

Beskyttelse i verdensrommet

A photograph of Earth from space, showing the blue atmosphere and white clouds. The foreground is filled with numerous pieces of space debris, including small fragments, larger chunks, and a prominent yellow cylindrical object, illustrating the problem of space debris.

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Stipendiat

SIMLab & SFI CASA, Institutt for konstruksjonsteknikk, NTNU

Agenda

SIMLab/CASA

Skjold mot romsøppel

Eksperimentelle studier

Numeriske studier

Oppsummering

SIMLab (Structural Impact Laboratory) & SFI CASA (Centre for Advanced Structural Analysis) @ NTNU

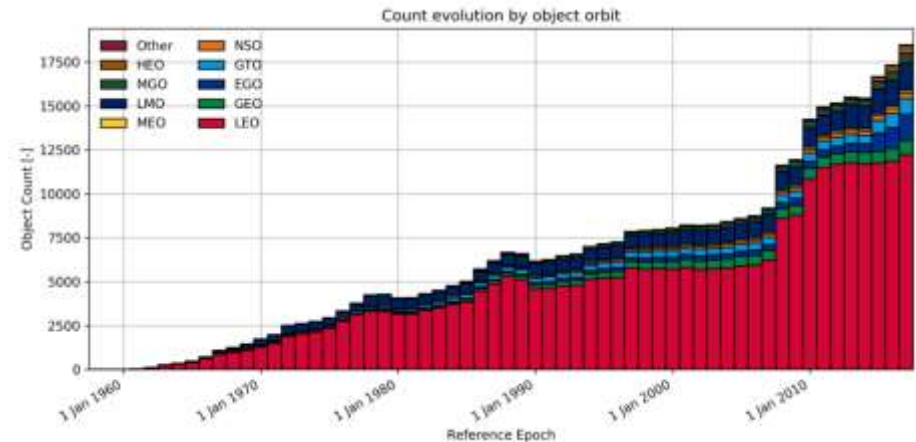
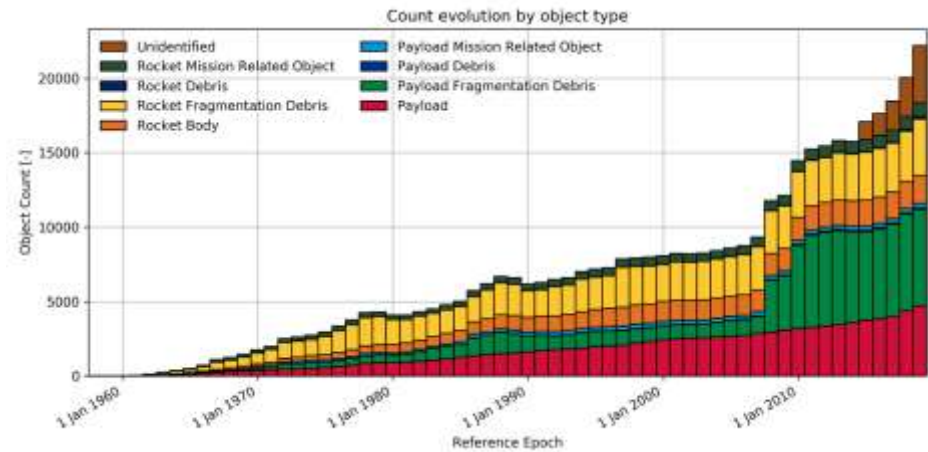
- Hvordan reagerer materialer og strukturer på ekstreme belastninger?
- Multiskala testing, modellering og simulering
- Hovedfokus på fysisk sikkerhet, transport, olje og gass



Romsøppelproblemet



< 10 cm: 34 000
1-10 cm: 900 000
1-10 mm: 128 000 000



Figures: European Space Agency. *Space debris*.
https://www.esa.int/Space_Safety/Space_Debris [17.10.2022]

Hvordan beskytter vi mot romsøppel?

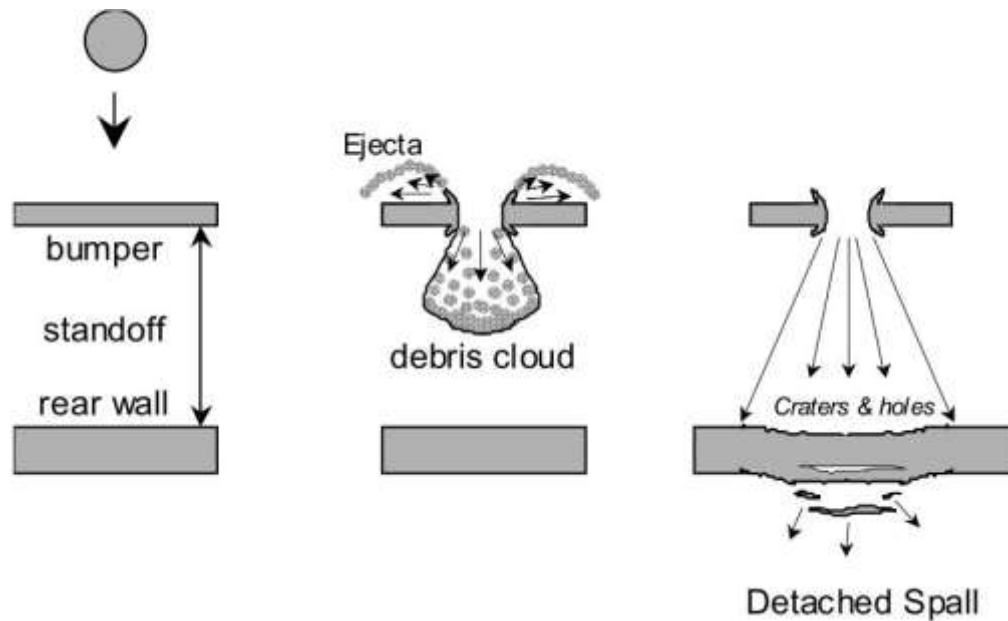


Figure: Christiansen, *Handbook for designing MMOD protection* (2009)

Hvordan beskytter vi mot romsøppel?

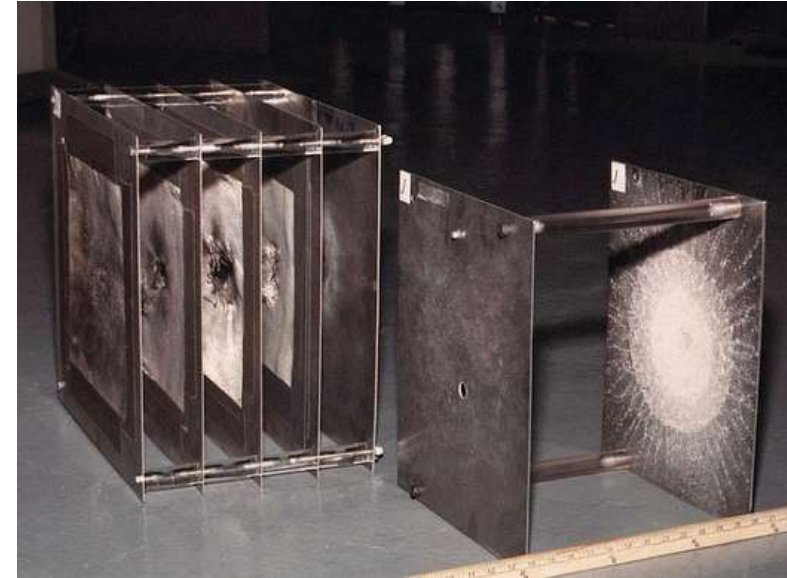
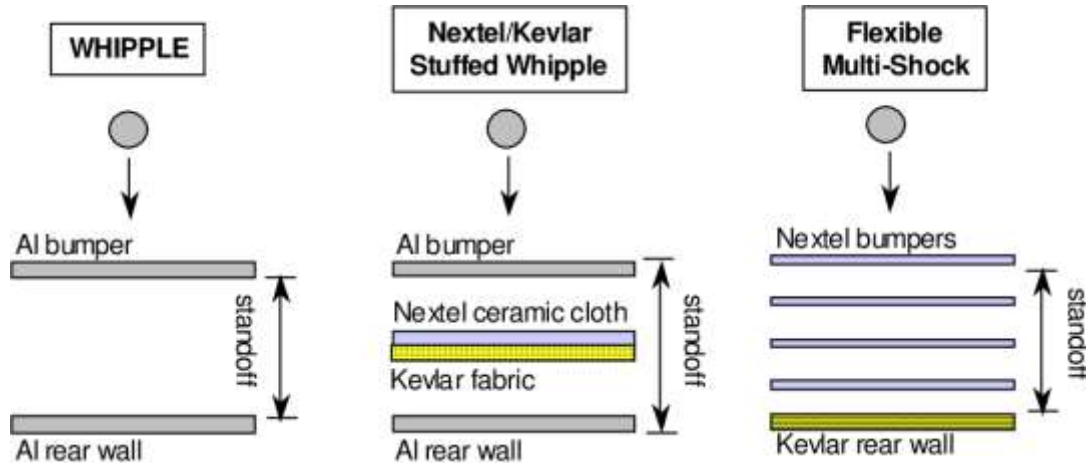


Figure: Christiansen, *Handbook for designing MMOD protection* (2009)

Monolithic shield:

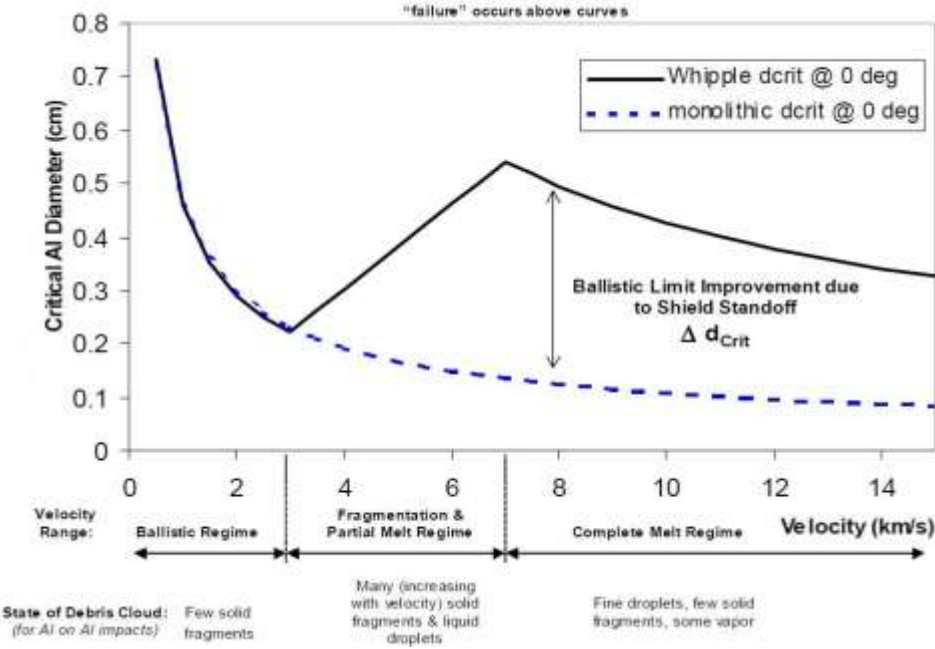
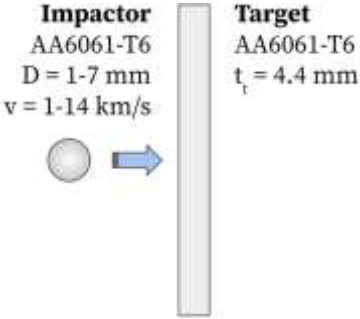
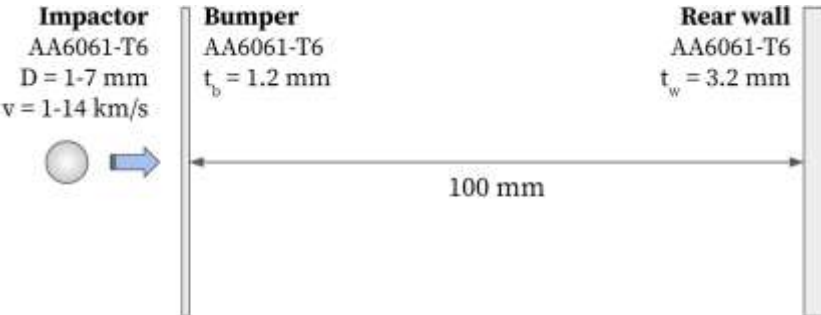


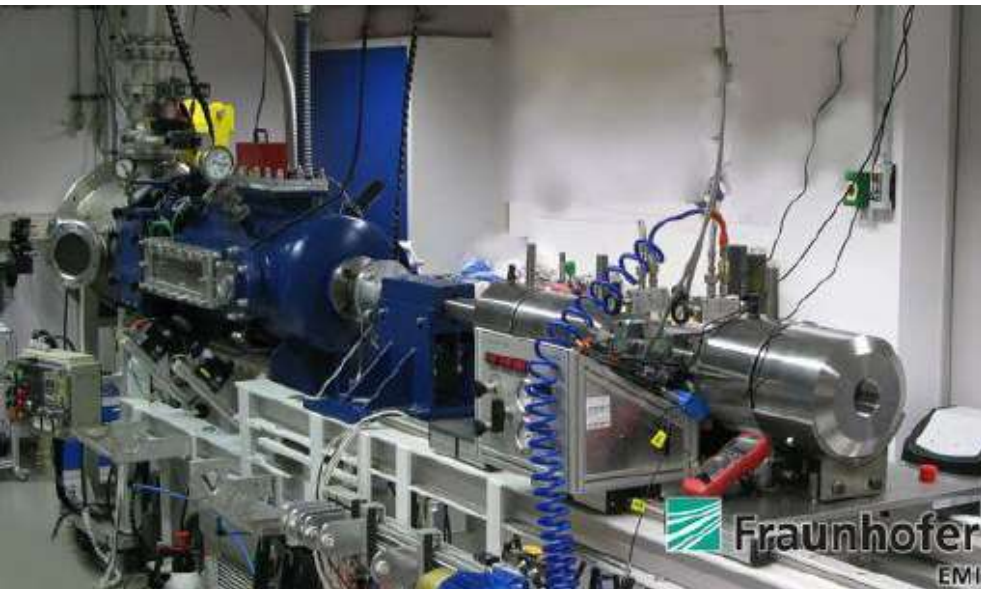
Figure: Christiansen. Handbook for designing MMOD protection (2009)

Whipple shield:



Eksperimentell testing

Two stage light gas gun:



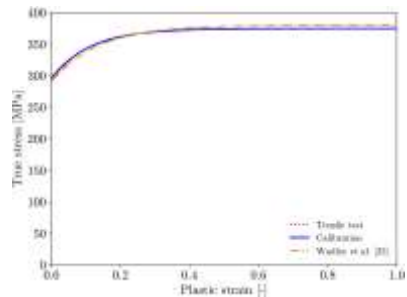
$\varnothing 2.8$ mm Al sphere
7.06 km/s

5724
-17.0 μ s

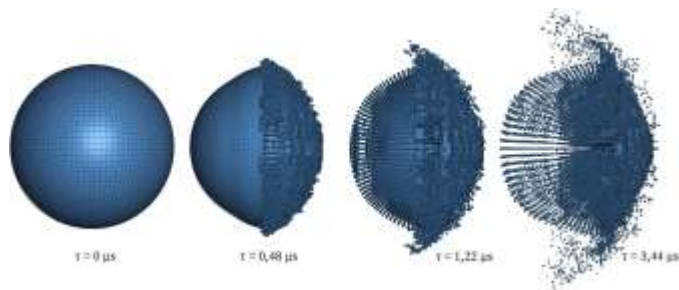
Fraunhofer Institute for High-Speed Dynamics 

Numeriske modeller

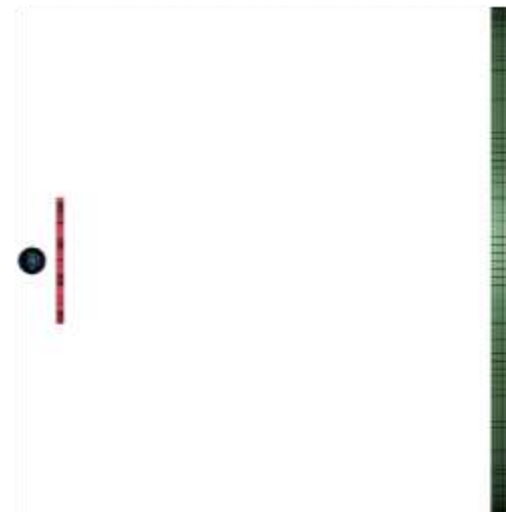
Kalibrering av materialmodell:



Valg av modelleringsmetode:



Modell av skjoldkonfigurasjon:





6.7 km/s
t=0.8 mm
D=9.53 mm

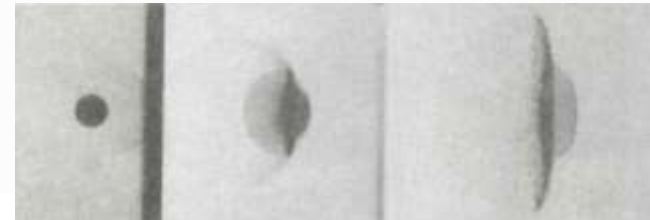
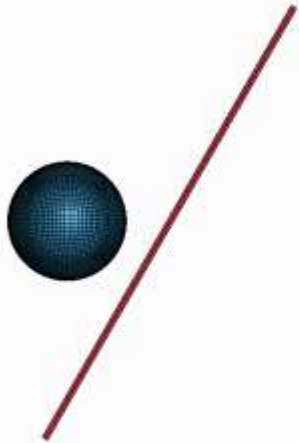


Figure: Piekutowski, *Formation and description of debris clouds produced by hypervelocity impact* (1996)

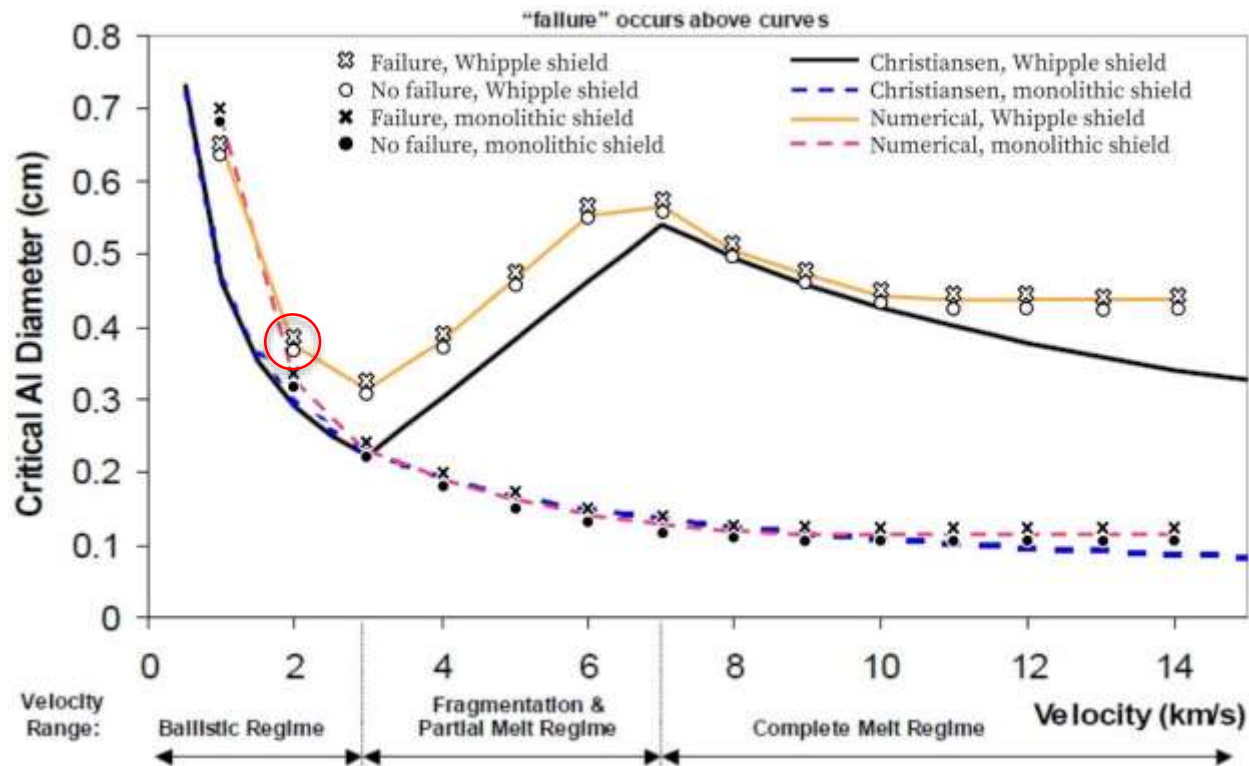


6.54 km/s @ 30°
t=0.5 mm
D=9.53 mm



Figure: Piekutowski, *Formation and description of debris clouds produced by hypervelocity impact* (1996)

Whipple shields

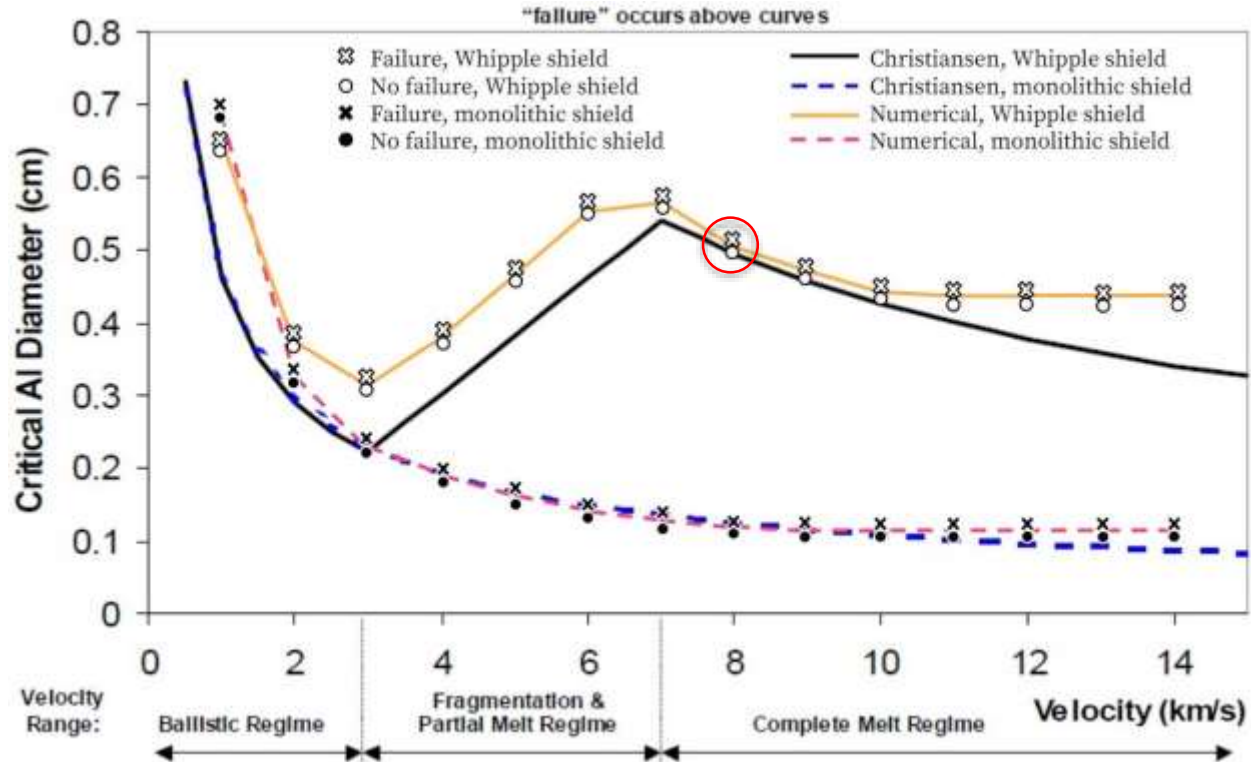




2 km/s
D=3.8 mm



Whipple shields





8 km/s
D=5.2 mm





LS-DYNA keyword deck by LS-PrePost
Time = 0



Oppsummering

- Romsøppel er en økende trussel for kritisk infrastruktur i bane
- Små fragmenter kan ikke spores fra bakken og utgjør stor usikkerhet og trussel
- Romfartøy må ha skjold for å beskytte kritiske komponenter og astronauter
- Omfattende eksperimentelle og numeriske studier gjennomføres for utvikling av skjold

