Close Proximity Operations

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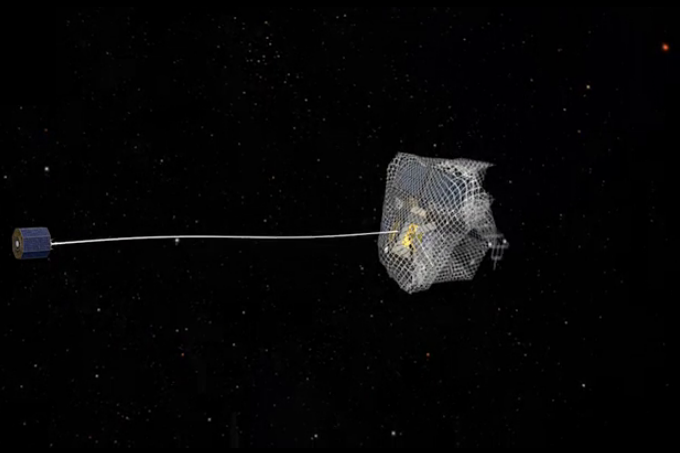
Cost Becomes a Driver for Commercial Applications



- Fault tolerance -> Fail Safe or Fail Operational?
- Human in the loop vs. autonomous
- Ground contact vs. higher autonomy
- All satellites cooperative?
- Unprepared satellites
- Complex operations replacing astronauts e.g. assembly

Why should we develop requirements/standards for Safe Rendezvous and Close Proximity Operations?

Mentimeter

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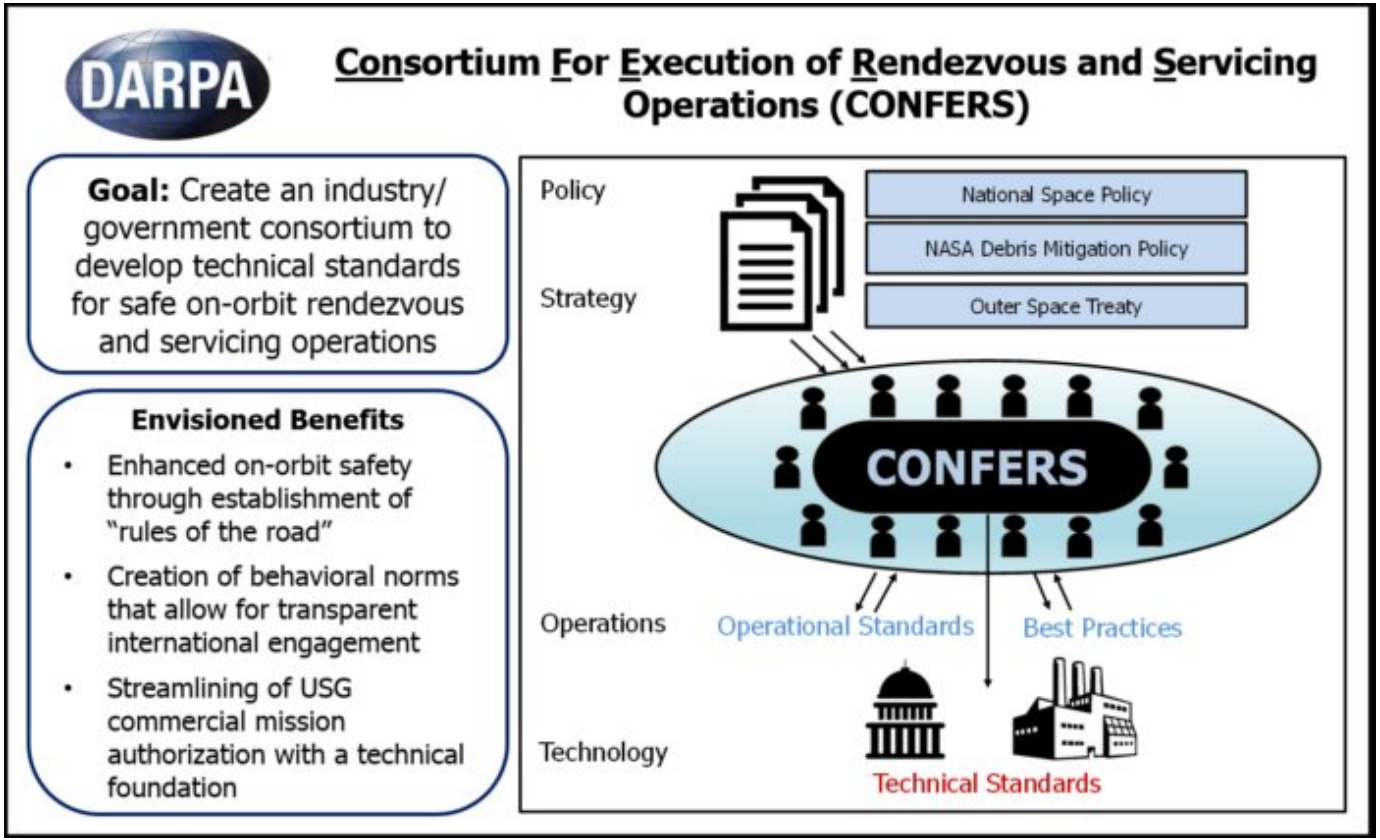
Why Should we Derive the CPO Design Principles?

- Protection to the orbital environment and other assets
- Support industry through technical guidance and identification of potential licensing methods
- Capture of knowledge
- Enable international engagement



From https://www.darpa.mil/news-events/

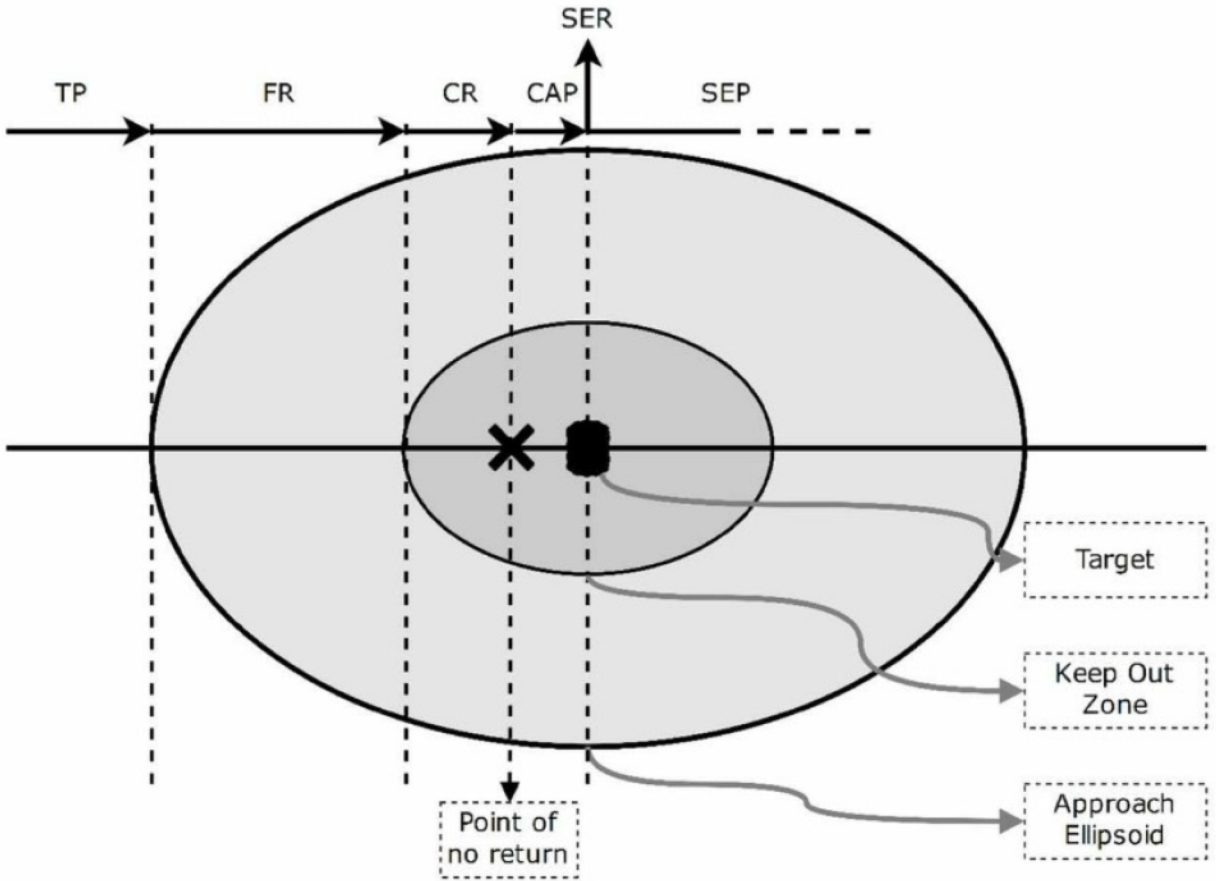
ESA Working Group

European Industry

Working Group

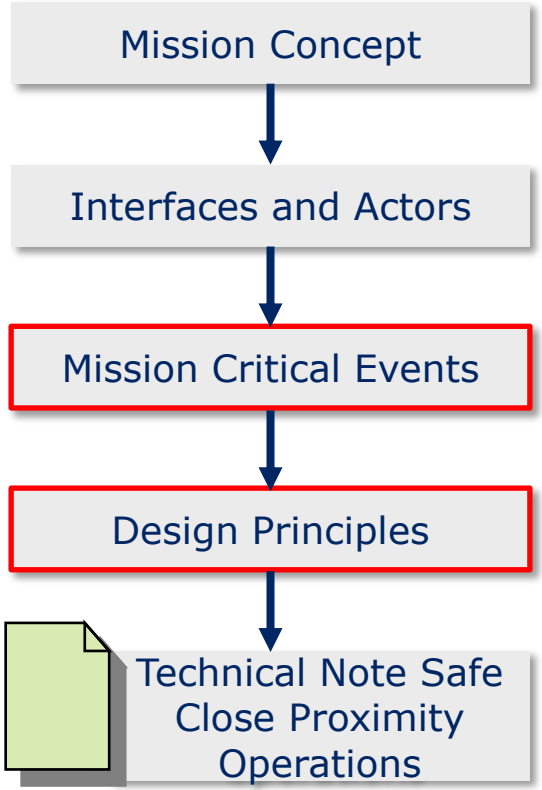
Robotics	Propulsion	Safety
Legal	Quality	ATV Operations
GNC	Systems	Operations

Output September 2018:
Technical input for a future design principles document


SER
TP
FR
CR
CAP
SEP
Target
Keep Out Zone
Approach Ellipsoid
Point of no return

Next up…

Methodology



- Interactive demonstration with example
- Challenge the methodology used

Physical Movement Required

Mission Critical Event

"An incident affecting safety"

Checklist for experts:

	Accident	Elements		Condition	Hazard		Phase		Effect
The SSV provokes a	collision	of the SSV and target	due to	the lack of	illumination	during	Phasing	Producing	a generation of debris
	uncontrolled reentry	of the SSV		presence of	GNC		Capture		a non-operation space servicing vehicle
	poullution	of the target		unexpected behavior of the	temperatur e		Stack		a non-operational target

The SSV provokes a collision of the SSV and target due to the lack/presence of illumination during capture producing a non operational SSV/target and/or generate debris.

Mission Critical Event

The SSV provokes a collision of the SSV and target due to the lack/presence of illumination during capture producing a non operational SSV/target and/or generate debris.

1. Should this MCE be tackled by Safe Close Proximity Operations?


no

yes

2. Is this MCE systematic, random, or both?


systematic

random

both

3. Should this MCE be mitigated through redundancy, analysis, or both?


redundancy

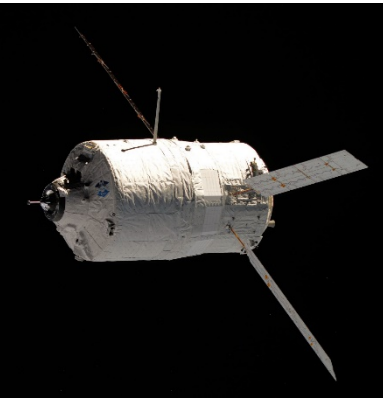
analysis

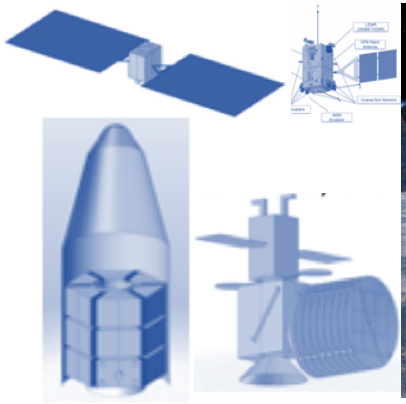
both

Design Principles

Reference documents

RD-2	IRSIS Draft C	**International** Rendezvous System Interoperability Standards
RD-3	CDF-179(A)	**CDF** Study Report SSV – Development of Servicing Vehicle (Space Tug) Concept
RD-4	e.Deorbit MSRD Issue 1 rev 0	**e.Deorbit** Consolidation Phase Mission and Systems Requirement Document (MSRD)
RD-5	NSTS-12820	**Automated Transfer Vehicle** (ATV)-ISS Join Flight Rules Volume E
RD-6	SSP 50235	Interface Definition Document (IDD) for **International Space Station** (ISS) Visiting Vehicles (VVs)





Design Principles

The SSV provokes a collision of the SSV and target due to the lack/presence of illumination during capture producing a non operational SSV/target and/or generate debris.

e.Deorbit
The Chaser shall be able to capture the target in any TBC lighting conditions.

SSV
The GNC shall be able to provide reliable 6 DOF relative state (pose) when the SSV is inside the Keep-Out Sphere (KOS) independently of the illumination conditions. Comment: The KOS has a radius of 200m (TBC)

e.Deorbit
The Chaser GNC shall be able to provide relative navigation solution w.r.t. the target object during the full target orbit anytime of the year (TBC). Note: The relative navigation solution should also be available during eclipses.

SSV
The GNC system shall be able to estimate position and velocity of the spacecraft in a target-centered reference frame (relative position and velocity) with a maximum Absolute Known Error (AKE) compatible with the relative sensors pointing, the passively safe trajectory margins and the collision risk assessment requirements.

Design Principles

The SSV provokes a collision of the SSV and target due to the lack/presence of illumination during capture producing a non operational SSV/target and/or generate debris.

MUL-0010	The SSV GNC shall be able to continuously provide relative navigation solutions w.r.t. the target object, independent of the illumination conditions encountered.
CAP-0010	The SSV shall be able to provide reliable 6 DOF relative state (pose) independently of the illumination conditions during capture operations.
CAP-0020	The SSV shall be able to capture the target independent of the illumination conditions encountered.

1. MCE covered?
2. Achievable?

yes

3. General?

no

4. Anything else?

if time allows

Design Principles

The SSV provokes a collision of the SSV and target due to the lack/presence of illumination during capture producing a non operational SSV/target and/or generate debris.

ALL-0030 The SSV shall provide the required relative navigation solutions w.r.t the target for the expected illumination conditions (e.g. shadowing) considering the relative sensors pointing and accuracy requirements.
Note: The verification shall consider the passive abort margins, the corridor margins, and the probability of collision requirements.

1. MCE covered?
2. Achievable?
3. General?
4. Anything else?

yes

no

QUESTIONS TO THE AUDIENCE

Where does a satellite switch from absolute navigation to relative navigation?

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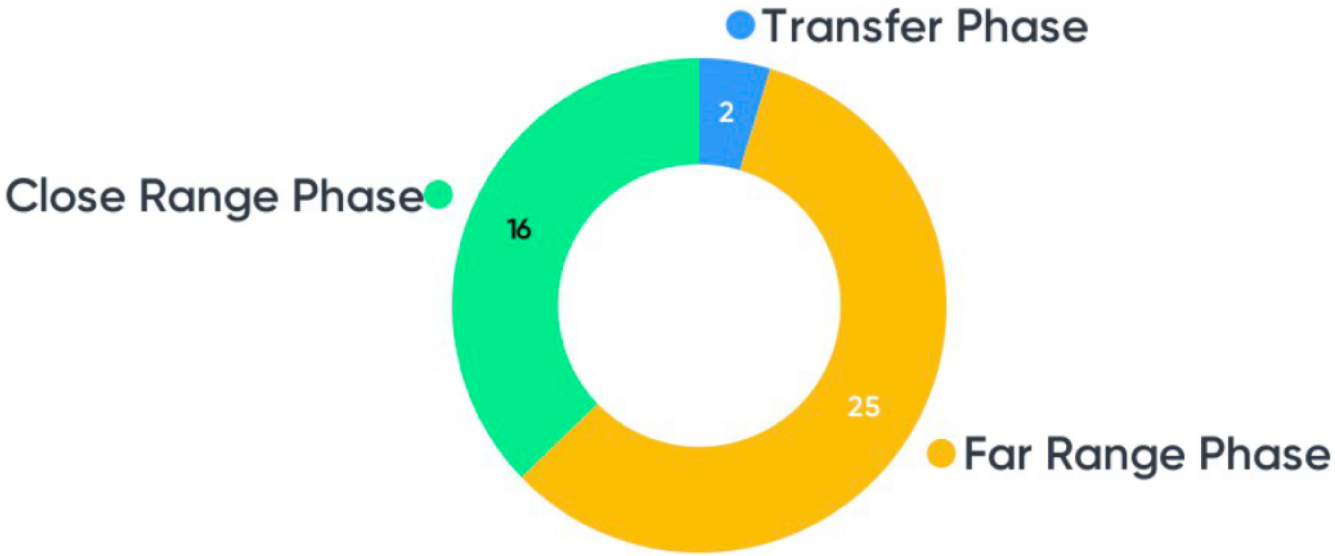

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From which phase should a standard for Close Proximity Operations start?

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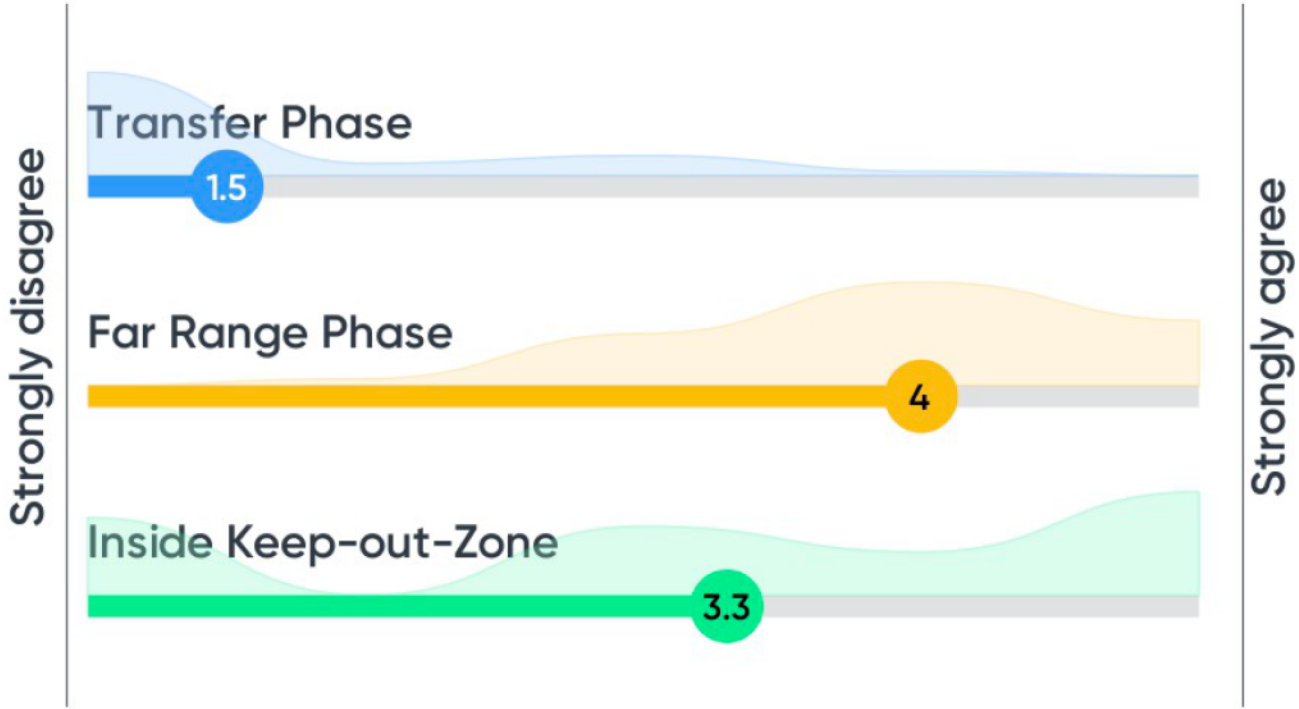

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Should the service operation be covered for Close Proximity Operations?

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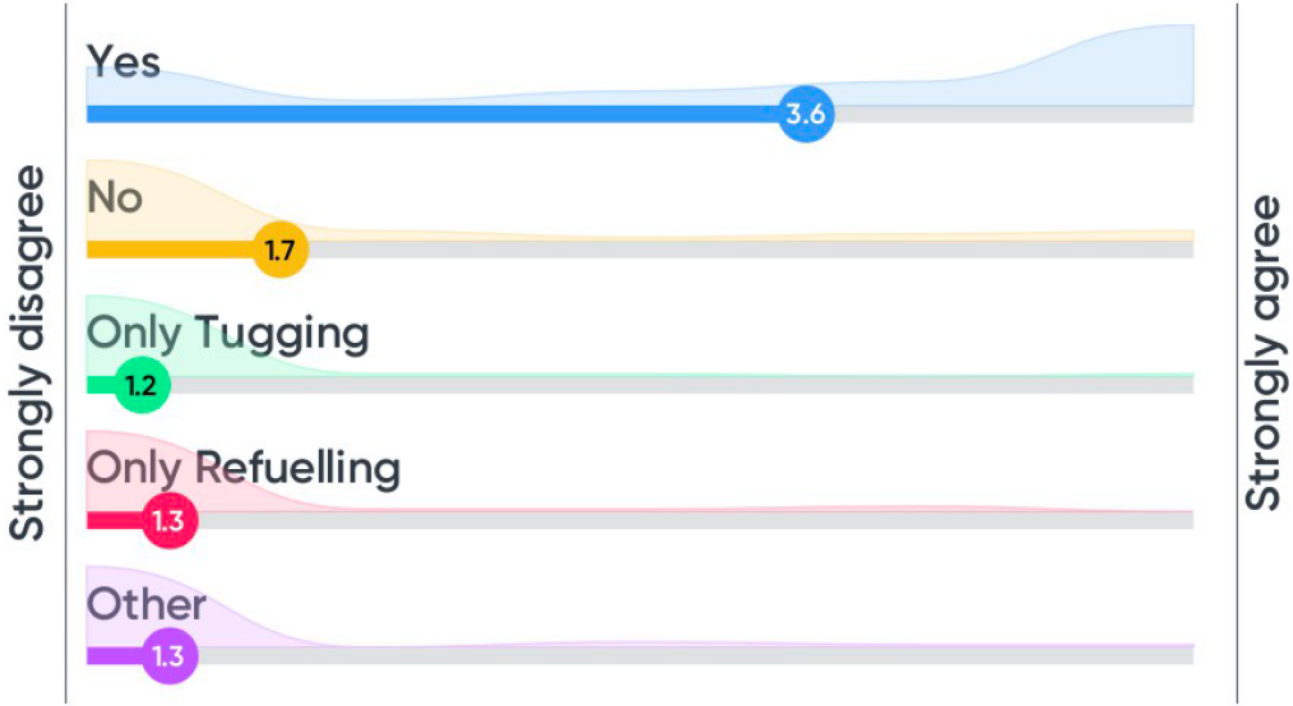

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What should a standard on Close Proximity Operations focus on?

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Safety of the Rendezvous and Capture Operations

Safety and Mission Success (success of service)

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