2I)

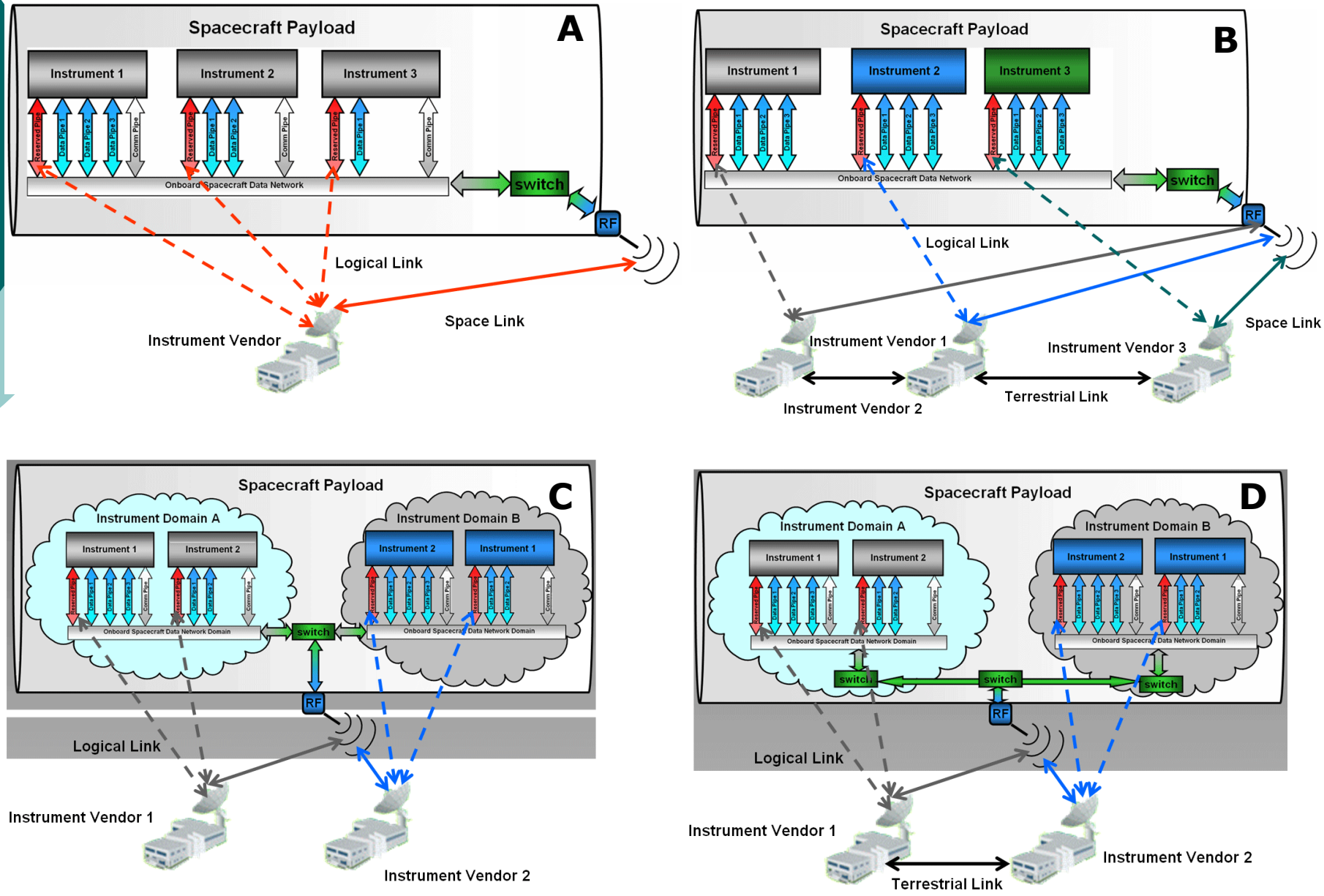


Figure 8: I2I communication

Experimenter-to-Instrument (E2I)

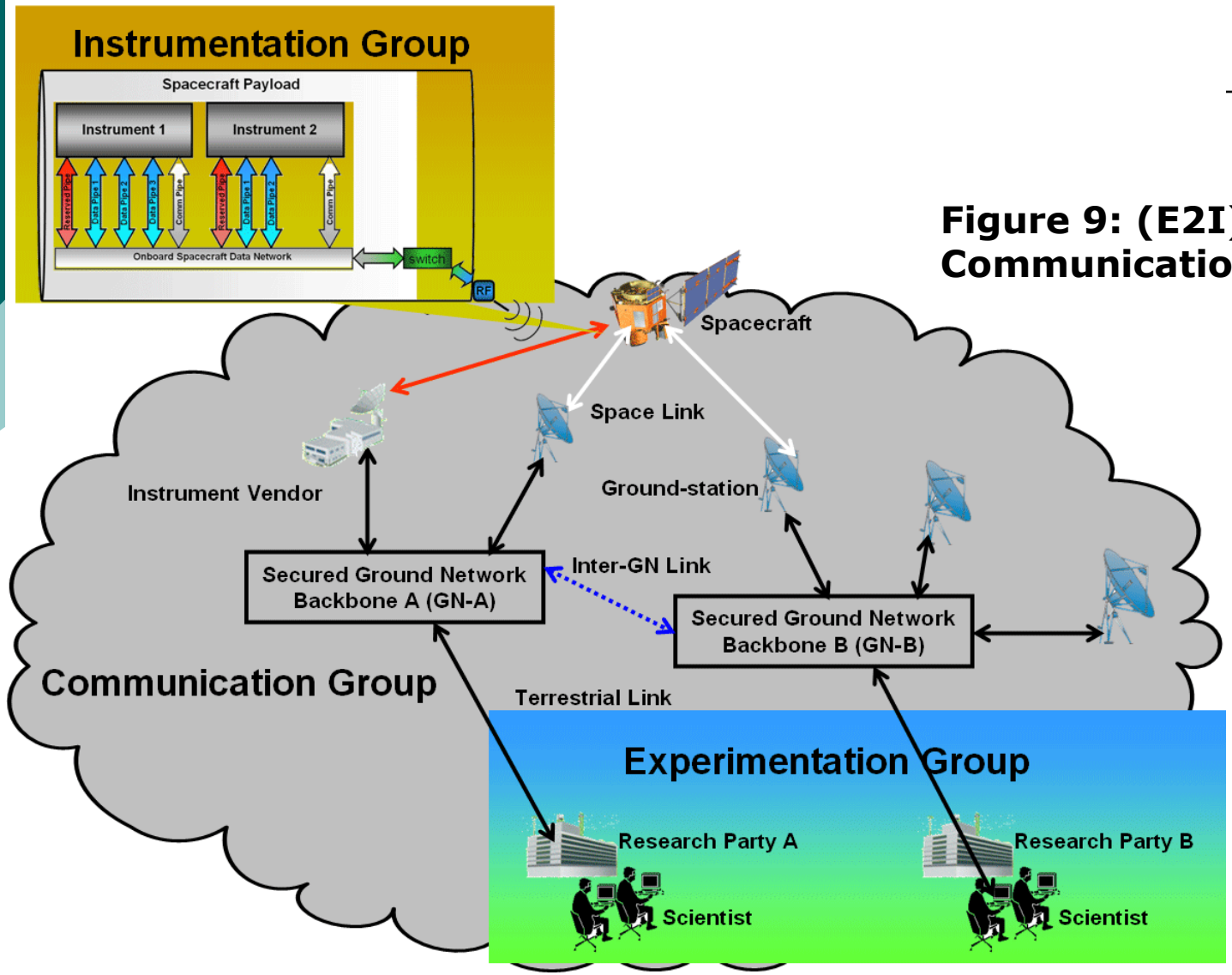


Figure 9: (E2I) End-to-End Communication

Experimenter-to-Instrument (E2I)

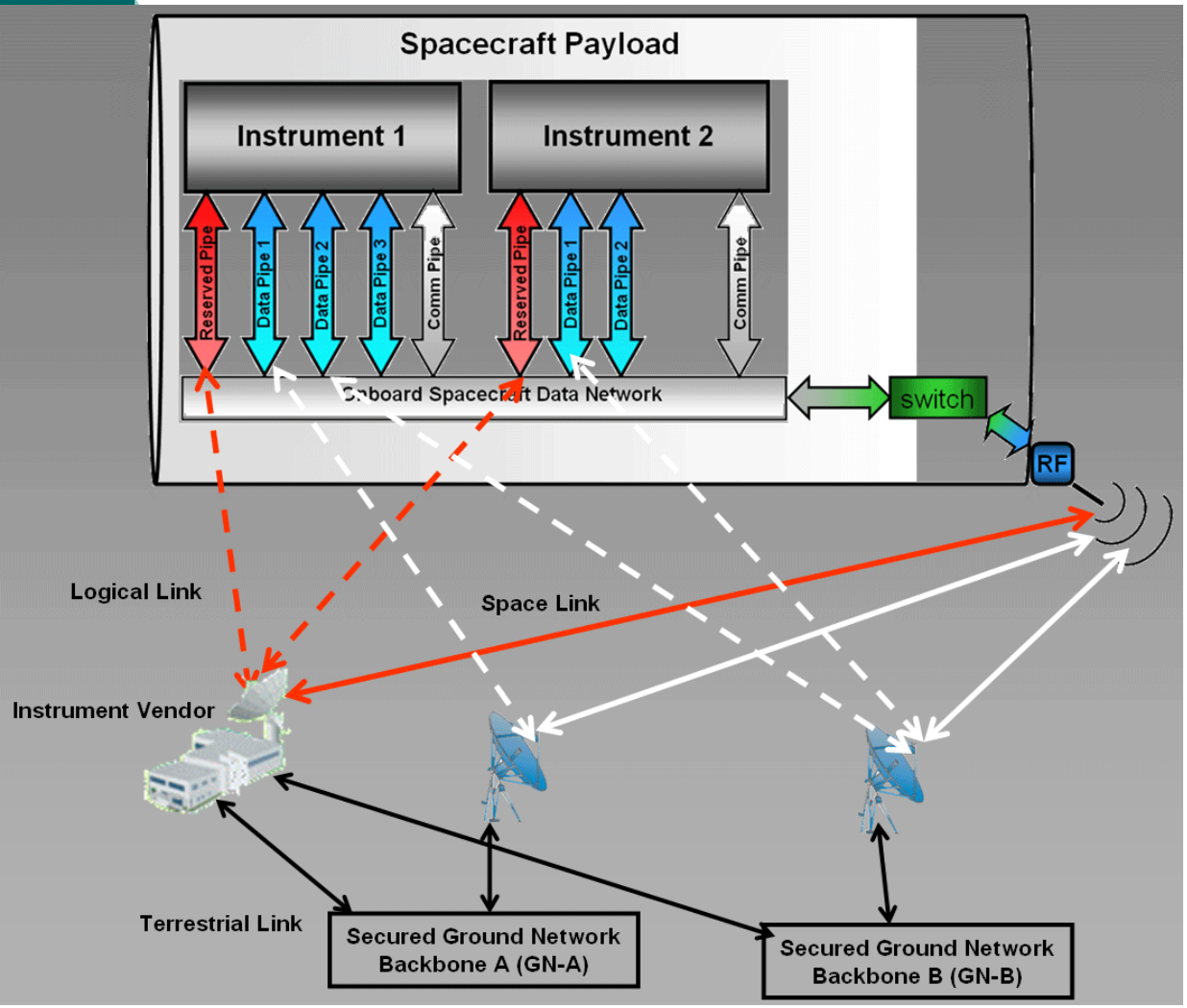


Figure 10: (E2I) Single Vendor Scenario

Experimenter-to-Instrument (E2I)

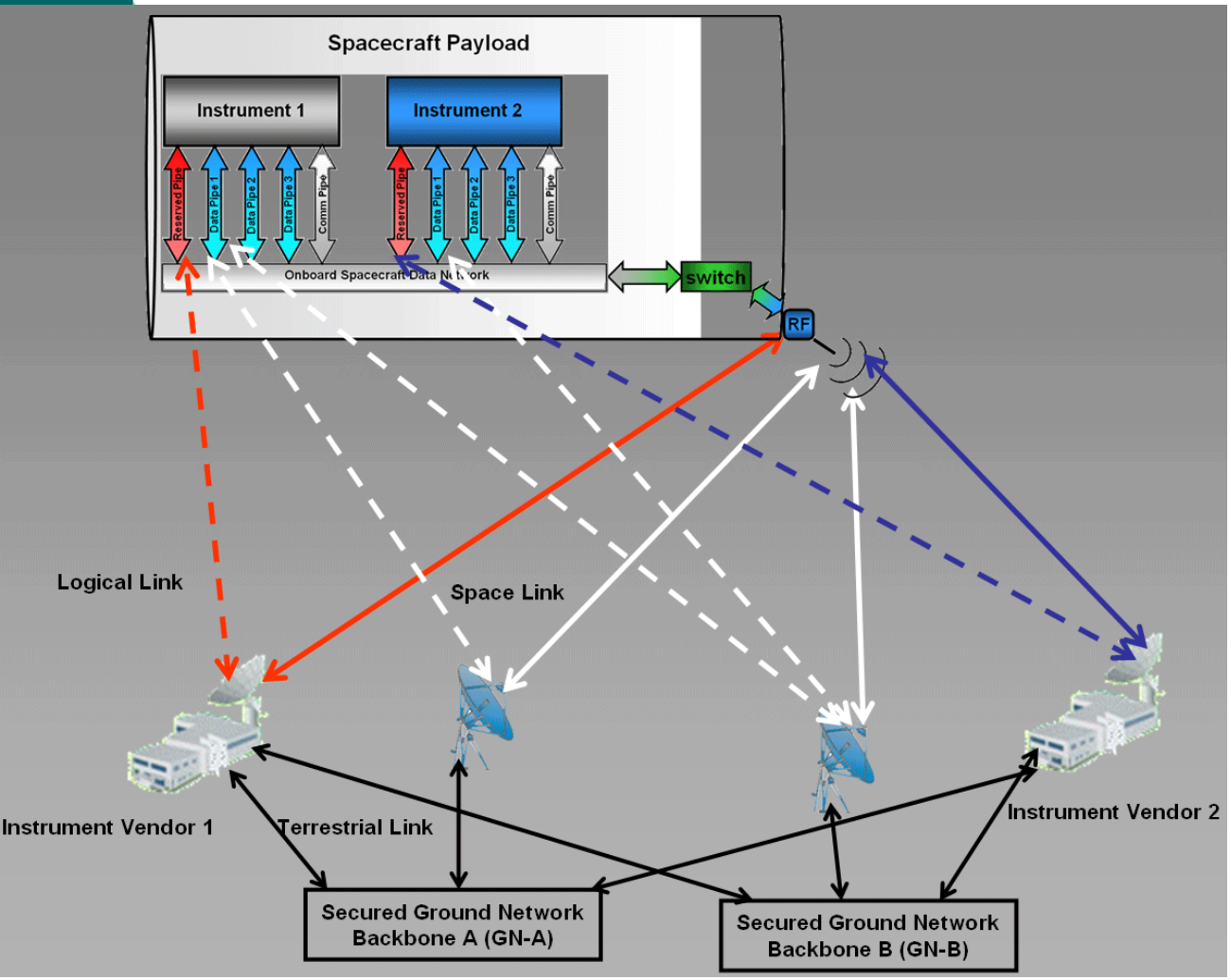


Figure 11: (E2I) Multiple Vendor Scenario

Experimenter-to-Instrument (E2I)

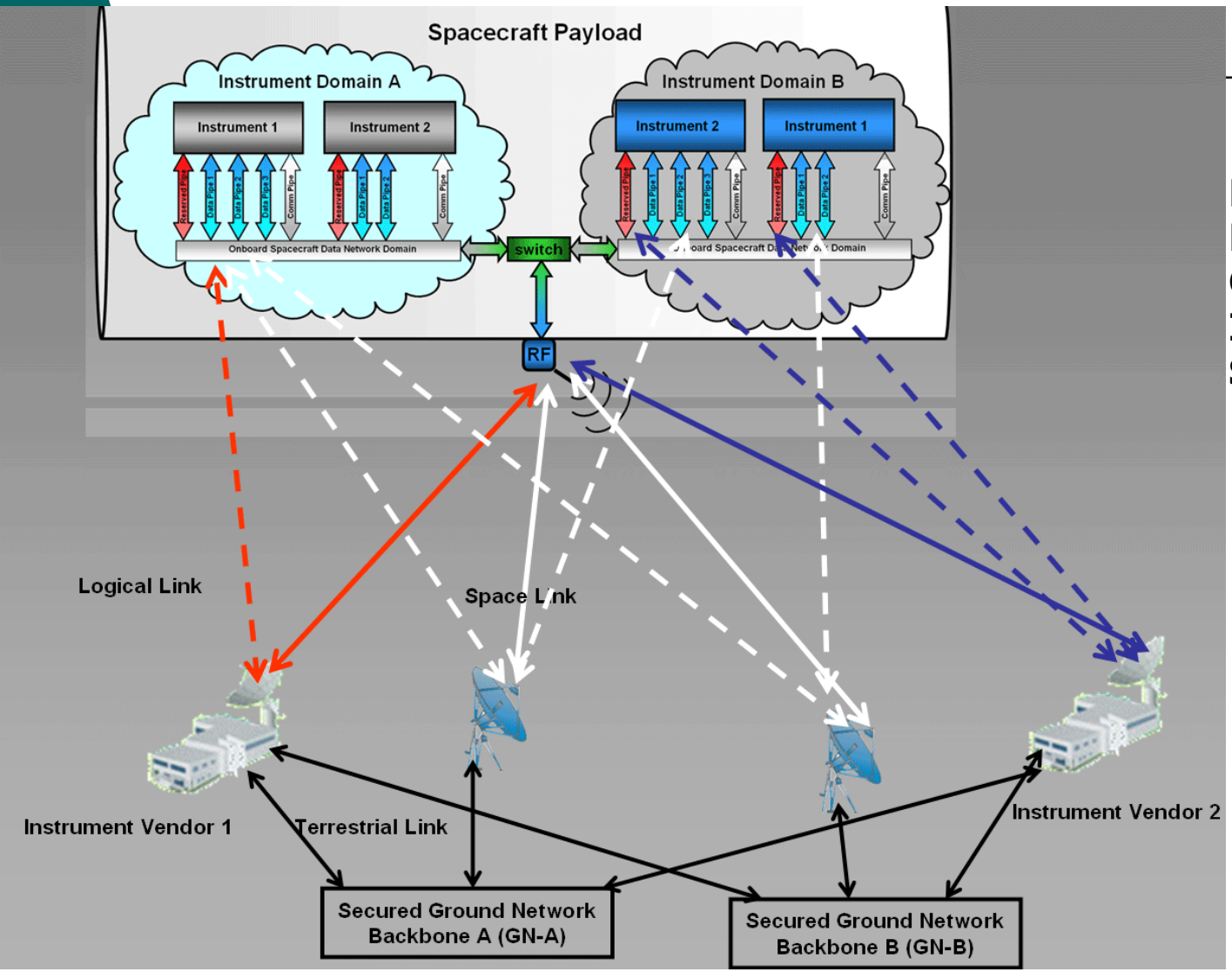


Figure 12: (E2I) Multiple Vendor-Connected Instrument Domain Scenario

Experimenter-to-Instrument (E2I)

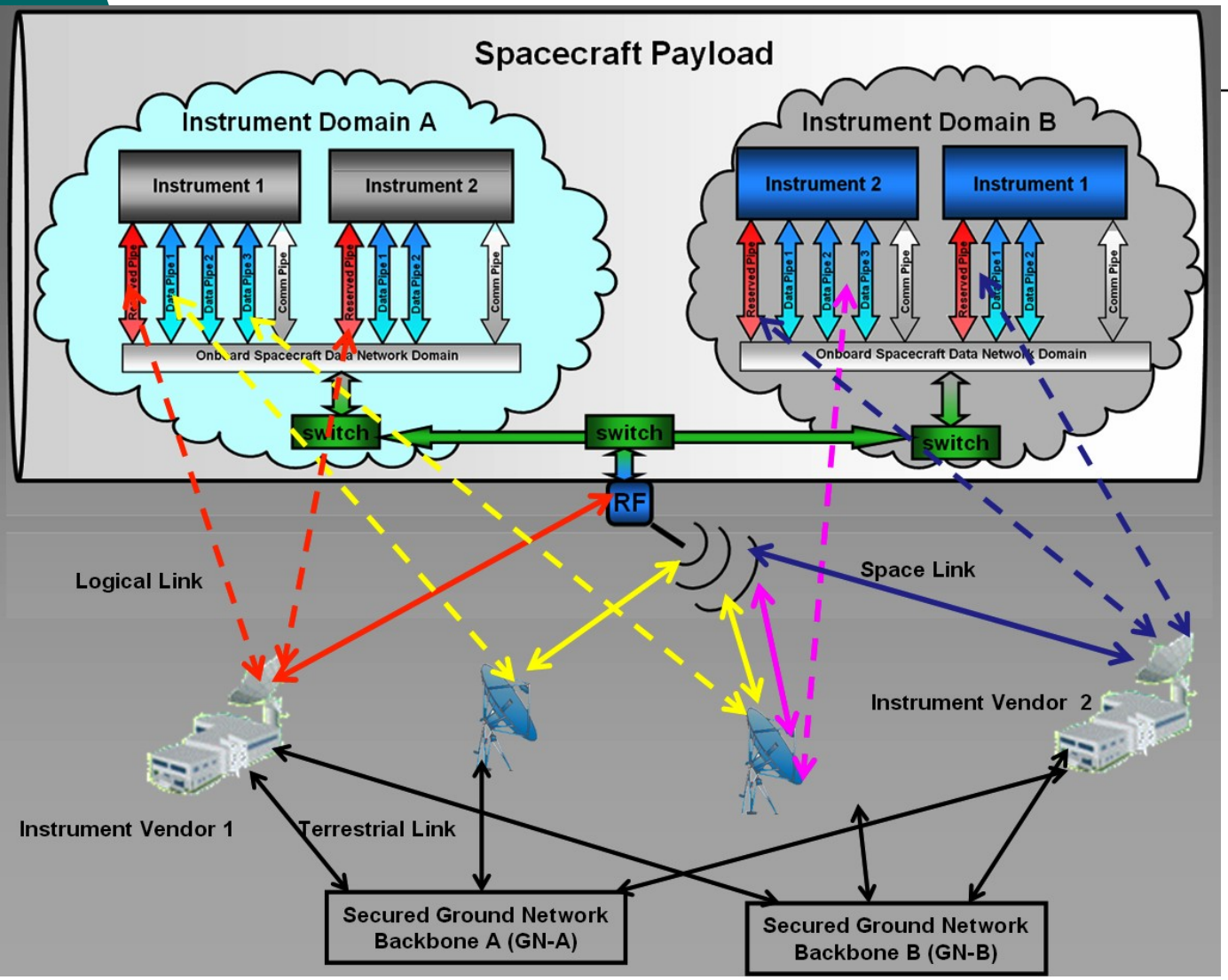


Figure 13: (E2I) Multiple Vendor-Disconnected Instrument Domains Scenario

The Envisioned Multi-party Space Communication Architecture

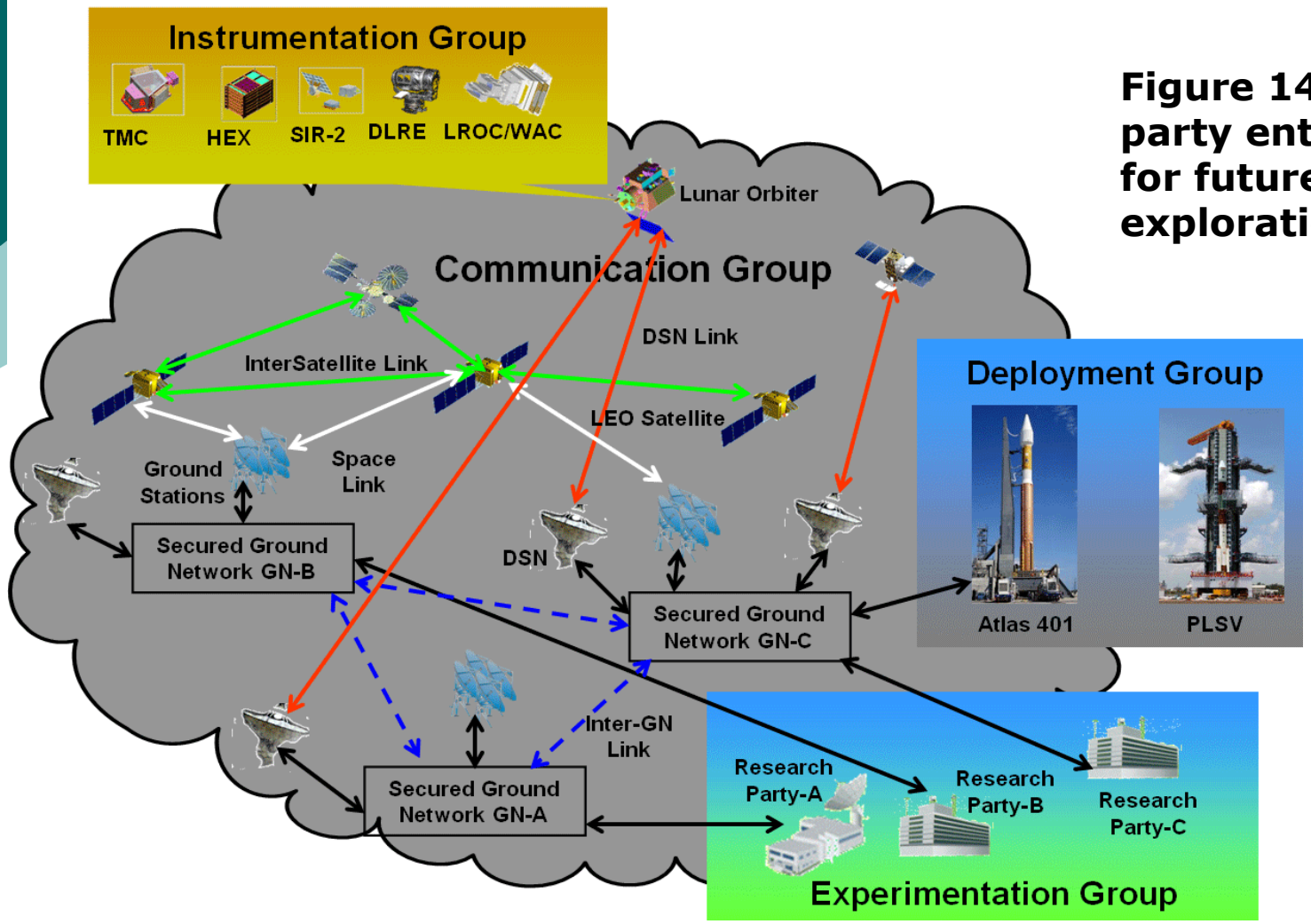


Figure 14: The multi-party enterprise model for future space explorations

The Cost Efficiency of the Communication Architecture

- The cost efficiency to be achieved by this architecture through the multi-party aspect in terms:
  - Manufacturing
  - Deployment
  - Operation
  - Administration

Conclusion

- multi-party explorations will be the signature of next space age.
- In this presentation, we described a multi-party enterprise model for future space explorations.
- Next, We presented a cost-effective space communication architecture to be serving the enterprise model.
- Through this architecture we elaborated three types of end-to-end communications: (E2E), (I2I), and (E2I).
- Finally, it is concluded that the presented multi-party enterprise model along with the architecture provide a potential communication-centric operations model for space explorations

References

[1] Khan, J., Tahboub, O., “A Reference Framework for Emergent Space Communication Architectures oriented on Galactic Geography”, to appear in AIAA Space Operations ‘08, Heidelberg, 2008.

Thank You