F 5688	**09034-SuRe-A-01**

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Nano-D connectors
Summary report.

Contract : ESA, ITT A0/1-126/09/NL/CO

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Civil	**Industrial**	
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TITLE: Nano-d connectors Summary Report

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Author's SUMMARY:
The aim of this document is to summarize all the works and all the tests done during the evaluation of Axon' electrical, rectangular, nanominiature connectors with non-removable crimp-type contacts and their associated wires.

Computer References		
	File ref. : W:\DJC09\DJC-09034 - nano d spatiale\Données de sortie\QTR\09034-QTR-A01-PV2913A.doc Type of computer : *PC*	**Document langage:** EN **Legal language :** EN

KEY WORDS:
Nano-D, ESA, ESCC 3401, twist pins,...

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Issue A	*02/04/2012*		*Creation of the document*

This page must be used for all documents.
For documents of category 1 this page is used until approval.

TABLE OF CONTENTS

1 Subject:

This summary report will be shared in several sections:

- Reason for the study (mass, volume saving, European source)
- Survey conclusions
- Achieved works
- Evaluation test plan and results
- Perspective (Commercial evaluation if still to be included in the Executive Summary Report by Axon' + estimated investment for qualification)

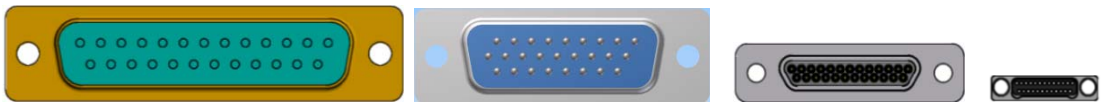
2 Applicable documents:

- **TEC-QTC/2009SoW02/DL:** Specification of work : Nano D evaluation
- **ESCC Generic specification n°3401** Connectors, electrical, non-filtered, circular and rectangular.
- **ESCC 3901/012:** Extruded cross-linked ETFE insulated wires and cables. -100°C to +200°C detailed specification.
- **ESA CA0611:** Construction analysis.
- **See applicable document lists** done during this evaluation in § 5 and 6

3 Reason for the study

3.1 Comparison between D-SUB, Micor D and nano D connectors.

The reason of choosing nano D connectors for wired harnesses is the mass and volume saving. Theses connectors allow much higher contact desnsity keeping a good ampacity. The table below illustrates well these arguments.
Surface is reduced by a ratio of 2.8 between D-SUB and Micro D.
Surface is reduced by a ratio of 14 between D-SUB and nano D.
Surface is reduced by a ratio of 5 between microD and nano D.

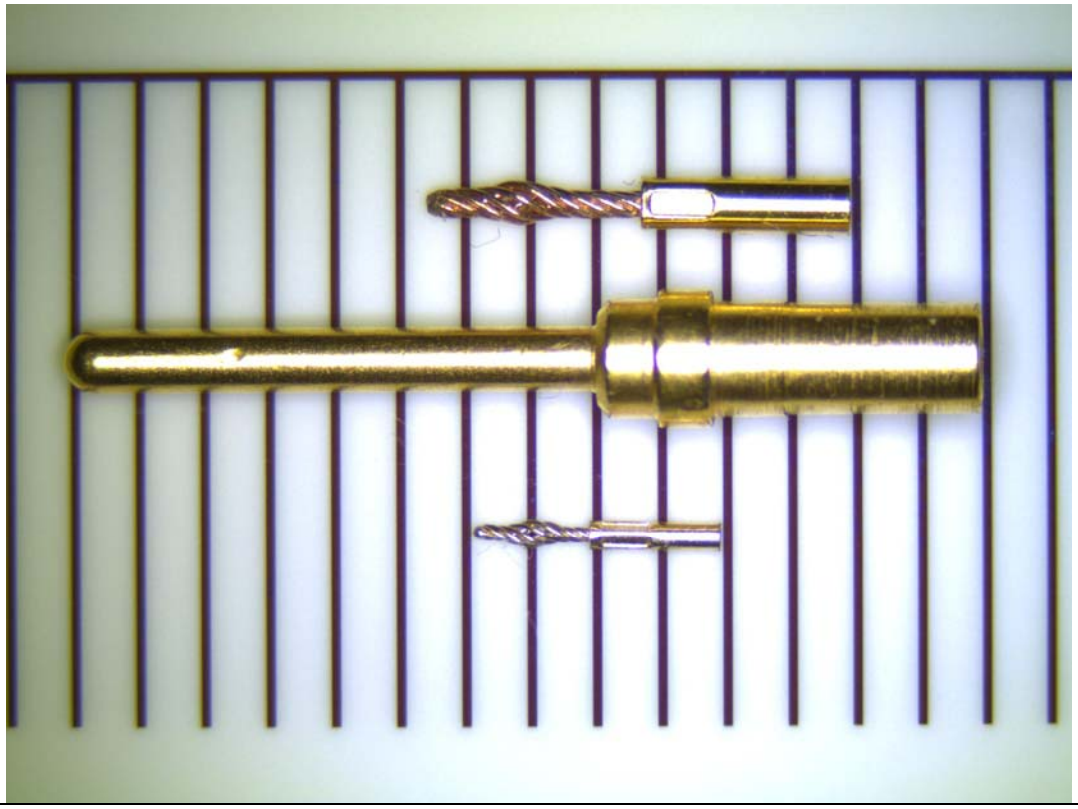


	D SUB SD ESCC.3401.01	D SUB HD ESCC.3401.02 (26way)	Micro-D ESCC.3401. 029 & 077	Nano-D * MIL.DTL. 32139
Pitch	2.74	2.41	1.27	0.635
Dimensions (mm)	53.04x12.55	39.14x12.55	30.1x7.82	14.61x3.18
Surface (mm²)	665	491	234	46.5
Weight (g)	13	7.6	3.6	0.5
Wire Awg	28 to 20	26 to 22	28 to 26	30
Removable	Y	Y	N/Y	N
Screwlocks size	4-40 UNC	4-40 UNC	2-56 UNC	0-80 UNF
Work. Volt. (Vrms)	300	250	150	250 *
Rated current (A)	3 to 7.5	3 to 5	1.5 to 2.5	1 *

No supplier has been evaluated on nanoD conenctors. The second argument is therefore to evaluate an European source. Axon is the only European company able to supply nanoD assembly for aeromil applications. The target of this evaluation was to assess the space environment behaviour of the existing connectors developed according to MIL-DTL-32139 for aeromil application. We learn from this evaluation that we need to change the jackscrew and add some tests to assure a quality compatible with space industry.

The target is to enter the family in EEPL2.

3.2 Comparison between D-SUB, Micor D and nano D connectors.



Drawing of D-SUB, MicroD and nano D contacts.

3.3 Existing axon nanoD line (ND2A)

- Designed according to MIL-DTL-32139 . Internal qualification performed.
  - 7 shell sizes :9-15-21-25-31-37-51 contacts
- Nickel 15-18 µm over aluminium plating
- Screwlocks: 0-80 UNF
- Wire AWG 30
- Electrical characteristics
  - Working voltage sea level: 250 Vrms
  - Rated Current: 1 A for AWG30

Detailed specification in our commercial brochure available on axon' web site.

A project of ESCC specification has been written. Some performances have been modified after completion of evaluation tests.

4 Survey conclusions

4.1 Worldwide nano D companies.

The survey report "09034-SR-A-01" lists all the different company able to supply nanoD assemblies. This document lists some improvements in terms of power handling, gauges, number of contact, temperature range and external condition

- 10 American companies: In USA the nanoD technologies are widely used everywhere.
- 2 European companies but one is limited to hermetic female connectors.
- 1 Chinese company.

Supplier	Nat	MIL QPL	Compliant with MIL	ITAR RESTR	Contact	Special design	Improvement
Airborn	USA	Y	Y	Y	FLEX	Mounting holes Circular connector EMI solution SPLASHPROOF	X
Axon'	FRA EUR	N	Y	N	TWIST	EMI solution Pannel mount Mix microD/nanoD	
CINCH	USA		Y	Y	TWIST	Solder cup	(X)
CRISTEK	USA	N	Y	Y	FLEX	-	
GUIZHOU	CHINA	N	Y		TWIST	-	
ITT	USA	N	Y	Y	TWIST	Specific JACKSCREW	X
MICROWAY	USA	Y	Y	Y	TWIST	Revers Hardware	
MIN-E-CON	USA	N	Y	Y	FLEX	RETR0041TA	
NANONICS	USA	N	N	Y	GUID	Combo	
OMNETICS	USA	Y	Y	Y	FLEX	Circular connector: plastic / break away STRIP one and dual row Latching Bi-Lobe® Panel mount Hermetically Sealed Bi-Lobe® Polarized Nano Series	
PA&E	USA	N	Y		N/A	Hermetic Limited to female hermetic receptacle. No wiring solution.	
SRI HERMETIC	USA	N	Y	Y	N/A	Hermetic Limited to female hermetic receptacle. No wiring solution.	
MICRONOR M7D	FRA EUR	N	Y		N/A	Hermetic Limited to female hermetic receptacle. No wiring solution.	

4.2 Contact flexpin or twist pin.

		
Contact twist pin. The contact is made up of 7 strands of precious alloy (gold) twisted together, welded then at both side and bumped forming a cord. This cord and the bump is compressed during insertion into the turned female contact and therefore a high number of electrical contact points is permanently assured, while retaining flexibility and ease of insertion/ extraction High number of electrical contact points Ease of insertion / extraction		**Contact flex pin.** The contact is in one piece to eliminate un-necessary joint. A BeCu strip is rolled & cut to obtain the final shape of the contact. Partial plating of the strip of 1.27 µ min of gold over 1 µ min of Nickel is done after forming. It has only 3 potential contact points instead of 7 for the twist pin. When the contact is removed from it's support plating is missing where the contact is cut. .

5 Achieved works

5.1 Design and technical works.

The works done during this evaluation has been reported through technical documents. Monthly reports give the status of the actions.

Achieved works	Document	Main conclusion
Technical survey of existing nano d connectors solutions from different suppliers.	09034-SR-A-01 Issue 1-3	All of them are mainly US or Chinese. Some US makers are MIL QPL. Twist or flex pins. See § 4 of this document.
Risk assessment report	09034-RiRe-A-01 Issue 1-1	Timescale.
Declared list of material **Declared lis of processes.** list of all materials list of all processes	09034-DML-DPL-A-01 Issue 2-1	Materials and processes are compatible with space industry. Pass out gassing requirements.
Technical specification under ESCC format. Design documentation including technical drawings	09034-TS-A-01 Issue 2-2	The design detailed in the specification is directly coming from our existing line developed for aeromil applications. The specification has been frozen after completion of the evaluation tests The ESCC specification shall be finalized by ESA Technical Writer.
Part identification document.	CNES-PID-A-12	In the frame of an ESCC, the PID would be reviewed by the QNSA (Qualification National Space Agency).
Failure mode and criticality analysis.	09034-FMECA-A-01 Issue 1-1	Failure mode and theur ciriticity are assessed.
Magnetism analysis. Investigation report Introduction to residual magnetism of Axon' nano-d connectors	09034-TN-A-01 Issue 1-1	AXON' nano-D range is not fully non-magnetic but responds to the NASA classification NMA (residual magnetic field < 2000 gammas). Based on AXON' know-how in the range of non-magnetic connectors, upgrade can be brought to reduce the residual magnetism of AXON' nano-D connectors if requested by ESA or customer.
High contact resistance technical note. Investigation report – High contact resistance of TV42 during the Axon qualification according to MIL-DTL-32139	09034-TN-A-07 Issue 1-1	The x-rays carried out on the test vehicle 42 do not reveal any particular issue in the crimping areas on the male and female sides. FA carried out at ESA/ESTEC conclusion are : - female side is OK. - Male side present higher resistance on one contact. - X-Ray and tomography confirm good crimping of the twist pin contact.
Photographic documentation	09034-TN-A-08 Issue 1-2	Presents the different type of nano-D and nomenclature, assembly of the connectors, vibration testing set-up,
EMC analysis.	09034-TN-A-02-AXON' Issue 3-1	The transfer impedance values expressed in dB are better than 60dB up to 100MHz for the four tests. Results are better than micorD.
Thermal analysis	09034-TN-A-02-AXON' Issue 3-1	The nano D connectors are compliant to the following temperature cycling -55°C to +150°C.
Mechanical analysis	09034-TN-A-02-AXON' Issue 3-1	The nano D connectors are compliant with vibration 20grms (196m/s2). No resonance or electrical interruption during vibrations ans shocks.
Construction Analysis. CA samples and CA report CA was done by ESTEC.	CA0611	Presence of metallic burs, plating irregularity. Corrective action taken. See § 6 of 09034-ETR-A-01.

Achieved works	Document	Main conclusion
User guide. Recommendation against this standard for nano connector NANO-D USER GUIDE	09034-USERGUIDE-A-01 Issue 1-4	Recommentations to be followed by users.
Summary report	09034-SuRe-A-01	This document §1 to 6
Commercial evaluation.	09034-SuRe-A-01	This document § 7

Evaluation tests are summarised on chapter § 6

5.2 Design of nanoD connectors for space application.

5.2.1) Jumper design.

IDENTIFICATION CODE: **ESCC/119 25 P P I W1 9 50 L L**

SERIES
ESCC/119: Nano-D 2 rows Space application.

NUMBER OF CONTACTS
09, 15, 21, 25, 37, 51

1st CONNECTOR TYPE
P: Plug connector.

2nd CONNECTOR TYPE
P: Plug connector.
S: Receptacle connector.

CONNECTION (see jumper wiring on §1.6)
D: Direct pin 1 to pin 1.
I: Indirect (usual for plug-plug jumper).

WIRE CODE
W1: Single wire ESCC 3901/012 – Variant 01 (AWG30)
W2: 2 x shielded jacketed twisted pair ESCC 3901/012 – Variant 51 (AWG30)
And the other wire with single wire ESCC 3901/012 - Variant01 (AWG30)

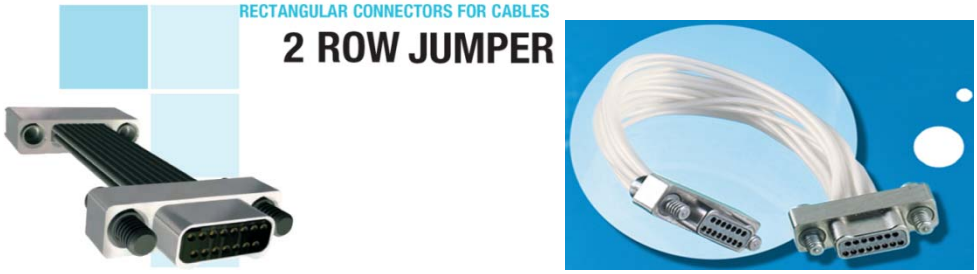
COLOUR CODE
0 (black), **1** (brown), **2** (red), **9** (White)

WIRE LENGTH: cm
Caution! Wire length in centimetres - (1cm = 10 mm = .394")

L	2 ≤ L ≤ 10	10 < L ≤ 100	L > 100
in cm (inches)	0.79≤ L ≤ 3.940	3.940 < L ≤ 39.40	39.40
TOLERANCE	-0 / +0.5	-0 / +3	-0 / +5
in cm (inches)	-0 / +0.200	-0 / +1.180	-0 / +1.970

HARDWARE 1st CONNECTOR
L: Short hex skt head jackscrews #0-80 UNF (captivated, plug only).
R: Retractable short hex skt head jackscrews #0-80 UNF (semi-captivated, plug only)
V :Retractable short hex skt head jackscrews #0-80UNF + backshell for prehension (semi-captivated, plug only)
B: No hardware.

HARDWARE 2nd CONNECTOR
L: Short hex skt head jackscrews #0-80 UNF (captivated, plug only).
P: Threaded hole #0-80 UNF (non removable jackposts, receptacle only).
R: Retractable short hex skt head jackscrews #0-80 UNF (semi-captivated, plug only)
V :Retractable short hex skt head jackscrews #0-80UNF + backshell for prehension (semi-captivated, plug only)
B: No hardware.



5.2.2) CBR design.

IDENTIFICATION CODE **ESCC/119 25 S CBR P T 1**

SERIES
ESCC/119: Nano-D 2 rows Space application.

NUMBER OF CONTACTS
09, 15, 21, 25, 37, 51
Other versions available on request

CONNECTOR TYPE
S: Receptacle **connector.**

FAMILY
CBR: AXON' Right Angle PCB connector

HARDWARE
P: Threaded hole #0-80 UNF (non removable jackposts).

TAIL PLATING
T : tin lead plated 1µm minimum (63-37 alloy). Tails are degolded and tined.

TAIL LENGTH
1: 2.77 mm (0.109")
2: 3.56 mm (0.140")
3: 4.37 mm (0.172")
4: 2.29 mm (0.090")
Tolerance: ±0.38mm (0.015")

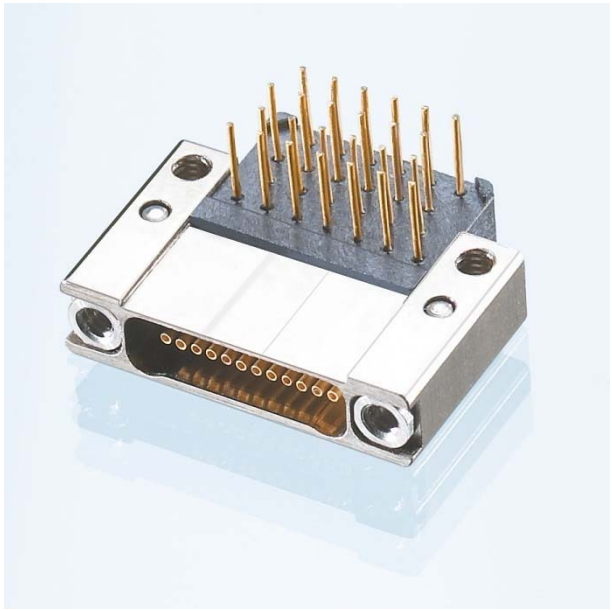
Connectors are supplied with #0-80 UNF screws 1/4" ± 0.004" long (for PCB mounting).

PCB RECTANGULAR CONNECTORS

CBR TYPE

2 ROW RIGHT ANGLE PCB RECEPTACLE

0.050" PITCH



5.2.3) SMV design.

ESCC/119 25 S SMV P T 1

SERIES
ESCC/119: Nano-D 2 rows Space application.

NUMBER OF CONTACTS
09, 15, 21, 25, 37, 51
Other versions available on request

CONNECTOR TYPE
S: Receptacle **connector.**

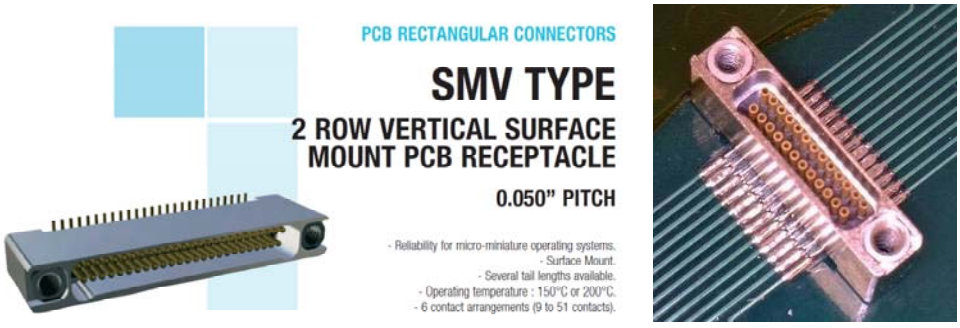
FAMILY
SMV: AXON' Right Angle PCB connector

HARDWARE
P: Threaded hole #0-80 UNF (non removable jackposts).

TAIL PLATING
T : tin lead plated 1µm minimum (63-37 alloy). Tails are degolded and tined.

TAIL LENGTH
1: 2.77 mm (0.109")
2: 3.56 mm (0.140")
3: 4.37 mm (0.172")
4: 2.29 mm (0.090")
Tolerance: ±0.38mm (0.015")

Connectors are supplied with #0-80 UNF screws 1/4" ± 0.004" long (for PCB mounting)



6 Evaluation test plan and results

The aim of this evaluation is to assess the margin and physical limits of Axon' electrical, rectangular, nanominiature connectors with non-removable crimp-type contacts and their associated wires.
The test plan has been defined to assess the limit of the product (Current/voltage step stress, high number of mating/unmating cycles, extended temperature storage) or to define the unknown parameter of ESCC specification (weight, insertion forces…)
Some additional thermal cycling have been done in collaboration with MSSL to test the nanoD connectors in condition representative of EXOMARS mission.

6.1 Test plans procedures and reports.

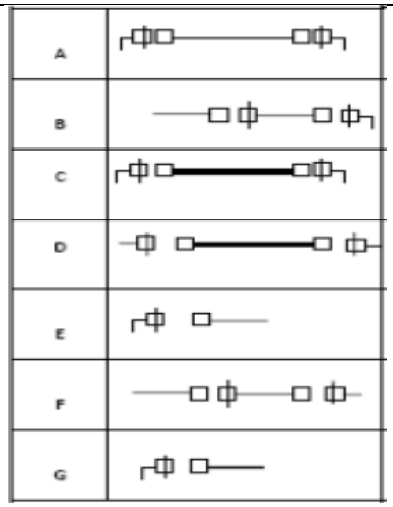
Achieved works	Document	Main conclusion
Test plan	09034-ETP-A-01 Issue 2-4	Test plan is composed by 6 groups: Group 0 : Exomars cycling tests Group 1 : Mechanical Group 2: Thermal and mechanical Endurance Group 3: Temperature tests Group 4: Voltage and current overload test. Group 5: Contact group.
Test procedures of nano-D connectors	09034-TN-A-05	Details of all the test procedure to be followed during evaluation.
Manufacturing of the connector assemblies Report on processing activities on manufacture of nano-D evaluation models.	090034-TN-A04 Issue 1-1	Drawing of test vehicles. Manufacture and control route cards of the test vehicles
Mechanical, thermal and electrical test reports.	09034-ETR-A-01 Issue 1-1	The tests performed on the test vehicles in the frame of this nanoD evaluation show that nanod connectors have real potential to be used for space industry.

6.2 List of test vehicles manufactured and used during the evaluation.

Representation		
Designation	Male to male Jumper AWG30 wires : L=50cm	Jumper male to male with shielded AWG30 wires : L=50cm

Representation		
Designation	Jumper male to female AWG 30 wires : L=25cm	Jumper male (pigtail) with AWG30 wires: L=25cm

Representation		
Designation	CBR	SMV



Representation of test vehicle

TV assembly type	Group 0	Group 1	Group 2	Group 3	Group 4	Group 5	Total of CBR/jumpers & contacts sets	Total of assemblies
TV9-B composed by:	**0**	**0**	**0**	**1**	**0**			**1**
CBR09	0	0	0	1	0		1	
J09P-W1	0	0	0	1	0		1	
J09PSW1	0	0	0	1	0		1	
TV9-C composed by:	**0**	**1**	**0**	**0**	**0**			**1**
CBR09	0	2	0	0	0		2	
J09PPW2	0	1	0	0	0		1	
TV9-E composed by	**0**	**0**	**0**	**0**	**2**			**2**
CBR09	0	0	0	0	2		2	
J09P-W1	0	0	0	0	2		2	
TV25-A composed by:	**0**	**1**	**0**	**0**	**0**			**1**
CBR25	0	2	0	0	0		2	
J25PPW1	0	1	0	0	0		1	
TV25-B composed by:	**2**	**0**	**0**	**1**	**0**			**3**
CBR25	2	0	0	1	0		3	
J25P-W1	2	0	0	1	0		3	
J25PSW1	2	0	0	1	0		3	
TV25-D composed by:	**0**	**1**	**0**	**1**	**0**			**2**
SMV25	0	2	0	2	0		4	
J25PPW2	0	1	0	1	0		2	
TV25-E composed by:	**0**	**0**	**0**	**0**	**2**			**2**
CBR25	0	0	0	0	2		2	
J25P-W1	0	0	0	0	2		2	
TV25-F composed by:	**2**	**0**	**0**	**0**	**0**			**2**
SMV25	2	0	0	0	0		2	
J25P-W1	2	0	0	0	0		2	
J25PSW1	2	0	0	0	0		2	
TV25-I composed by:	**0**	**0**	**1**	**0**	**0**			**1**
CBR25	0	0	1	0	0		1	
J25P-W2	0	0	1	0			1	
TV51-A composed by:	**0**	**1**	**0**	**0**	**0**			**1**
CBR51	0	2	0	0	0		2	
J51PPW1	0	1	0	0	0		1	
TV51-B composed by:	**0**	**0**	**0**	**1**	**0**			**1**
CBR51	0	0	0	1	0		1	
J51P-W1	0	0	0	1	0		1	
J51PSW1	0	0	0	1	0		1	
TV51-E composed by:	**0**	**0**	**1**	**0**	**0**			**1**
CBR51	0	0	1	0	0		1	
J51P-W1	0	0	1	0	0		1	
Total							**48**	**18**
Set of contacts (male & female)						35		

6.3 Tests results summary:

Type of test	Specification requirement §	Requirement	Compliancy	Page index
Group 0 : Cycling tests				
G0-1 : Electrical tests	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G0-2 : Cycling test		333 cycles at 10°C per min with a 15; min dwell Sequence 1: +80°C to -124°C (16 cycles) Sequence 2: +66°C to -115.5°C (240 cycles) Sequence 3: -40°C to -115.5°C (57 cycles) Sequence 4: +66°C to -115.5 °C (20 cycles) Electrical test during cycles.	Ok	
G0-3 : Electrical tests	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	Tests not done. Parts not available for additional testing.	
Group 1 : Mechanical				
G1-01 : Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G1-02 : Pre storage		Storage at 8 hours at -120°C	OK	
G1-03 : Vibration	ESCC 3401 §9.11	Absence of discontinuity Dismouting torque : Initial ±25%	OK One jackscrew damaged 09034-NCR-A12-S15-01	
G1-04 : Shock	ESCC 3401 §9.12	Absence of discontinuity Dismouting torque : Initial ±25%	Evolution is 30%.	
G1-05 : Electrical test Mating verification Visual examination X-rays photos.	EN2591-207	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK Jackscrew damaged : 09034-NCR-A12-S15-01 One wire damaged on T25-A 09034-NCR-A12-S15-02	

Type of test	Specification requirement §	Requirement	Compliancy	Page index
Group 2 : Endurance				
G2-01 : Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G2-02 : Mechanical endurance	ESCC 2263400 §8.3.2		OK Mechanical endurance **700** Cycles achieved One couple of contact damaged : See 09034-NCR-A12-S15-03	
G2-03 : Electrical endurance	ESCC 2263400 §8.3.3		OK Electrical endurance : **1695** h achieved	
G2-04: Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK See 09034-NCR-A12-S15-03	
Group 3 : Temperature				
G3-01 : Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G3-02 : Prestorage		Storage at 8 hours at -120°C	OK	
G3-03 Rapid change of temperature	ESCC 3401 §9.16	N Cycles from -55°C to + 150C	**1205** cycles achieved.	
G3-04 : Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	

Type of test	Specification requirement §	Requirement	Compliancy	Page index
Group 4 : Electrical performances				
G4-01 : Electrical test Mating verification Visual examination X-ray photos.	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G4-02 : Overload current test	ESCC 3401 §9.26 modified	dT<50°C dR<100%	OK With thermal stabilisation. Up to a Δt=50° Dc current up to 1.6A for 25 pins, 2.4A for 9 pins Transient current (duty cycle=16%): - up to 2 A for 25 pins - 3A for 9 pins. As per overload current ESCC3401 §9.26: **5 A** on a 9 pins connector to reach 150°C.	
G4-03 : Overload voltage test	ESCC 3401 §9.1.1.1 modified		OK - Ri Vdc Test done up to 1850Vdc - Ri Vac Test done up to 900 Vac	
G4-04 : Electrical test	ESCC 3401	Rcl <71mΩ under 10mA Rcr <71mΩ under 1A Ri>5000MΩ under 100Vdc Il<5mA	OK	
G4-05 : Insert retention	ESCC 3401 §9.23	Insert retention >34N/cm²	OK	
G4-06 : Contact retention	ESCC 3401 §9.17	Contact retention >2.22N		
G4-07 Visual inspection	ESCC 20500		OK	
Group 5 : Contact design				
G5-01 : Engagement and separation force	ESCC 3401 §9.28	Engagement <1.39N Separation >0.11N	OK	
G5-02 : Plating thickness	ESCC3401 §9.14	gold >1.27µm nickel >0.3µm	OK	
Contact capability.	ESCC3401 §9.4	Pick-Up Weight : 10 g Drop Weight;: 80 g	OK	

6.4 Main conclusion

The tests performed on the test vehicles in the frame of this nanoD evaluation show that nanod connectors have real potential to be used for space industry.
The test vehicles withstand:
- space thermal environment (EXOMARS 333 cycles from -124 to + 80°C)
- mechanical vibrations (20Hz to 2000Hz, with a spectral density of $0.4g^2/Hz$ during 2 hours)
- Mechanical shocks (30 half-sine shock pulse of 50g amplitude and 8ms duration), mechanical endurance (700 cyles)
- 1695 hours of thermal endurance (1695 hours at +150°C)
- 1205 rapid change of temperature cycles (from -55°C to +150°C)
- …

These tests provide requirements listed in the draft ESCC specification (rated current, rated voltage, insert retention…).

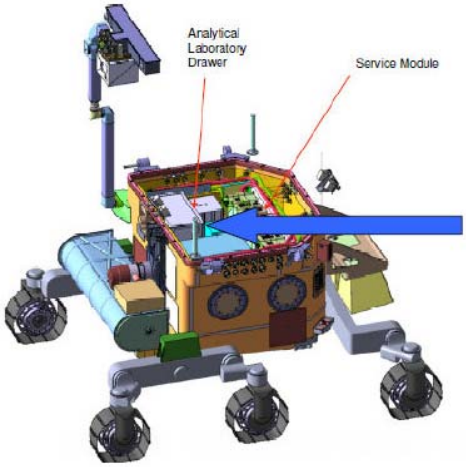
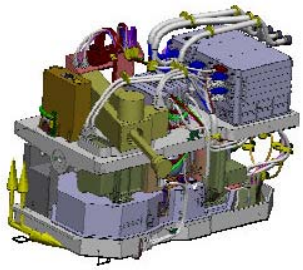
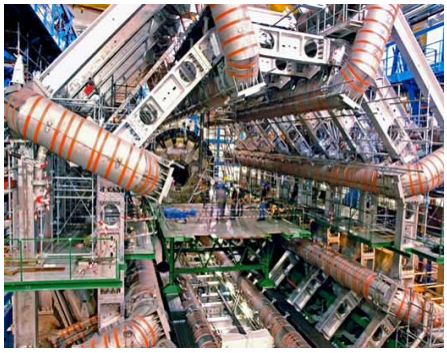
Of course, the use of such connectors brings some constraint on handling and installation. Refer to the user guide to get all the different recommendations for using nanod connectors (09034-USERGUID-A-01-axon').

7 Perspectives (Commercial evaluation)

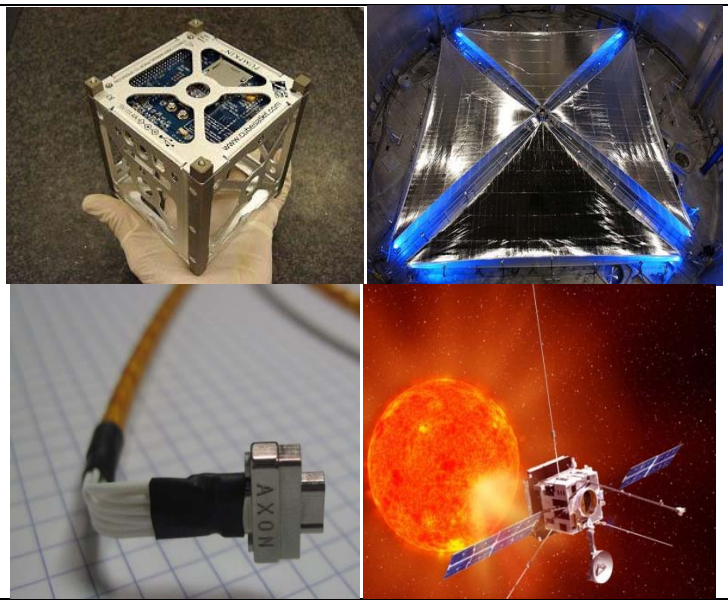
As a matter of fact, Nano D connectors are not new products for some markets apart from the Space one; it is well known to be used in military applications for which an international standard specification exist already (MIL-DTL-32139). The offshore market is another field showing interest and using nano D with similar design.

It means nano D connector technology has already proved to be a reliable solution for these “non-Space” markets. And the main point of this evaluation was to clarify as many of the remaining uncertainties on the existing Axon’ connector variants as possible. As a result of this Technology Research Program study, it was demonstrated that from a general point of view nano D connectors are suitable for space applications with regards to many ESA standard requirements and they have real potential to become Space flight components.

Perspective of commercial need where high density connection is needed

o Rovers o Pan Cam o Radars o Scientific application o Plug-in Optronic Payload o …	  Analytical Laboratory Drawer  

- Perspective of commercial need where mass saving is requested :

o Low mass Spacewire. o Cube Sat o Solar Sail o Solar Orbiter boom	

The nano D test vehicles were manufactured in the frame of this evaluation largely based on the MIL standard design. It involved only the following minor modifications:

1. connector shell plating thickness was increased from its current MIL requirement following the same principle as what happened before for micro D connectors between military grade and space grade.

2. cables and wires terminated to the nano D contacts switched from military grade to ESCC qualified cables and wires.

Reaching so many encouraging test results in this evaluation by implementing only the few minor changes described above proves the maturity of the nano D connector technology as it stands.

Nevertheless some areas for improvement have been identified.

First, there is apparently a need for systematic manufacture in clean-room for future flight and qualification models as to avoid any contamination during assembly.

In order to comply with this requirement, Axon' is substantially investing to extend its clean-room (class 100,000) capacity by the end of this year. This clean-room extension will count a specific area for nano D connector manufacture including equipment and trained staff. This is in line with the recent observations of the ESA analysis on some Axon' nano D samples which were torn apart. These samples had been made in an environment with lower constraints on cleanliness.

Second, the twist pin contacts used in the test vehicles of this evaluation was supplied to Axon from an external source because Axon' was still in the process of internalising this contact when time to manufacture the test vehicles came. But this is Axon' intention to use this externally sourced twist pin no more and replace it by its own twist pin contact fully developed and currently being industrialised in-house.

Axon' invested in control equipment for nano D twist pin contacts which will allow guaranteeing better quality while increasing yield and reducing delivery time.

Third but not least, the major improvement in the design could be provided to the screwlocks used to secure mated nano D connectors together. It turns out from the evaluation indeed that the current available Axon' screwlock designs, representing also what most of the competitors can propose as a standard, are limiting the mating-demating lifecycle and do not allow a handy and robust solution when users will handle the connectors.

Fourth, for some potential specific application, it may be interesting for customers to have an non-magnetic nano D solution at hand. Axon' has the capacity to manufacture amagnetic nano D shells based on its experience with EPPL2 qualified micro D connectors. The current screwlocks are more problematic since they are magnetic due to stainless steel material and Axon' recognise the difficulty to propose an alternative as of today to the current material used.

The magnetic aspect as well as the screwlock issue for nano D could be investigated further by Axon' if the need is confirmed by Agencies or customers with associated funding.

In conclusion, as illustrated in this section, Axon' is clearly interested in taking this evaluation to the next level meaning a full qualification to reach EQPL/EPPL1. Substantial investments (clean-room, equipment, staff training and so on) have already been massively made this year by Axon' to try and follow this

. Additional funding is necessary to achieve the remaining work to reach EQPL, that will confirm the good results of this evaluation and that will will decrease the nanoD connectors procurement cost (no PAD, no LAT, Non conformance management...) for space application.