

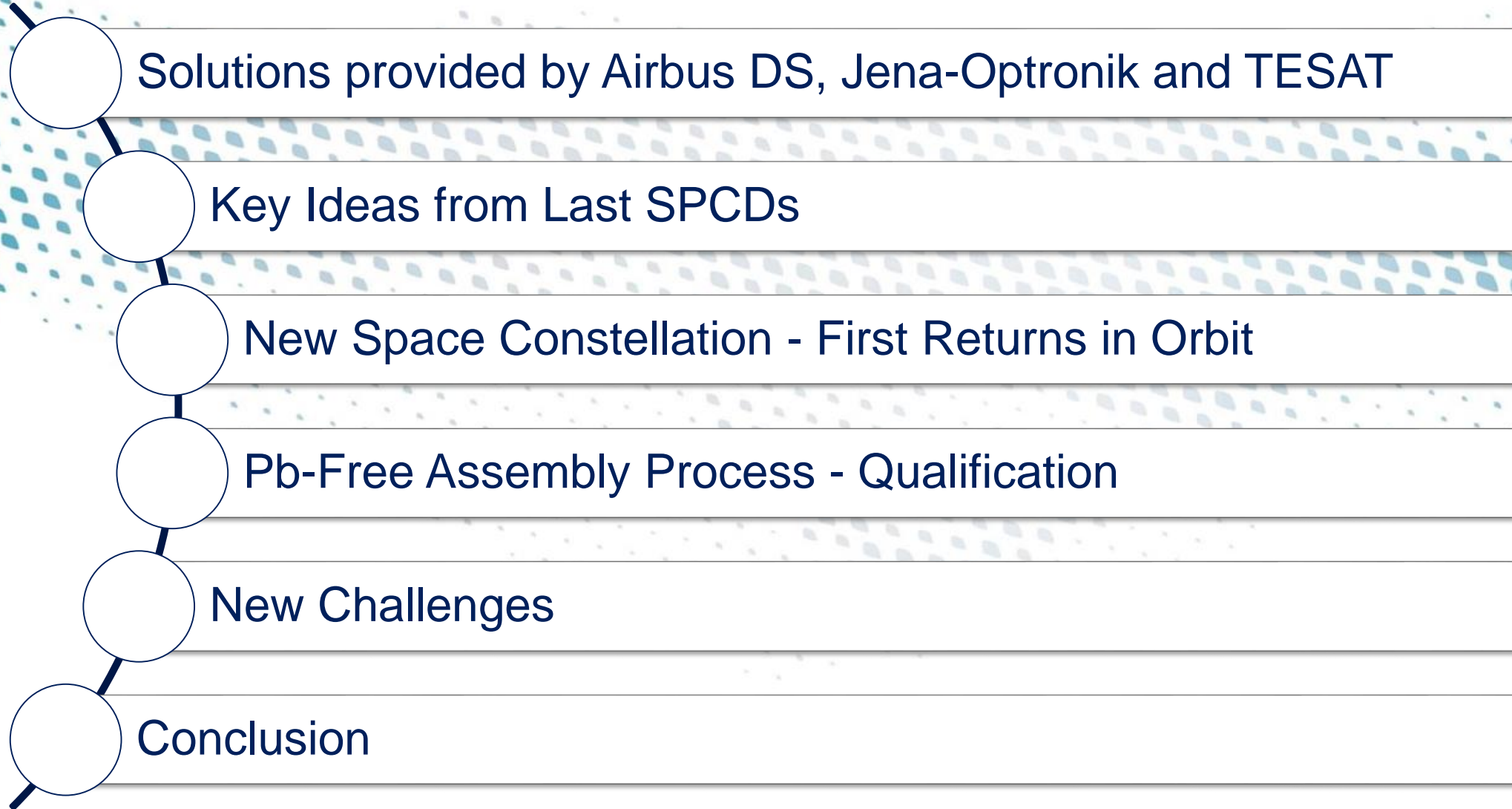


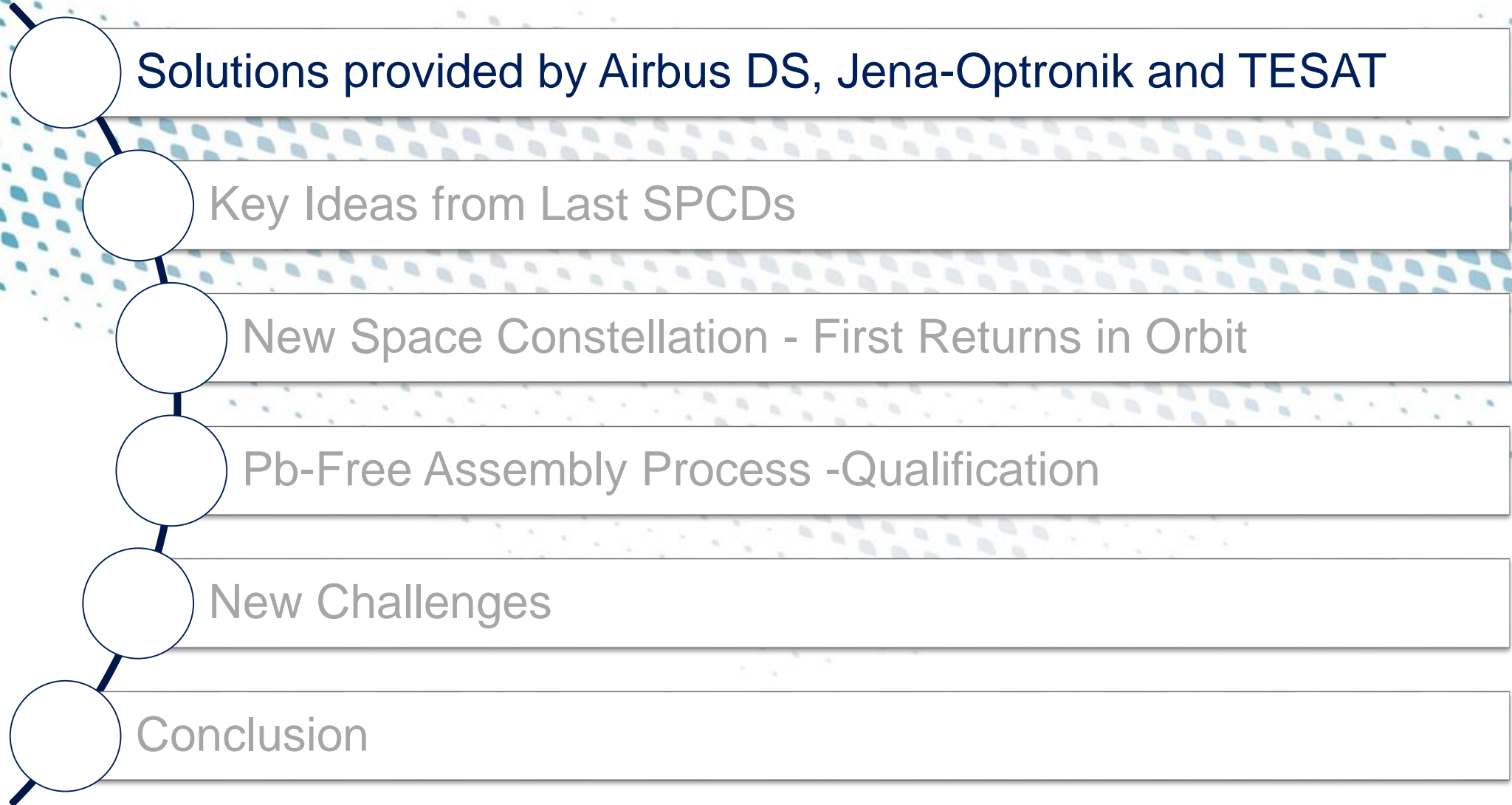
SPACE PASSIVE COMPONENTS DAYS 2022

AIRBUS DEFENCE AND SPACE ROAD-MAP



AIRBUS

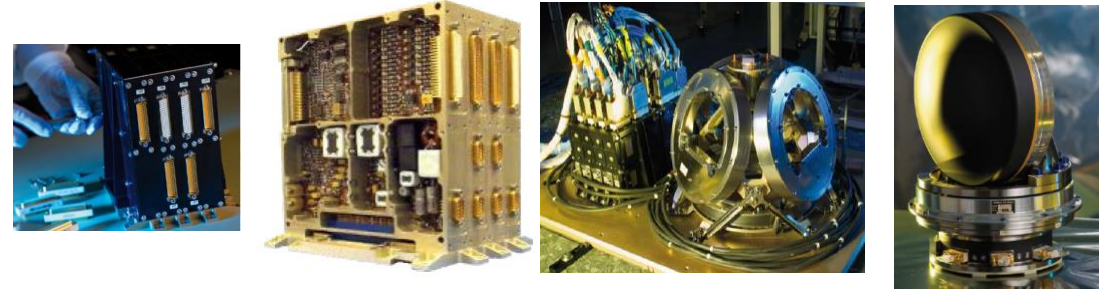




Solutions provided by Airbus DS, Jena-Optronik and TESAT

■ Avionics

- On-Board computer, Fibre-Optic Gyro, Control Momentum Gyro, GNSS, Pay-load Interface Unit, Star and Sun Sensors, LIDARs



■ Power

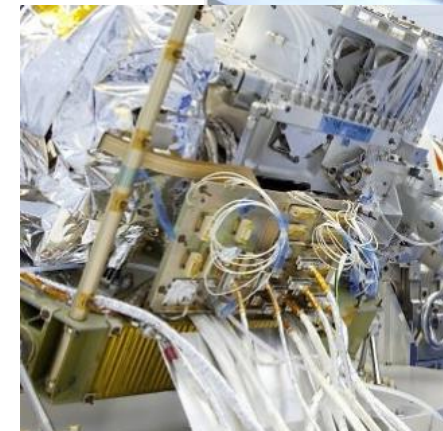
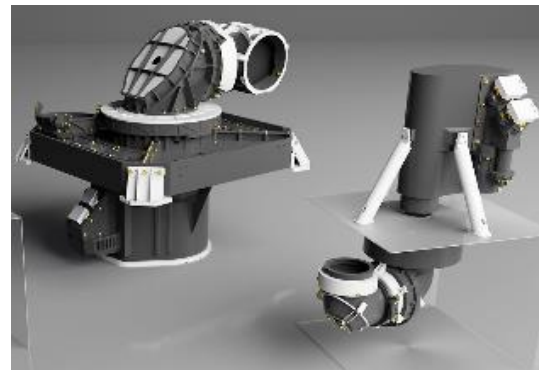
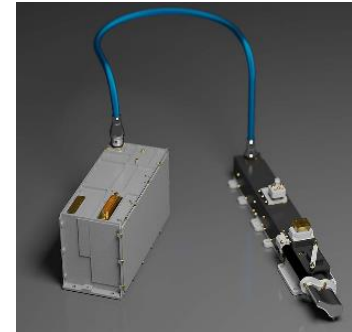
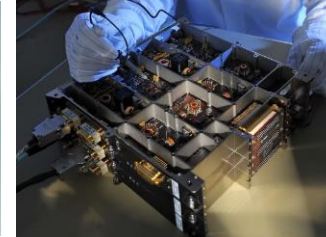
- Power Control and Distribution Unit, Power Propulsion Unit, Solar Arrays, Power DC-DC Converters



Solutions provided by Airbus DS, Jena-Optronik and TESAT

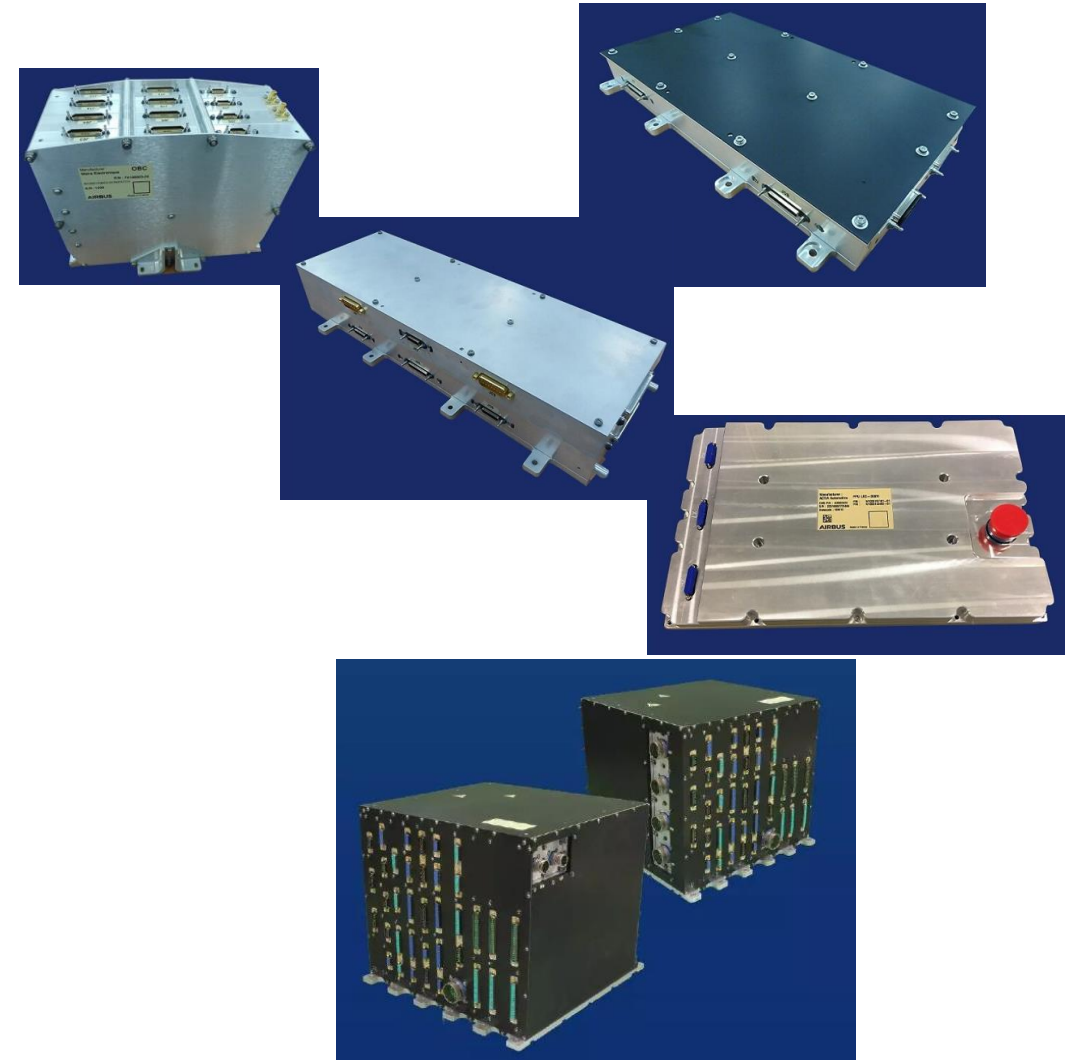
■ Payload

- Solid State Recorder, Compression, Ciphering, High Performance Data Processing
- Navigation Sub-system
- RF Payloads: Datalink Products, Active and Passive Products
- Instruments: Multi-Spectral Imager, Air Quality and Greenhouse Gas
- Laser Communication Terminals



Solutions provided by Airbus DS, Jena-Optronik and TESAT

- New Space equipment
 - On-Board Computer, Power Control and Distribution Unit, Payload Interface Unit, Electric Propulsion
- Launcher
 - Ariane 5 and Vega: Sequential Electronics, Turbo-Pump Speed Conditioner
 - Vega; Multi-functional Unit (1553 Repeater, Power Source and Distribution, Safety Management,...)
 - Ariane 6 and Vega-C: Centralized Multi-functional Unit (OBC, Triggered Ethernet Switch, EV Command, Power Distribution), Pyro Command, Battery Assembly



Solutions provided by Airbus DS, Jena-Optronik and TESAT

- This large portfolio requires a large panel for passive components including
 - Resistors: chip thick and thin film, shunt, wire-wound, ...
 - Capacitors: multiple-layer ceramic chip type I and II, single layer ceramic chip, metallized film, reconstituted mica, solid tantalum, ...
 - Inductors: chip RF, power with low DCR, power with high current saturation, ...
 - Transformer: current measurement, gate drive command, data-bus interface, planar, high power, high voltage, ...
 - Connectors: Sub-D, Micro-D, RF, high data-rate, circular, rack and panel, interposer ...
 - Electromechanical relays are still used!
 - ...

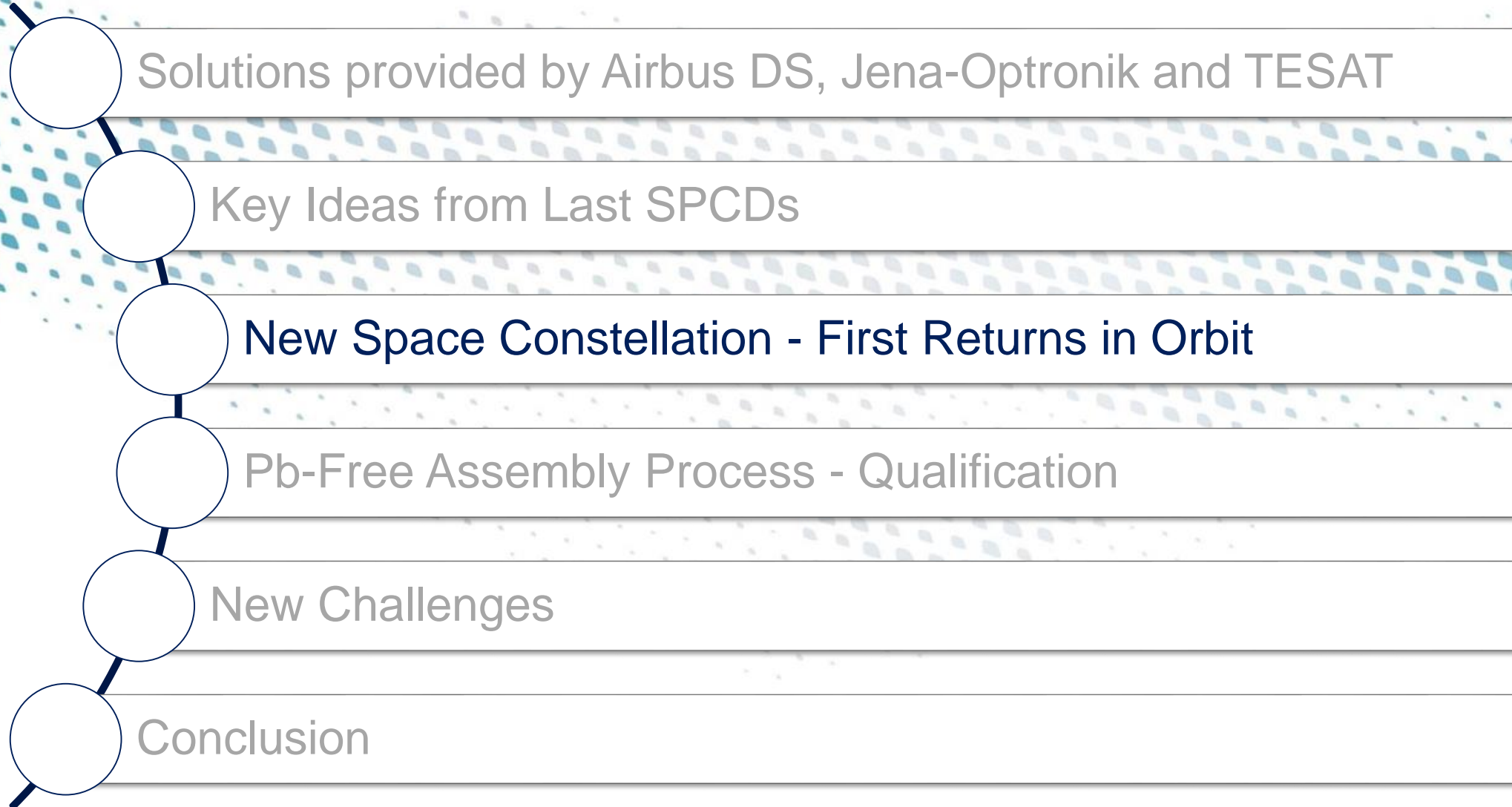


Key Ideas from the Last SCPDs

- Remarks from all SCPDs: lower size, higher performance, higher frequency, higher power and current to be managed and lower cost Still valid
- Usage of System-On-Chip and Large FPGA with many low supply voltages, high current, high frequency interface Introduced
- Usage of GaN FET with high switching frequency and high current Introduced
- Optical Link Management Introduced
- High Data Rate Management (frequency to be increased) In progress

Key Ideas from the Last SCPDs

- New Space Electronics with AEC-Q200 Introduced
- Pb-Free Assembly Process Qualified
- 100% in Automatic Assembly Almost achieved
- European Manufacturer Offer vs Required Technology Not complete

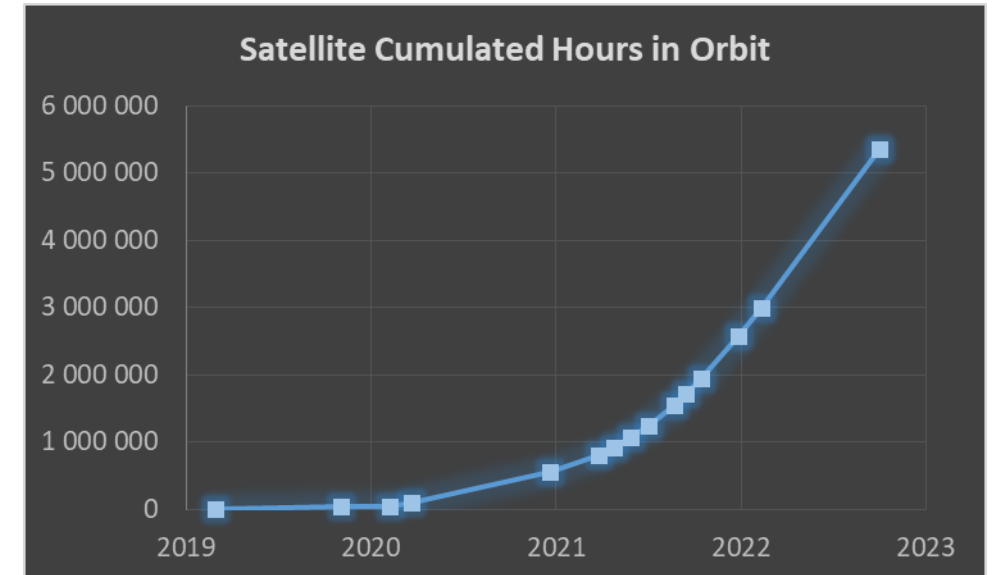


New Space Constellation - First Return of Experience

- Remainder for the selection, procurement, validation and assembly for passive components
 - Automotive AEC-Q200 for most of the part
 - No additional validation test, except for magnetic components with outgassing check
 - No additional screening and lot acceptance
 - Pb-free assembly process
 - No additional derating on ESA standard ECSS-Q-ST-30-11C Rev. 1

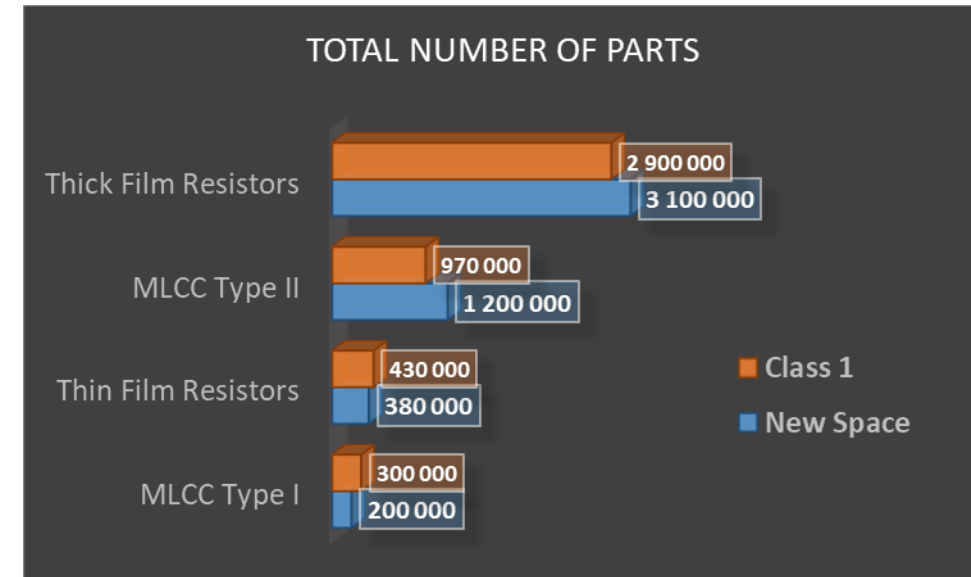
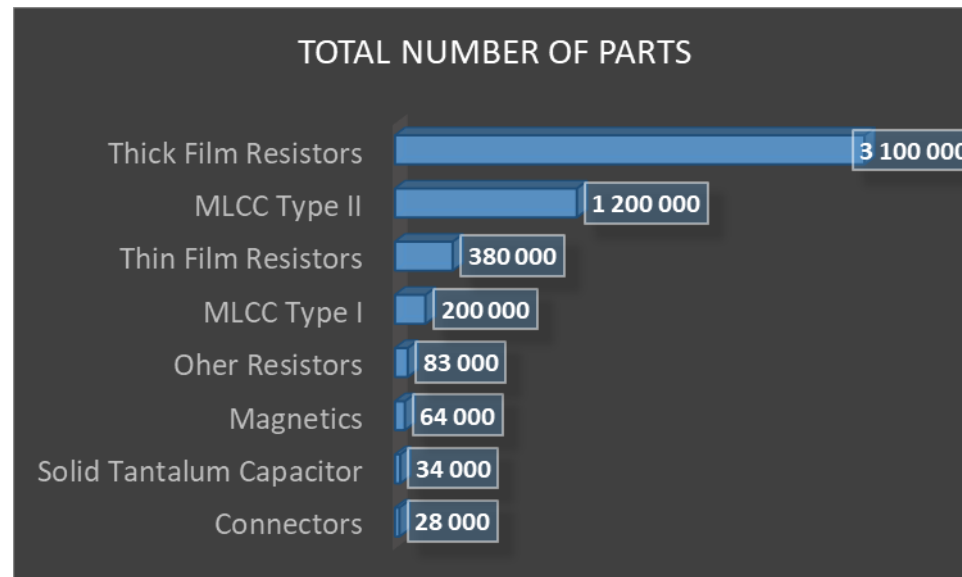
New Space Constellation - First Return of Experience

- New Space
 - 424 satellites in LEO orbit, first launch in 2019
 - More than 610 cumulated years in orbit (more than 5.5 Millions hours)
 - No lost in orbit due to passive component failures
- To Be Compared with Standard Space for Telecom
 - 104 delivered Telecom Geo for the last 30 years
 - 55 currently in Operation
 - More than 1000 cumulated years in orbit (more than 9 Millions hours)
 - No lost in orbit



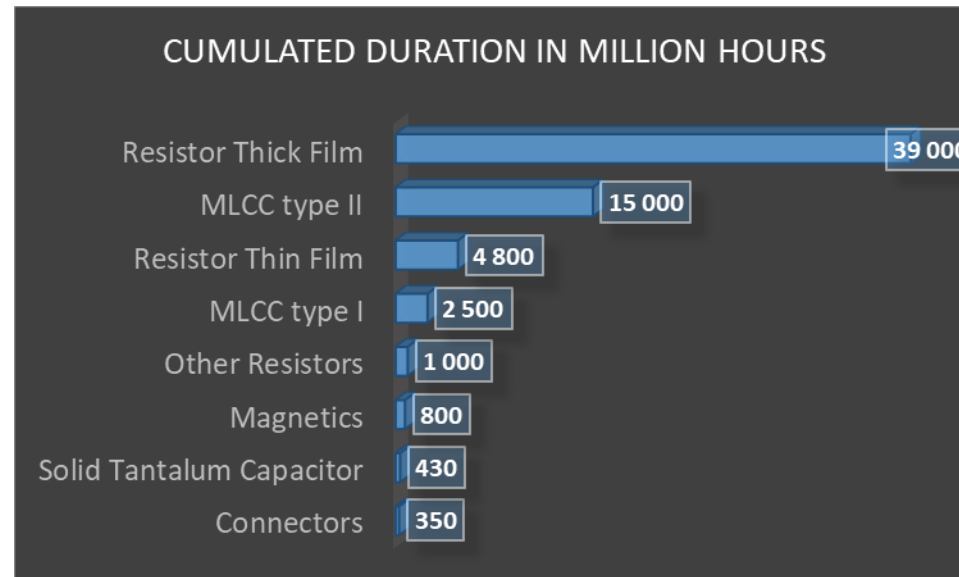
New Space Constellation - First Return of Experience

- Perimeter for cumulated number of components and hours in orbit of Airbus DS electronics
 - On-Board Computer, Power Control Distribution Unit and Pay-load Interface Unit
 - The number of components in orbit is equivalent to 10-year procurement of GEO plate-form parts



New Space Constellation - First Return of Experience

- Cumulated number of hours in orbit vs passive part families without failure



- These figures would tend to confirm the very low Early Failure Rate of Automotive components



Pb-free Assembly Process - Qualification

■ Principles

- 3 sites (in Germany, France and Spain)
- Sharing a list of common parts, including chip resistors and ceramic capacitors, with same foot-prints
- But with specific parts for example magnetics, shunt, thermistors, ...
- Using the same assembly process: brazing past, vapour phase apparatus and profiles, cleaning process, coating, ...

■ Component Selection

- Automotive AEC-Q200 qualified
- ROHS terminations: mainly 100% matte tin, SAC405 for some magnetics parts, ...
- More than one manufacturer for the most standard parts (chip resistors, chip ceramic capacitors, ...)

Pb-free Assembly Process - Qualification

■ Assembly Process

- 2 vapour phases, except for heavy components, and repair operation
- Gluing when necessary
- Coating

■ Qualification Tests

- Vibrations for all parts
- Mechanical shocks (for sensitive components, like magnetics, stacked ceramic capacitors,...)
- Thermal cycling (at least 500 cycles for surface-mount components)

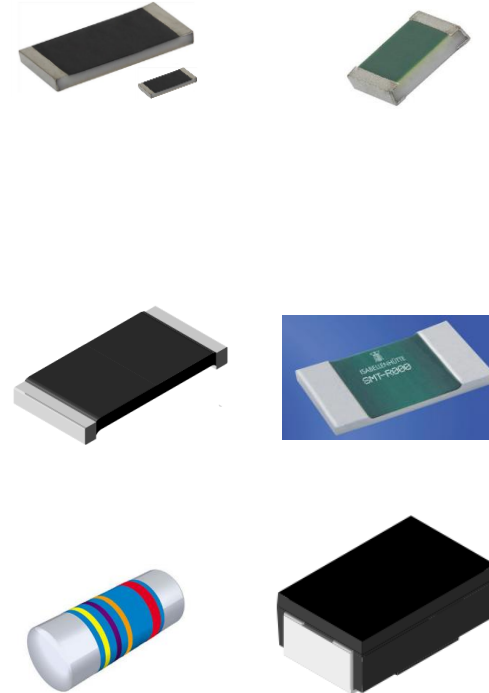
■ Check Procedure (depending on site)

- Micro-sectioning after thermal cycles
- And/Or electrical monitoring
- And/Or Electrical measurements for magnetics and stacked capacitors considered as sensitive

Pb-free Assembly Process - Qualification

■ Results

- Chip resistors with thin and thick film, including jumpers
 - Several manufacturers
 - Size from 0402 up to 1206
 - No issue
- Shunts resistors
 - Several manufacturers
 - Size from 0603 to 2520
 - No issue
- Other resistors like carbon film or wire-wound
 - MELF 0207 and EIA 2515 and 6927
 - No issue



Pb-free Assembly Process - Qualification

■ Results (cont'd)

• Chip ceramic type II capacitors

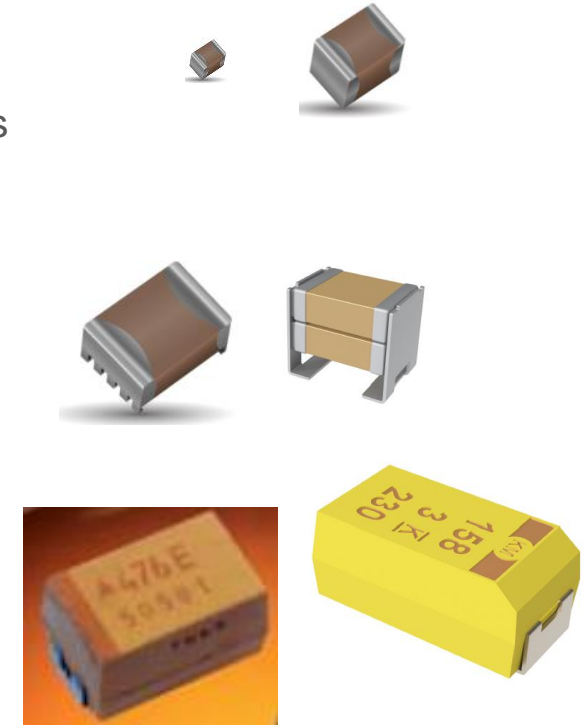
- Several manufacturers for the same part, BME technology, standard and flex terminations
- Size 0402 to 1210 for standard parts, bigger sizes up to 2220 for one site
- No issue, no crack even with hand soldering process, no difference between parts with or without flex terminations

• Stacked ceramic type II capacitors

- Two manufacturers with similar packages, BME technology
- Size: 2 stacked 2220 chips
- No issue, no crack even with hand soldering process

• Solid tantalum capacitor, MnO₂ and polymer, multi-anode

- Several manufacturers
- Size case E (EIA 7343-43) for MnO₂ and X (EIA 7343-40) for Polymer
- No issue

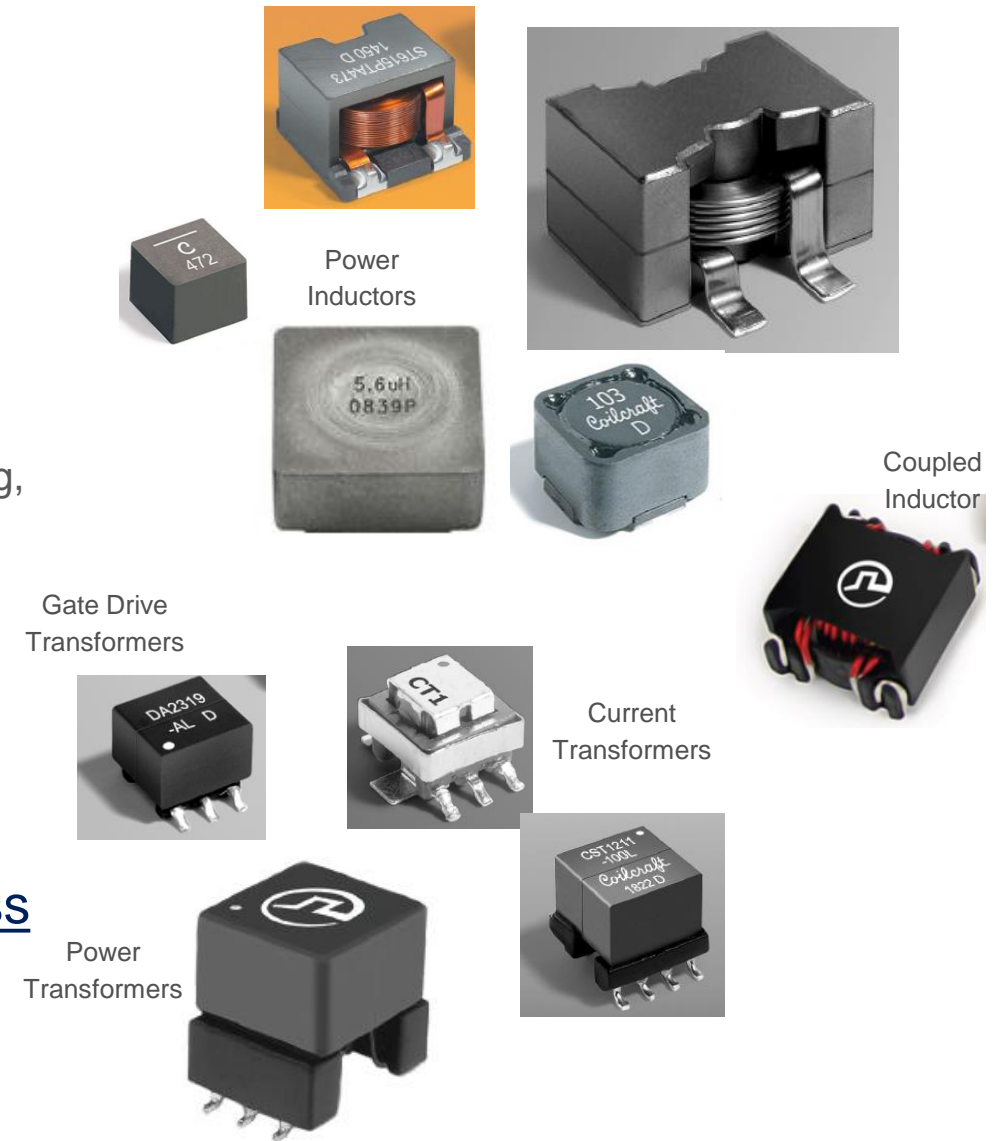


Pb-free Assembly Process - Qualification

■ Results (cont'd)

- Magnetics: inductors, coupled-inductors, transformers
 - Many different packages and technologies
 - 4 different manufacturers
 - All AEC-Q200 parts
 - Electrical measurements after each step (assembly, gluing, coating, vibrations, shocks and thermal cycles)
 - No issue, except for one inductor series presenting a significant $\Delta L/L$ but not directly due to the Pb-free reflow

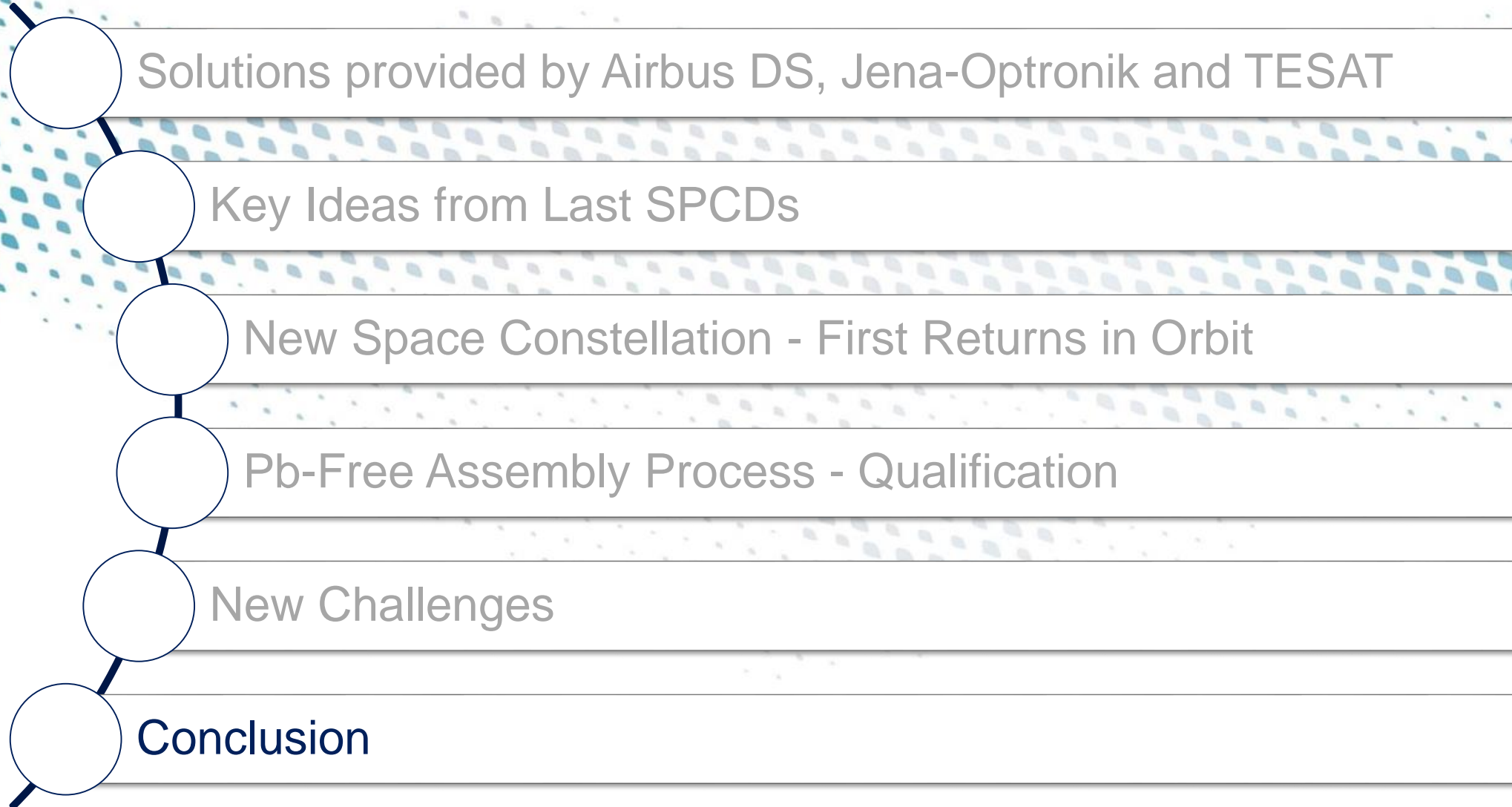
- Major return: less non-quality issues than SnPb process





New Challenges

- Down Sizing
 - Multi Layer Chip Ceramic 0201 size for type I and II: large FPGA or SoC decoupling
 - Thick film resistors 0201 size for pull-up and line signal damping
 - RF Chip Inductors 0201 size for RF signal filtering
 - Power Inductors, reducing volume for high current and low voltage applications
- Components to achieve 100% full automatic assembly
 - High temperature metallized film for Pb-free assembly process, with preserved self-healing properties
 - Gluing process suppression → lighter inductors
- Connector press-fit assembly
 - Mandatory for high data rate applications and well adapted for high current applications
 - Definition of a standard for space (interaction between the connector and the printed circuit board to be taken into account)



Conclusion

- All considered evolutions in electronics for the last 10 years have been integrated: SoC and large FPGA, high data-rate links, power increase in RF, GaN FET, optical links, ... → space qualified passive parts are available
- First returns in orbit of new-space component approach are quite positive
- Pb-free assembly process is qualified and BME MLCC present less manufacturing quality issues
- European manufacturers cover most of the needs, even if we can regret some technology backwardness for magnetic components and high data-rate connector for example
- Press-fit process has to be validated and normalized with the Agencies

Thank you