Space-Wire Applications for the MMO Spacecraft in BepiColombo Mission

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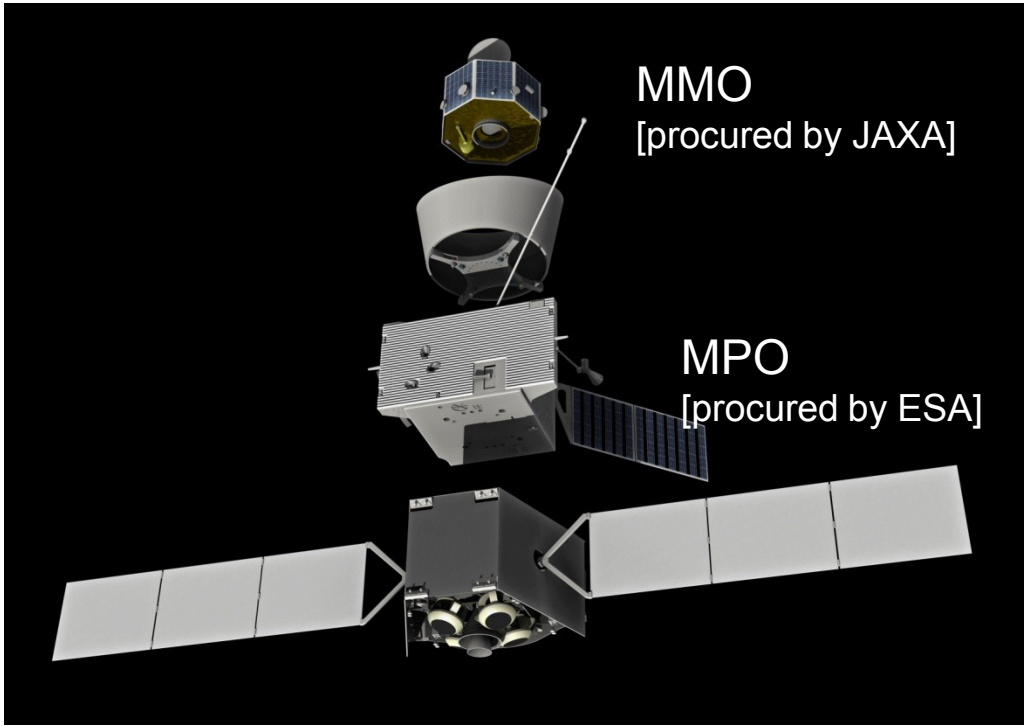
MHI

BepiColombo MMO project Data handling team

NTS, NEC soft, e-SOL

BepiColombo project

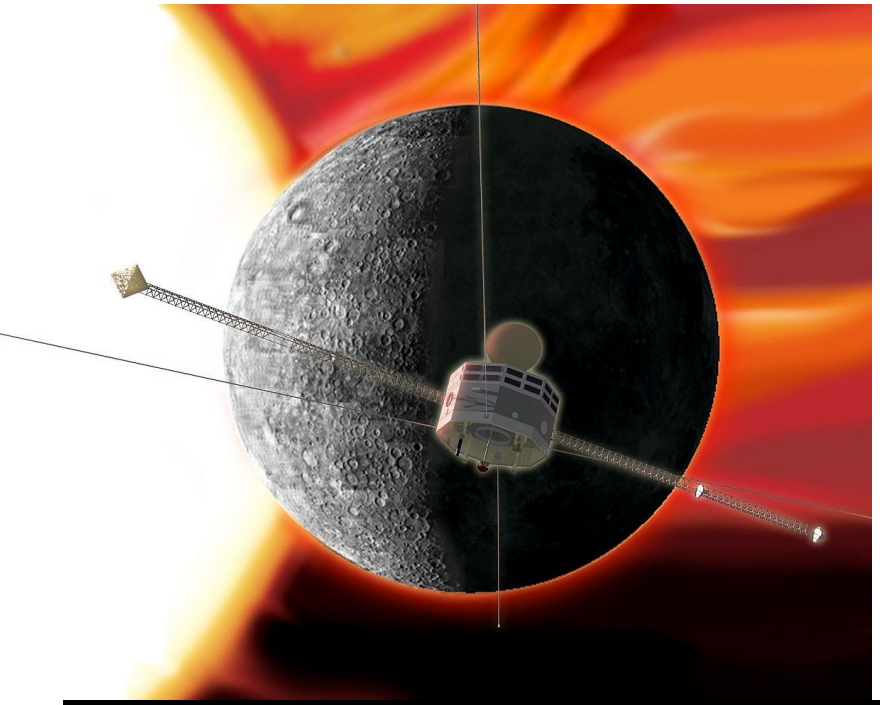
ESA-JAXA joint mission to Mercury



- BepiColombo will set off in 2013 on a journey lasting approximately 6 years.
- It arrives at Mercury in August 2019.
- It gathers the data during 1 year nominal operation & 1-year extension.

1. Origin and evolution of a planet close to the parent star
2. Mercury as a planet: form, interior, structure, geology, composition and craters
3. Mercury's vestigial atmosphere (exosphere): composition and dynamics
4. Mercury's magnetized envelope (magnetosphere): structure and dynamics
5. Origin of Mercury's magnetic field
6. Test of Einstein's theory of general relativity

MMO: procured by JAXA



The MMO spacecraft mainly aims
the first complete study of
the magnetic field and
the magnetosphere
of this unique terrestrial-type planet.

JAXA is responsible for its development and employment on the Mercury orbit.

The main objectives of the MMO spacecraft are as follows:

- **Structure and origin of Herman magnetic field**
  For the first comparative study of other planetary magnetic field.
- **Structure, dynamics, and physical processes of Herman magnetosphere**
  For the first complete study of other planetary magnetospheres.
- **Structure, variation, and origin of Herman exosphere**
  For the thin 'atmosphere' : their generation / disappearance processes.
- **Environment of inner solar system**
  For the powerful environment near the sun and their the energy process

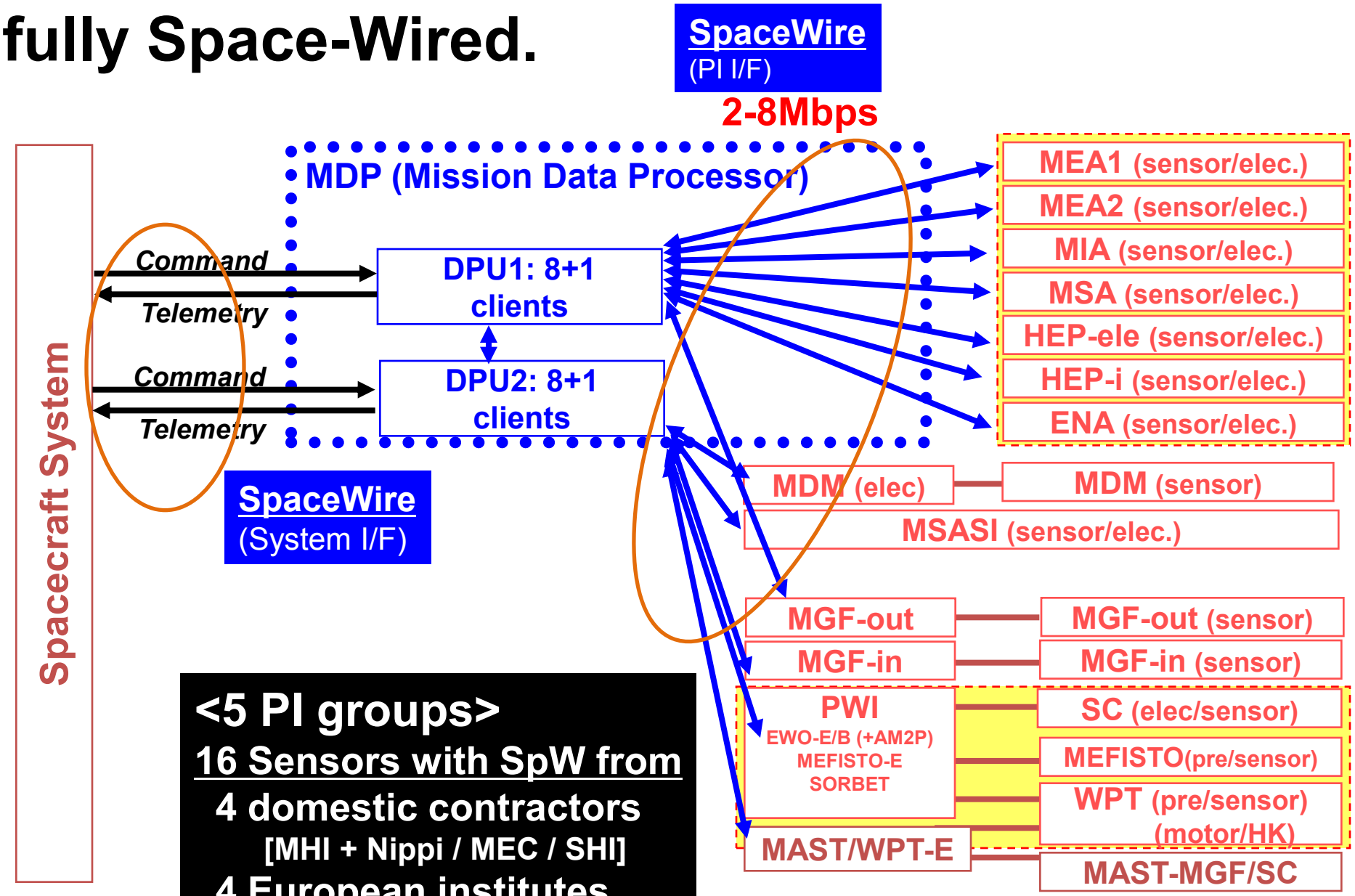
MMO Science Instruments

Particle	Electron Spectrum Analyzer (ESA)	Low-energy electrons	10eV ~ 30keV, dt=1sec
	Ion Mass Spectrometer (MSA)	Low-energy ions	10eV ~ 30keV, dt=2sec
	Solar Wind Analyzer (SWA)	Solar wind ions	10eV ~ 30keV, dt=4sec
	High-Energy Electrons (HEP-e)	High-energy electrons	30keV ~ 700keV
	High-Energy Ions (HEP-i)	High-energy ions	30keV ~ 1MeV
	Energetic Neutral Atmos (ENA)	Plasma imaging	100eV - 3keV
Field	Magnetometer (MGF) MGF-O / MGF-I	Magnetic field	DC ~ 64Hz [MAST:5m]
	Plasma Wave Investigation (PWI) EWO / SORBET / AM2P WPT / MEFISTO / SC-DB / SC-LF	Electric field, Plasma wave, Radio wave	DC ~ 10MHz (E) [probe:15m x 4] few ~ 640kHz (B) [MAST:5m]
Image	Mercury Imaging Camera (MSASI)	Na-atmosphere spectral imaging	FOV=~8°
Dust	Mercury Dust Moniter (MDM)	Interplanetary Dust	PZT: Count & Velocity

- To be developed by different institutions and different countries.
- There is a suspicion of misunderstanding of the I/F.

In order to simplification of the I/F and testing,
JAXA selected SpaceWire for all TLM/CMD interfaces.

Logical connection is fully Space-Wired.



<5 PI groups>

16 Sensors with SpW from

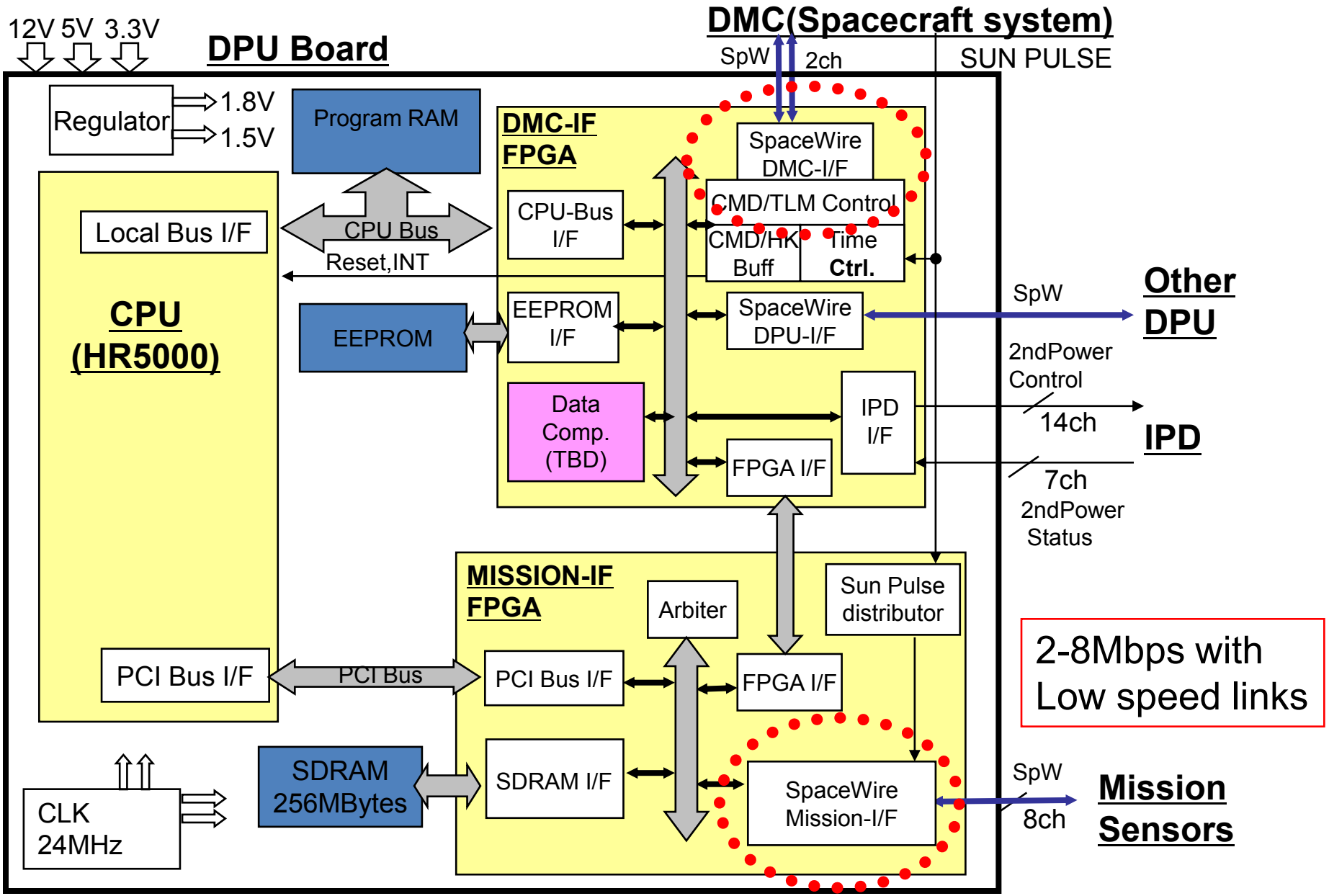
4 domestic contractors

[MHI + Nippi / MEC / SHI]

4 European institutes

[Austria/France/Sweden]

Overview of data acquisition: by MDP/DPU



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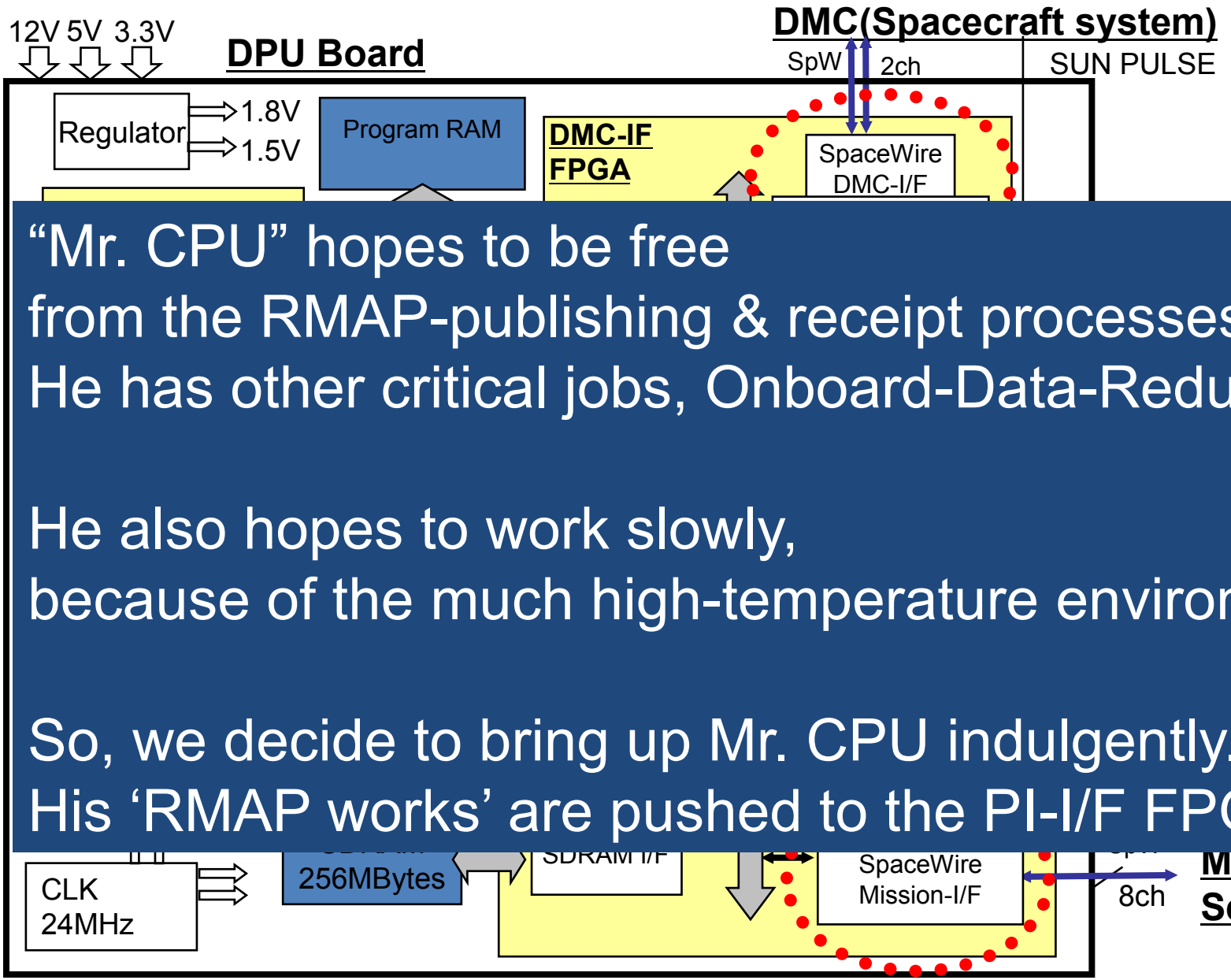


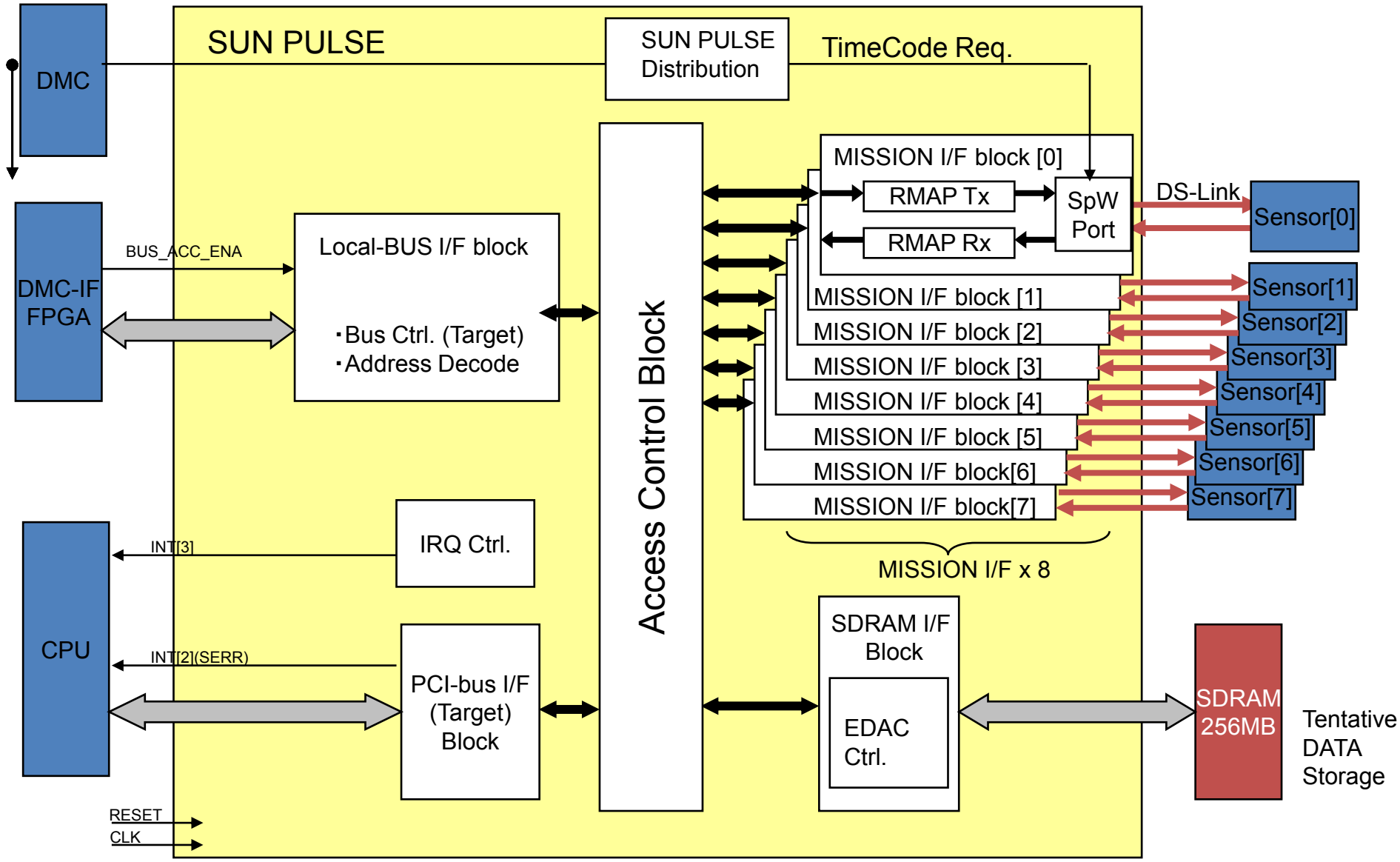
"Mr. CPU" hopes to be free
from the RMAP-publishing & receipt processes.
He has other critical jobs, Onboard-Data-Reduction!

He also hopes to work slowly,
because of the much high-temperature environment.

So, we decide to bring up Mr. CPU indulgently.
His 'RMAP works' are pushed to the PI-I/F FPGA.

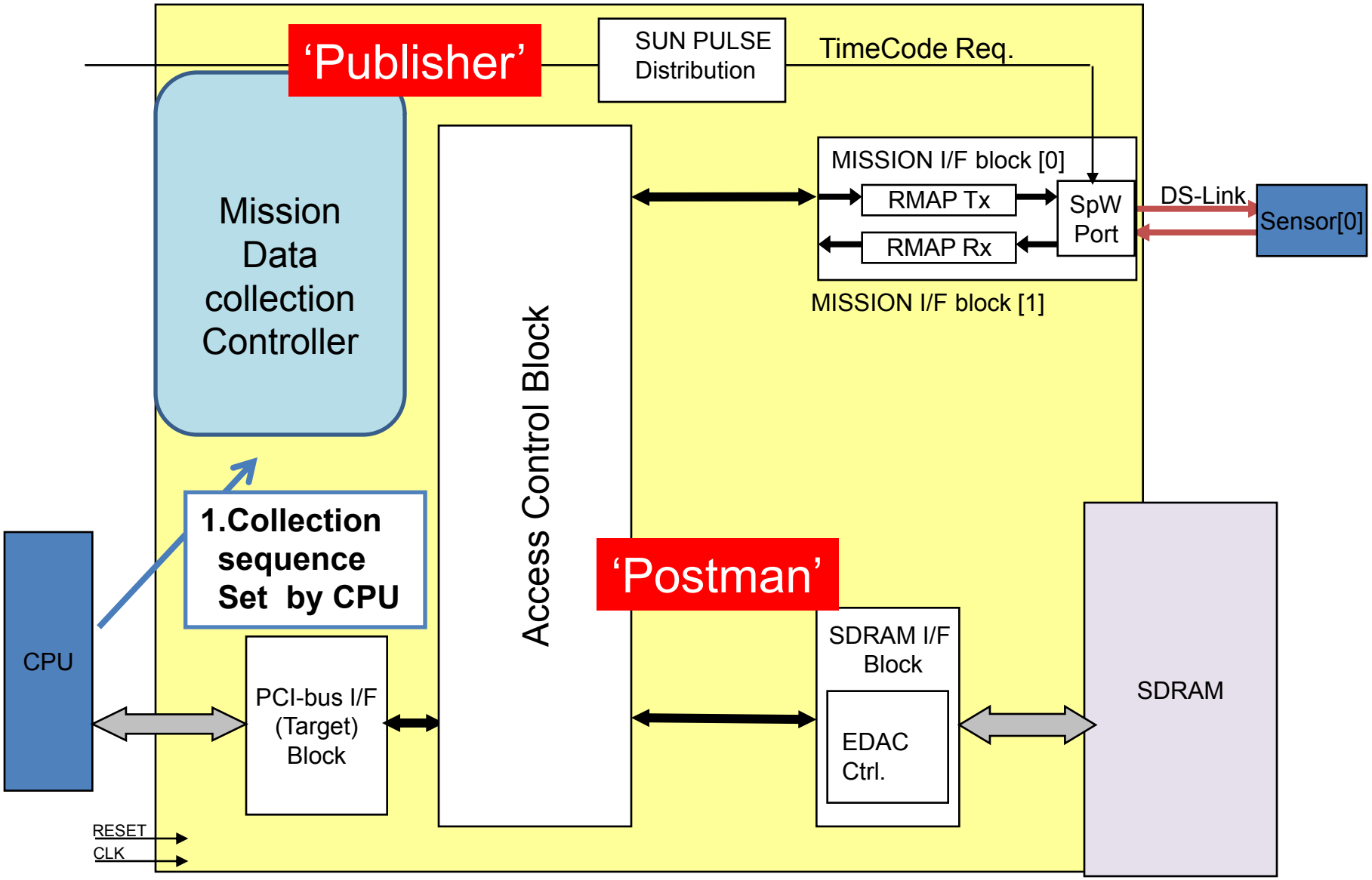
Mission-I/F FPGA

~ The manager for SpW and Data Storage ~



TLM collection: by RMAP Read

~automatic RMAP-read process by MDP-FPGA~



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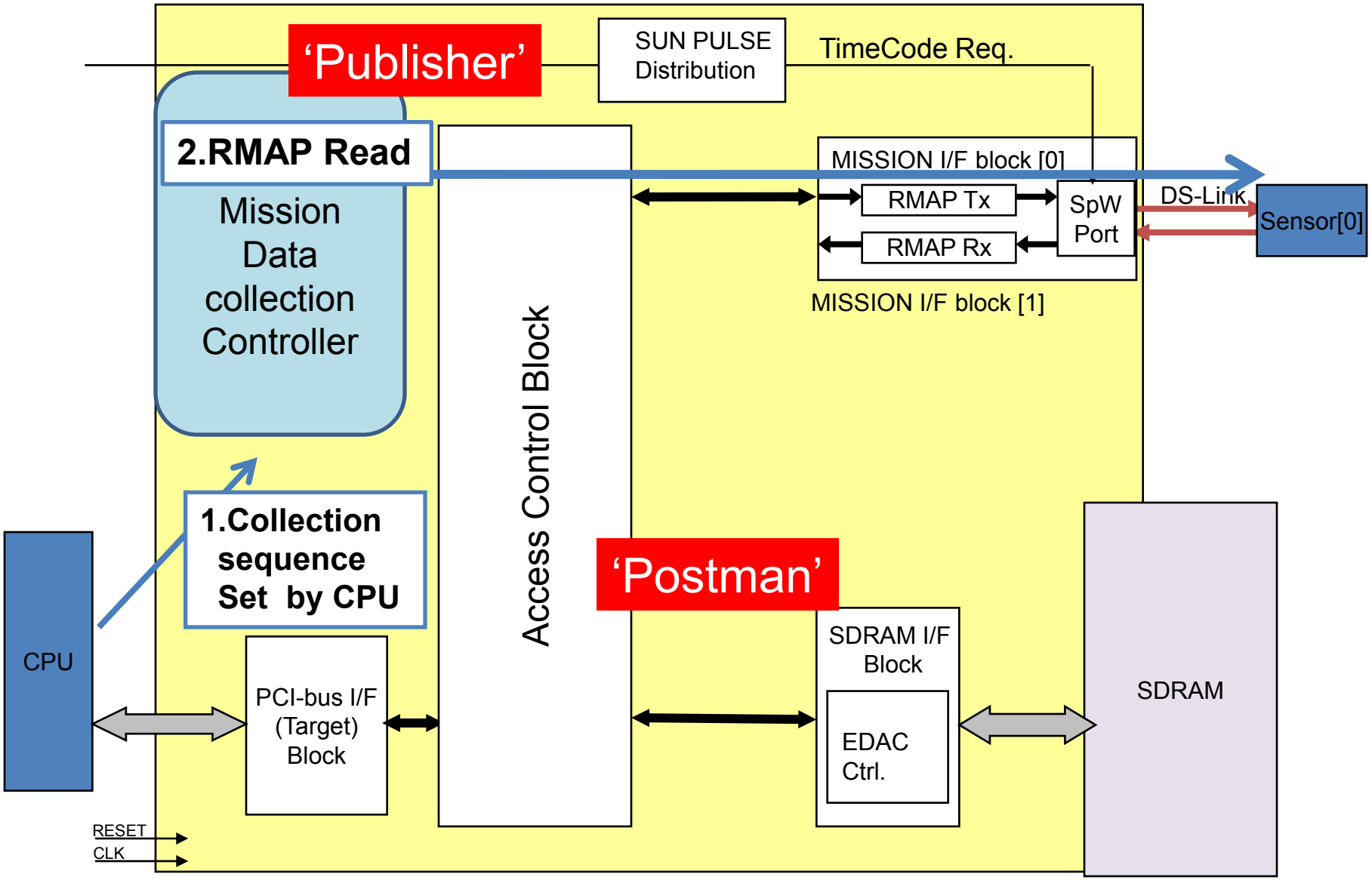

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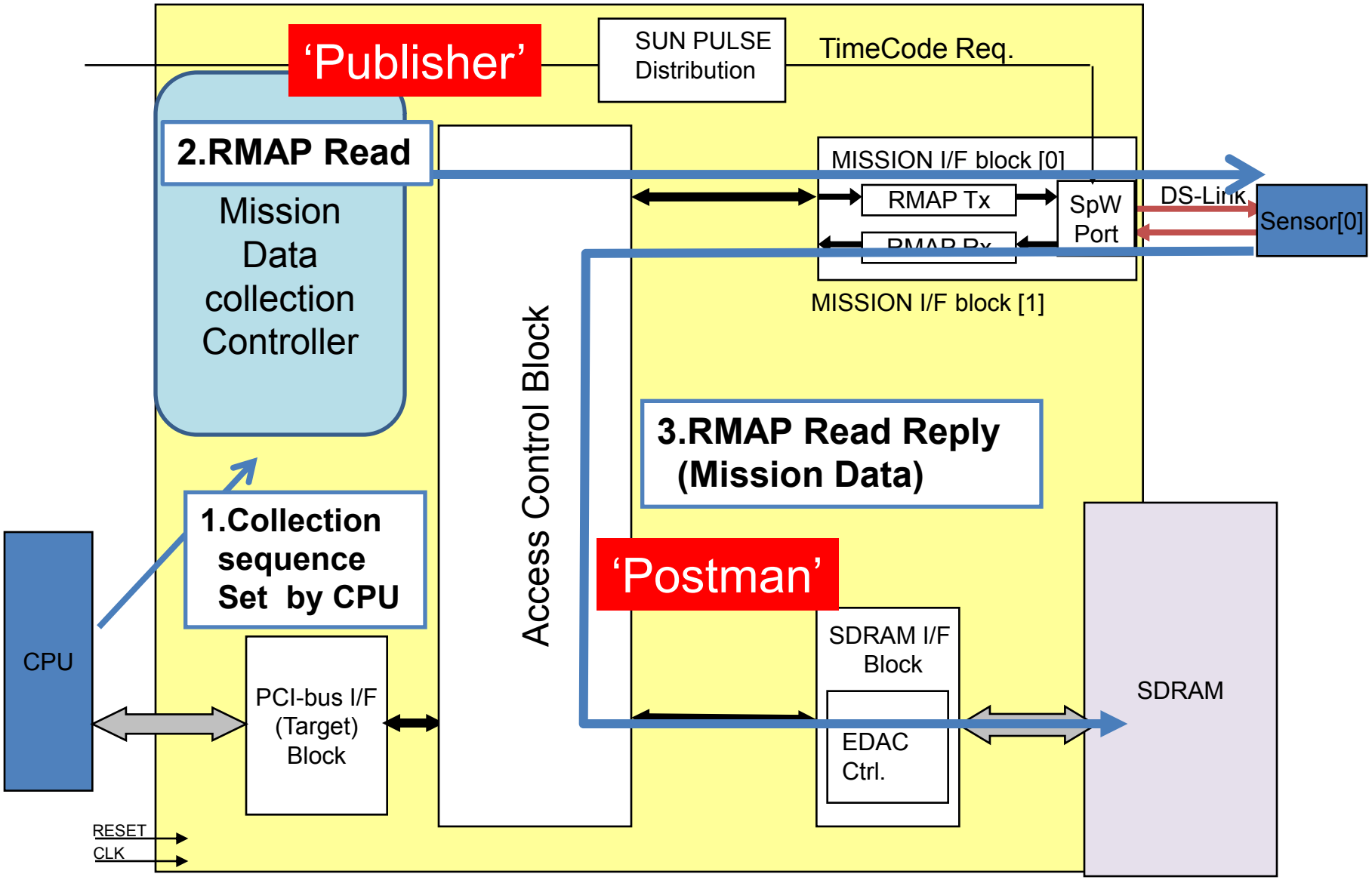

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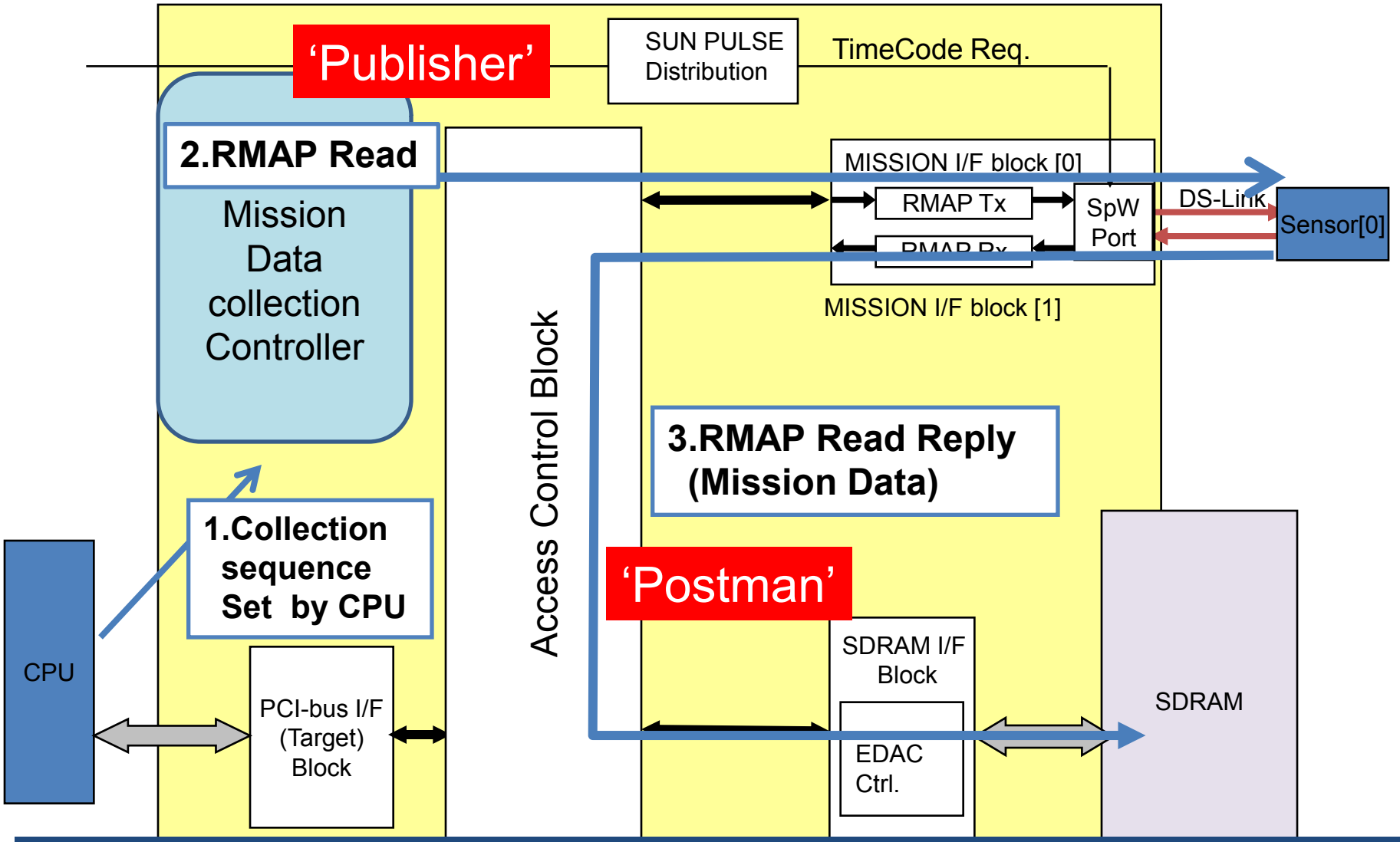
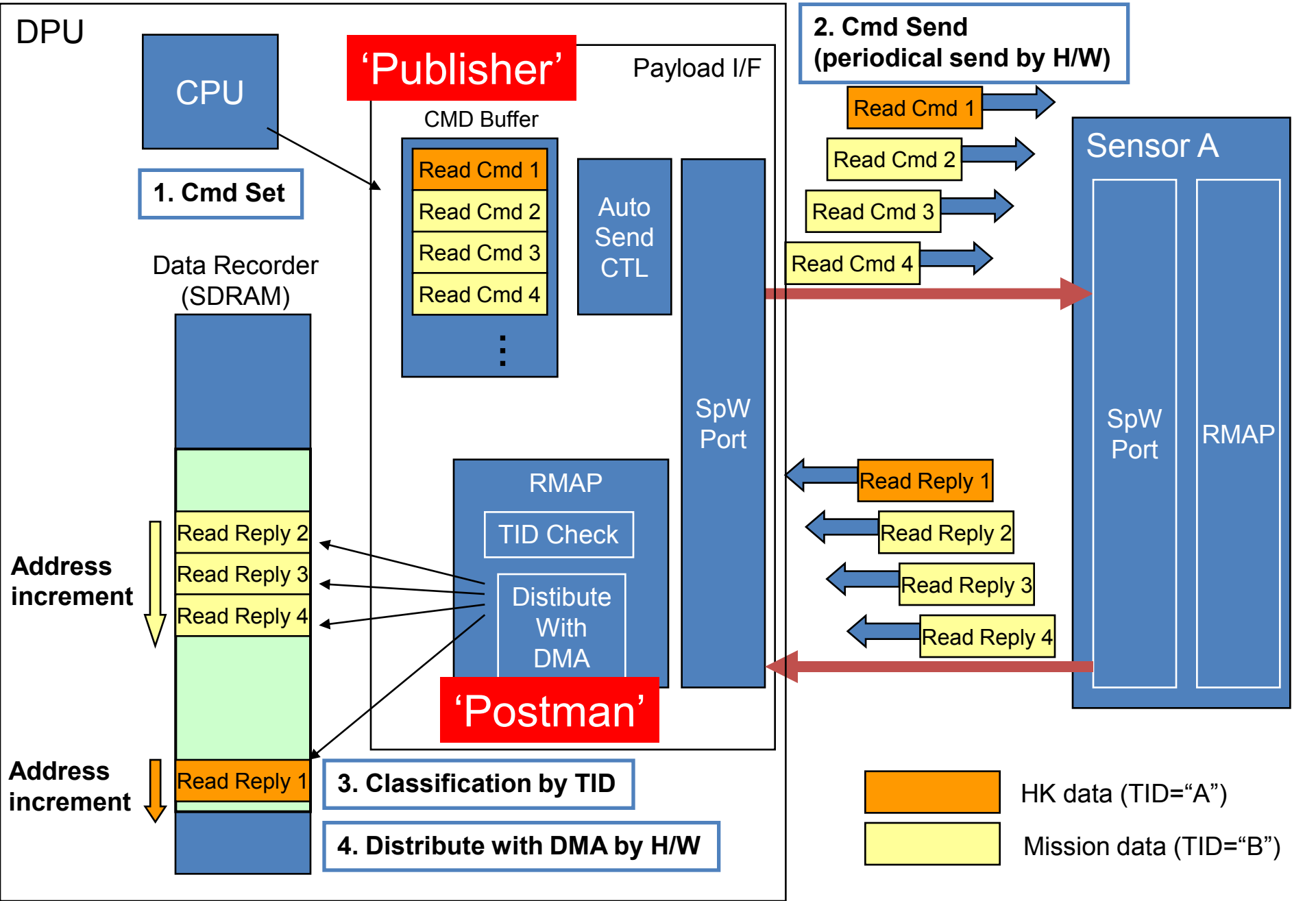
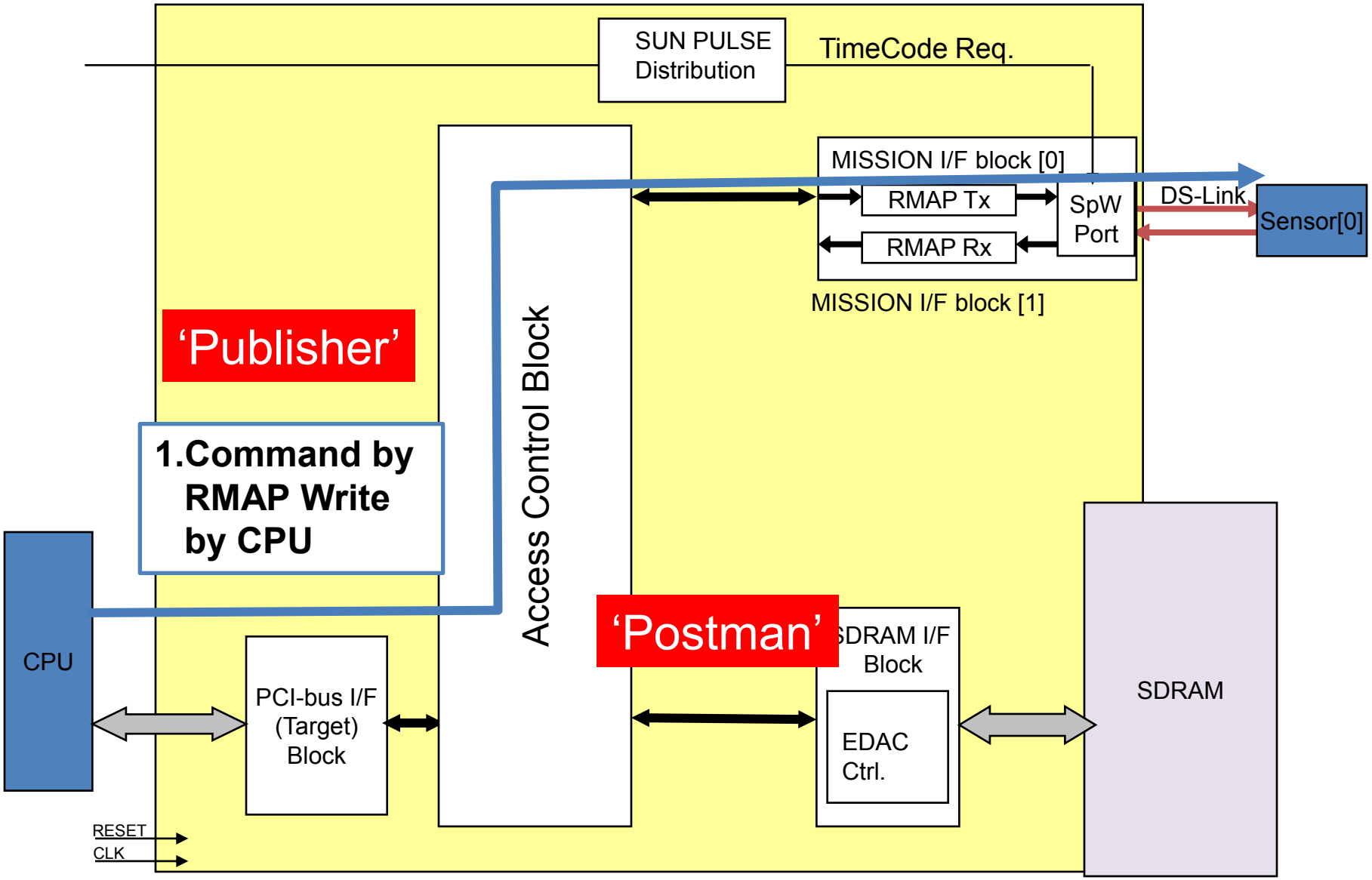


CPU only does 'Set CMD-sequence' & 'Activate the sequence'.

TLM collection: by RMAP Read



Command: by RMAP Write



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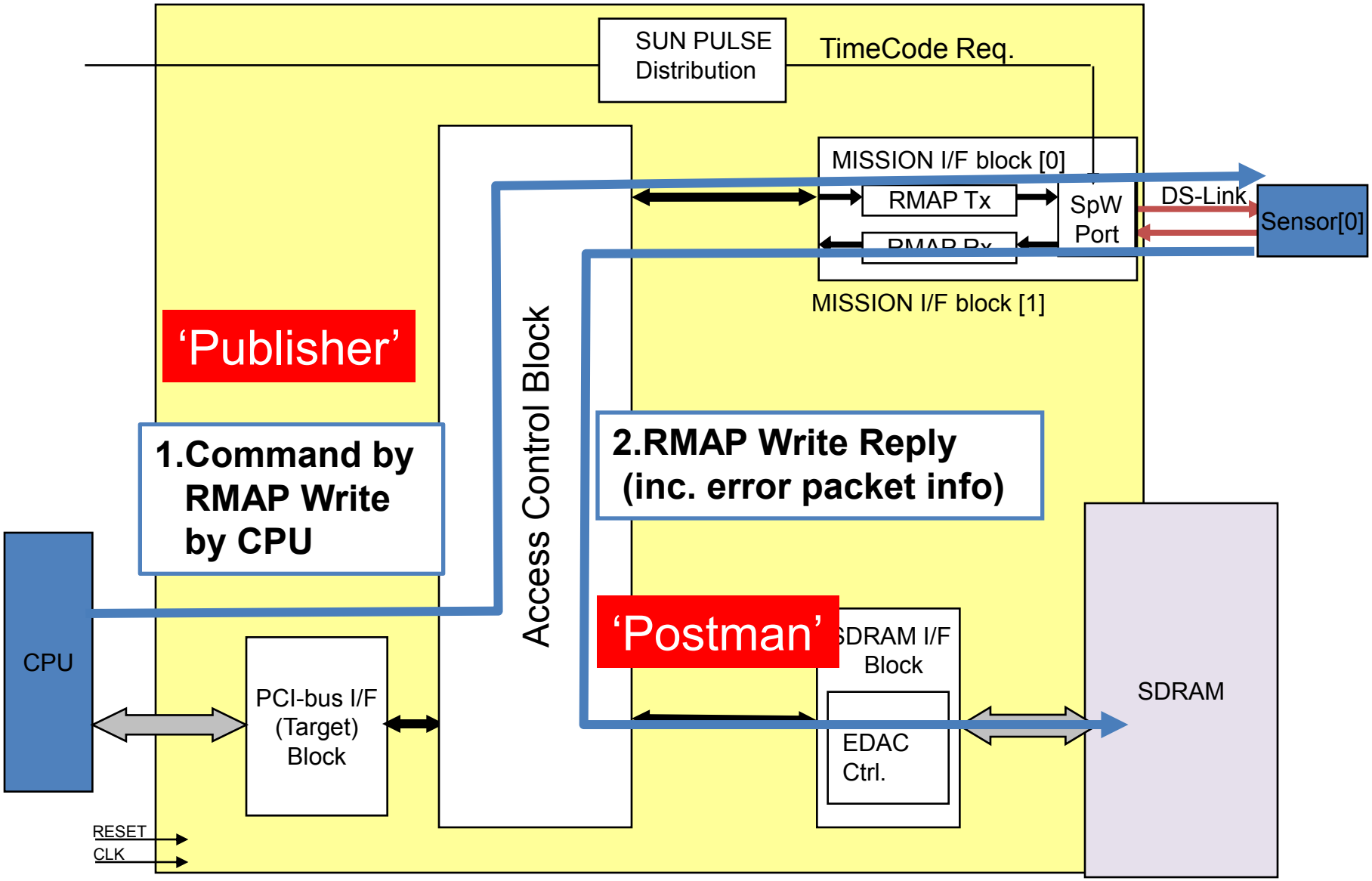

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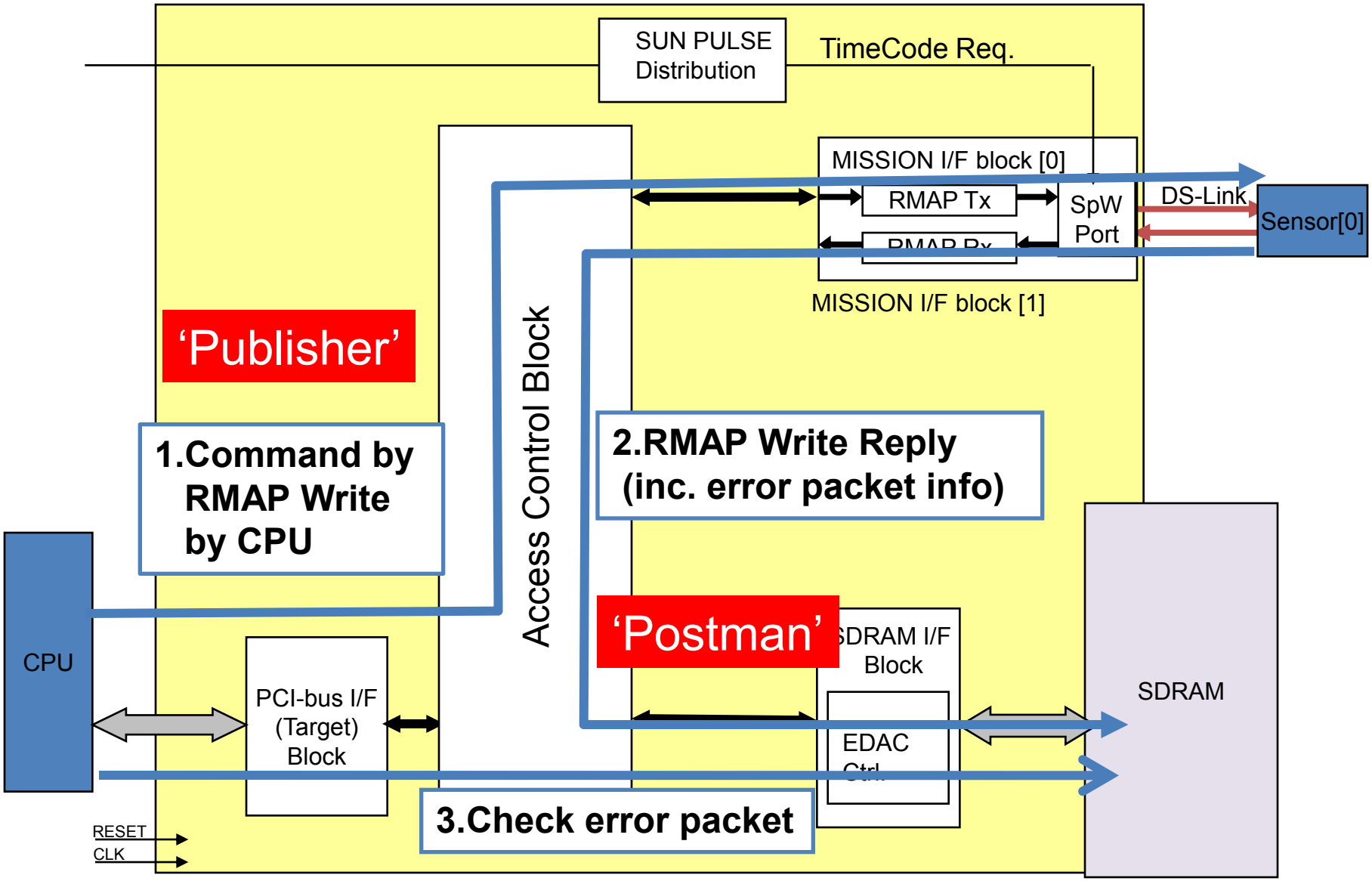

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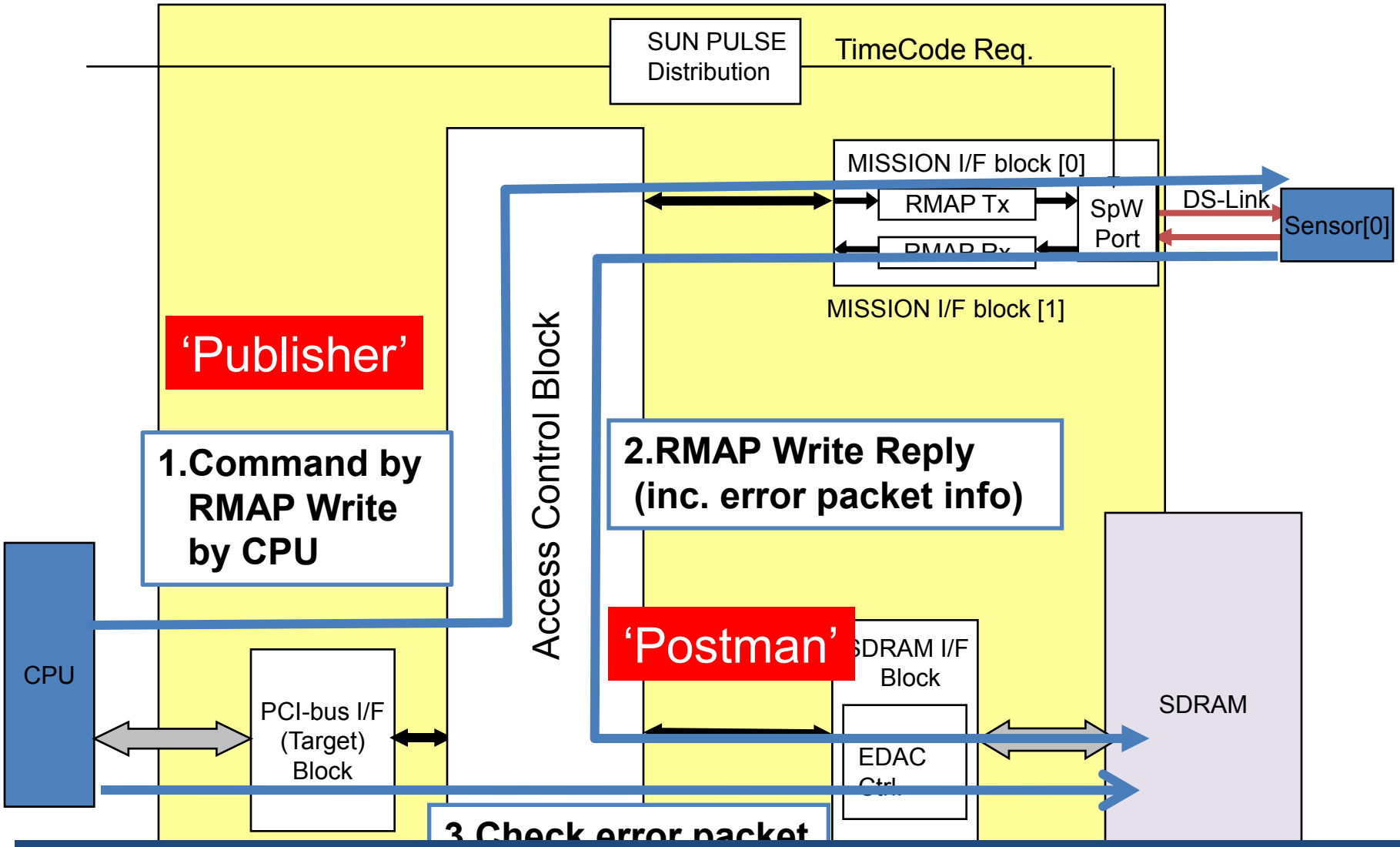
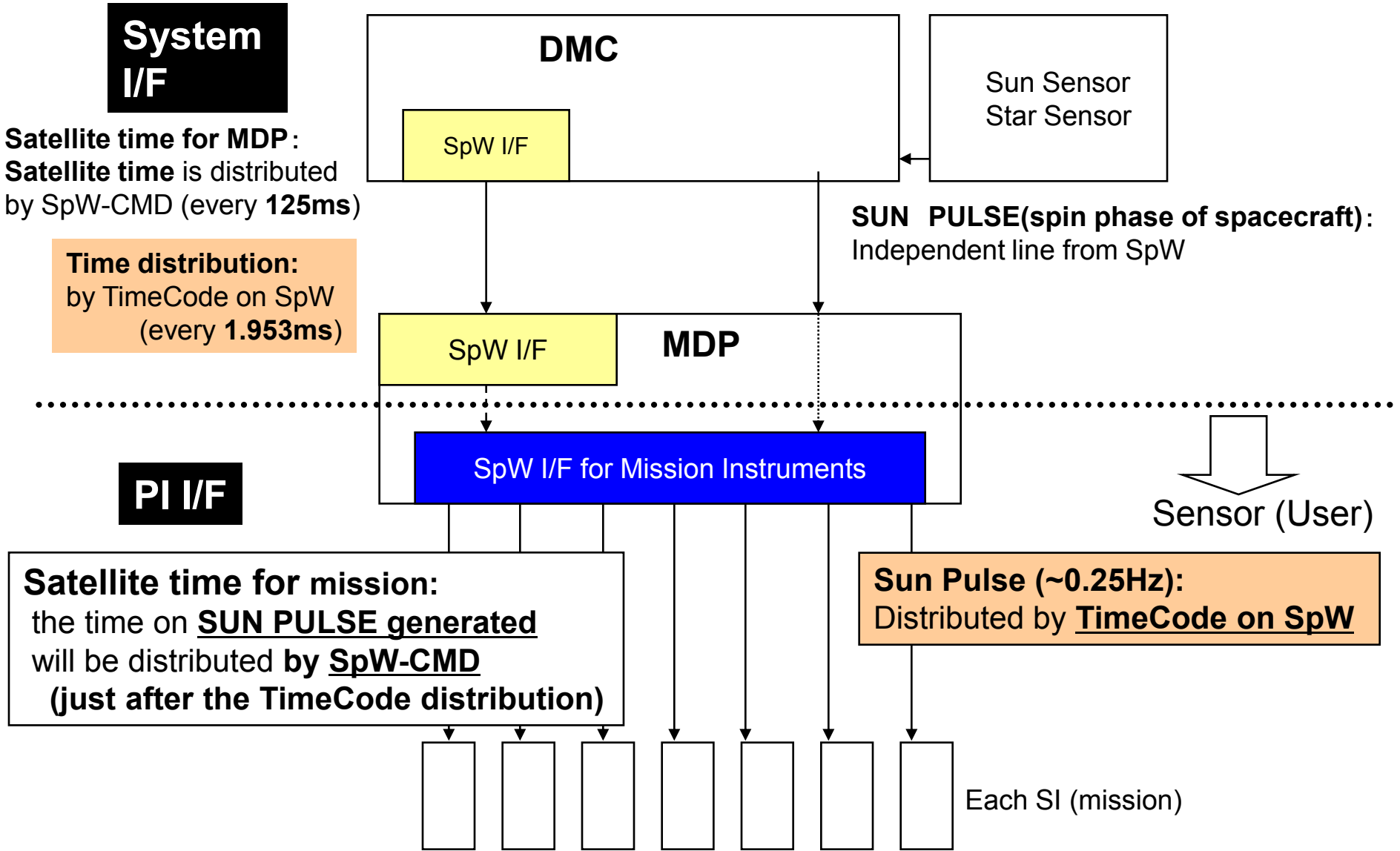


CPU only does 'Set CMD-sequence' & 'Activate the sequence'.

Timing Control

"Time tick" is used by synchronous timing pulse
[TLM timing (system I/F) / Spin phase of spacecraft (PI I/F)]



Summary

- All over the MMO TLM/CMD communications are designed using SpaceWire I/F.
- Data collection sequence from mission sensors is controlled by the Mission I/F FPGA
  by RMAP Read / Read-reply (TLM) &
  RMAP Write / Write-reply (CMD).
  CPU only does the set up & start triger.
- Time-Code on SpaceWire is used to distribute
  spacecraft time to MDP (system I/F) &
  the timing of sun-pulse (PI I/F).