Primer for The CCSDS File Delivery Protocol - CFDP (FTP for space?)

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CFDP – A bit of history

- CFDP has been around for a long time:
  - Initially proposed (by ESA) in 1998
  - Underwent exhaustive international testing
  - First published as a CCSDS standard in 2002, reviewed in 2007 and now due for 5 year review

- Lots of Information at www.ccsds.org:
  - CCSDS 727.0-B-4 **Blue Book Standard**
  - CCSDS 720.1-G-3 **Introduction and Overview**
  - CCSDS 720.2-G-3 **Implementers Guide**
  - CCSDS 720.3-G-1 **Interoperability Testing**

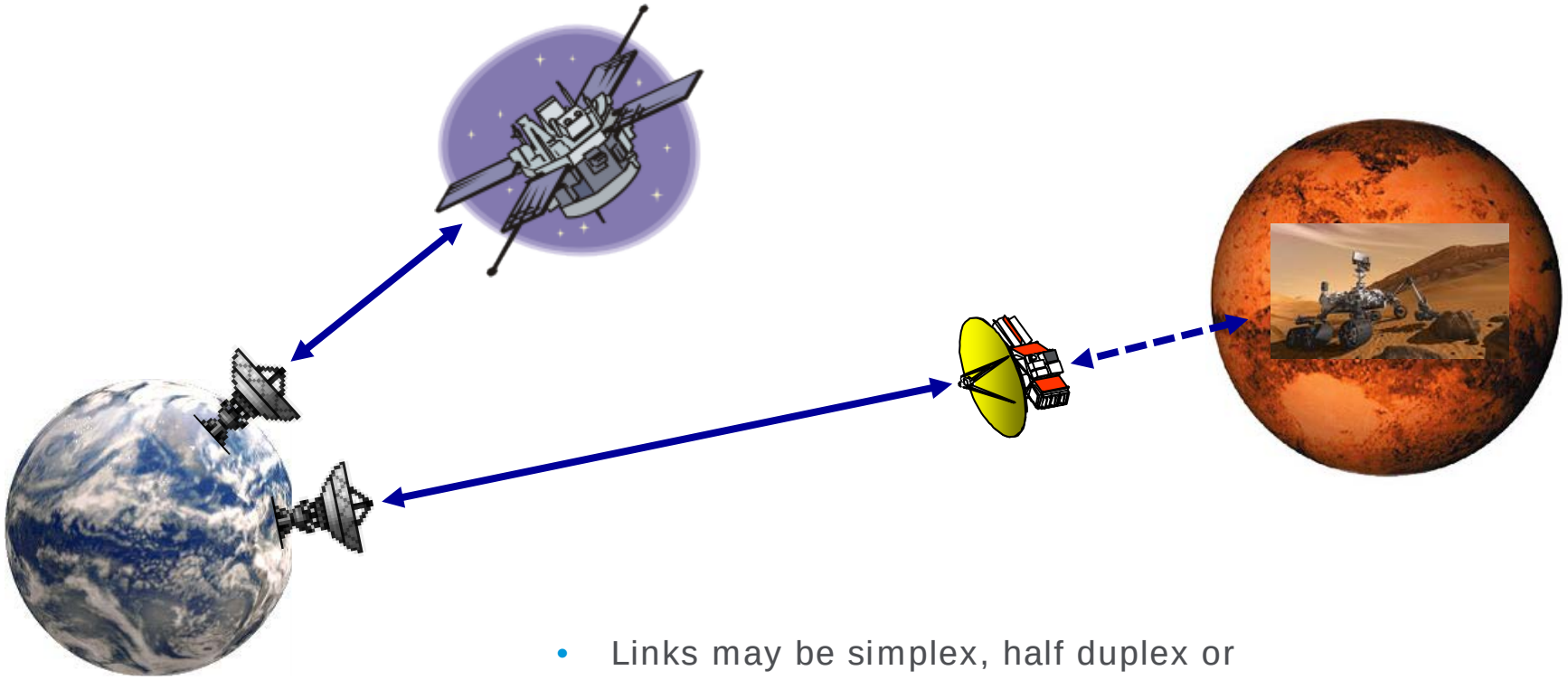
- Used on many NASA missions and standard in their ground segment but not (yet) by ESA missions!

CFDP – What is it?

- CFDP provides the capability to transfer ‘files’ and associated ‘Meta data’ to and from a spacecraft mass memory
- The content of the files may be anything from a conventional timeline update to a SAR image
- Files can be transmitted with a **unidirectional link**, a **half-duplex link**, or a **full-duplex link**, with near-Earth and deep space delays
- Files can be transferred **reliably**, where it is guaranteed that all data will be delivered without error, or **unreliably**, where a ‘best effort’ delivery capability is provided
- Meta data is used to setup the file transfer and to convey requests between CFDP user applications

- *CFDP works differently to FTP and uses negative rather than positive ACKS (all internet stacks assume permanent, duplex connectivity, low delay/error rate and congestion based data loss – this is not true in space)*

CFDP – Context



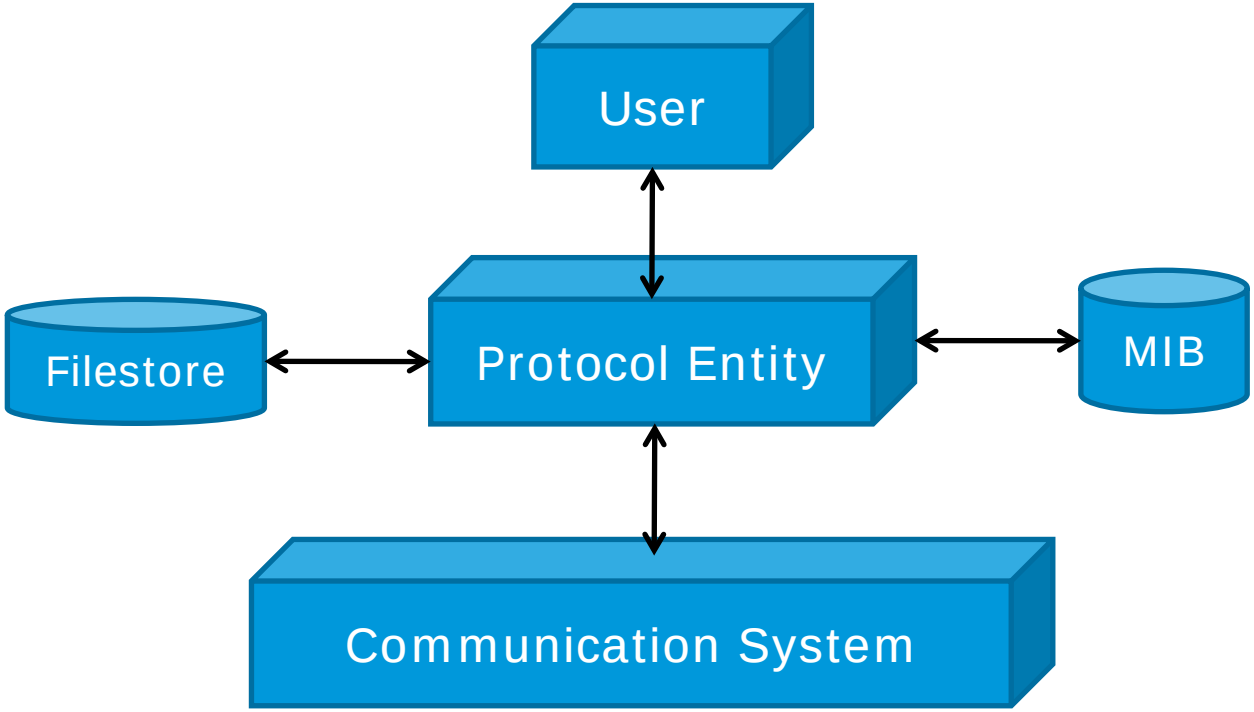
- Links may be simplex, half duplex or duplex
- Delays will vary according to orbits and visibility
- Ground segment configuration maybe mission specific

CFDP - Scalability

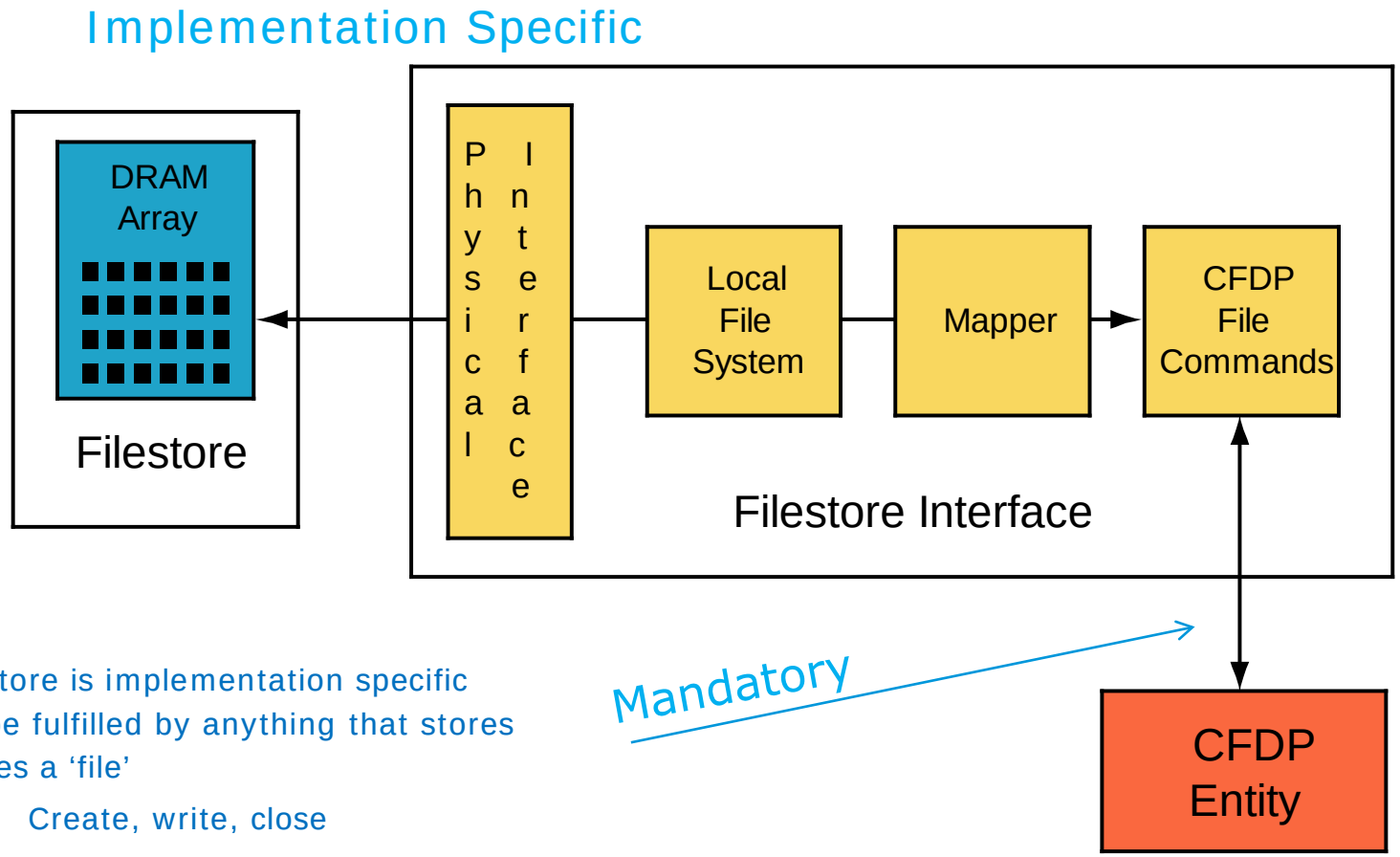
- CFDP has a rich mixture of features to cover many different scenarios and this results in a relatively complex specification – you don't get something for nothing!
- The specification reduces complexity by providing selectable classes of operation and options:
    - Class 1—Unreliable transfer
    - Class 2—Reliable transfer
    - Class 3—Unreliable transfer via one or more Waypoints (relays)
    - Class 4—Reliable transfer via one or more Waypoints
    - SFO – Provides a simpler alternative to class 3 and 4
    - User operations - provides CFDP user to CFDP user communication

- *Of the above only class 1 and 2 are the most applicable and possibly some of the user operations e.g. Proxy for remote file transfer initiation*

CFDP – Required Elements



CFDP - File Store Architecture

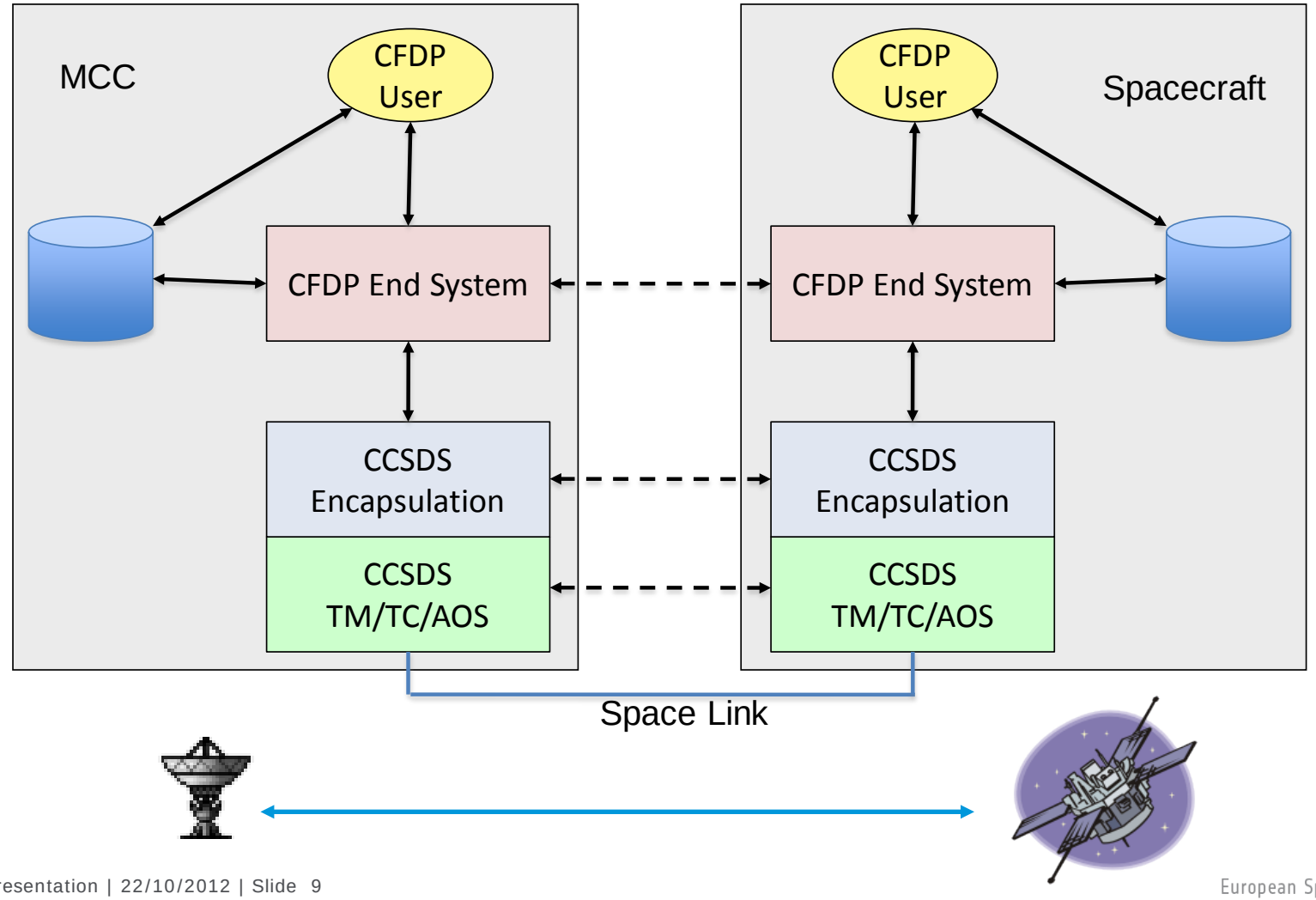


- The File store is implementation specific and can be fulfilled by anything that stores or retrieves a ‘file’
  - Create, write, close
  - Open, read, close

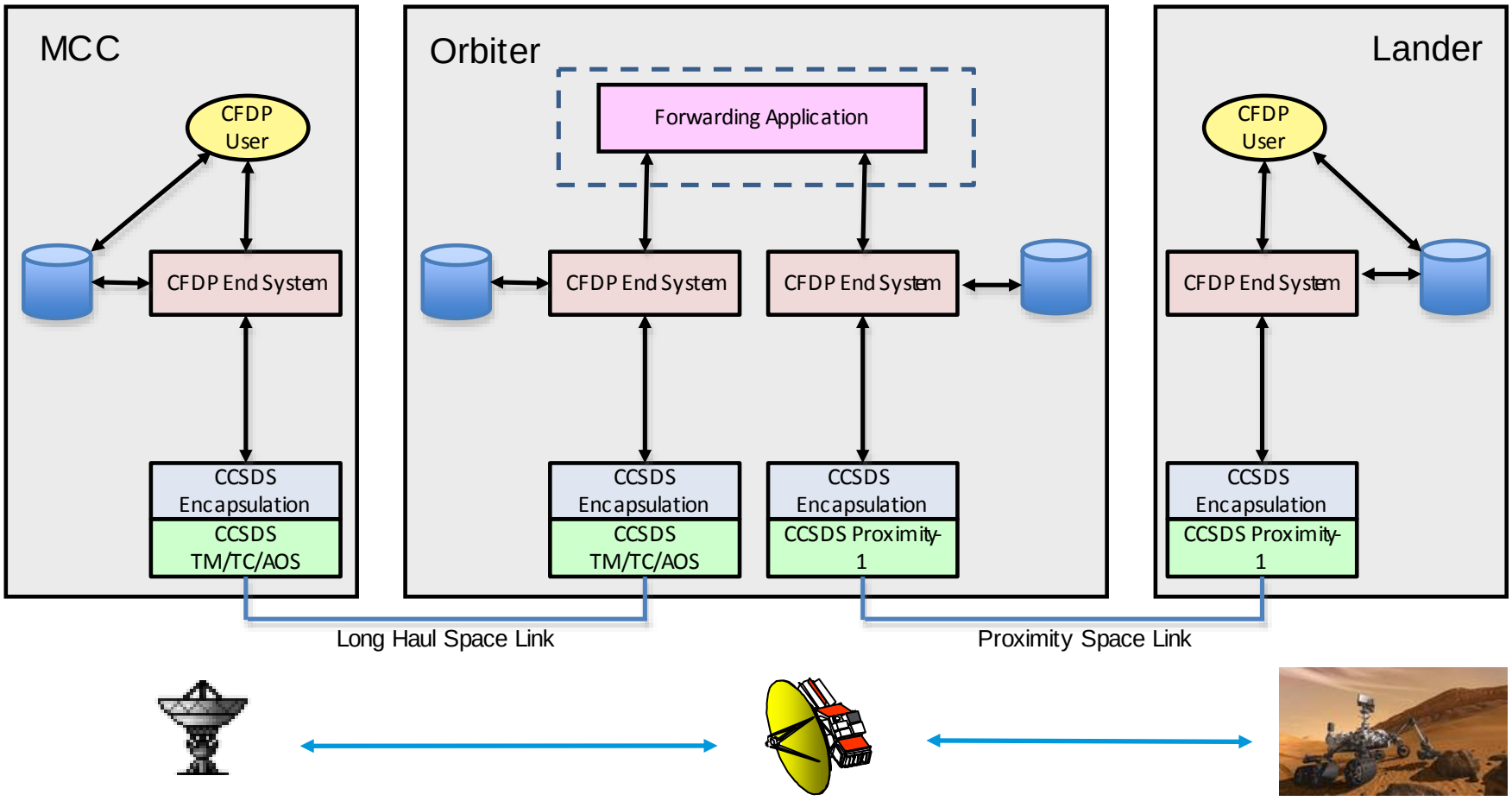
CFDP – Information transfer

- CFDP transfers **files** and **meta data**
- Files:
  - Files can be up to 4 Gbyte
  - Files are segmented at source into the maximum underlying transmission unit (packet) and reconstituted at the destination
  - Files are protected by a checksum
- Meta data:
  - Meta data is used to convey the file name and file size to the destination
  - Optionally, Meta data can be used to communicate with the remote user to perform a sequence of events, e.g.:
    - Start a remote transfer (remote Put), or manipulate the remote file store

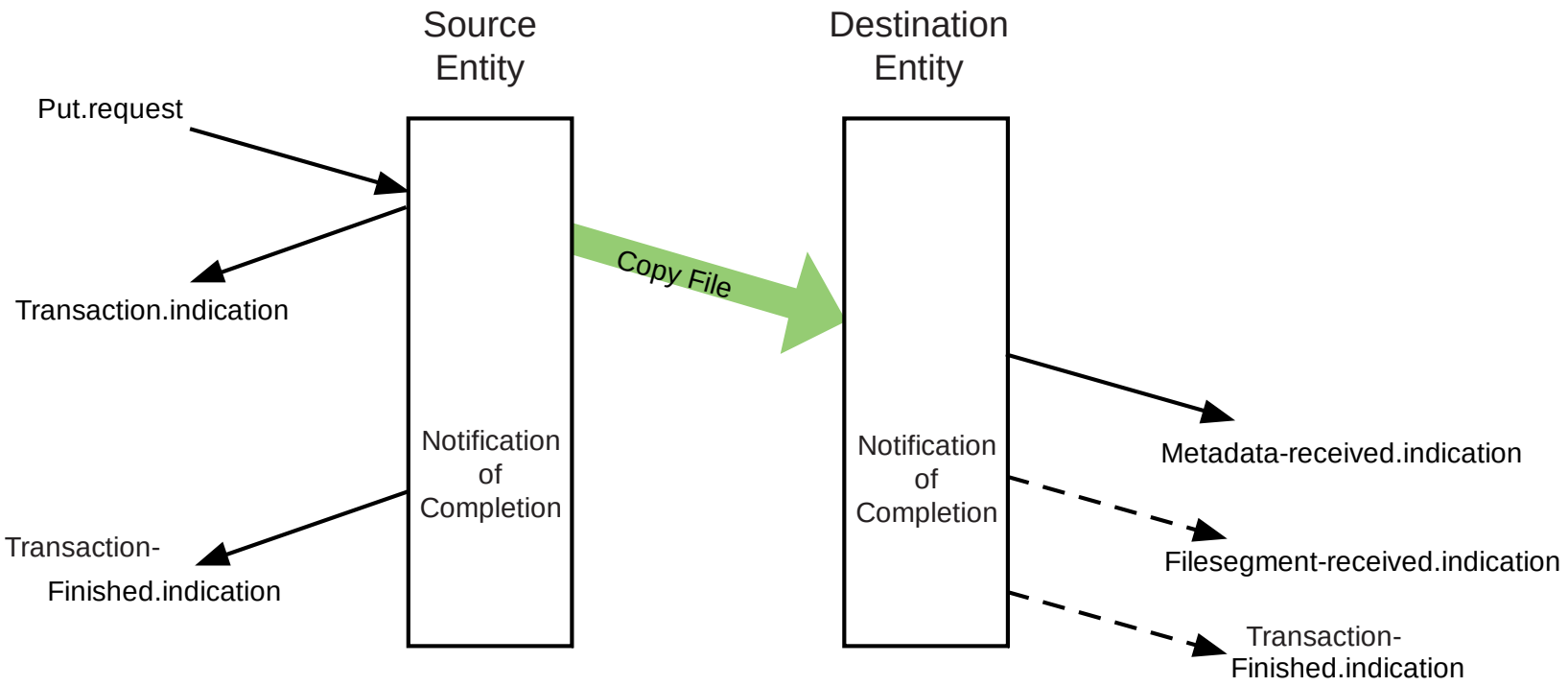
CFDP – Single Spacecraft



CFDP – Relay operation Example

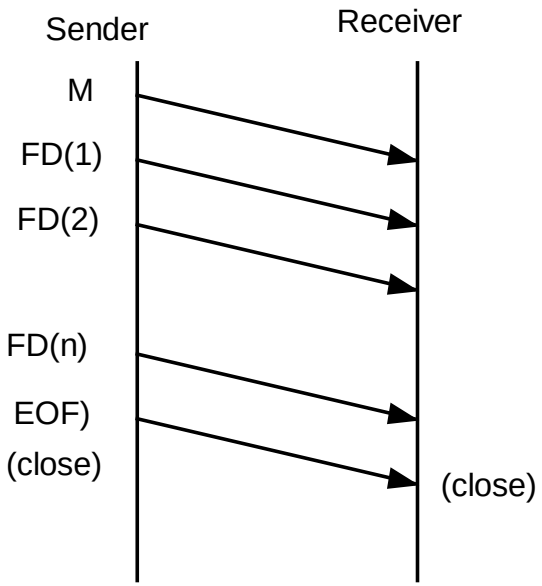


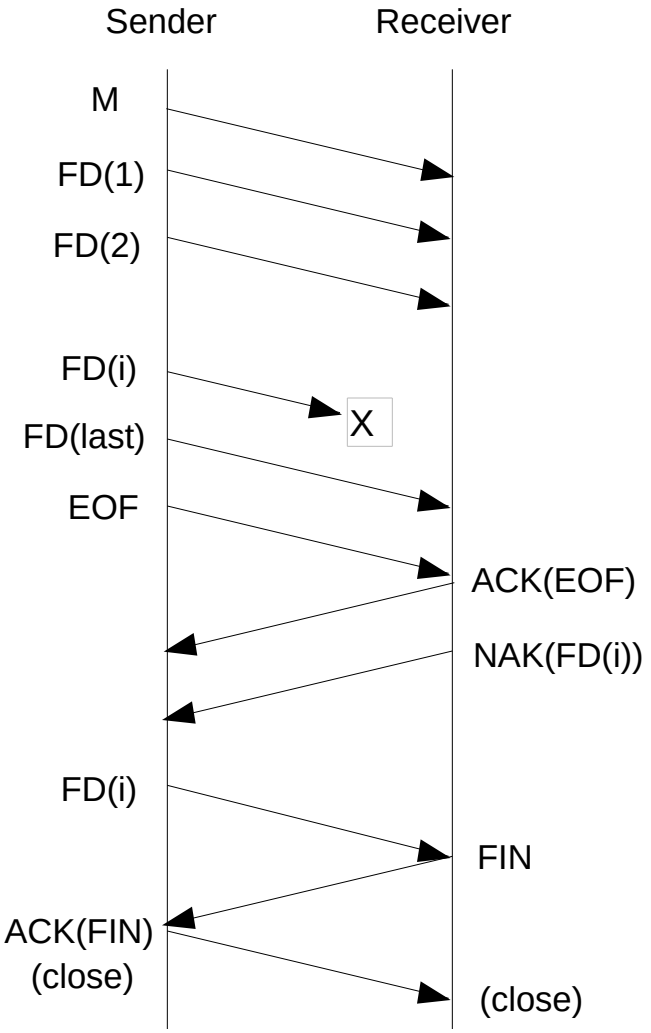
CFDP – Put and Copy



- All File transfers start with a Put.request
- The Put.request can be initiated in different ways
- All File transfers use the copy procedure
- The file checksum is sent at the end of transmission

CFDP – Basic Transmission





NAK procedures are utilized throughout the transmission. There are four user selectable options associated with the issuance of NAKs:

- Deferred
- Immediate
- Prompted
- Asynchronous

CFDP – Considerations

- Some things to consider
  - There are reference implementations available from ESA
  - An ESOC/ESTEC test-bed for files Ops is under initiation
  - ESOC have announced that CFDP will be available as a standard service in the ground segment
  - A software based flight version is available from Spacebel
  - Pre-development activities for mass memories which include CFDP are underway

- When running CFDP (or any other protocol) at high speed there will be a need for hardware acceleration
  - An prototype IP core for this purpose is under development

- PUS is under update and taking into account file based operations

- The CCSDS SOIS group has just released a File and packet store standard compatible with CFDP and PUS

CFDP – Is it needed?

- Before considering adoption of CFDP we should confirm the need for file transfer:
  - Is it needed to solve a technical mission requirements?:
    - Move to K-band requiring retransmission
    - Increased data rates requiring automation
    - Cross-supported missions
  - Is it related to cost?:
    - Improvement or simplification in mission operations
    - Need to rationalise ad-hoc solutions

- If the need is confirmed, is CFDP is the best available solution?:
  - ✓ International standard, open specification, verified, mission heritage, standard in ground segment, flight avionics support

- Or do we continue to extend the use of PUS service 13
  - ✓ PUS based, so some familiarity, ….?

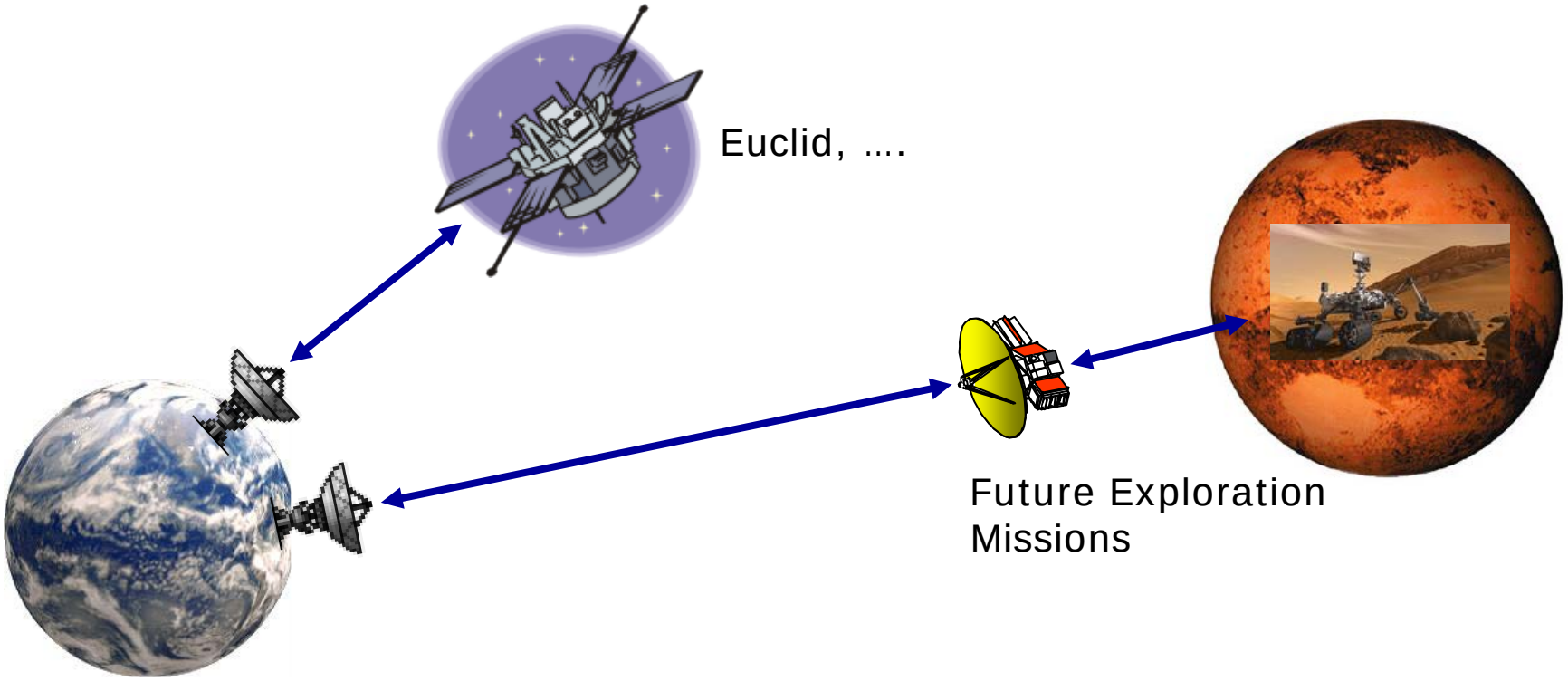
CFDP - Conclusion

- CFDP is an international standard with solid heritage and support

- CFDP was designed to cover many scenarios and this results in some complexity but under the 5 year review we will propose simplifications:
  - Removal of class 3 and 4 (covered by future DTN protocols)
  - Adding of receive file completion capability in class 1
  - Increased file size
  - Better profiling of mandatory and optional features
  - ?? - inputs are welcome

- ***If our missions would benefit from file transfer then it is proposed that CFDP provides the best solution***

Thank you – Questions?



1. backup

CFDP - Basic Operation