Results of SEL Testing Performed on Selected Components used in PCDF & MSL Equipments for ISS

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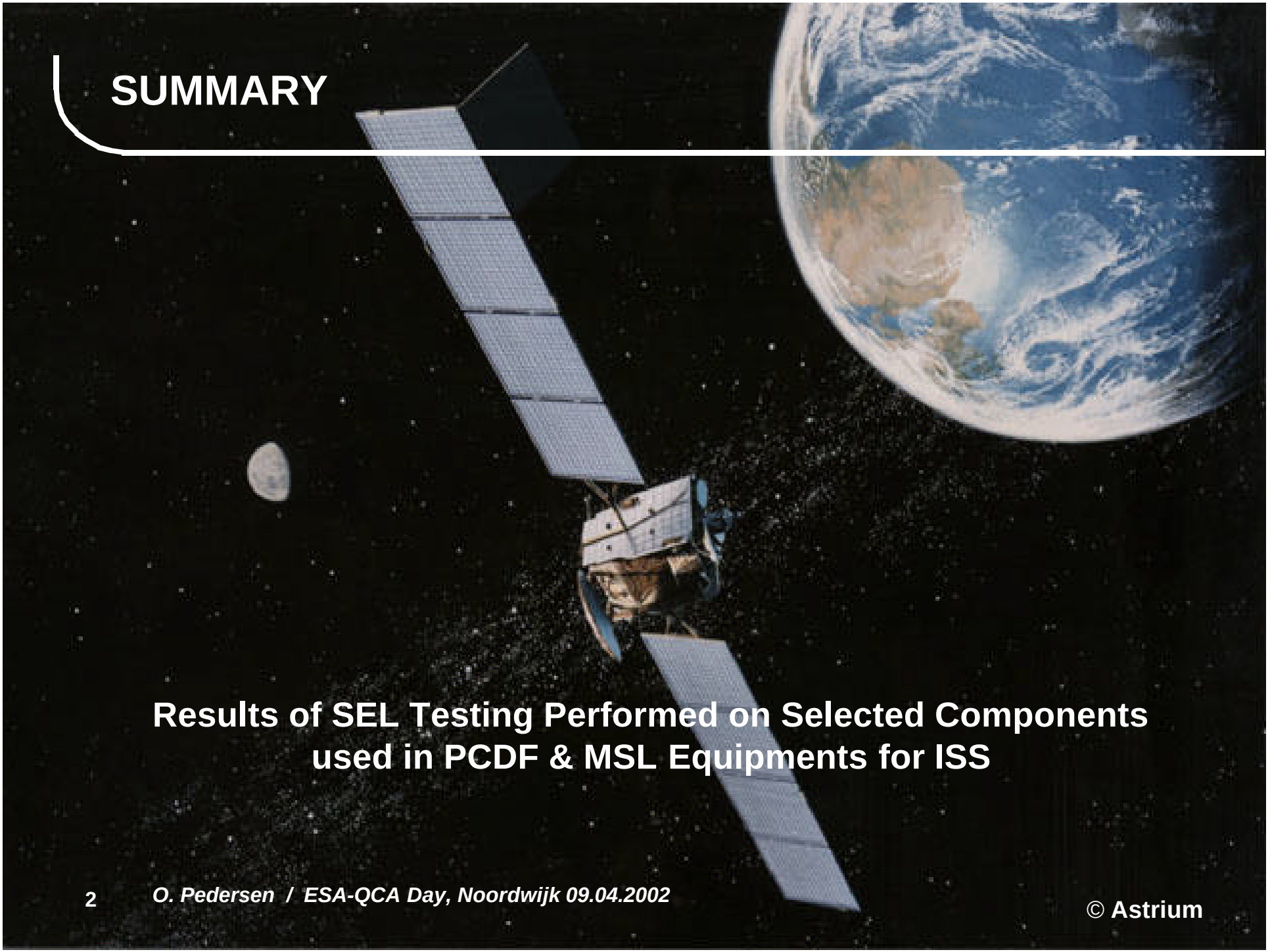
SUMMARY



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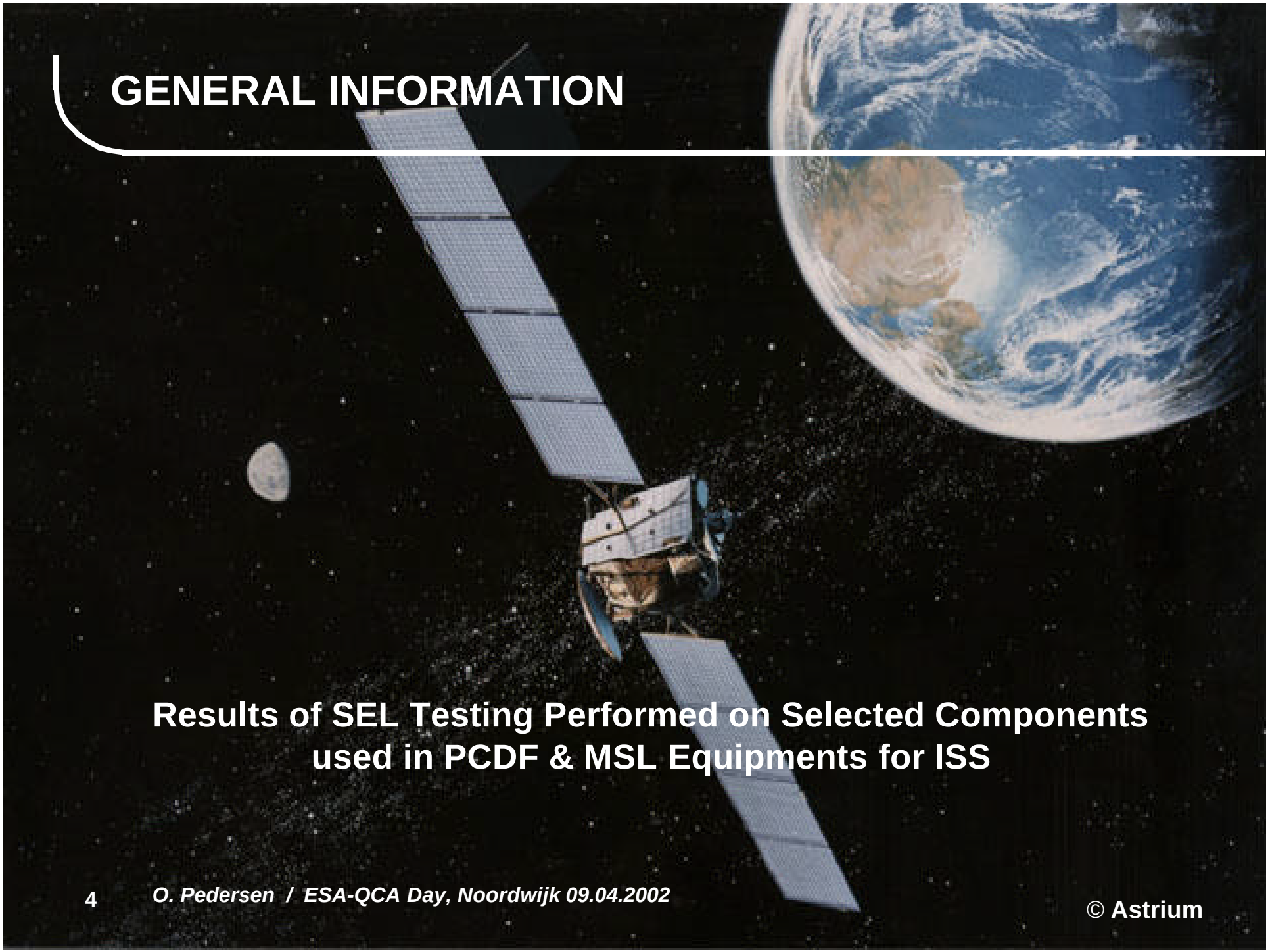
SUMMARY

GENERAL INFORMATION



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GENERAL INFORMATION (1)

SCOPE:

- Single Event Latch-up (SEL) testing on selected components used in equipments and experiments for International Space Station (ISS)
- Minimum project SEL LET_{eff} threshold of 36 MeV cm^2/mg
- Further major test goals
  - ⇒ Testing up to at least twice the SEL threshold requirement
  - ⇒ Where applicable other effects like SEB, SEGR should be detected and analysed
  - ⇒ Two components of each selected part type should be tested
  - ⇒ Application conditions or “worst case” bias should be applied
  - ⇒ Test candidate harmonizing between parts in various ISS equipments
- Irradiation test facility
  - ⇒ ESA Heavy Ion Test Facility (HIF) at UCL, Belgium

GENERAL INFORMATION (2)

ISS EQUIPMENT COMPRISED:

- PCDF:
  - ⇒ EEE Parts Lists supplied by
    - – Chevalier Photonics for components used in ISS/COF
    - – Papst for components used in fans

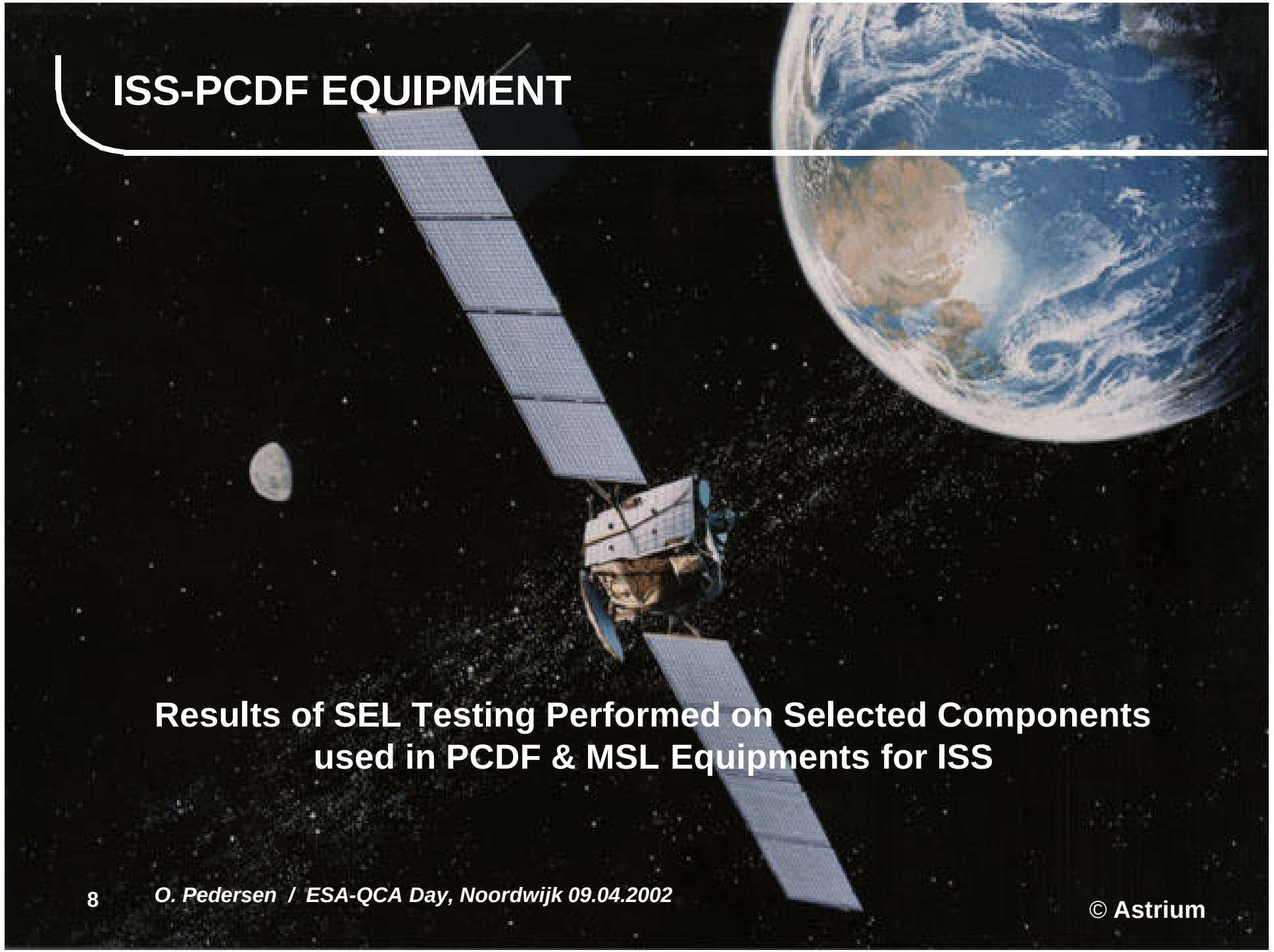
- MSL:
  - ⇒ EEE Parts Lists supplied by
    - – Astrium Space Infrastructure Division for components used in CAM equipment of MSL

GENERAL INFORMATION (3)

WORK STRUCTURE:

- Phase 1 involved
  - ⇒ Review and analysis of EEE parts lists to identify all SEL sensitive parts
  - ⇒ Identification and selection of test candidates with subsequent approval of project and ESA
- Phase 2 involved
  - ⇒ Preparation and approval of Test Plan and test hardware development
- Phase 3 involved
  - ⇒ SEL testing using ESA HIF at UCL
- Phase 4 involved
  - ⇒ Summary of test results and reporting

ISS-PCDF EQUIPMENT



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ISS-PCDF EQUIPMENT (1)

ISS-PCDF COMPONENT PARTS SELECTION:

- Component Parts Lists
  - ⇒ 3 parts lists supplied from Chevalier Photonics
  - ⇒ 2 parts lists supplied from Papst

- Identified components types
  - ⇒ 30 component types identified as potentially sensitive to SEL
    - – 9 component types had SEL LET_{eff} threshold data >36 MeV cm^2/mg
    - – 3 component types were later identified as not SEL sensitive (based upon information and correspondence with manufacturer)
    - – 18 component types finally selected for SEL testing

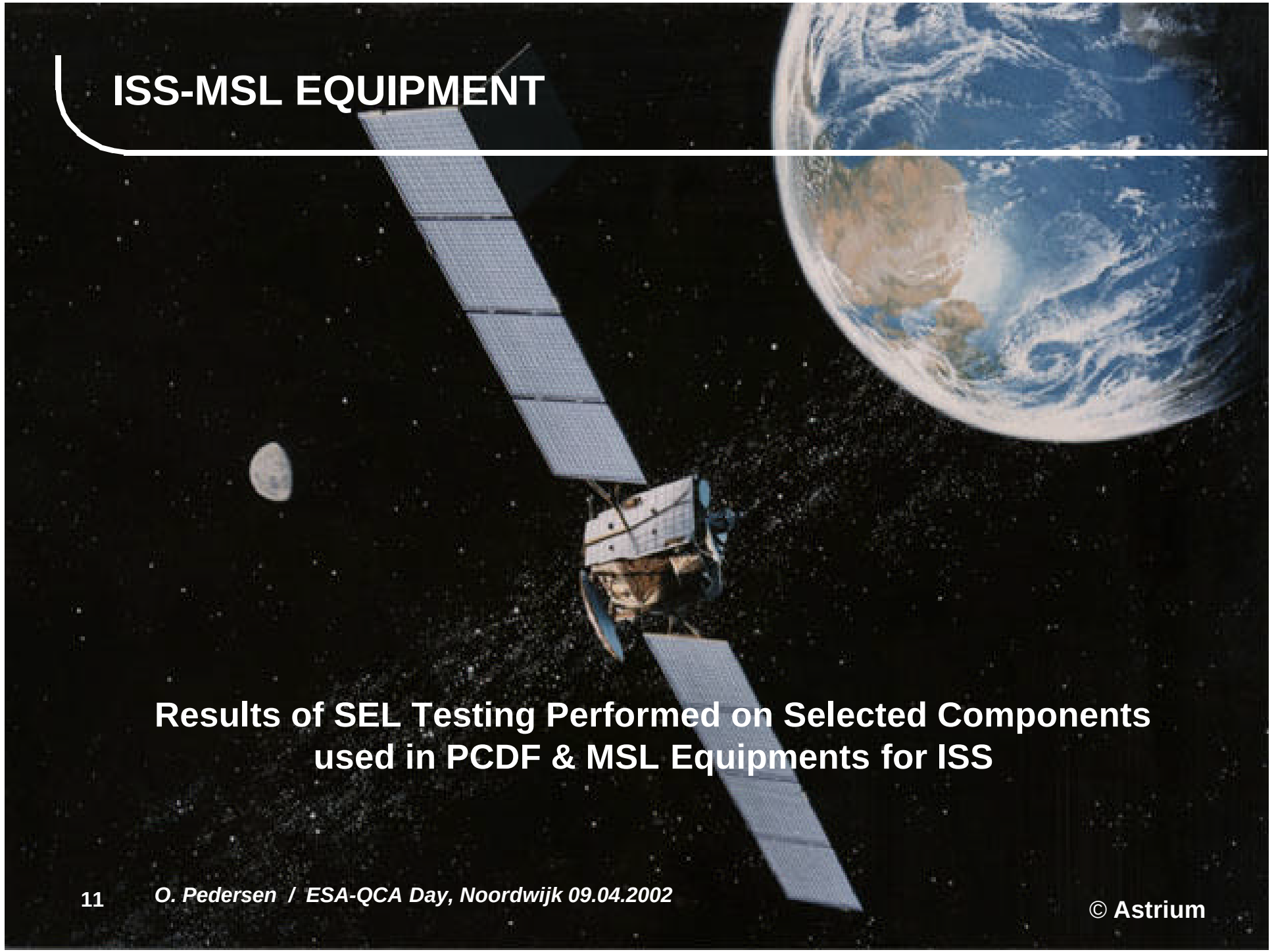
- PCDF Review Report, REP-002, Issue 1 of 17.11.2000

ISS-PCDF EQUIPMENT (2)

- ISS-PCDF SEL irradiated part types:

– JANTXV2N6782	N-Channel HEXFET	Intersil
– JANTXV2N6845	P-Channel HEXFET	International Rectifier
– SNJ55ALS194J	Line Driver	Texas Instruments
– SNJ55ALS195J	Line Receiver	Texas Instruments
– LT1086MH/883	Positive Voltage Regulator	Linear Technology
– AS5C4008F-25	512K x 8 SRAM	Austin Semiconductor
– AD822AR	FET Input Operational Amplifier	Analog Devices
– AD9816JS	12-bit Digital Signal Processor	Analog Devices
– M55310/28-B11A	20 MHz Oscillator	Corning Frequency Control, Inc.
– MIC4452BM	CMOS MOSFET Driver	Micrel Semiconductor
– 54ACTQ04LMQB	CMOS Hex Inverter	National Semiconductor
– 54FCT245T	8-bit Bus Transceiver	Integrated Device Technology
– JD54F38BCA	NAND Buffer Driver	National Semiconductor
– 54HCT04	Hex Inverter	Texas Instruments
– AD620SQ	Operational Amplifier	Analog Devices
– LM2991J-QML	Voltage Regulator	National Semiconductor
– DG406AK/883	16-ch. CMOS Analog Multiplexer	Siliconix
– LM117H/883	Voltage Regulator	National Semiconductor

ISS-MSL EQUIPMENT



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ISS-MSL EQUIPMENT (1)

ISS-MSL COMPONENT PARTS SELECTION:

- Component Parts Lists
  - ⇒ 15 parts lists supplied from Astrium Space Infrastructure Division

- Identified components types
  - ⇒ 89 component types identified as potentially sensitive to SEL
    - – 9 component types had SEL LET_{eff} threshold data >36 MeV cm²/mg
    - – 28 component types were assessed to have a possible SEL LET threshold < 36 MeV cm²/mg
    - – 20 component types finally selected for SEL testing

- MSL Assessment Report, REP-001, Issue 1 of 06.07.2000

ISS-MSL EQUIPMENT (2)

- ISS-MSL SEL irradiated part types:

– SAB80C166M	16-bit CMOS Microcontroller	Infineon
– ST62C65CB6	8-bit CMOS Microcontroller	STM
– LMC6062/883	CMOS Operational Amplifier	National Semiconductor
– LMC662AIN	CMOS Operational Amplifier	National Semiconductor
– TLC272BCP	CMOS Operational Amplifier	Texas Instruments
– LT1298IN8	12-bit ADC	Linear Technology
– MAX538BEPA	12-bit DAC	Maxim
– FM93C56EN	2K CMOS EEPROM	Fairchild
– TL7705ACP	Bipolar Voltage Supervisor	Texas Instruments
– PIC16-F84-04I/P	8-bit CMOS Microcontroller	Microchip Technology
– MAX328CJE	8-ch. CMOS Analog Multiplexer	Maxim
– AD7228ACQ	8-bit BiCMOS DAC	Analog Devices
– AD7846AQ	16-bit BiCMOS DAC	Analog Devices
– 80C196KC-20	16-bit CMOS Microcontroller	Intel
– DS1225Y-200	64K CMOS SRAM	Dallas
– COM20020IP	8-bit CMOS LAN Controller	Standard Microsysteme
– PSD301-B-90JI	CMOS Programmable Peripheral	Wafer Scale Integration
– K6T1008C2E-DB70	1M CMOS SRAM	Samsung
– LMC6482AMJ/883	CMOS Operational Amplifier	National Semiconductor
– ICM7555MJA	CMOS Analog Timer	Maxim

TEST RESULT SUMMARY AND REMARKS

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TEST RESULT SUMMARY AND REMARKS (1)

ISS-PCDF TEST RESULT SUMMARY:

- 18 component types tested between an SEL LET_{eff} range of 5.85 and 73 MeV cm²/mg

- Test results
  - ⇒ 14 types had an SEL LET_{eff} threshold >73 MeV cm²/mg
  - ⇒ 1 type (LT1086) showed SEL at 34 MeV cm²/mg but not at 28.2 MeV cm²/mg
  - ⇒ 2 types (AD9816, LM117) showed SEL at 14.1 MeV cm²/mg but not at 9.1 MeV cm²/mg
  - ⇒ 1 type (LM2991) showed SEL at 5.85 MeV cm²/mg which was the lowest LET_{eff} used

TEST RESULT SUMMARY AND REMARKS (2)

ISS-MSL TEST RESULT SUMMARY:

- 20 component types tested between an SEL LET_{eff} range of 5.85 and 73 MeV cm²/mg

- Test results
  - ⇒ 11 types had an SEL LET_{eff} threshold >73 MeV cm²/mg
  - ⇒ 1 type (DS1225Y) showed SEL at 34 MeV cm²/mg but not at 14.1 MeV cm²/mg. Note: High supply current prevented reliable data
  - ⇒ 1 type (PSD301) showed SEL at 28.2 MeV cm²/mg but not at 19.9 MeV cm²/mg
  - ⇒ 1 type (80C196) showed SEL at 19.9 MeV cm²/mg but not at 14.1 MeV cm²/mg

TEST RESULT SUMMARY AND REMARKS (3)

- ISS-MSL Test results (cont.)

  ⇒ 5 types (SAB80C166, ST62C65, FM93C56, PIC16-F84, COM20020IP) showed SEL at 14.1 MeV cm²/mg but not at 9.1 MeV cm²/mg

  ⇒ 1 type (LTC1298) showed SEL at 9.1 MeV cm²/mg but not at 5.85 MeV cm²/mg

- At an LET_{eff} of 5.85 MeV cm²/mg no SEL was detected at any part type

TEST RESULT SUMMARY AND REMARKS (4)

TEST RESULT REMARKS:

- 38 component types, mostly of COTS quality, have been SEL tested
  - ⇒ 25 types passed project SEL requirements, i.e. LET_{eff} threshold of 36 MeV cm²/mg or greater
  - ⇒ 13 types **(34%)** failed the relatively low project SEL requirement
  - ⇒ 9 types showed very sensitive results, i.e. LET_{eff} threshold of 14.1 MeV cm²/mg or below

- Possible reasons for poor results
  - ⇒ Unknown technology, quality and performance for COTS
  - ⇒ Equipment manufacturers inexperience w.r.t. space radiation requirements
  - ⇒ Use of existing equipment designs not intended for space usage

TEST RESULT SUMMARY AND REMARKS (5)

TEST RESULT REMARKS (cont.):

- Possible consequences of poor results
  - ⇒ Component replacement
  - ⇒ Circuit / equipment redesign (latch-up protection, etc.)
  - ⇒ Significant project delays and cost increase
  - ⇒ Reduction of circuit / equipment performance

- Possible improvements
  - ⇒ Use of known radiation tolerant components
  - ⇒ Involvement of radiation expertise at an early project phase should be mandatory

TEST RESULT SUMMARY AND REMARKS (6)

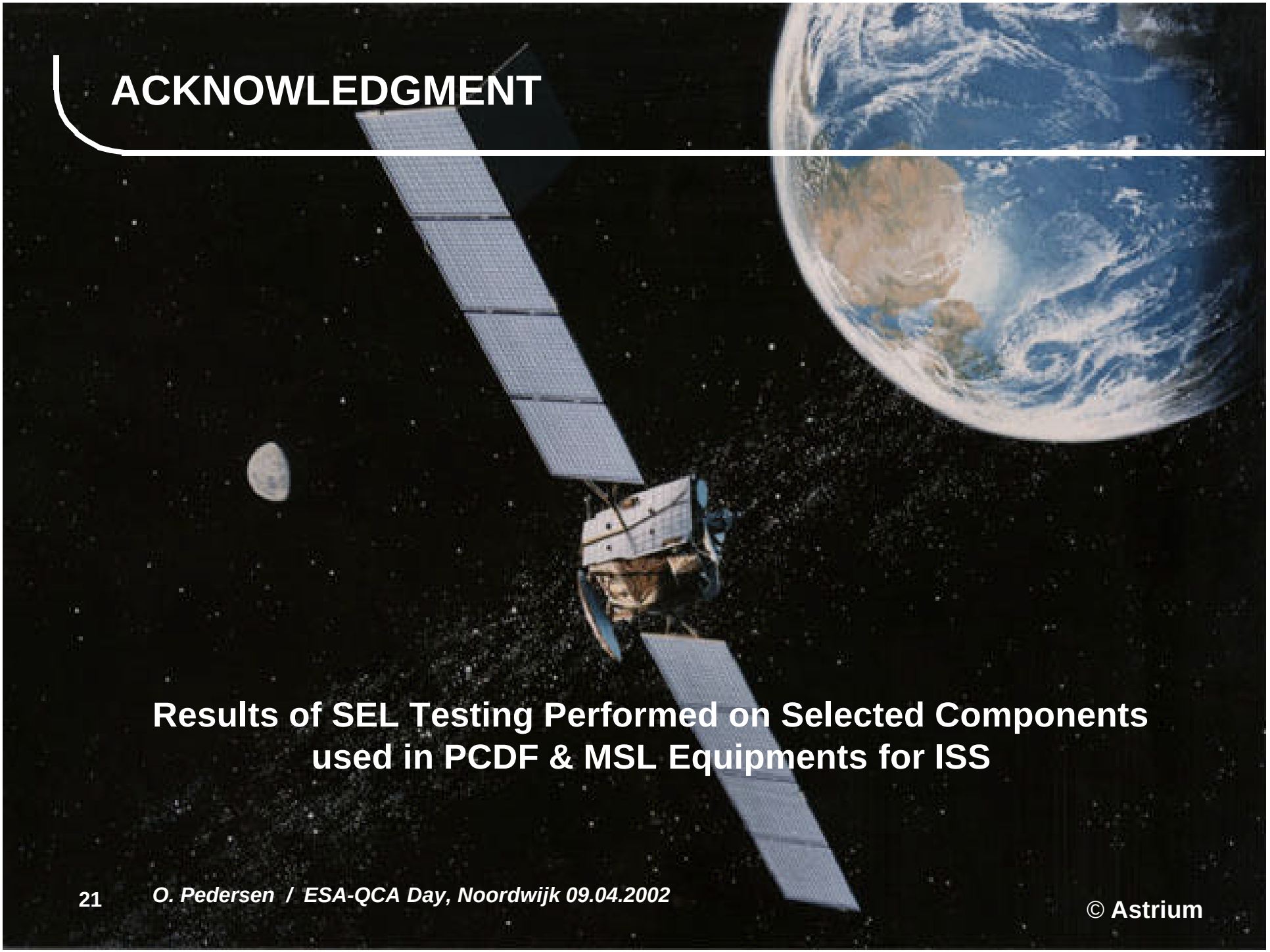
REPORT REFERENCES:

- PCDF
  - ⇒ Irradiation Test Report, ITR_926_01_1.pdf, Issue 1 of 19.07.2001
  - ⇒ Irradiation Test Plan, ITP_01_01_1A.pdf, Issue 1A of 03.05.2001

- MSL
  - ⇒ Irradiation Test Report, ITR_927_01_1.pdf, Issue 1 of 22.10.2001
  - ⇒ Irradiation Test Plan, ITP_02_01_1A.pdf, Issue 1A of 07.09.2001

- All test reports are available at ESA-QCA

ACKNOWLEDGMENT



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