AEROSPACE,
DEFENCE & RAILWAYS

esa cleansat

ALTRAN_D4D Building Blocks

Evolutions & Way Forward

Rockwell Collins nimesis

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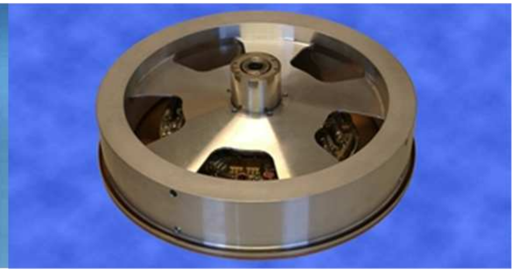
BB 11:
DEMISE Wheels

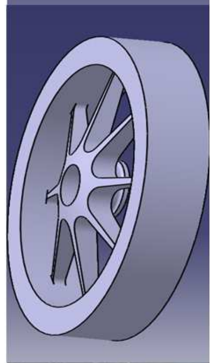
Reaction **W**heels **A**ssemblies are **DEMISE -** problematic for LSI LEO S/Cs

- **B11** investigated **several options & proposed several D4D Initiatives**

— **Option 1 : Mechanical Upgrade** (-11% inertia - Iso Volume – Iso Mass ?)

=> Take opportunity of RCD Initiative on **Monobloc Flywheels (68Nms)**

ALTRAN D4D Design (RSI68) with flywheel material swap **Steel**->**Aluminium**

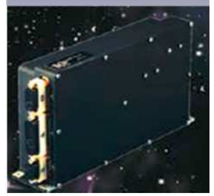



— **Option 2 : Electrical Upgrade** (-45% inertia – PWR x2 – Iso Mass?)

=> Take opportunity of RCD Initiative on **High-Torque Electronics (BBM, EQM)**

Mechanical downsizing (RSI45) & **Increase of Speed and Torque Capabilities**

GOAL: DEMISE COMPLIANCE and AOCS performance increased to COMPLIANCE



— **Option 3 : Internal D4D techniques** (BBU : Ball Bearing Unit)

Internal Dismantlement, **Core Material Swap**, **Re-use of Magnetic Wheels Technologies**,

Core Down-sizing (Ball Bearing Unit Assembly)

BB 11: DEMISE Wheels

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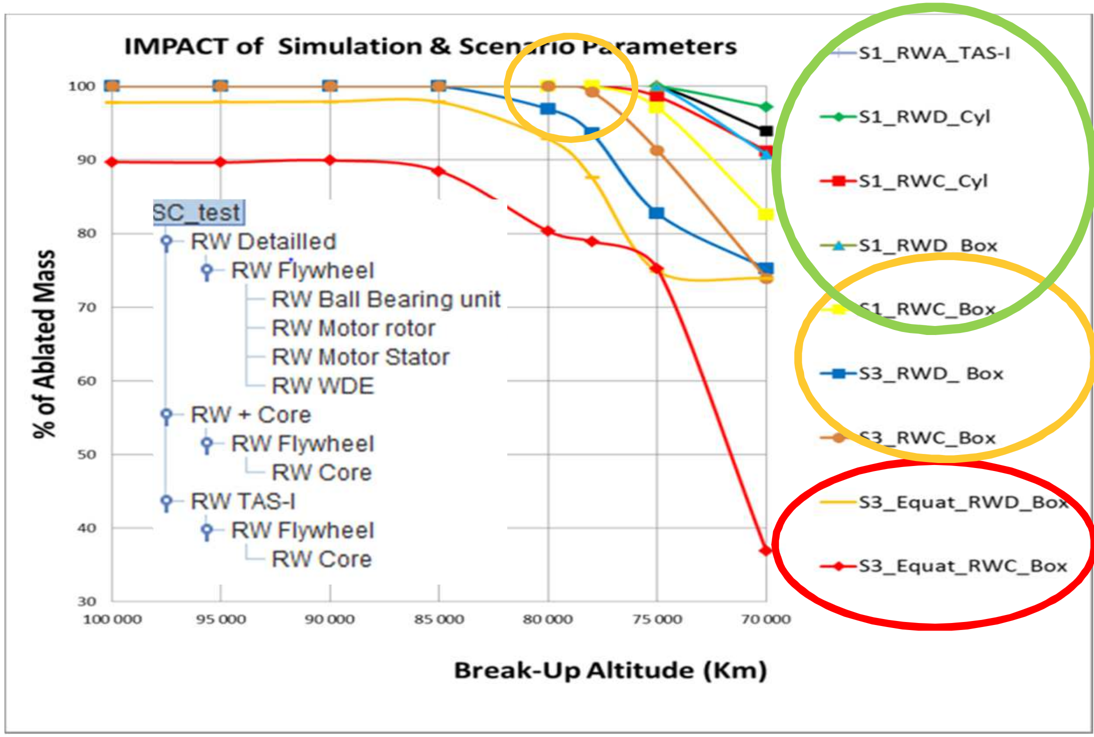
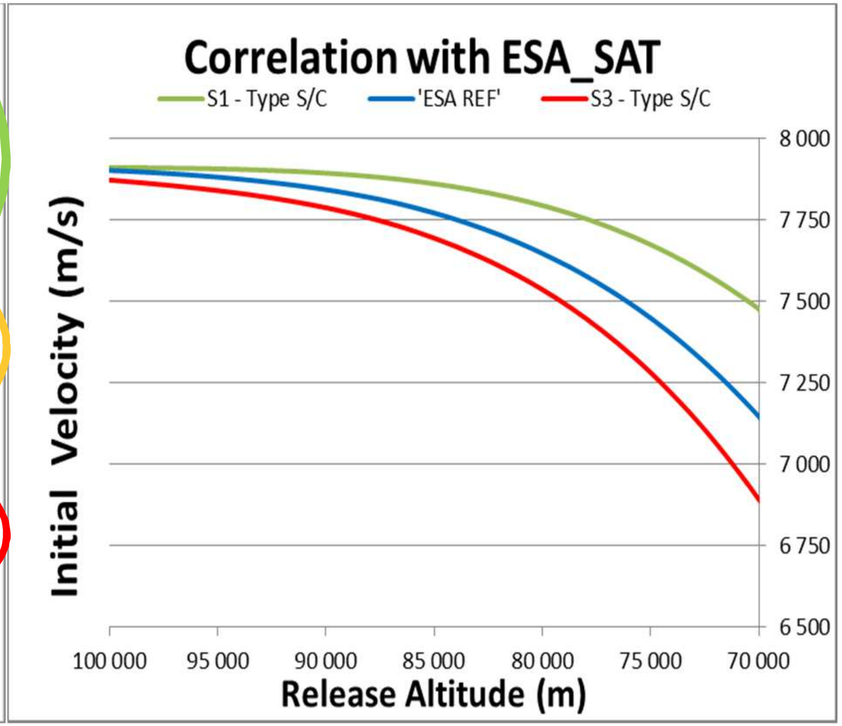
Main DEMISE Investigations & Results : DEBRISK v2015: S/Ctest = **S3** & **S1 P/F**





- **BB11_Options 1&2** demonstrated **MARGINAL** COMPLIANCE (**DEBRISK > 78km**)
- **BB11_Options 1&2** demonstrated **NON-**COMPLIANCE (**DEBRISK <78km**)
- **Securisation needs ADDITIVE D4D Techniques**

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BB 11: DEMISE Wheels

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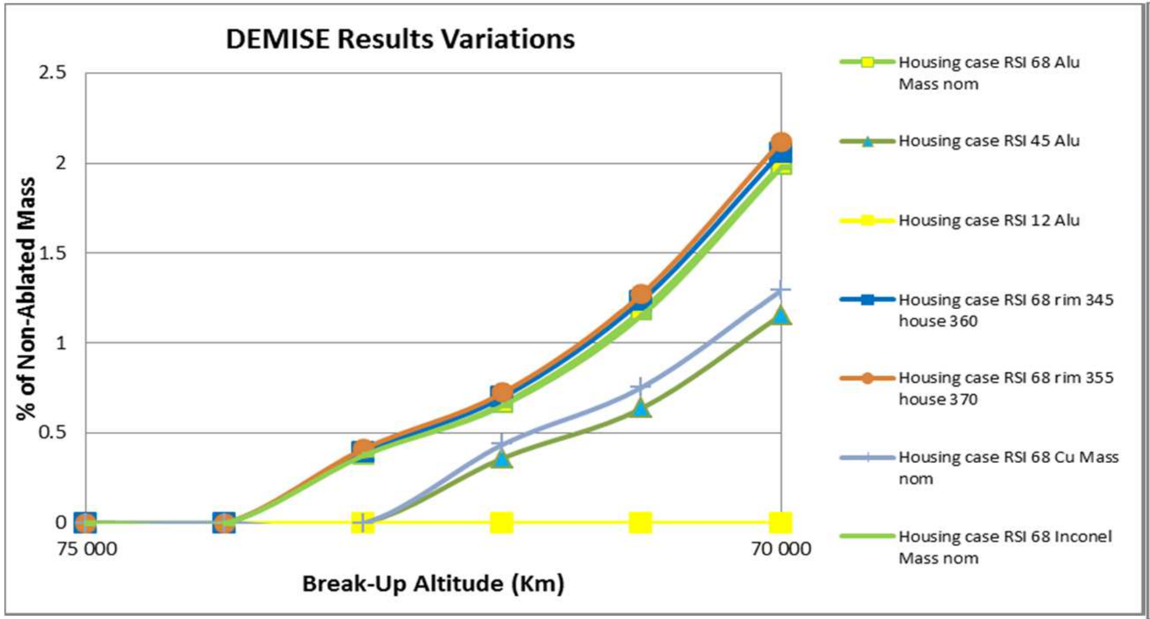
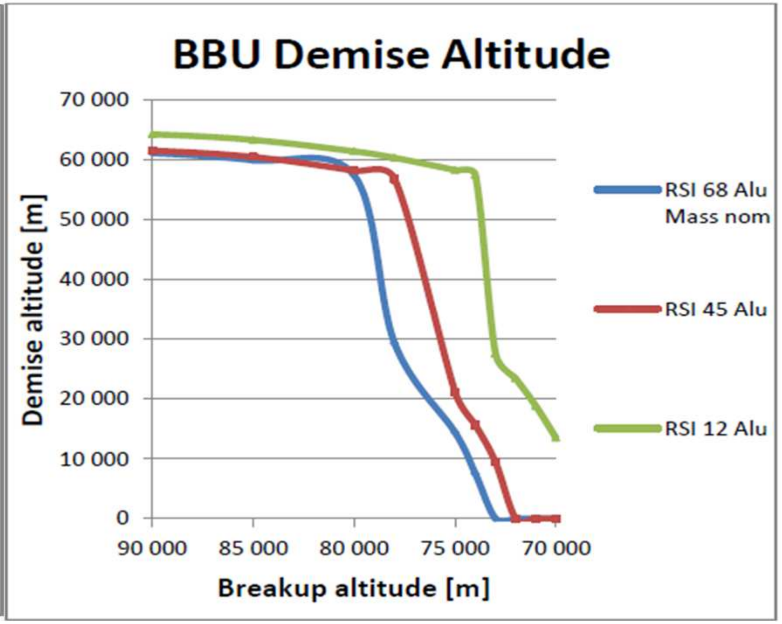
Main DEMISE Investigations & Results :

Impact of Alternative Design: **Material** (Cu/Al/Ni) **& Size** (RSI 68/45/12) & **Diameter**





Conclusions :

- **DEMISE** impact **: Al > Cu > Ni & DEMISE vs Inertia** Efficiency **: Cu > Al > Ni**
- **Size impact :** BBU Demise **always PROBLEMATIC** for COMPLIANCE **@ 65km Alt**
- **Diameter Impact : Larger Al Flywheels degrade RSI68 ballistic coefficient**

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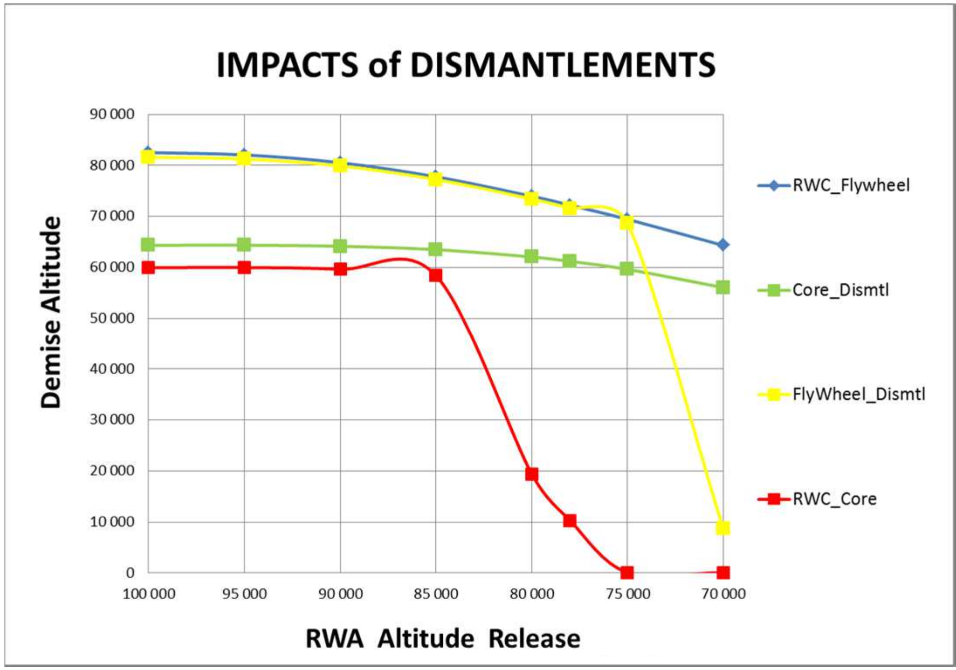
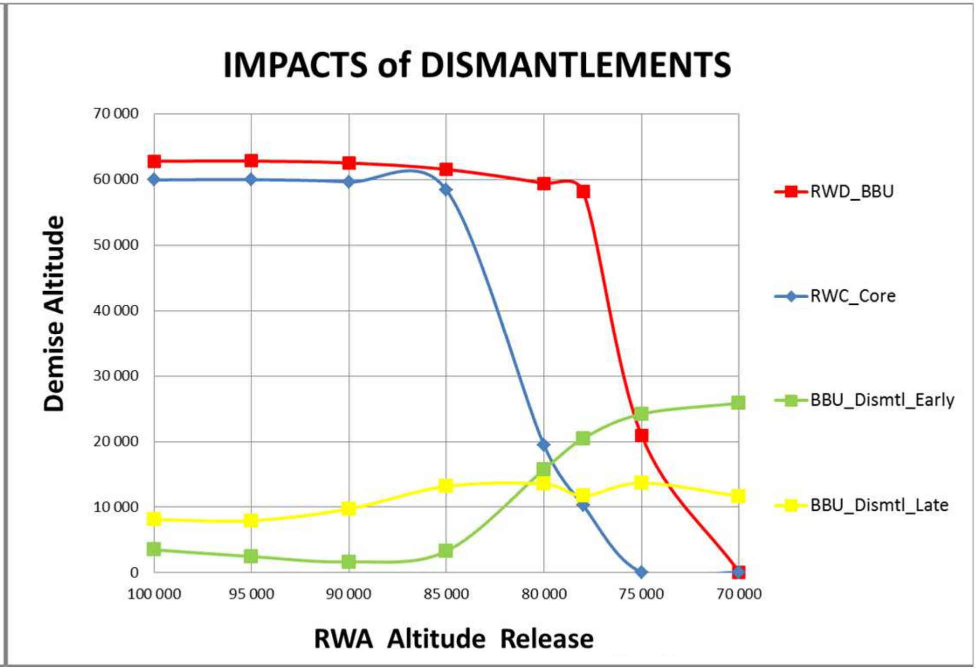
BB 11: DEMISE Wheels

Main DEMISE Investigations & Results

- o RWC_Flywheel: details Flywheel in RW **Coarse model (**Core attached to Flywheel)
- o RWC_Core: detail Core element in RW **Coarse model** (Core demise after flywheel)
- o Core_Dismtl: Core in **dismantlement scenario** Flywheel / Core
- o Flywheel_Dismtl: Flywheel in **dismantlement scenario** Flywheel / Core
- o RWD_BBU: details BBU block (with no dismantlement) in **Detailed model**
- o RWC_Core: detail Core element (with no dismantlement) in **Coarse model**
- o BBU_Dismtl_Early: Dismantlement of **each BBU part** after **Housing demise**
- o BBU_Dismtl_Late Dismantlement of **each BBU part** after **Flywheel demise**





- ➢ **BBU Dismantlement is promising but raise risk on flywheel (Al->Cu?)**
- ➢ **BBU parts EARLY dismantlement sound the more promising but more risky**
- ➢ **BB11_Options 3** demonstrated **CHALLENGING COMPLIANCE** (**DEBRISK<78km**)

BB 11: DEMISE Wheels

Main DEMISE Investigations & Results :

DEBRISK vs TAS-I & SCARAB (**2015**): **+10%** Ablated Mass / **-10km** release altitude

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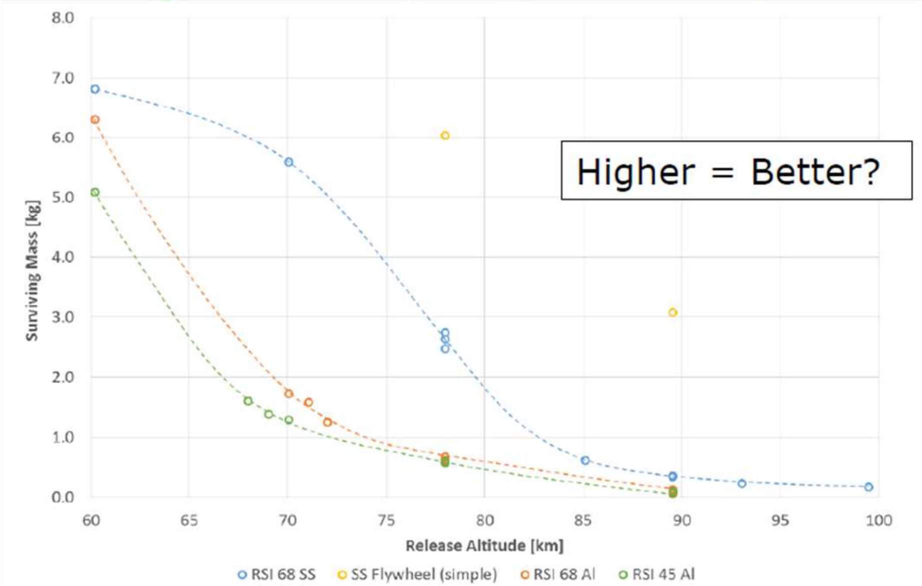

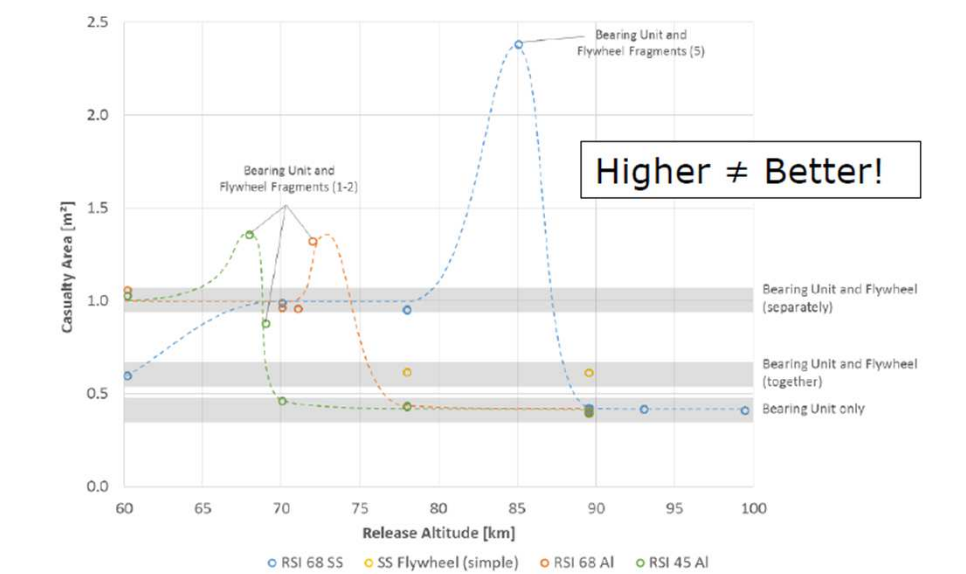

BB 11: DEMISE Wheels

Main RECOMMENDATIONS :

At RWA Equipment Level: Inspiration=NASA Goddard DEMISE Wheel

- Flywheel **spokes-brazed** design -> **Monobloc** (risk of several debris /uncontrolled release)
- RW Housing as **thin & DEMISE** as possible (few impact: 2km Alt / 1mm)
- Flywheel & **large apertures** spoke-like design: see RSI designs vs Simu models)
- Drive Electronics: **External unit** instead of internal: see RCD(S1&S3) vs MOOG(S2)
- Internal **Dismantlement techniques** assessed as DEMISE-attractive but **risky** (case by case)
- Material swap (**Core parts** only) **too risky** for **BBU & tribology** aspects

RCD Position : "Don't change smtg working!!"=>Risk on 40 years flight heritage

=> Main BB Lessons learnt: **Manage D4D Techniques @ S/C & P/F level instead**

At S/C Architectural Level :

- RWA **External S/C** location (Airbus @ ESA D4D S/C activity)
- RWA on **Easy dismountable** panel (Thales @ ESA D4D S/C activity)
- RWA mounted on **Release I/Fs** SMA Mechanisms (ALTRAN BB10 CLEANSAT)
- RWA mounted on RWA (+Tank?) Architectural **DEMISE Block** (ALTRAN BB proposal)

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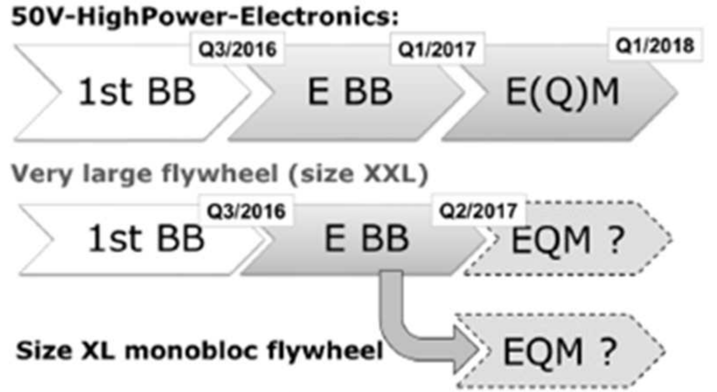
BB 11: DEMISE Wheels

Roadmap : => Assumed **NO CHANGE since CLEANSAT** BB11 closure

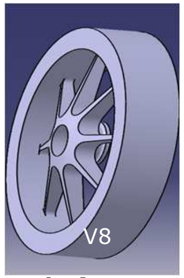
But ALTRAN/RCD NDA ended early 2018 => No MORE Feed-Back from RCD

At RCD Level:

- EBBM EU units -> Status ?
- EQM EU Units -> Status ?
- Large Monobloc FlyWheel Redesign -> ?
- ESA TRP BBU demise improvement -> KO ?
- ESA CLEANSAT V2 Demise Wheels RFP ?



: RCD development Roadmap for 50V-HP-electronics and XL monobloc flywheel



At ALTRAN Level:

- Support for Mechanical Large Flywheel **Redesign (BB11 REX)**
- Support for **Design for Demise Techniques** inside RWA
- Support for Demise **DRAMA/DEBRISK simulations** Coarse model (D4D trends)
- Support for Demise **Material DATABASE**: ALTRAN RESEARCH/ESTIMATE/Others ?
- Collaboration with **HTG -> SCARAB** Detailed model simulation of best technique ?

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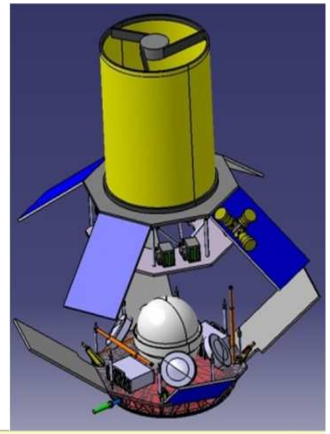
BB10 – Shape Memory Alloys Mechanisms

Shape **M**emory **A**lloys are used as **Release devices** activated by temperature

Application: ➔ S/C Controlled Dismantlement (asset for uncontrolled re-entry)

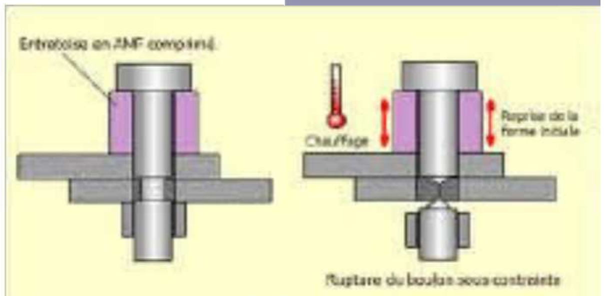


Step1 : D4D Release Devices Applications on S/C

- Appendage Dismantlement, Structural Frames dismantlement
- Panels Dismantlement, Modules Dismantlement P/F vs P/L ?

Step2 : Release Mechanisms Investigations & Pre-Design

- Frangilbolts, Mechanisms, Cryofits, Pyro Cords : **Pyro -> SMA?**

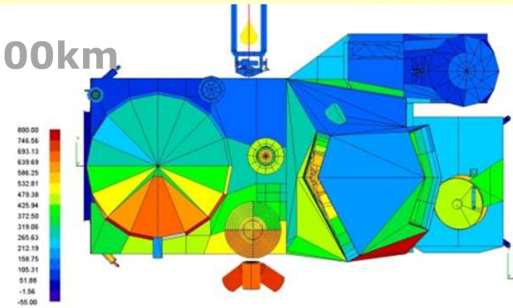


Step3 : Shape Memory Alloys Development & Investigations

- European Supply source of Frangibolt®-like TiNi alloys
- **H**igh-**T**emperature SMA development + **UHT** SMA investigation

Step4 : SAT Thermal Characterization Analysis in Pre-Rentry **>100km**

=> Activation T° Triggering vs **Safety** Margin (Internal / External)



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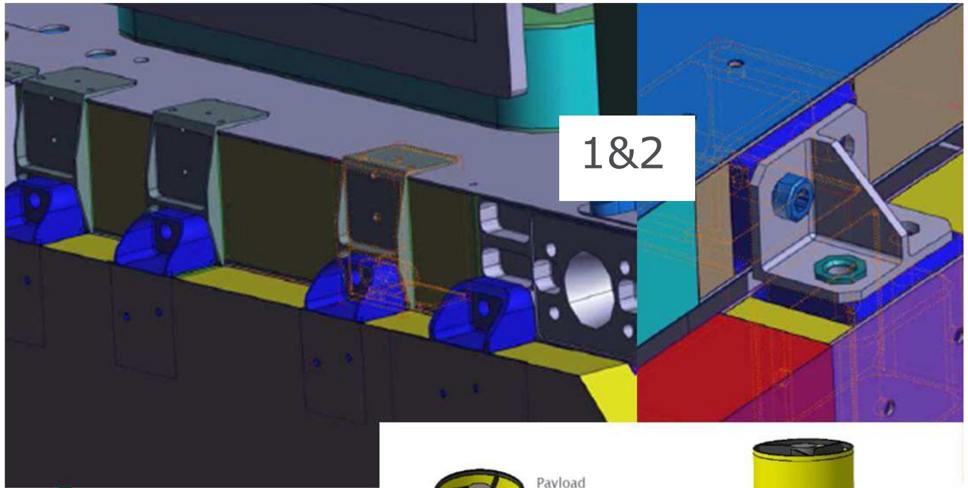
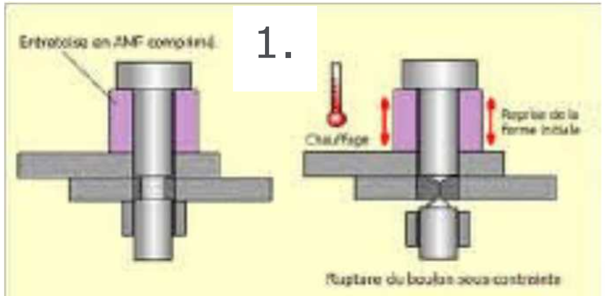
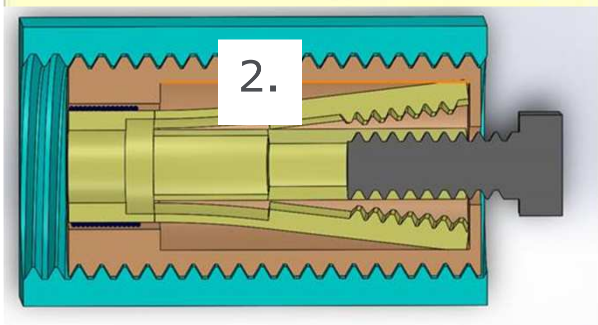
BB10–SMA Mechanisms

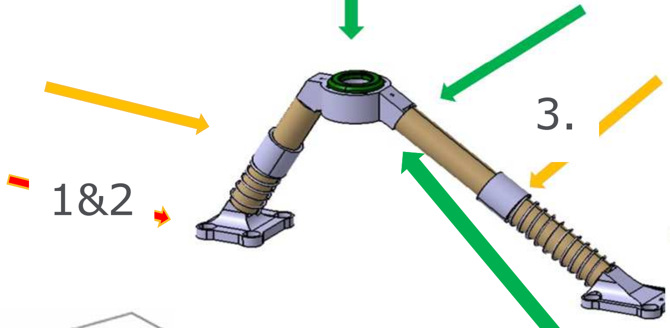
Outcomes: Baselined devices

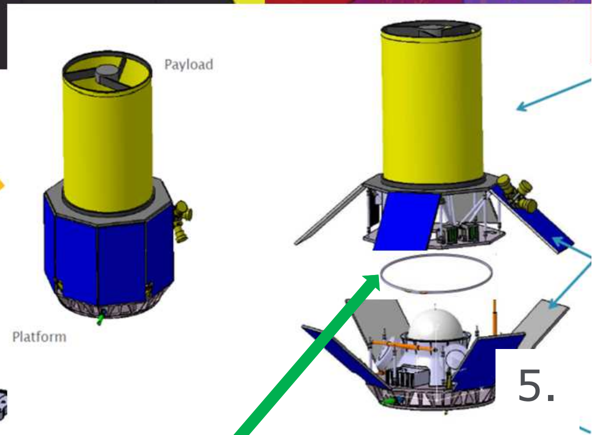
1. **SMA Washers** (Struts, Screws, Clamp Band)
2. **SMA Inserts** (middle & end CFRP panel insert)
3. **SMA Sleeves** (Struts, P/L Booms)
4. **SMA Cutting Cords** (Tubular frames)
5. SMA Hinges (Fold Panel & Release at end)

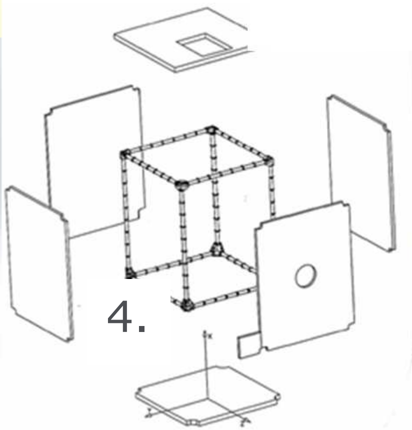


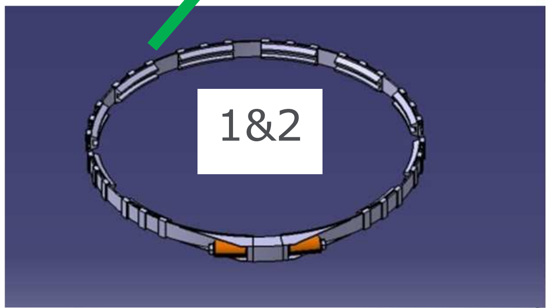


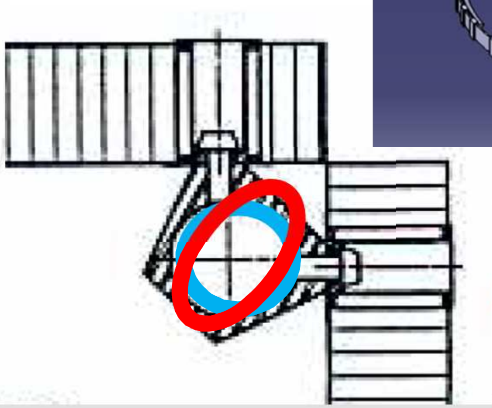


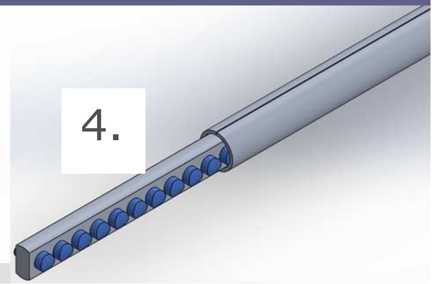








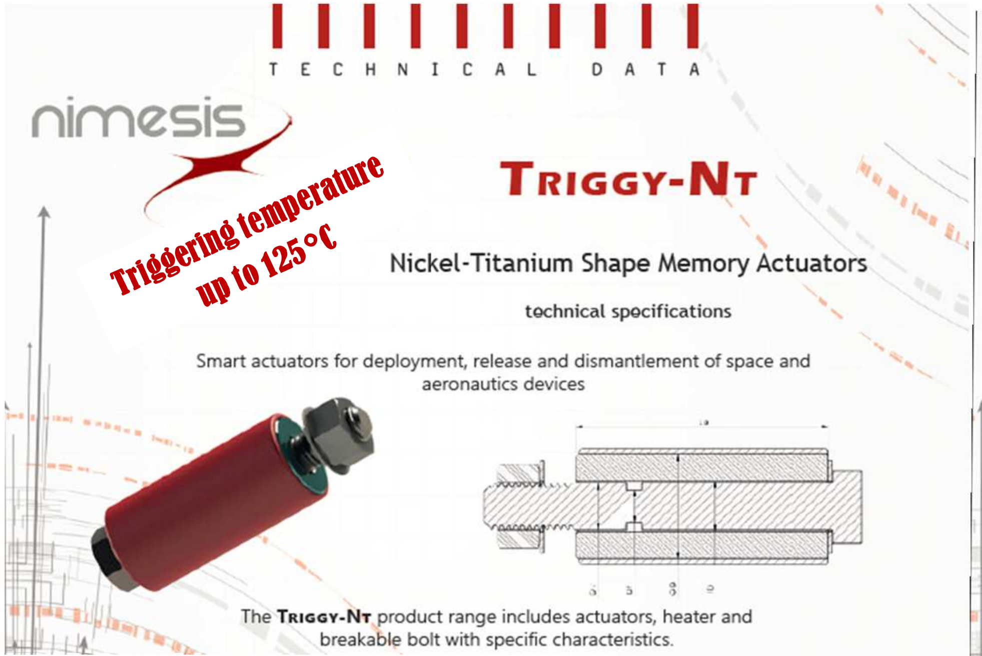


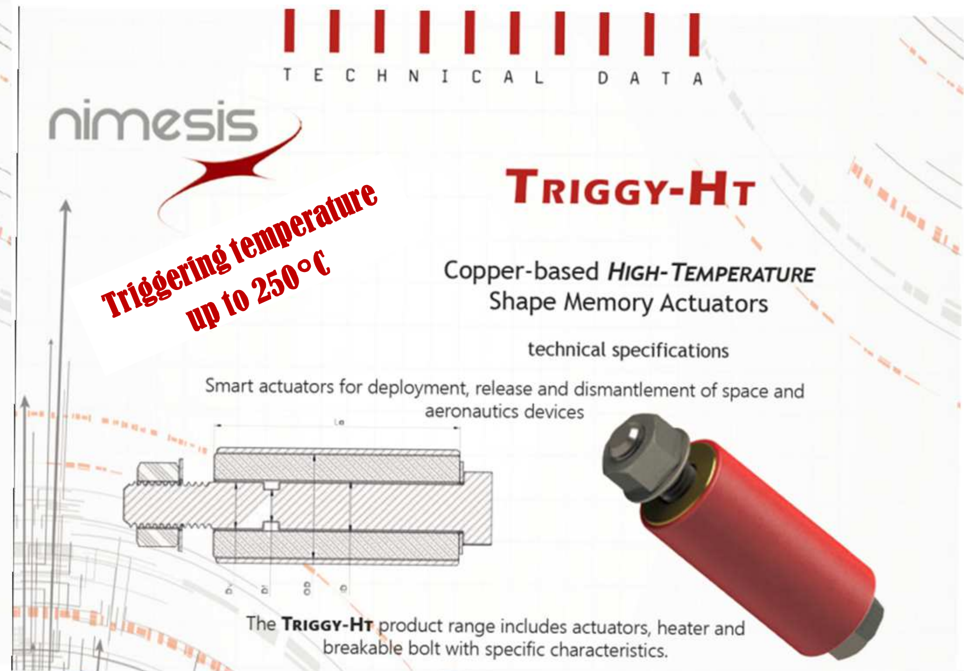


BB10–SMA Mechanisms

PROS & CONS : Concept 1 : **SMA Washers**

Active & Passive devices available	Screw Tension @ 50% Screw Rupture
Simple & Rustic / Testable / Reusable /Demise	M6 Design => M5 Tension (screw striction)
Triggering T° : <**75-125°**C (**NT**) / <**100-250°C** (**HT**)	CTE: (**NT**=11->Ti) (**HT**=17-> SS & Ti?)
Safety Margin T° : **35°C** (**NT**) / **50°C** (**HT**)	OverLength => 4D (washer & screw)
TRL:**NT**=6 / **HT**=5->**ESA-OHB dismantlement Test @ DLR !!**	Density: 6-7 (Mass **x4** vs Standard I/Fs)





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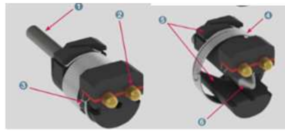
BB10–SMA Mechanisms



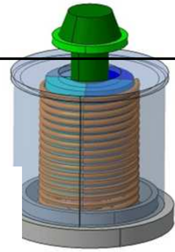
PROS & CONS : Concept 2 : SMA Inserts : Thread parts enlaced & released with SMA actuator

PROS	CONS
Same SMA Materials & supplier / Same PROS	More Complex: Tribology & Mechanisms
Dismountable / Testable / Reusable / Demise	TRL: 3 -> 4 (end 2018) -> 5 (OHB tests 2019 ?)
ISO-Screw I/F definition => Length/Diameter/Material	Development / Validation: Higher NRCost
ISO-Thread I/F (TBC) => Tension/Material/Torque	More Parts: Iso – RCost ?
FEW SMA material => Not used in I/F structural path	
Compact & Light => **50% mass saving** vs Frangibolts	

Concepts Evolution :

(2016->2018)

1\.



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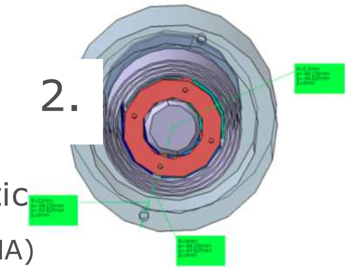

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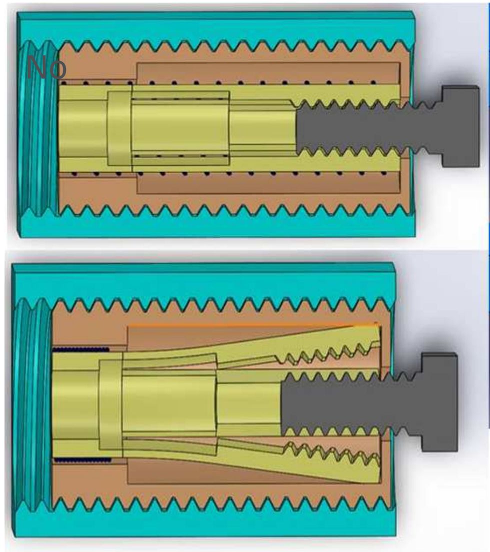

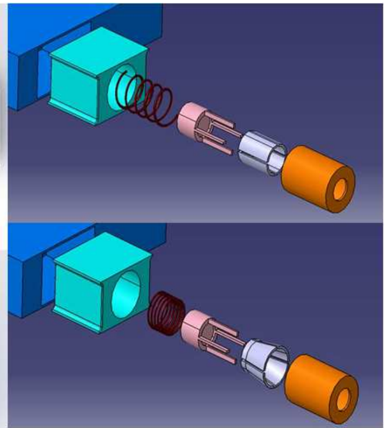

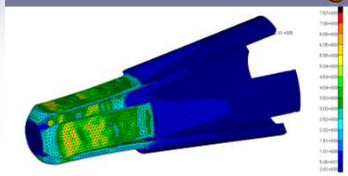

Lessons Learnt :

SMA resistance Cold/Hot 1:4

=> No Cold SMA for structural purpose

(screw tension axial/radial need large amount of SMA)

Metallic **Elastic Return** after 40yrs is erratic

Shock Release Helps !! (to be adapted for SMA)

Compact **Cylinder** Panels Inserts fits **Everywhere**

Device Mounting : **Rear** / **Front** (1.2.3.)

Device Tension : **1.**Spring Wire / **2.** Strip Spring

3.Blocking part push released under screw/thread radial tension

Device Actuator:

1. SMA Springs / **2.** Small Frangibolt / **3.** Belleville SMA Washers

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BB10–SMA Mechanisms

ROADMAP : => Almost **NO CHANGE since CLEANSAT** BB10 closure

NOTA: ALTRAN/NIMESIS partnership is now more than 4 Yrs Old !!

At NIMESIS Level:

- CNES R&T (large SMA-HT parts engineering) -> **Starting right now !!**
- Concept 1 Design authority : **SMA Washers**
- SMA Mechanical Characterization
- SMA Alloy Process Engineering / Development / Production

At ALTRAN Level:

- Concept 2 Design authority : **SMA Inserts** / Other D4D mechanisms
- Impacts on Satellite architecture & Design for Demise
- Space Qualification Documentation (Test plan / Test reports / File Justification)
- Support for Product & Qualification Assurance / Material & Process compliance

At PARTNER(s) Level: => TBD (every partner & customers are **WELCOME !!**)

- Mechanism Assembly / Integration / Environmental Tests (**Qualification** Phase)
- Mechanism Assembly / Integration / Environmental Tests (**Mass Production** Phase)

PS: Thanks to OHB Team for their Intention Letter @ ESA ITI initiative 2017

SPIN-OFF : Reentry Simulation

TOPIC : S/C Thermal Characterisation

ALTRAN_ESATAN S/W on S/C Thermal Models

Correlated Model (post CDR & TVAC thermal balance)

=> Full Representativity of Th couplings / Accuracy Int & Ext

APPROACH : S/W Reentry Trajectography

DEBRISK-DRAMA Trajectory (no attitude) +

Aerothermal Flux calculation= f° (alt , time)

(Free molecular – Non Tumbling Box)

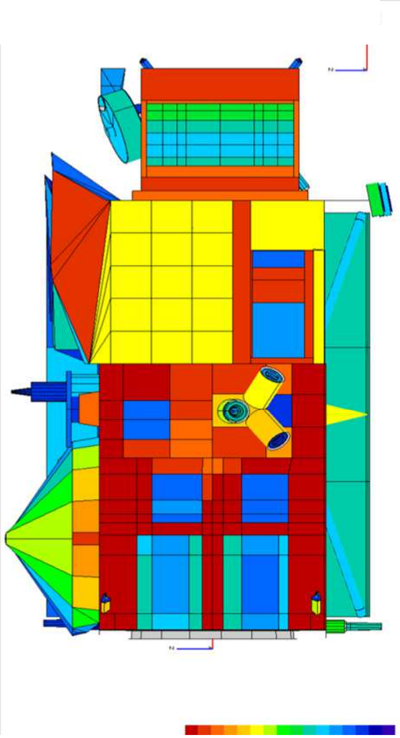
Assumed **Non-Tumbling** (REALISTIC: SAW trail drag)

=> Considered as a **Worst Case** (T° Gradient)

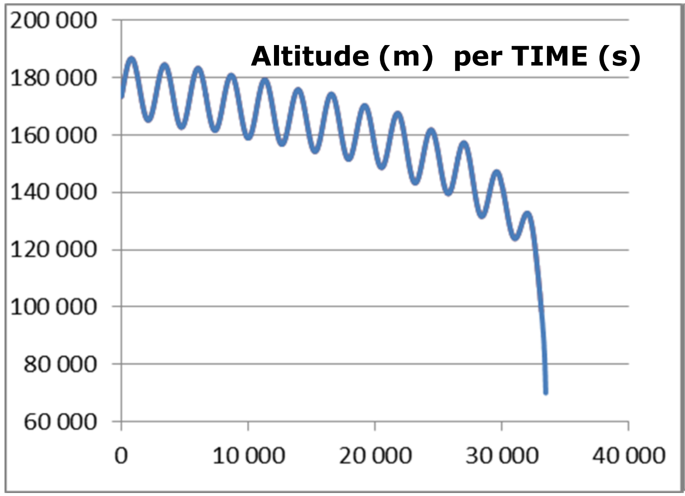
CONCLUSION:

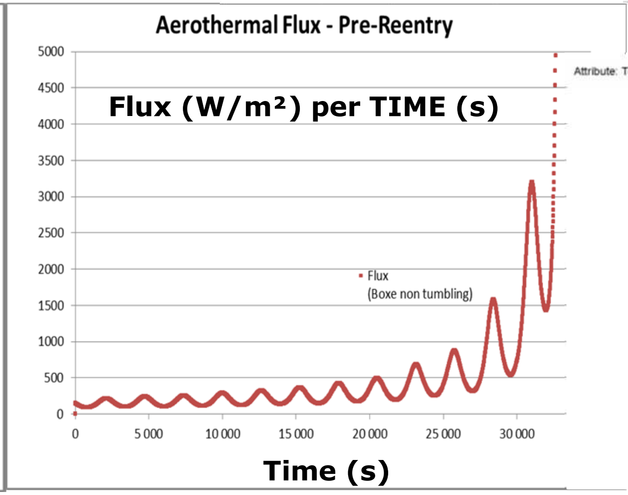
⇒ Worst Hot Case : Front MLI Faces : 250-300°C

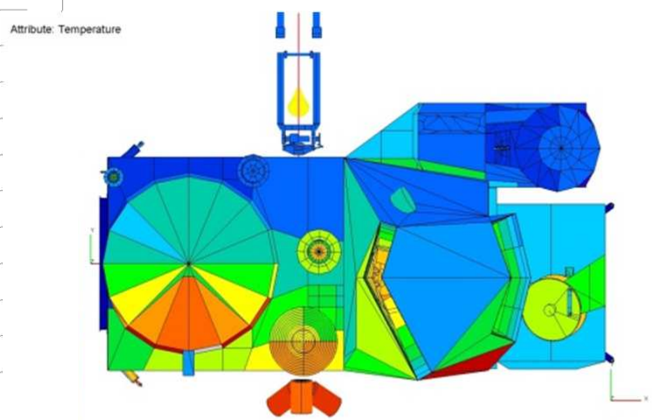
⇒ Worst Cold Case : Rear Faces : <0°C



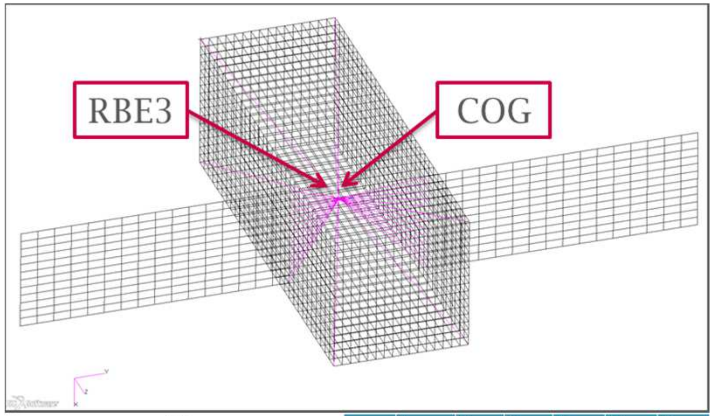
t DEBRISK (s)	Altitude (Km)	Aero Th (W/m^2) Flux	Corrected Alt (Km)	t ESATAN (s)	Ext T° Max (°C)	Ext T° STR (°C)
32 222	131 115	1 638	110 860	32220	185	116
32 262	130 477	1 729	110 163	32260	190	120
32 302	129 734	1 842	109 454	32300	196	125
32 342	128 887	1 982	108 735	32340	234	156
32 382	127 938	2 158	108 006	32380	239	166
32 422	126 890	2 377	107 268	32420	245	178
32 462	125 747	2 652	106 522	32460	255	185
32 502	124 514	2 998	105 770	32500	269	197
32 542	123 194	3 433	105 012	32540	284	235
32 582	121 795	3 997	104 249	32580	302	250
32 622	120 323	4 733	103 481	32620	324	270
32 662	118 784	5 705	102 709	32660	350	292
32 702	117 185	7 005	101 933	32700	379	319
32 742	115 534	8 802	101 152	32740	415	351
32 782	113 837	11 290	100 366	32780	460	390
32 822	112 102	14 862	99 573	32820	512	436
32 862	110 334	20 246	98 771	32860	575	493
32 901	108 604	27 526	97 984	32900	648	514
32 942	106 740	35 608	97 295	32940	725	531
32 980	104 965	51 531	96 297	32980	809	594
33 022	103 005	72 499	95 351	33020	903	665
33 061	101 165	100 273	94 425	33060	1008	745
33 097	99 456	135 621	93 523	33100	1124	831







SPIN-OFF : Reentry Simulation



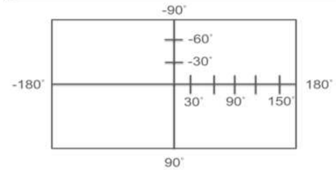
TOPIC : **S/C Dynamic Characterisation**

ALTRAN_NASTRAN S/W on S/C CAD model

Full Geometrical Correlated Model (post CDR CAD design)

⇒Full Representative of external shapes & Accurate MCI (inertias)

⇒No remodelisation



	Fx	Fy	Fz	Mx	My	Mz
0	6.10E-07	-2.22E-06	4.00E+06	7.08E-04	4.85E-05	-1.10E-07
30	-3.01E-04	2.53E+06	4.37E+06	-7.30E+05	1.29E-04	7.04E-04
60	4.99E-05	4.21E+06	2.43E+06	-2.69E+05	1.39E-05	-1.63E-04
90	-7.94E-08	3.00E+06	1.75E-06	2.91E+05	5.44E-07	3.14E-06
120	2.39E-05	4.18E+06	-2.41E+06	-1.67E+05	4.51E-05	-6.43E-05
150	-1.7722E-05	2740625	-4746900	-1.03E+06	-3.18E-05	1.13E-04
180	-6.28E-07	2.18E-06	-4.00E+06	-7.08E-04	-4.85E-05	1.09E-07
210	2.45E-04	-2.70E+06	-4.68E+06	9.35E+05	-1.66E-04	-5.58E-04
240	7.00E-05	-4.11E+06	-2.38E+06	-1.08E+04	-3.78E-05	1.27E-04
270	4.08E-07	-3.00E+06	-4.42E-07	-2.91E+05	-1.04E-06	-2.33E-06
300	-8.86E-05	-4.37E+06	2.53E+06	5.08E+05	-3.22E-05	-1.79E-04
330	2.18E-05	-2.56E+06	4.44E+06	6.96E+05	2.83E-05	-1.09E-04

APPROACH : **S/W Reentry Trajectography**

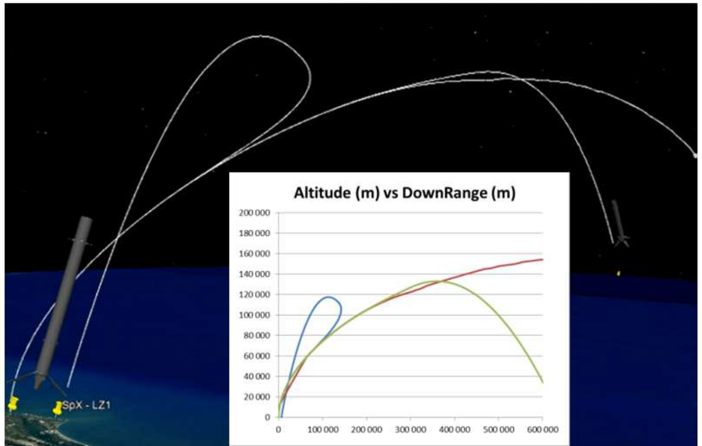
DEBRISK-DRAMA Trajectory (no attitude) +

Dynamic Characterisation (NASTRAN)

Flux direction & intensity : **MSISE-00** assumption = **f° (alt, time)**

=> **3 axis Torque & Force NASTRAN characterisation** per Azimut/Elevation

(Only front faces exposed to Flux produces Torque -> shadowing effect)



NEXT STEP : (Reuse of 3D LAUNCH/ ORBIT & 3D AOCS simulator -> 6D)

Simulation S/W: **Torques/Forces during Reentry step by step**

⇒ **Attitude & Dynamic rate** on Reentry Trajectory => INPUT for **ESATAN**

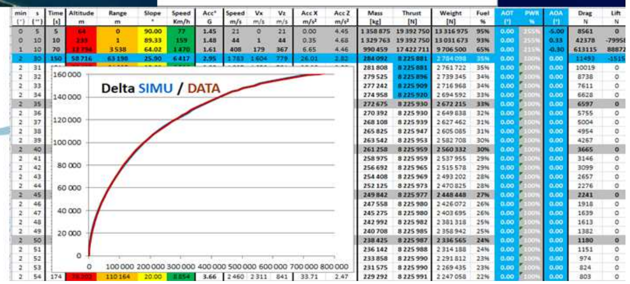
⇒ **Downtrack/CrossTrack impact** vs initial Trajectory => **Google Earth** Movie

CONCLUSION: *(Expected End 2018)*

Dynamic & Attitude Determination in high Atmospheric perturbation

⇒ **Uncontrolled Reentry** : 3 Axes Dynamic Behaviour (-> ESATAN)

⇒ **Controlled Reentry** : Attitude Control (or NOT) in low perigee

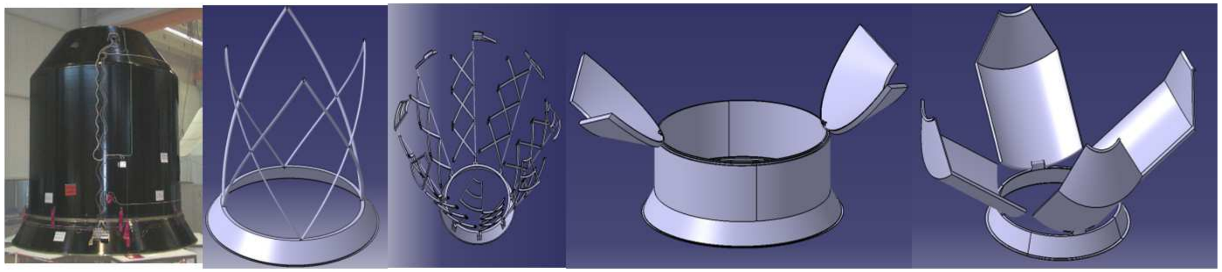


SPIN-OFF : ALTRAN / CLEANSPACE

ALTRAN RESEARCH Cannes Evolution => **Launcher Elements Debris**

ALTRAN Cannes_ **"SYLDA Not Released"** _CNES_DLA (2016-2017)

⇒ **Petals , Expansible Gantry , Lift , Robotic Arm**



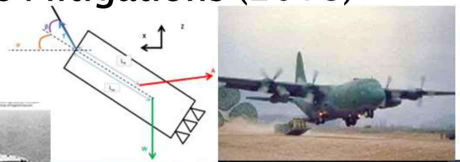
CENTRE NATIONAL D'ÉTUDES SPATIALES

ALTRAN RESEARCH Cannes_ **LAUNCHER Stage Debris Mitigations** (2018)

ST1R: 1rst Stage : **Suborbital Reentry** /Recovery / Reuse

⇒ **Air Capture** : A.C / Drone A/S Air Capture

⇒ **CATAPULT Launch** (SPIN LAUNCH -like)



ST2R: 2nd Stage **Orbital Reentry**/Recovery / Reuse

⇒ **Reentry Kits** : Inflatable Cone / Inflatable Wings

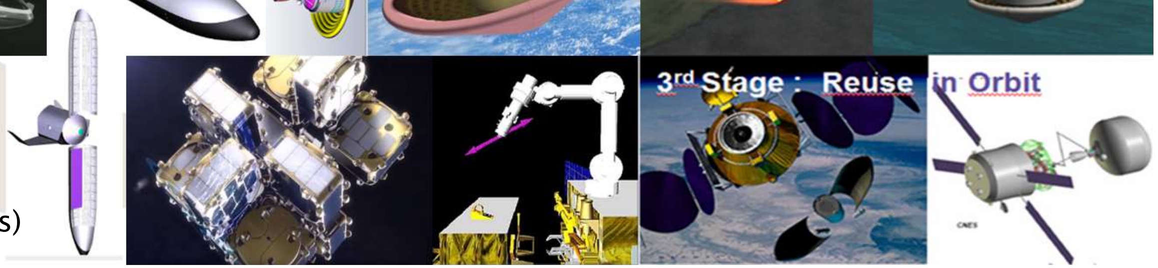
⇒ **Shuttle Transfo** : Folded Wings / Fairing / SSTO

ST3R: 3rd Stage **NO Reenty ,** Reuse in Orbit

⇒ **ADR, Servicing, Maintenance,**

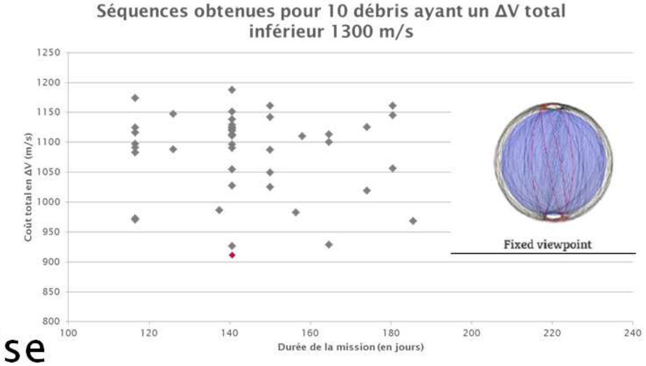
⇒ **Fuel Deposit, Space Tug** (Cargo,Crew)

⇒ **Assembly, Built in Space , Modular S/C** (SATLETs)



SPIN-OFF : ALTRAN / CLEANSPACE

TOPIC : EXTENSION of “CLEANSPACE” Spin Off @ ALTRAN = “GREENSPACE Community “?



ALTRAN RESEARCH Toulouse _ CIR “SPACE CLEANER “

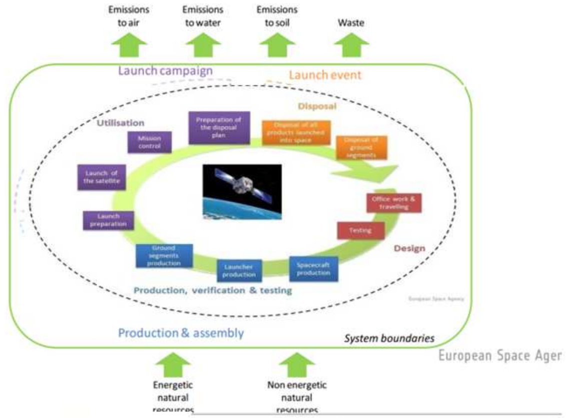
ADR Research – Small Debris / Large Quantity / High Rate Contacless Capture

⇒Main FOCUS on **multiple RDV** capability & optimisation in **debris swarm**

⇒ GTOC 9– Like initiative & Exercise

ALTRAN Aerospace Toulouse_ **Life Cycle Assessment** Expertise

Environmental Impact of Aerospace Production/Operations*



ALTRAN Aerospace Cannes _ **SPACE SAFETY** Expertise

Space Industry **Material/Process Database** -> **REACH** compliance

ALTRAN RESEARCH Toulouse _ CIR NACIN

Airliner Engine Exhaust section optimised by **SMA actuators**

=> SMA **FEM simulation Codes** for behaviour prediction

ALTRAN RESEARCH Aix _ CIR INSIDE

3DPrinted – Heat exchanger development -> **Industry 4.0** Topics :

Topological design optimised for Thermal/Mechanical Efficiency

For all contacts :

AEROSPACE,
DEFENCE & RAILWAYS

ALTRAN RESEARCH

Space Innovations - CIR MMOD

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TEAM Presentation

TEAM Presentation

ALTRAN_FR Key Personnel :

Stephane Heinrich is a senior **ALTRAN consultant**
with experience working for customers on-site such as Thales, Airbus, Safran Groups.
With almost **25 years experience,** he mostly worked on space and **ESA projects** (GOMOS - IASI instruments, ATV avionics chain, PLANCK, Sentinel-3 satellites).

He has a clear expertise in **avionics and propulsion equipments**.
He was trained by TAS-F dependability and safety department and IAASS in ALTEC_I
He is an IAASS professional fellow attending most **space safety** conferences

He is currently leading an **ALTRAN Research** Team working on **Space Debris** topics :
"**MMOD** : Satellite Robustness to Micro-Meteoroid and Orbital Debris"
"**ODAR** : Orbital Debris Atmospheric Reentry" for satellite & launchers
"**MMOD L/V** : Mitigation Measures for Orbital Debris of Launch Vehicles"

Arthur HUMBERT is a **Young Graduate Trainee** from **ESTACA-ISAE**
He is involved as internship at ALTRAN Research in innovative studies relative to Launchers technologies and performance
He is the former **leader** of **SPACE ODYSSEY** (rockets building / testing)