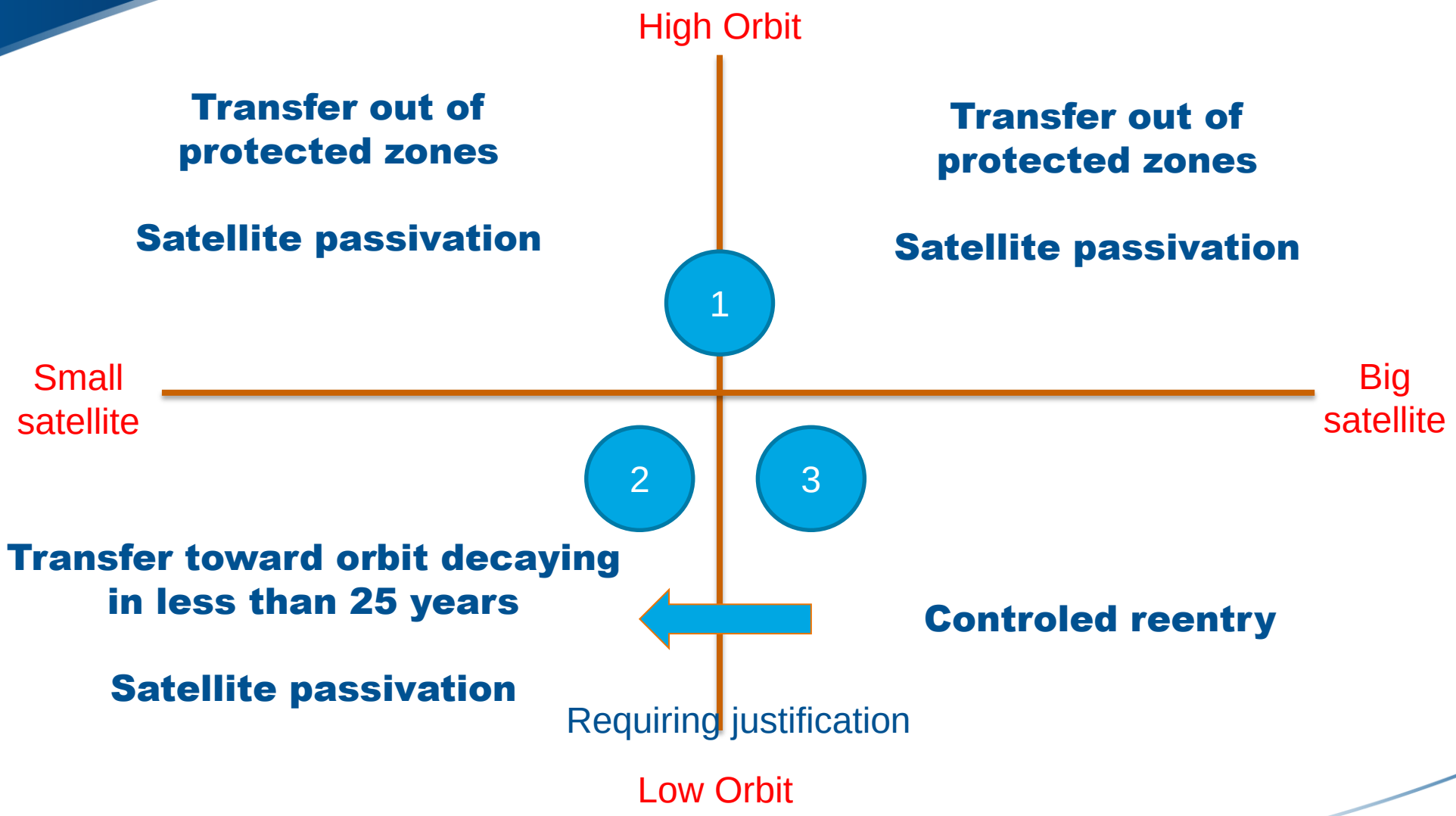
SRL

CNES initiative for satellite compliant with French Space Operations Act

Arnaud VARINOIS,
Denis DILHAN,
Julien ANNALORO

Summary

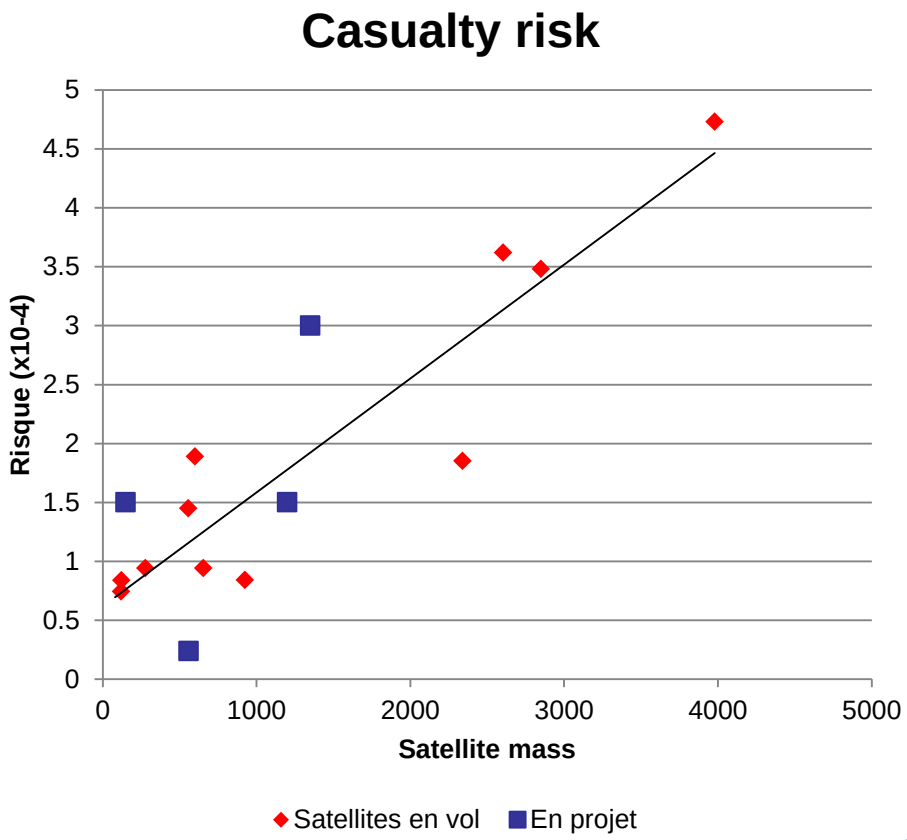
Overview


High Orbit
Transfer out of protected zones
Satellite passivation
Transfer out of protected zones
Satellite passivation
1
Small satellite
Big satellite
2
3
Transfer toward orbit decaying in less than 25 years
Satellite passivation
Controled reentry
Requiring justification
Low Orbit

Modeling issue

- « LOS » authority is verifying conformity
  - With certified tools
    - STELA: 25 years limit
    - DEBRISK: Fragmentation and demisability
    - ELECTRA: Casualty risk assessment in controlled or uncontrolled reentry
  - These tools are available for free

- Issues
  - Reentry Behaviour is not well known
  - Safety in stake so need for conservative approach



Passivation

- High in flight experience in CNES
  - Spot/Helios, TDF/TC2, Mini/Micro (more than 10 satellites passivated)
- Several R&T and development ongoing (see next slides)
- Now well known until satellite switch off
  - Tank depressurization
  - Battery depletion
- But long terme behaviour not well known
  - Thermal behaviour after 20 years in orbit ???
  - Tank pressure in long term

    1% liquid hydrazin remaining after passivation can lead to more than 30 bars pressure due to vaporization/decomposition
- Roadmap
  - Elecrical Passivation

    Long term: New PCDU development embedding SA short or open circuit

    Short term: additionnal specific equipement or low cost HW/SW strategy (NOP OBSW + bypass)
  - Fluidic passivation

    Long lifetime pyro valves

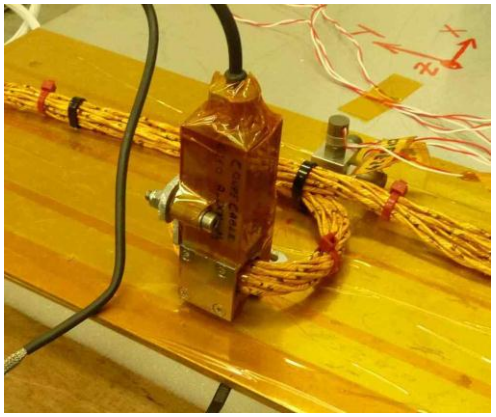
    Micro peforator (see next slide)

- **No issue identified**

Passivation R&T activities :

Contact : denis.dilhan@cnes,fr

Demonstration of the performances of an Off the Shelf cable cutter :



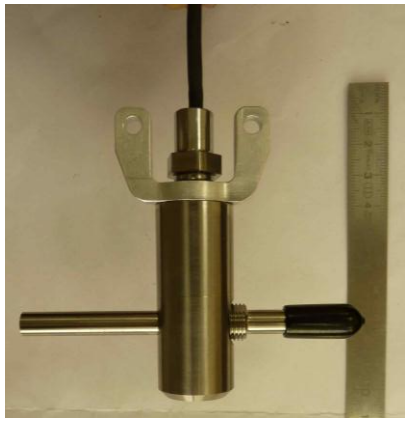
TRL5 demonstrated : Verification of the performances on a harness of 12 twisted pairs of AWG 18.

Key characteristics :

- Reliability >0,995 @95% confidence
- Lifetime of explosive components demonstrated >20 years at 30° C
- Qualified for a French Air Force programme
- REACH Free energetic materials

Perforator for the passivation of pressurant gases - CNES patent :

Development in progress : CDR : Nov, 2015 and Fully Qualified by March 2016



TRL 4 demonstrated : Verification of the performances on ¼ inch pipes (SST e0.9 mm / Ta6V e0.7 mm).

Key characteristics :

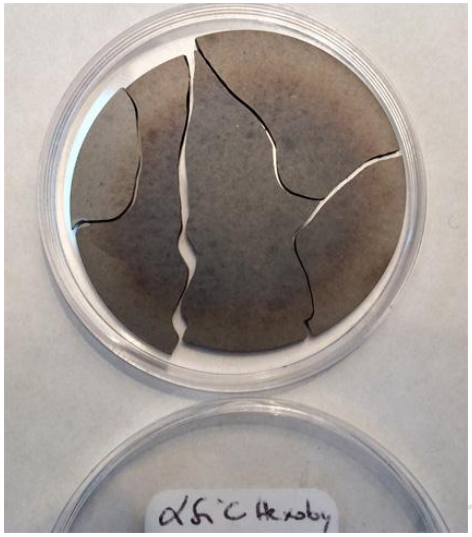
- Reliability >0,985 @90% confidence
- Lifetime of explosive components already demonstrated : >20 years at 30° C
- Interchangeable with pyrovalves (mechanical & electrical)
- Compatible with HP and LP environment
- REACH Free energetic materials

Fragmentation Analyses

- Aim: Reduce the casualty risk

- Tools
  - ✦ Many tools developped or under development
    - ESA
    - NASA
    - CNES (see next slides)
    - Others ….
  - ✦ Tests to be performed
    - In test set-up
    - in orbit

- Materials
  - ✦ Metals are well known (except emissitivity)
  - ✦ Other materials knowlegde could be improved
    - Composite
    - Glass
    - SiC, Si3N4
  - ✦ Tests foreseen this year.



- System architectures
  - ✦ D4D
  - ✦ Thermites
  - ✦ …

Fragmentation R&Ts

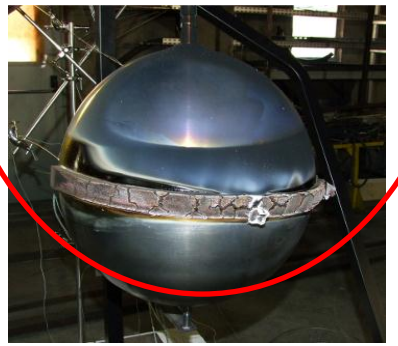
Contact : denis,dilhan@cnes,fr

Pressurant tank found in Colorado in March 2011 and tentatively linked to a Zenit launch vehicle stage.

Objectives :

Facilitate the burning or the ablation of satellite critical structures**.**

Implementation of the reentry thermal fluxes for the initiation of **passive** explosive system



«SELF FRAGMENTATION» TECHNOLOGY

Linear shaped charges cords and thermal detonators

TRL3 : CNES patent

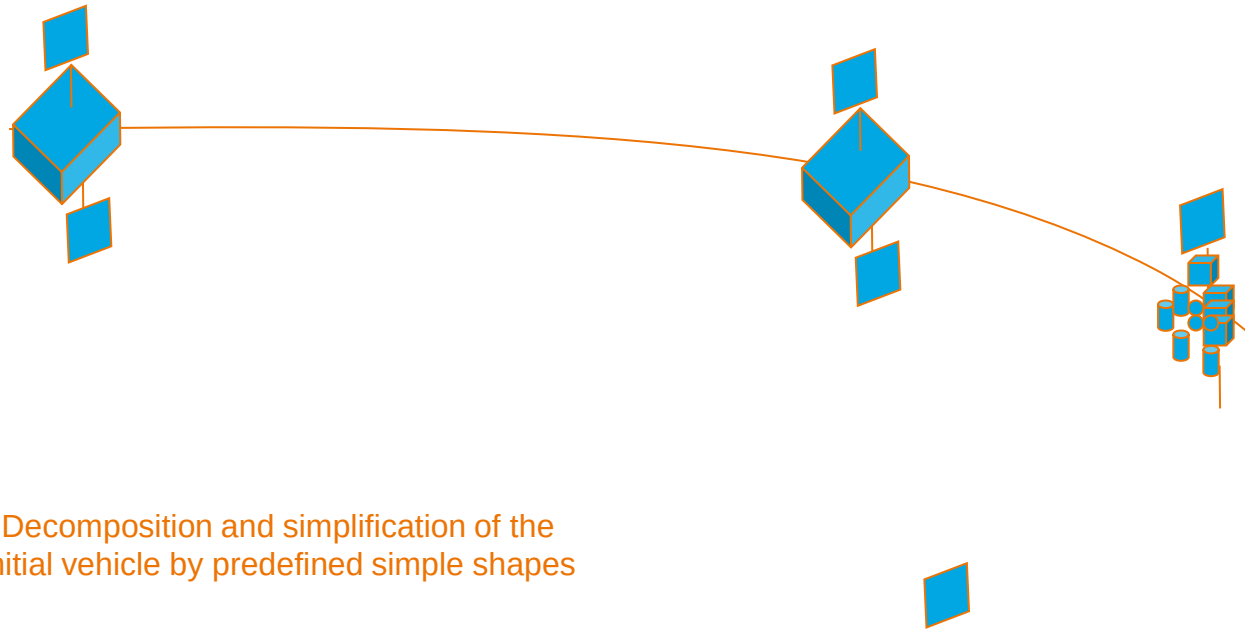
«BURNING ASSISTANCE» TECHNOLOGY

Burning of thermite pellets on Ta6V plates (propellant tank) :

TRL3 : CNES patent

DEBRISK (OBJECT-ORIENTED TOOL)

CONTACT : JULIEN.ANNALORO@CNES.FR



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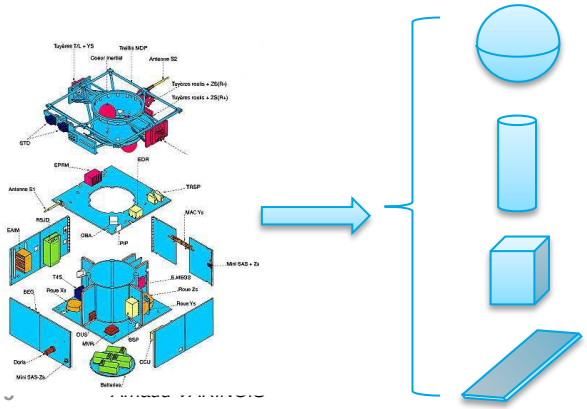
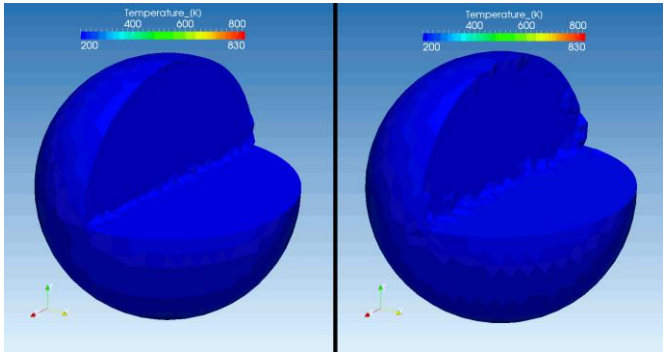
Decomposition and simplification of the initial vehicle by predefined simple shapes



PAMPERO (SPACECRAFT-ORIENTED TOOL)

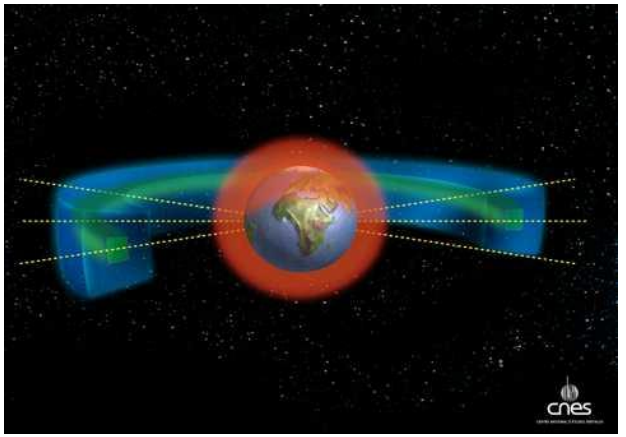


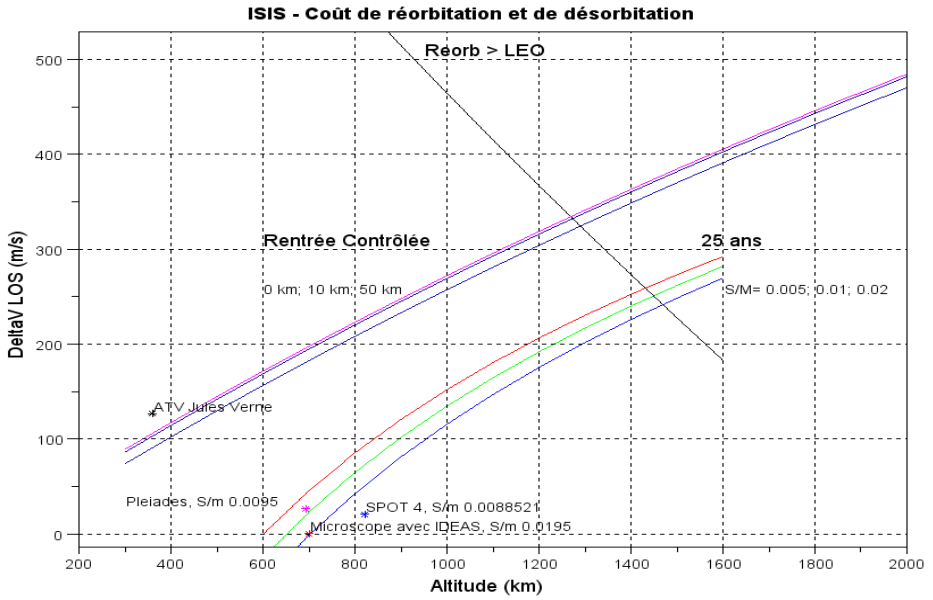
- CNES code
- 6 degrees of freedom model (3 for positions and 3 for attitudes)
  - Local calculation of the pressure coefficients
  - Estimation of the object attitude by the calculation of forces and moments
  - For the considered object, calculation of the entire trajectory from the last orbit
- Local calculation of the parietal heat flux (convective and radiative) by empirical/correlation laws
- Heat transfer modeling by a 3D thermal conduction module
- Preliminary estimate of the local ablation when a mesh reaches the melting temperature

Orbit changes

- GEO
  - ✦ All satellites equiped with propulsion
    - Available deltaV: Nx100m/s
  - ✦ Need is limited
    - ~11 m/s
  - ✦ No showstopper

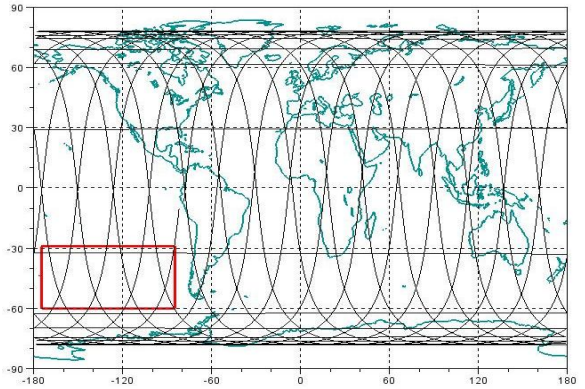
- LEO
  - ✦ Rough need is to bring perigee down to
    - 500km for uncontrolled reentry
    - 50km for controlled reentry
  - ✦ Available deltaV depends on design
    - Nanosat: 0m/s (might increase)
    - Microsat: between 0 and 150m/s
    - Others: 100m/s to 200m/s
  - ✦ Need depends on initial orbit
    - Nx10m/s
  - ✦ Solutions
    - Available propellant increase (if any)
    - Solid propulsion kit
    - Drag sail (but limited to few orbits)
    - Tether

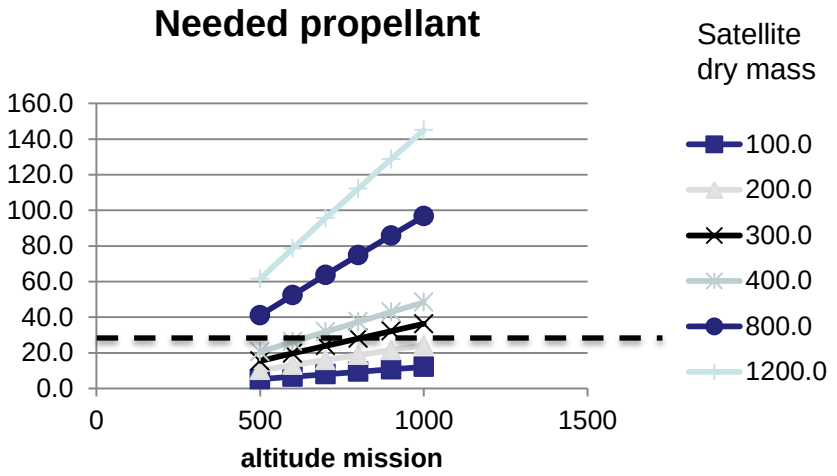




Controled Reentry

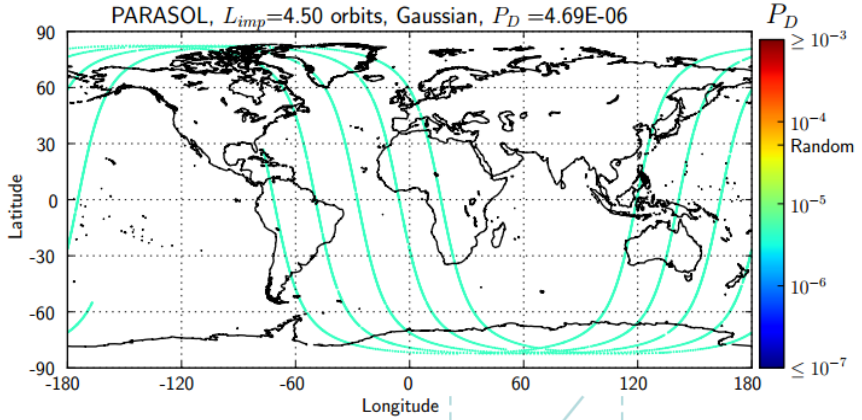
- Aim
  - ✦ Target area free of population (typically SPOUA)
- Drivers
  - ✦ Propellant capacity (>150m/s)
  - ✦ High Thrust (typically 0.04N/kg)
  - ✦ Reliability (but limited in time)
  - ✦ AOCS controlability down to 250km (typically)
- Solutions
  - ✦ Liquid Propulsion system modifications
    - Bigger tank
    - Power thrusters
  - ✦ Solid propulsion kit
- Duration
  - ✦ Few days/weeks



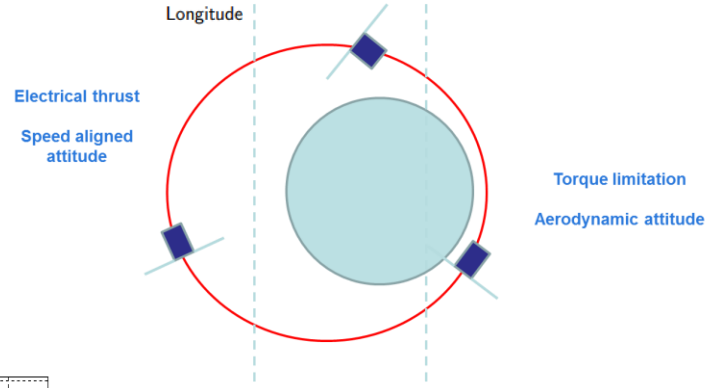


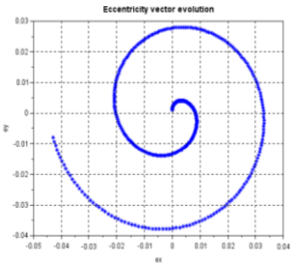
Semi-Controled Reentry

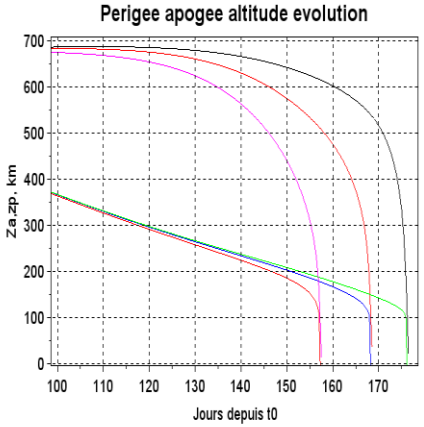
- Aim
  - ✦ Target a wider area: typically 3 to 5 orbits
    - Casualty risk divided by 10 !
  - ✦ Get proper phasing to be out of populated areas
  - ✦ With same casualty area, get less casualty risk

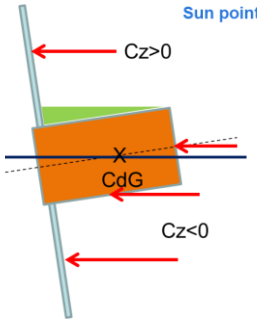


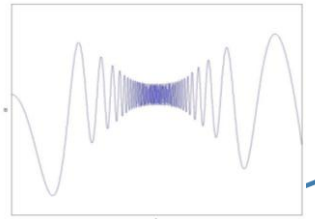
- Drivers
  - ✦ DeltaV > 150m/s
  - ✦ Limited thrust: 5^{E}-5N/kg
    - Achievable with electrical propulsion
  - ✦ AOCS controlability down to 120km (typicallv)
    - Specific strategy under analysis
  - ✦ Requires satellite symetric geometry
  - ✦ Duration: few monthes











Conclusion

Thank you for your attention

Arnaud.varinois@cnes.fr
Denis.Dilhan@cnes.fr
Julien.annaloro@cnes.fr

Warning, Cleansat is a Registered TradeMark

Anyway,

Let’s try to clean space not only saturdays !!!