B1

世界のデブリ管理状況と JAXA の対応

Global Debris Mitigation Control and Corresponding Activities in JAXA

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デブリの発生防止管理は、国連や IADC が推奨するガイドライン、国際標準化機構が進めている一連の規格類、並びに宇宙先進国政府あるいは公的機関が発行する標準書等にて進められている。 これらで規制されているデブリ対策の主要項目は、①破壊行為や爆発事故の防止、②部品などの放出の抑制、③衛星やロケットの運用終了後の有用な軌道からの排除、④排除した物体が再突入する場合の地上安全の確保、⑤衝突被害の防止などである。 JAXA は昨年、従来から適用してきたデブリ発生防止標準を ISO の最新規格と同等の規制となるように改訂した。これで国内衛星開発企業が JAXA の標準へ適合した製品を開発する努力は、そのまま世界の規制に合致した製品の供給が可能になる体制を保証するものとなる。今後、衛星国際調達市場や打上げサービス市場では軌道環境への配慮が入札条件に含まれることが考えられる。JAXA では規制面のみでなく、種々の解析ツールなどを整備して産業界のデブリ対策技術の確立を支援している。

Debris mitigation effort is being progressed by the guidelines registered by the United Nations, and IADC, standards by the International Standardizing Organization (ISO), and other standards registered by the national governments and space agencies. The primary objectives of these rules are “Prevention of Break-ups”, “Limitation of Releasing Objects during Operations”, “Disposal of Mission Terminated Spacecraft and Launch Vehicle Orbital Stages from the Useful Orbital Regions (with considering ground safety from the re-entering objects)”, “Avoiding damage caused by on-orbital collisions or impact”. Last February JAXA revised its Space Debris Mitigation Standards to be equivalent with “ISO-24113 Space Debris Mitigation Requirements”. It will enable that the space system manufacturers deliver the merchandizes which comply with global debris mitigation guidelines through the process that they try to develop the technology to comply with the JAXA standard. In near future, the international trade market for spacecraft and launch services may add a requirement to consider the orbital environment as a coessential condition to apply the contract. JAXA is providing not only regulations but also various kinds of analysis tools and support documents to support industry.

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1. Debris Mitigation Rules and Their Background

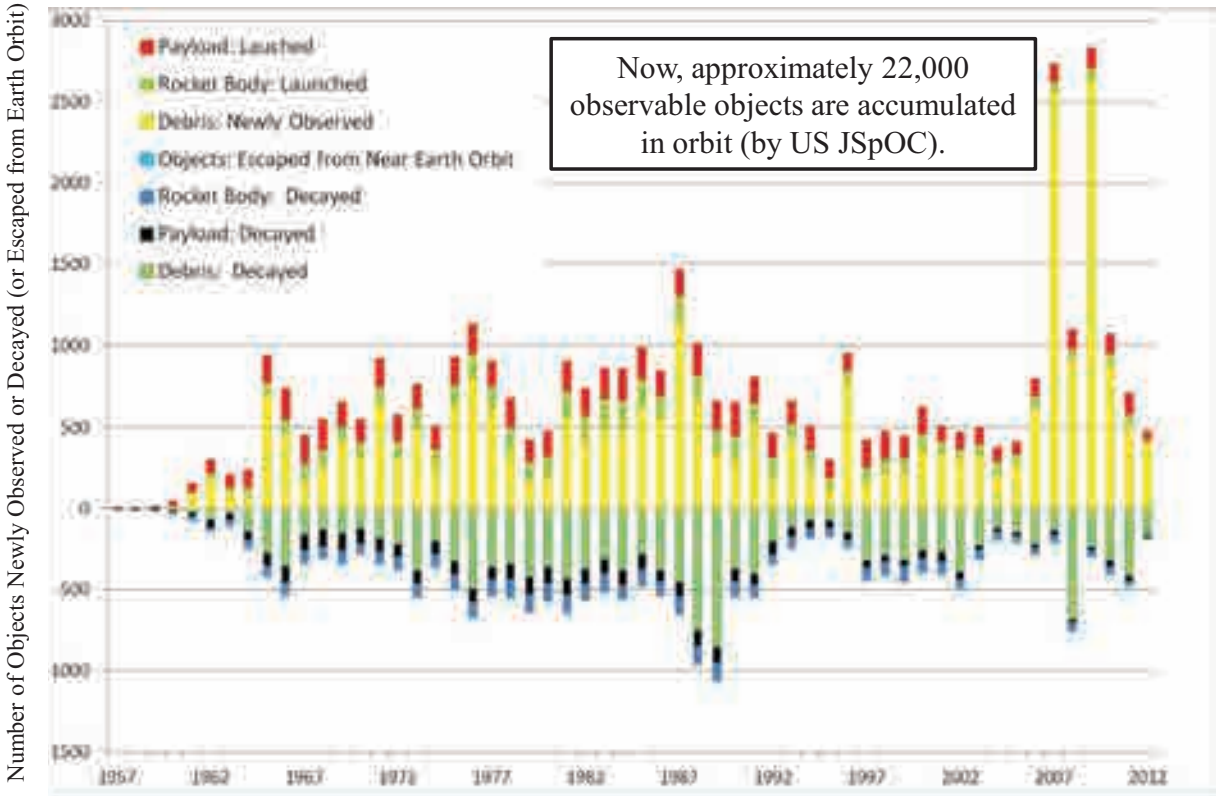
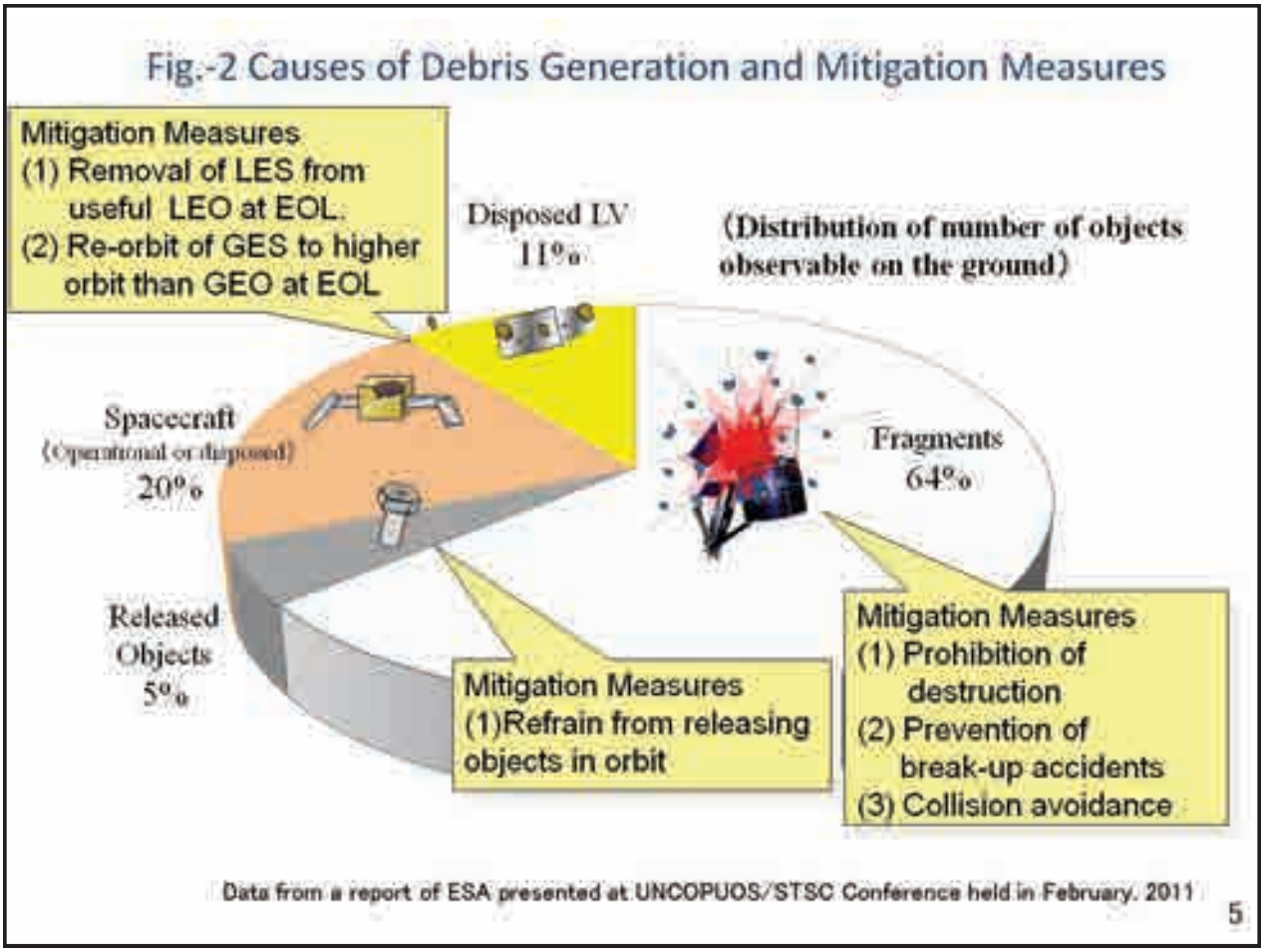
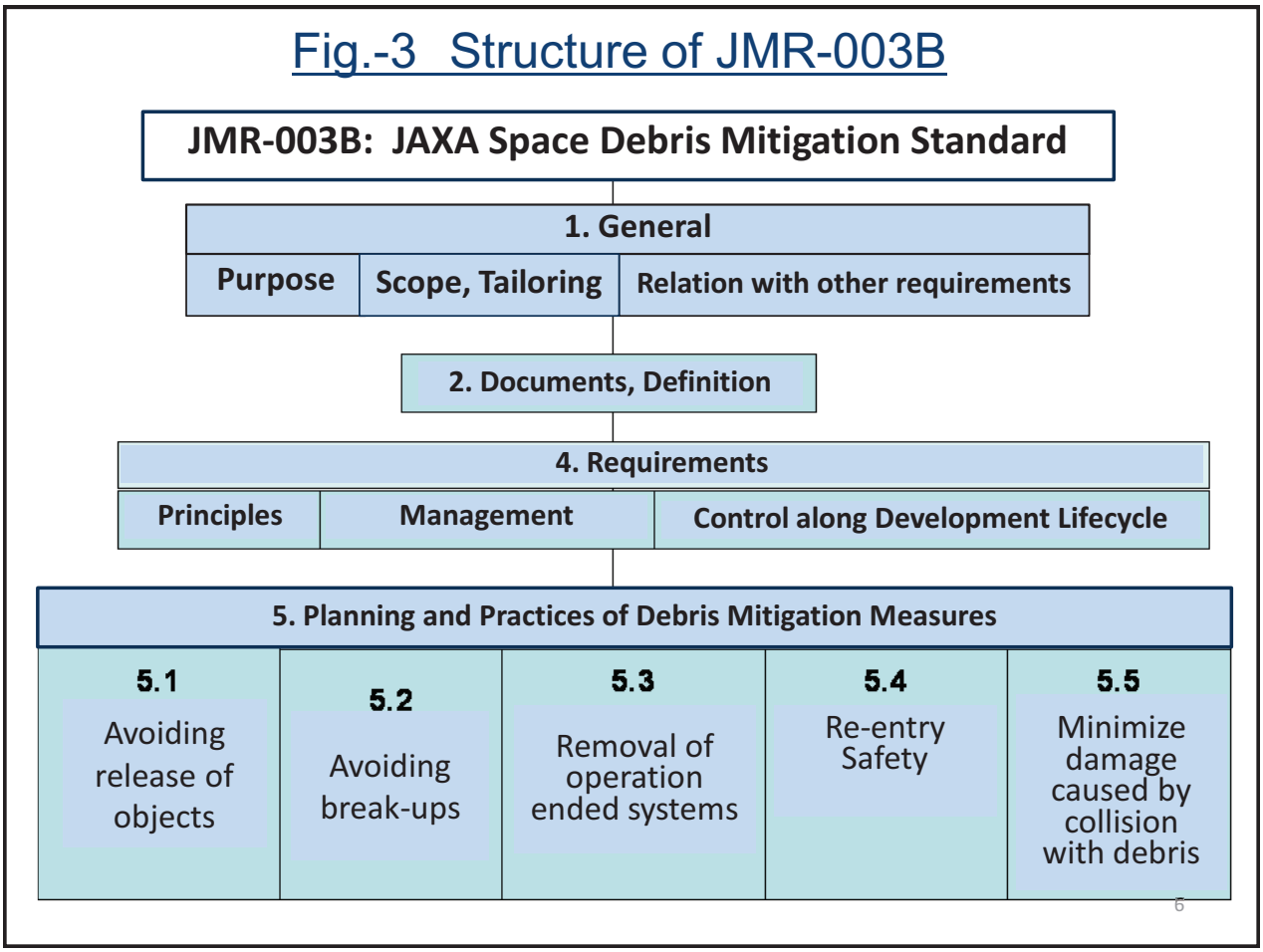


Figure 1 Number of Objects Newly Observed or Decayed (or Escaped from Near Earth Orbit)
(Ref. Data from Satellite Situation Report / Space-Track / USSTRATCOM, @June 25, 2012) (processed by A. Kato)





2. Global Situation and JAXA Standard

Fig.-4 International Framework for Debris Control

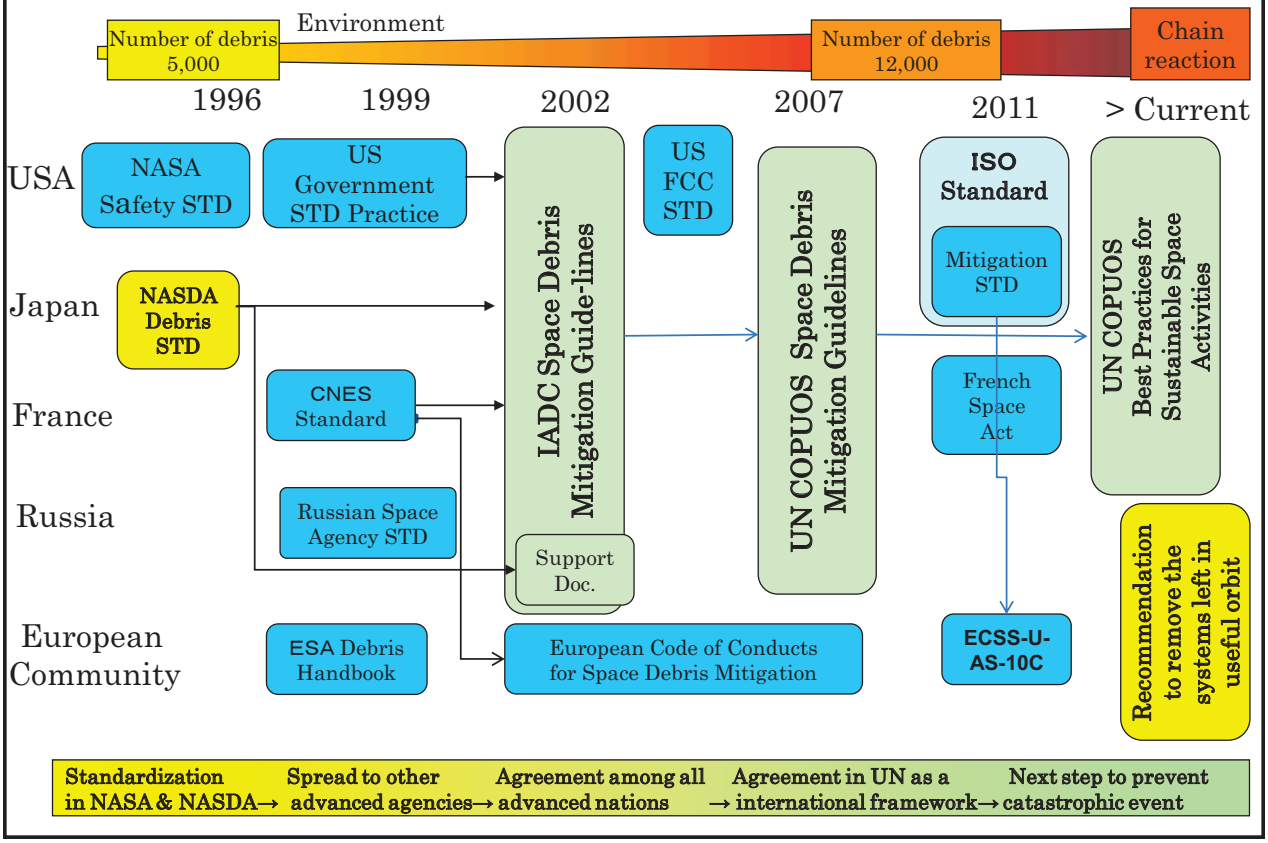
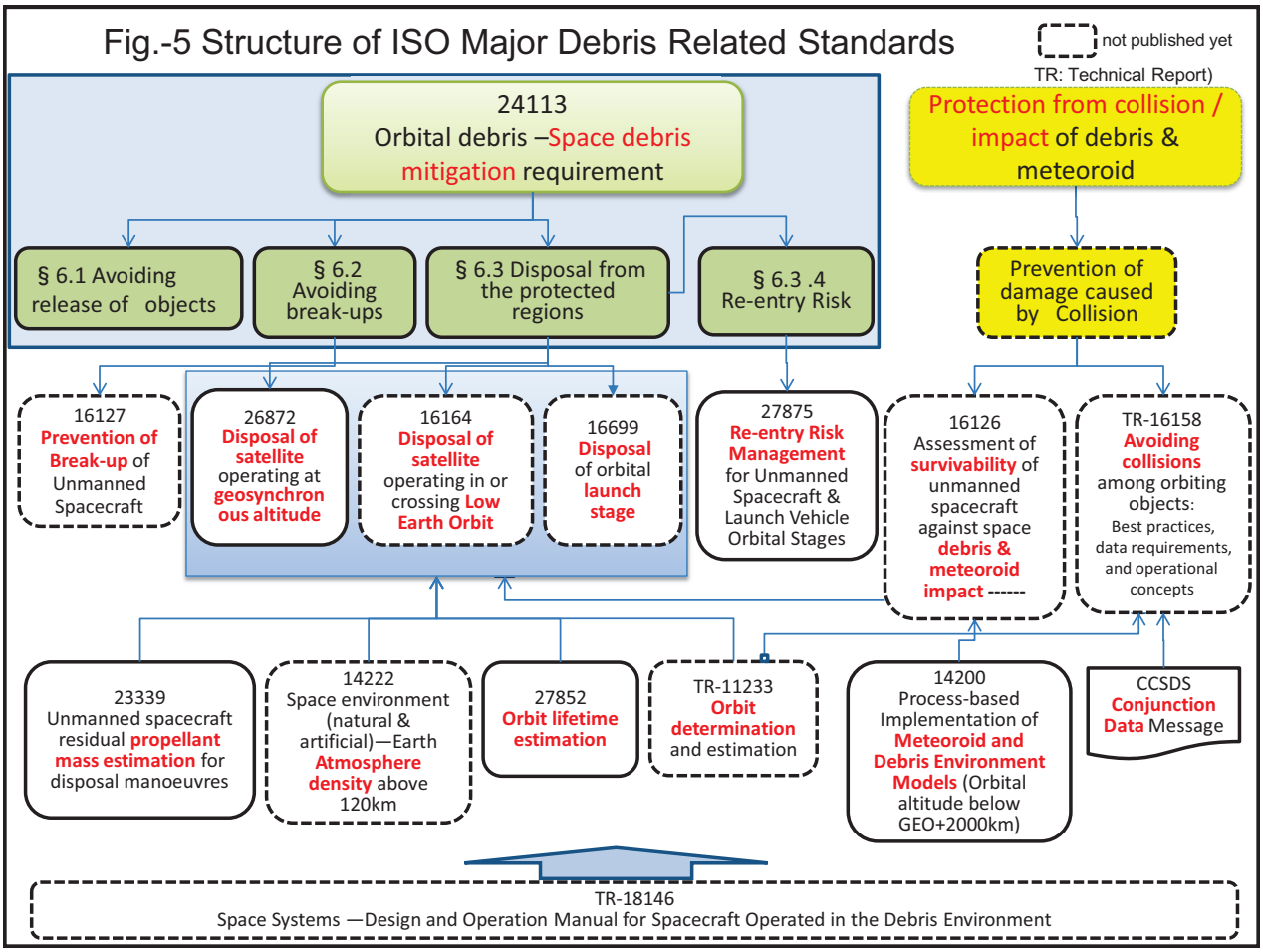


Table-1 global debris mitigation rules and JAXA standard

JAXA-003 was revised in the following yellow-colored parts

		Measures	ISO Standards (or Technical Reports)	JAXA (JMR-003B)	IADC Guidelines [g]
Limiting Debris Generation	*Released Objects*	General idea to refrain from releasing objects	**ISO-24113 / § 6.1.1**	Required	§ 5.1
		Slag from Solid Motor	**ISO-24113 / § 6.1.2.2, § 6.1.2.3**	Required	--
		Combustion Products from Pyrotechnics	**ISO-24113 / § 6.1.2.1** (Combustion Products < 1 mm)	Combustion products < 1 mm	--
	On-orbital Breakups	Intentional Destruction	**ISO-24113 / § 6.2.1**	Required	§ 5.2.3
		Accident During Operation	**ISO-24113 / § 6.2.2** (Probability < 10^{-3})	Required (Monitoring) (Probability < 10^{-3})	§ 5.2.2 (Monitoring)
		Post mission Breakup (Passivation, etc.)	**ISO-24113 / § 6.2.2.3 (Detailed in ISO-16127)** (Probability < 10^{-3})	Required	§ 5.2.1
Disposal at End of Operation	*GEO*	Reorbit at EOL	**ISO-24113 / § 6.3.2 (Detailed in ISO-26872)** § 6.3.2.2: 235 km+ (1,000・Cr・A/m), e < 0.003 § 6.3.1: Success Probability > 0.9	235 km+ (1,000・Cr・A/m) e < 0.003 Success Probability >0.9	§ 5.3.1 235 km+ (1,000・Cr・A/m), e < 0.003
	LEO (MEO)	Reduction of Orbital Lifetime	**ISO-24113 / § 6.3.3 (Detailed in ISO-16164)** § 6.3.3.1: EOL Lifetime < 25years § 6.3.1: Success Probability >0.9	EOL Lifetime < 25years Success Probability > 0.9	§ 5.3.2 (Recommend 25 years)
		Transfer to Graveyard	**ISO-24113 / § 6.3.3.2 (f)** (guarantee 100 years' non-interference)	Required	Mentioned in recommendation-6
		Other manners	**ISO-24113 / § 6.3.3.2 (a) ~ (e)**	--	§ 5.3.2
Re-entry		Ground Casualty	**ISO-24113 / § 6.3.4 (Detailed in ISO-27875)**	Ec < 10^{-4}	§ 5.3.2
Collision Avoidance with Large Debris			**ISO-16158**	Required (CAM, COLA)	§ 5.4
Protection from Impact of Tiny Debris			**ISO-16126**	Required	§ 5.4

Fig.-5 Structure of ISO Major Debris Related Standards



Current Status of JAXA Debris Mitigation Standard

- Last February JAXA revised its Space Debris Mitigation Standards to be equivalent to “ISO-24113 Space Debris Mitigation Requirements”.
- Then the effort of the Japanese spacecraft manufacturers to comply with the JAXA standard will ensure that their merchandizes would be accepted in the global market.
- In near future, the international trade market for spacecraft and launch services may require to consider the preservation of the orbital environment as an essential condition.

- JAXAは昨年、従来から適用してきたデブリ発生防止標準をISOの最新規格と同等の規制となるように改訂した。
- これで国内衛星製造企業のJAXA標準への適合努力は、そのまま世界の規制に合致した製品の供給が可能になる体制を保証するものとなる。
- 今後、衛星国際調達市場や打上げサービス市場では軌道環境への配慮が入札条件に含まれることが考えられる。

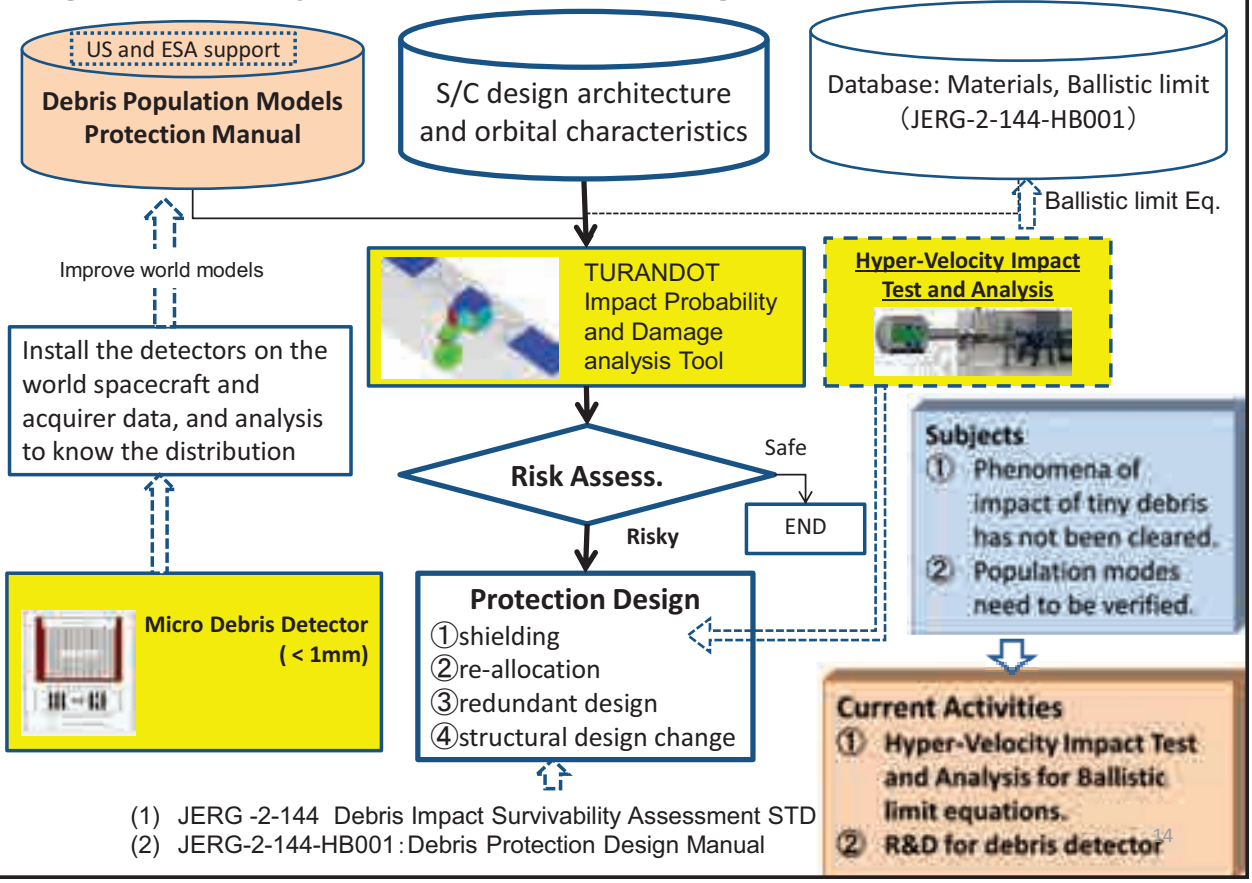
3. Support Documents and Analysis Tools

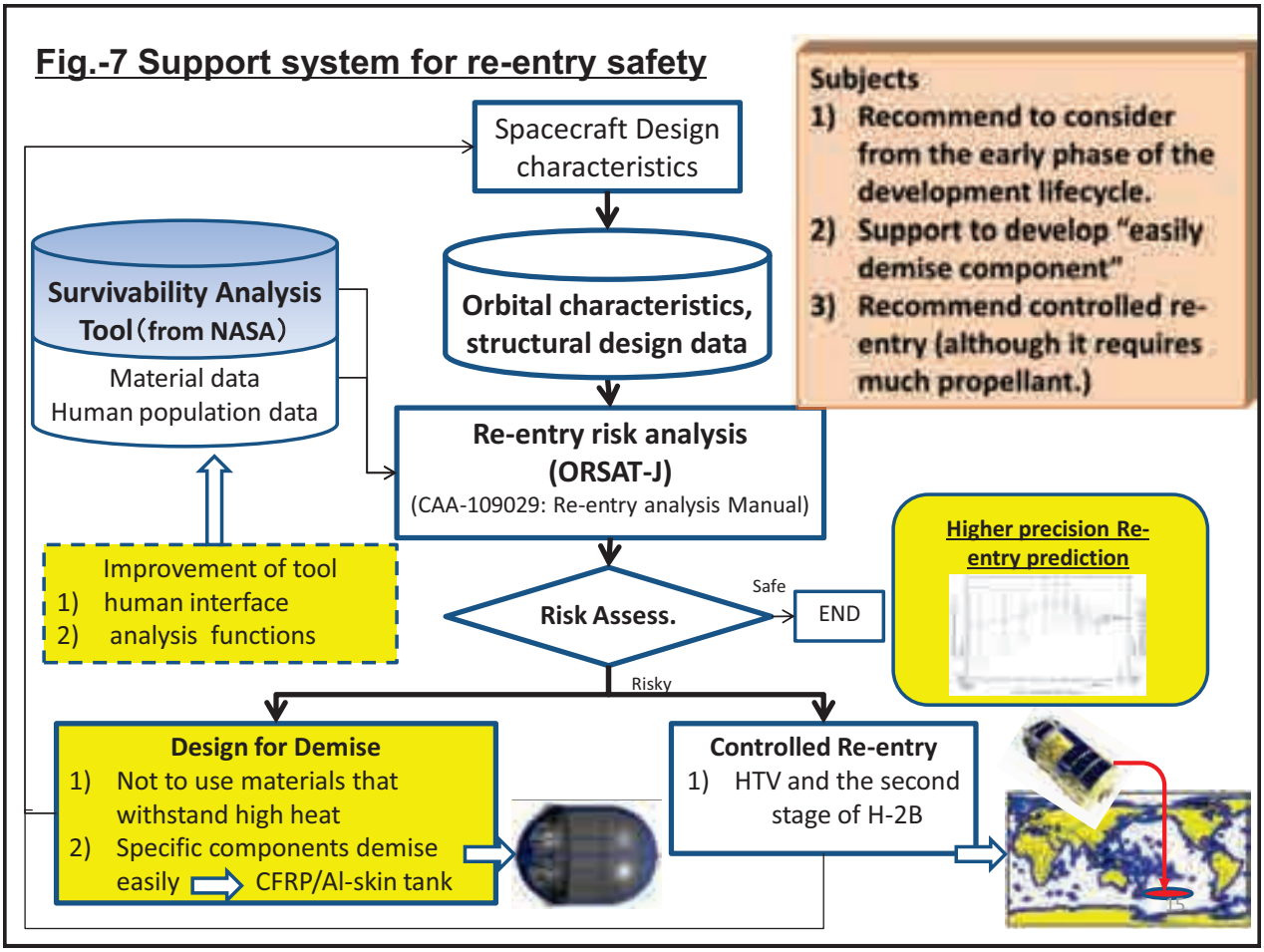
JAXAでは支援文書、解析ツールなどを提供し、産業界のデブリ対策を支援している。
JAXA is providing various documents and analysis tools to support industry.

Table-2 Tools and Documents to Support Debris Mitigation Design and Operation

	Subjects	Support Tools and Documents
1	General Mitigation Tec. -Collision probability - Orbital Lifetime - Required Fuel for disposal -Re-entry survivability	(1) JERG-0-0-002A: JMR-003B Support Handbook (2) JAXA/DEMIST (Debris Mitigation Assessment Tool) (3) NASA/Debris Assessment Software (DAS) (4) JAXA-CAA- 111003: L/V Debris Mitigation Design & Operation Technique (5) JAXA-CAA- TBD : S/C Debris Mitigation Design & Operation Manual (to be released in 2013)
2	Debris Population Model	(1) ESA/MASTER-2009, NASA/ORDEM
3	Orbital Lifetime	(1) JAXA Orbital Lifetime Analysis Tool (追跡管制設備付属)
4	Protection Design	(1) JERG -2-144 Debris Impact Survivability Assessment STD (2) JERG-2-144-HB001 : Debris Protection Design Manual (3) JAXA/TURANDOT (tool for debris impact probability and damage analysis)
5	Re-entry Survivability	(1) ORSAT-J (being revised every year) (2) CAA-109029: Re-entry analysis Manual

Fig.-6 Support system for protection design





4. Further Subjects

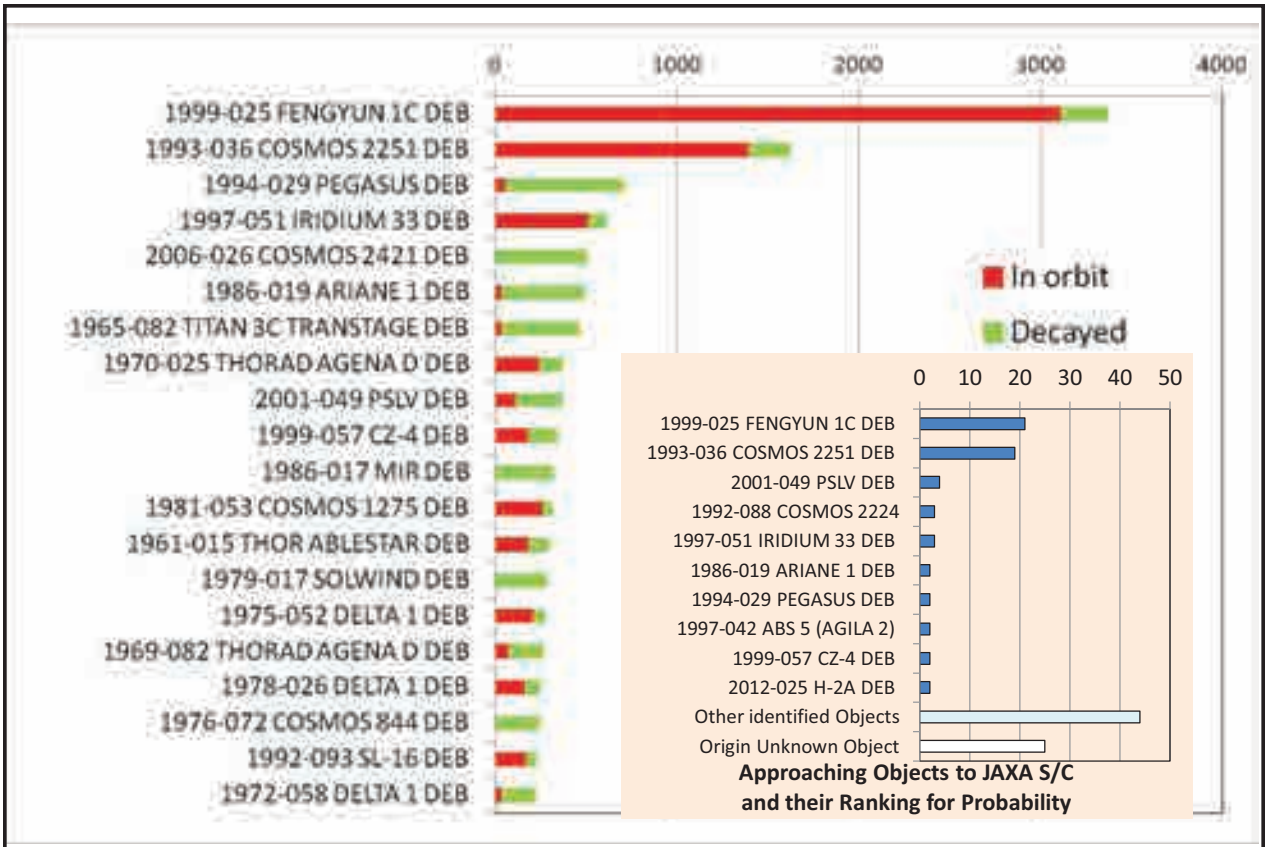


Fig.-8: Top 20 space objects which generated many debris
(data from the Space Situation Record of USSTRATCOM, dated June 2012)

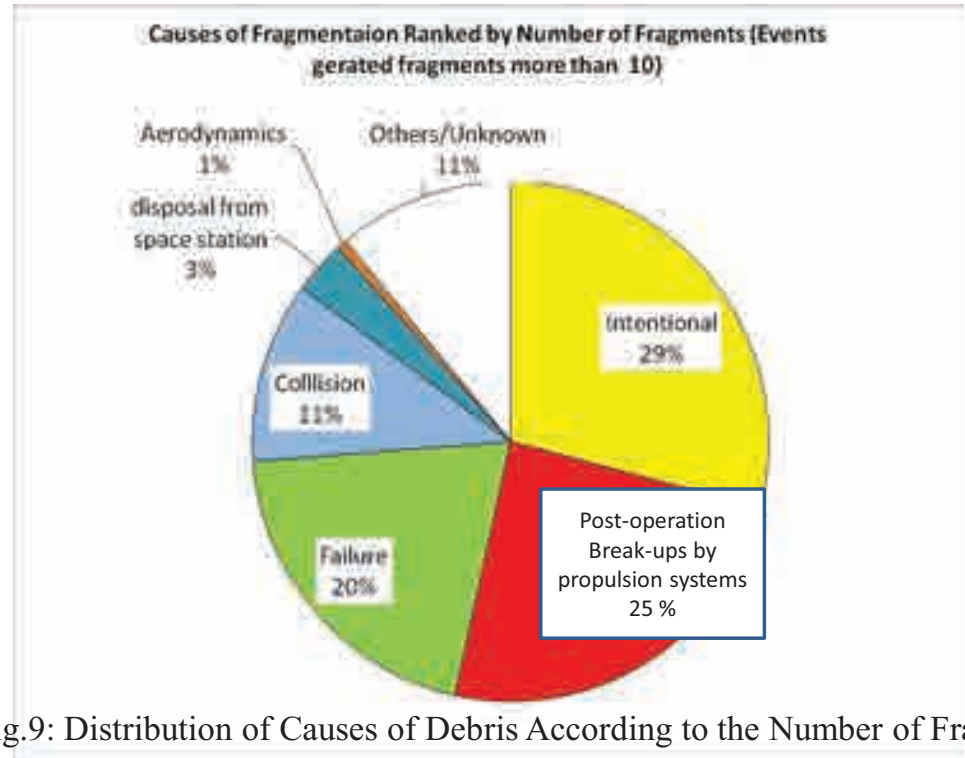


Fig.9: Distribution of Causes of Debris According to the Number of Fragments

The objects which generated less than 10 objects were excluded.
The events were assumed as “induced by failure” when spacecraft generated fragments within 5 years after launching, or the launch vehicles caused break-ups on the same day of launching.

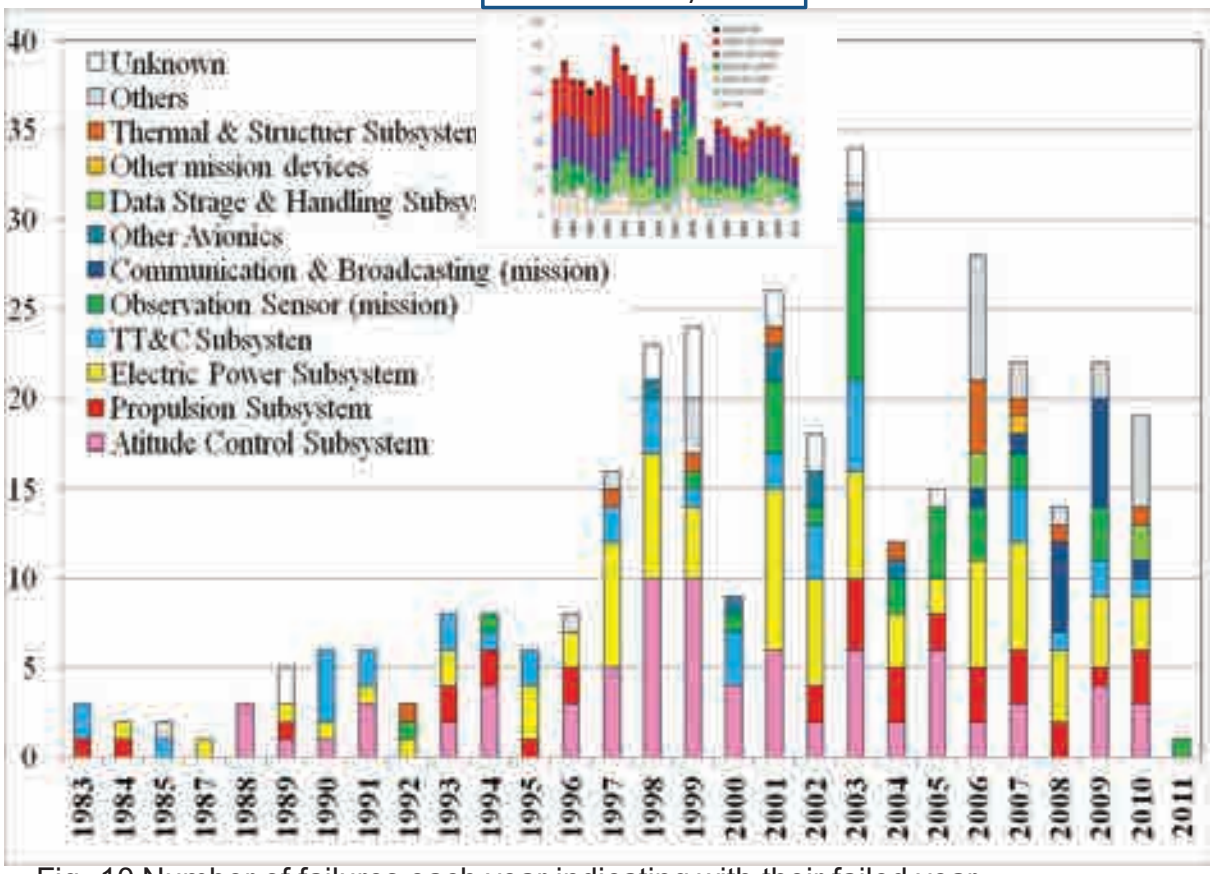


Fig.-10 Number of failures each year indicating with their failed year

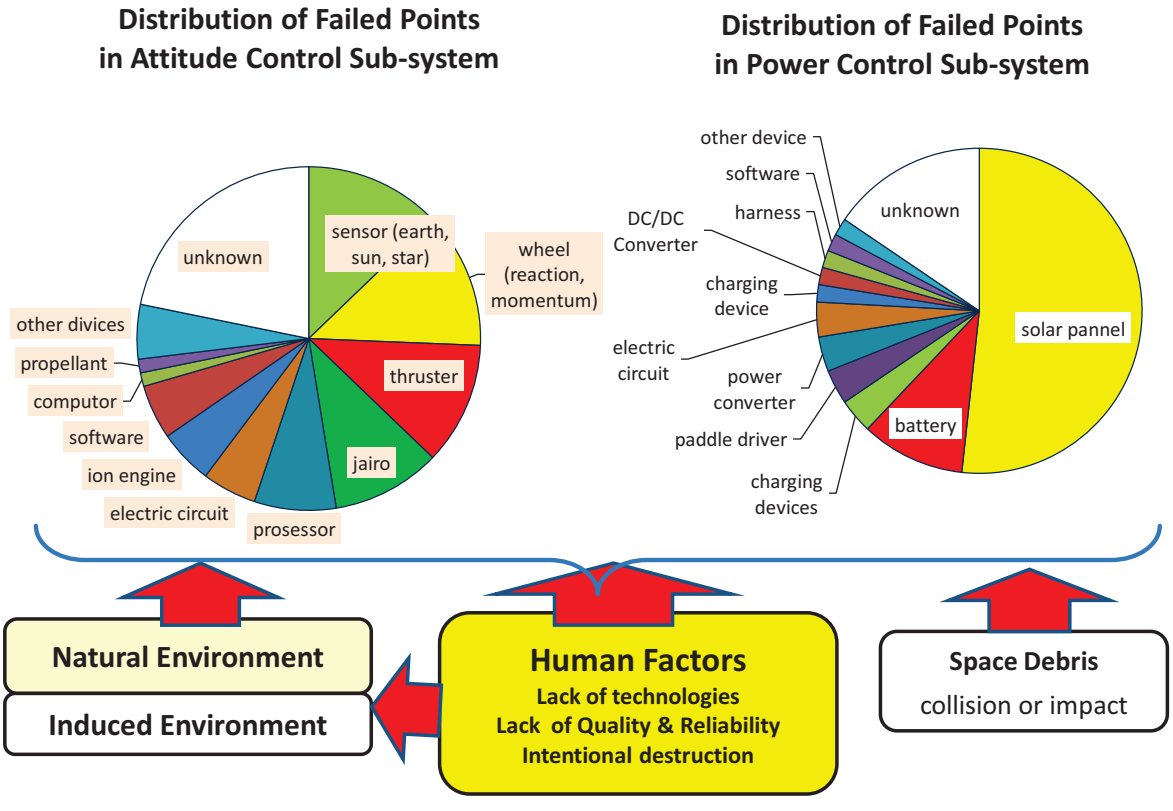


Fig.-11 Failed components in the “attitude control” and “power control” sub-system