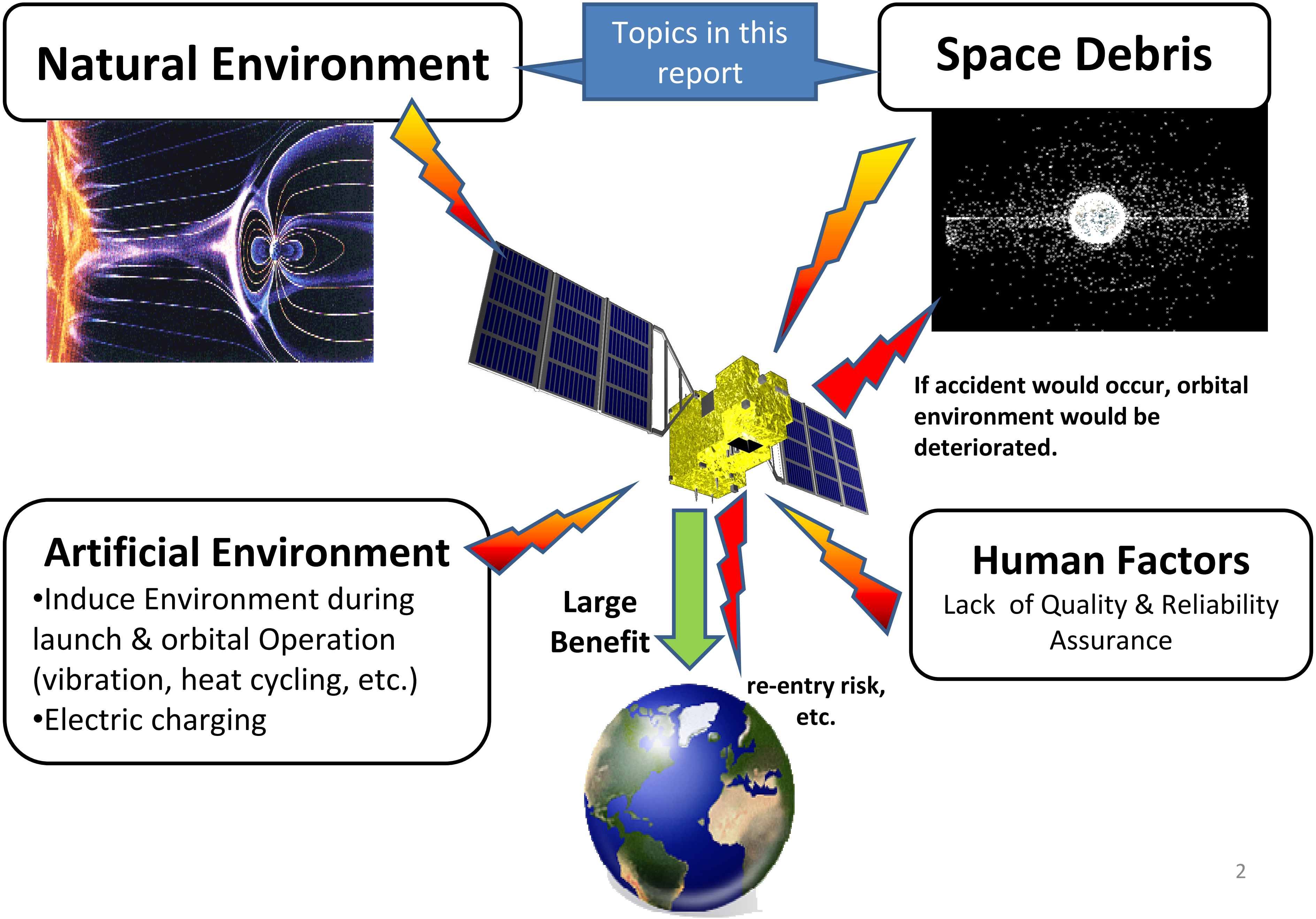
Japan's View on
"the Long-Term Sustainability of Outer Space Activities of the STSC"

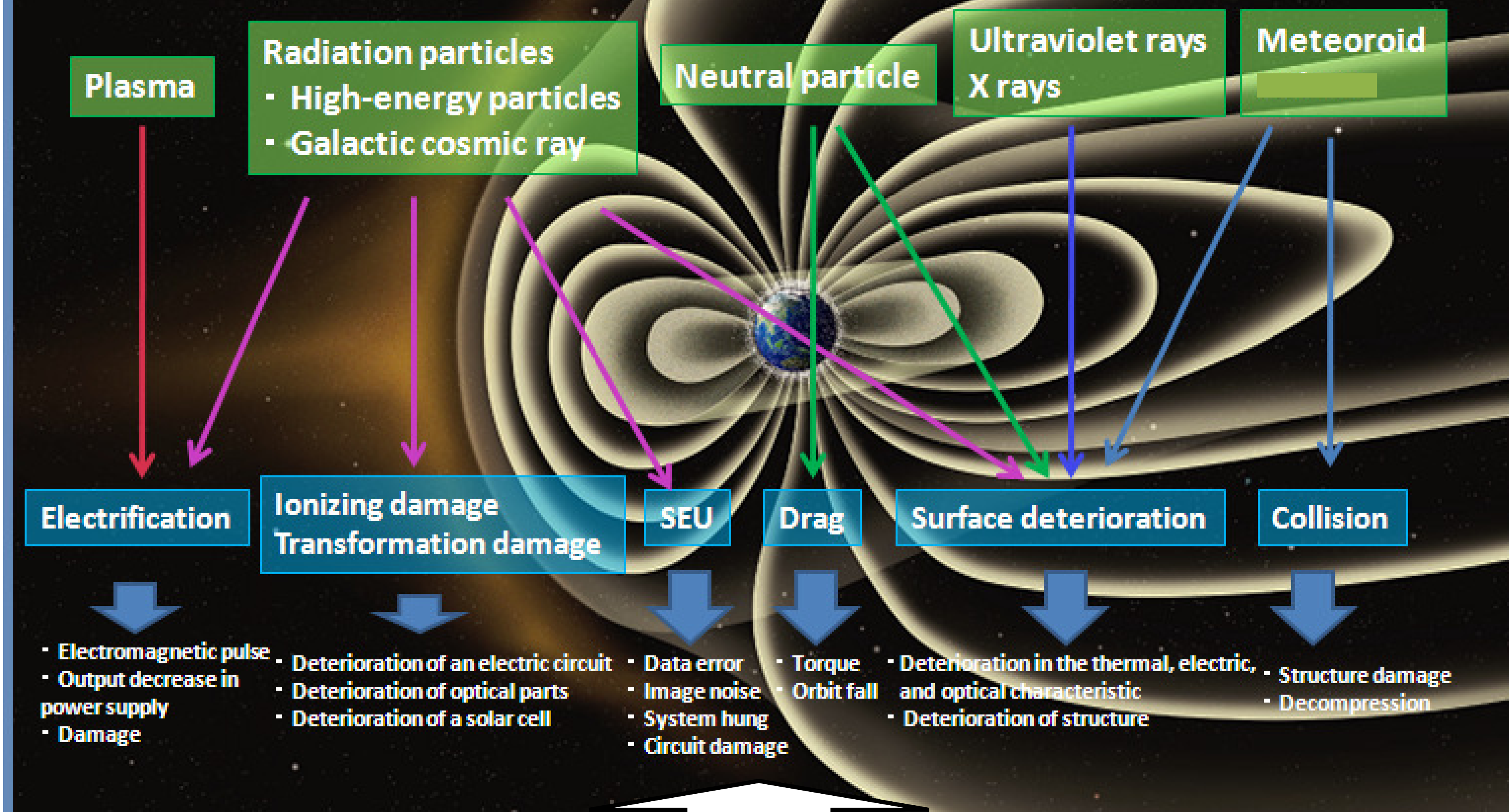
10 February 2012

Japan

1. Major Threats for Space Activities



2. Natural Environment (Factors, Effects, Counter Measures)



Modeling, Monitoring, Forecasting, Warning, Design measures, Operational actions, etc.

Preventive Actions	Modeling, Monitoring, Forecasting	Models of natural environment are being developed in ISO and other organizations. Some satellites have monitoring sensors. Research is being done to forecast with higher precision.
	Design Measures	Design standards, radiation hardness design for example, are being applied, and need to be developed more.
Detection of risk	Monitoring Detection Sending Alert / Warning	Monitoring and warning services are available by the ISES. Provide space weather forecasting and send alert / warning if needed. They are expected to be developed more.
Corrective Action	Risk Avoidance	In case of warned situation, operation mode will be shifted to safe-mode. Space crew will hide behind shielded area.
Permanent Action	Monitoring, Analysis	On-ground and in-orbit monitoring and sharing of observation data are encouraged.
	Failure Analysis	In-orbit failures should be analyzed for their causes, and if they were induced by the natural environment , design standards will be modified.
	Subject to be Discussed in EG-C	It is expected that the "International Space Warning Service" will be continued and improved.

Fig.-1 Contingency Plan for Natural Environment

Conclusion for EG-C

The “International Space Warning Service” is expected to be continued and improved.

Efforts are still needed for modeling, monitoring, forecasting, warning, design measures, and operational actions against risks stemming from the natural environment.

3. Space Debris

3.1 Typical Causes of Debris Generation and Basic Mitigation Measures

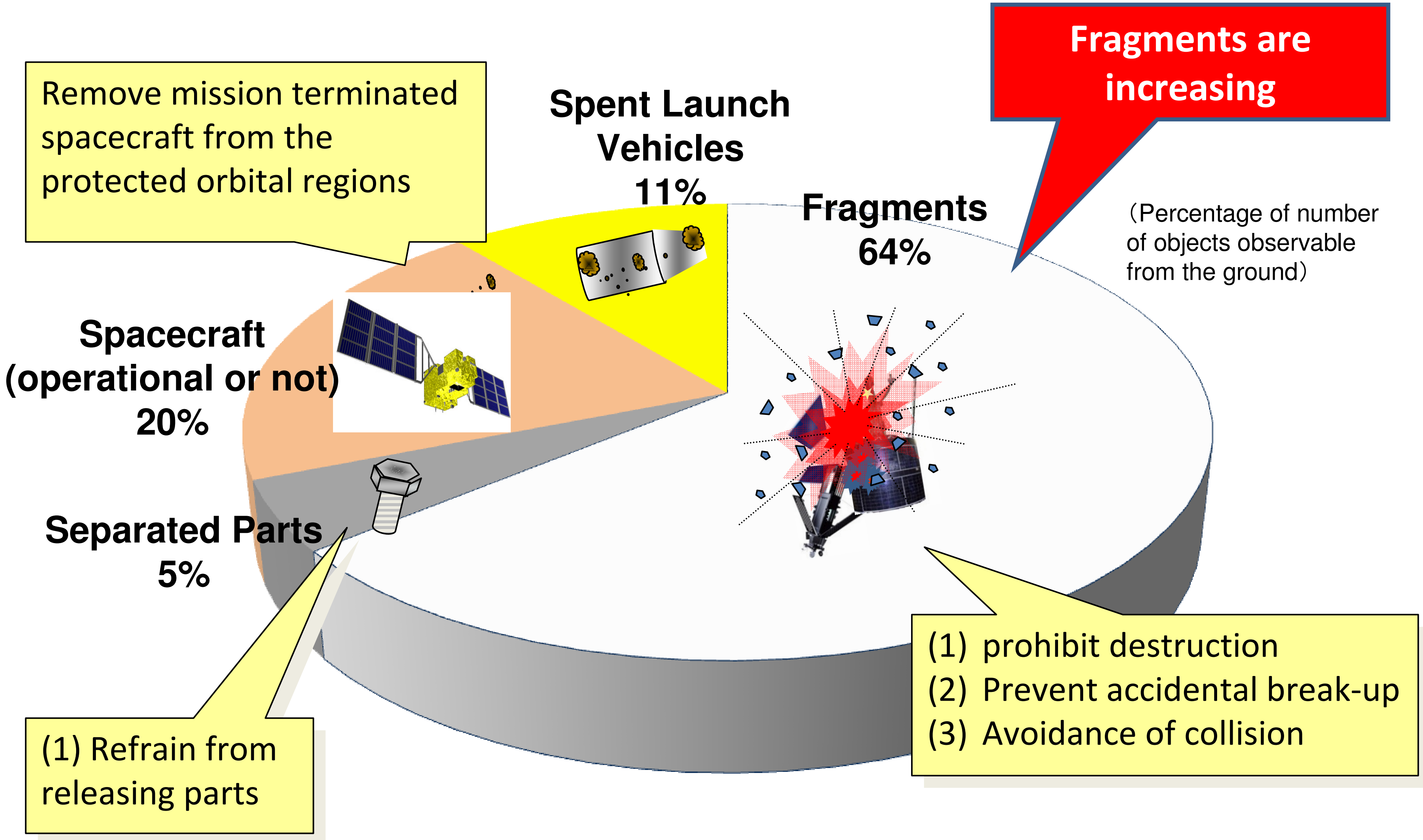


Table-1 World Space Debris Mitigation Rules

to illustrate the agreement of JAXA standard with others

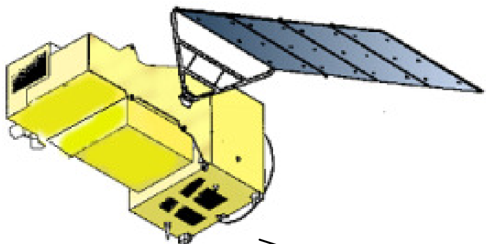
		mitigation measures	IADC Guidelines[a]	UN Guidelines	ISO 24113[c]	NASA (NASA-STD 8719.14)[d]	European Code of Conducts for Space Debris Mitigation[f]	JAXA (JMR-003B[g])
Mission Related Objects		Operational Debris	○	○ (Rec-1)	○	○ ·1mm	○	○
		Slag from solid motor			○		Slag · 1mm	○
		Pyrotechnics			Combustion products · 1mm		fragments · 1mm	Combustion products < 1mm
		Intentional Destruction	○	○ (Rec-4)	○	100 object-years	○(SD-DE-04)	○
On-orbital Break-ups		Accident during Operation	○	○ (Rec-2)	Break-up rate $<10^{-3}$	Break-up rate $<10^{-3}$	Break-up rate $<10^{-4}$	Break-up rate $<10^{-3}$
		Post Mission Break-up (Passivation, etc.)	○	○ (Rec-5)	○	Required	○	○
		with Large Objects	○	○ (Rec-3) (CAM, COLA)		define by other document	○	○
Collision		with Small Objects	○			Risk assessment	define by other document	○
Post Mission Disposal	GEO	Reorbit at EOL	ITU Recommend. e · 0.003	○ (Rec-7)	ITU Recommend. e· 0.003 Success rate ·0.9	ITU Recommend. e· 0.005	ITU Recommend. Success rate ·0.9	ITU Recommend. e· 0.003 Success rate ·0.9
		GEO Lower Limit	-200 km			GEO - 500 km	-200 km	-200 km
		Reduction of Orbital Lifetime	Recommend (with in 25-years)	○ (Rec-6)	Orbital lifetime · 25years Success rate ·0.9 Ensuring 100-year non interference	Total orbital lifetime· 30 years post mission lifetime · 25 years Success rate ·0.9	post mission lifetime · 25 years Success rate ·0.9	post mission lifetime < 25 years Success rate>0.9
	LEO (MEO)	Transfer to Graveyard	No mentioning		○	2,000 km ~ (GEO-500 km) (exclude 19,100 - 20,200 km)	○	○
		Ground Casualty	○	○ (Rec-6)	○	○(Ec· 10^{-4})	○(Ec· 10^{-4})	○(Ec· 10^{-4})

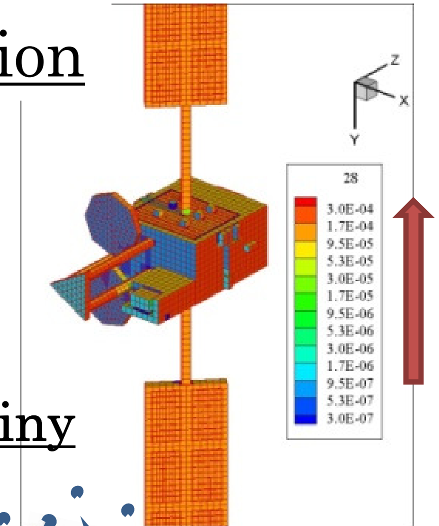
Table-2 Compliance with Debris Mitigation Standard in JAXA
to illustrate the relatively good compliance with requirements.

	Requirements	Situation in Japan
1	Not releasing mission related objects	Good compliance
2	Prevention from break-ups	Good compliance
3	Removal from the GEO protected region	Good compliance
4	Removal from the LEO protected region	(1) Since February 2011, 25-year-rule has been strictly applied. (2) Large satellites are complying with this rule.
5	Ground safety from re-entering debris	(1) JAXA conducted controlled re-entry for HTV and H-2B orbital stage. (2) R&D for the composite propellant tank is being conducted for easy demising.
6	Protection from collision	(1) Collision avoidance will be done if needed. (2) Protection design is applied for tiny debris. (3) Launching vehicle is coordinated not to collide with manned systems.

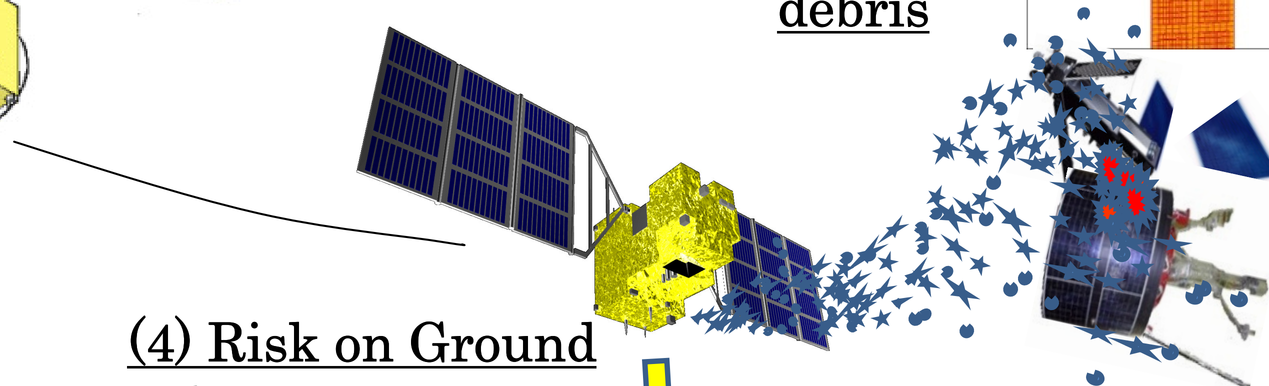
3.2 Risk of Debris in Need of Further Attention

(1) Risk of Collision with Large Objects (with other spacecraft, manned space systems, and other large debris)





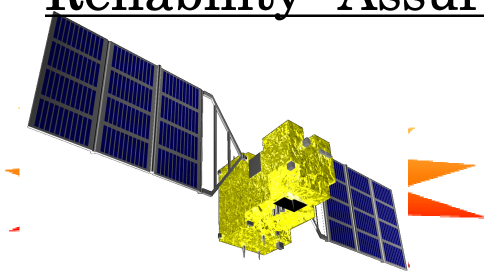
(2) Risk of Collision with tiny debris



(4) Risk on Ground due to Re-enter

(3) Risk of Collision when diving into Debris Clouds = Fragments from Break-up

(5) Risk of Debris Increase due to lack of Quality & Reliability Assurance

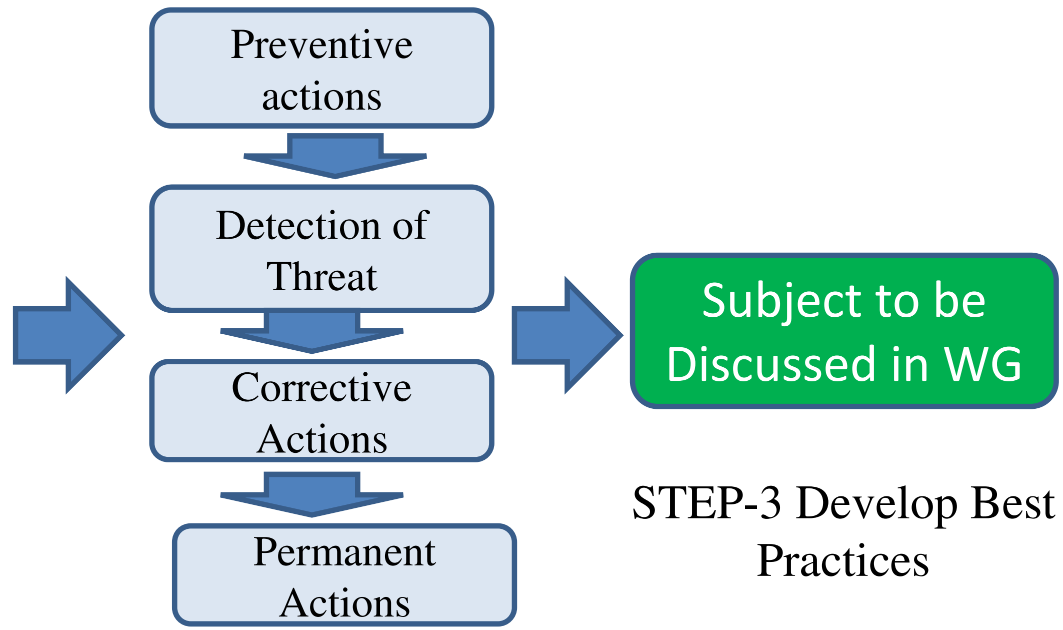


Concept of Risk Analysis, Contingency Planning, Identification of Best Practices, as presented last year

1. STEP-1: Assess the risk by its probability and influence, and identify the items for which risk magnitude is not small.
2. STEP-2: For each major risk, review the contingency plan, and identify the subjects to be improved.
3. STEP-3: Assess the subjects to be developed as best practices

	Minor (Minor failure)	Moderate (Loss of partial function)	Significant (Loss of function)	**Catastrophic** (Break-up)
0. 1				
0. 01				
0. 001				
0. 0001				
0. 00001 以下				

STEP-1: Risk Assessment matrix



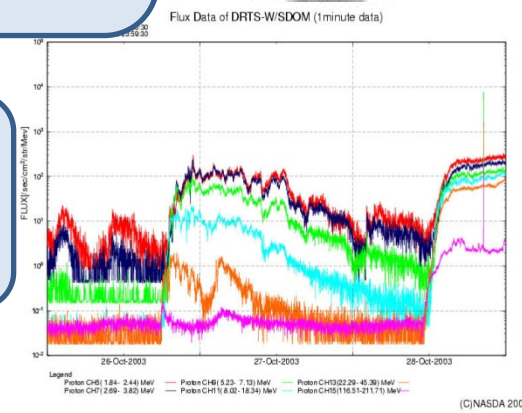
STEP-2 Contingency Planning

STEP-3 Develop Best Practices

3.3 Concept of Contingency Planning Approach

Preventive Actions

(1) Modeling the Risk by monitoring, prediction, etc.
(2) Exchange and sharing of information,
(3) Risk Analysis and Risk Preventive design

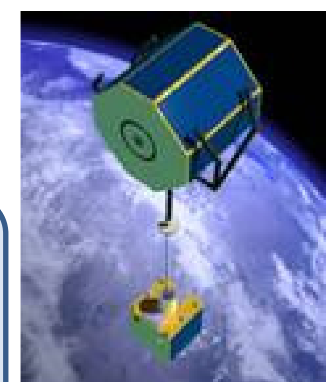


Detection of Threat / Risk

(1) Monitoring and Detection of risk
(2) Warning

Recovery & Corrective Actions

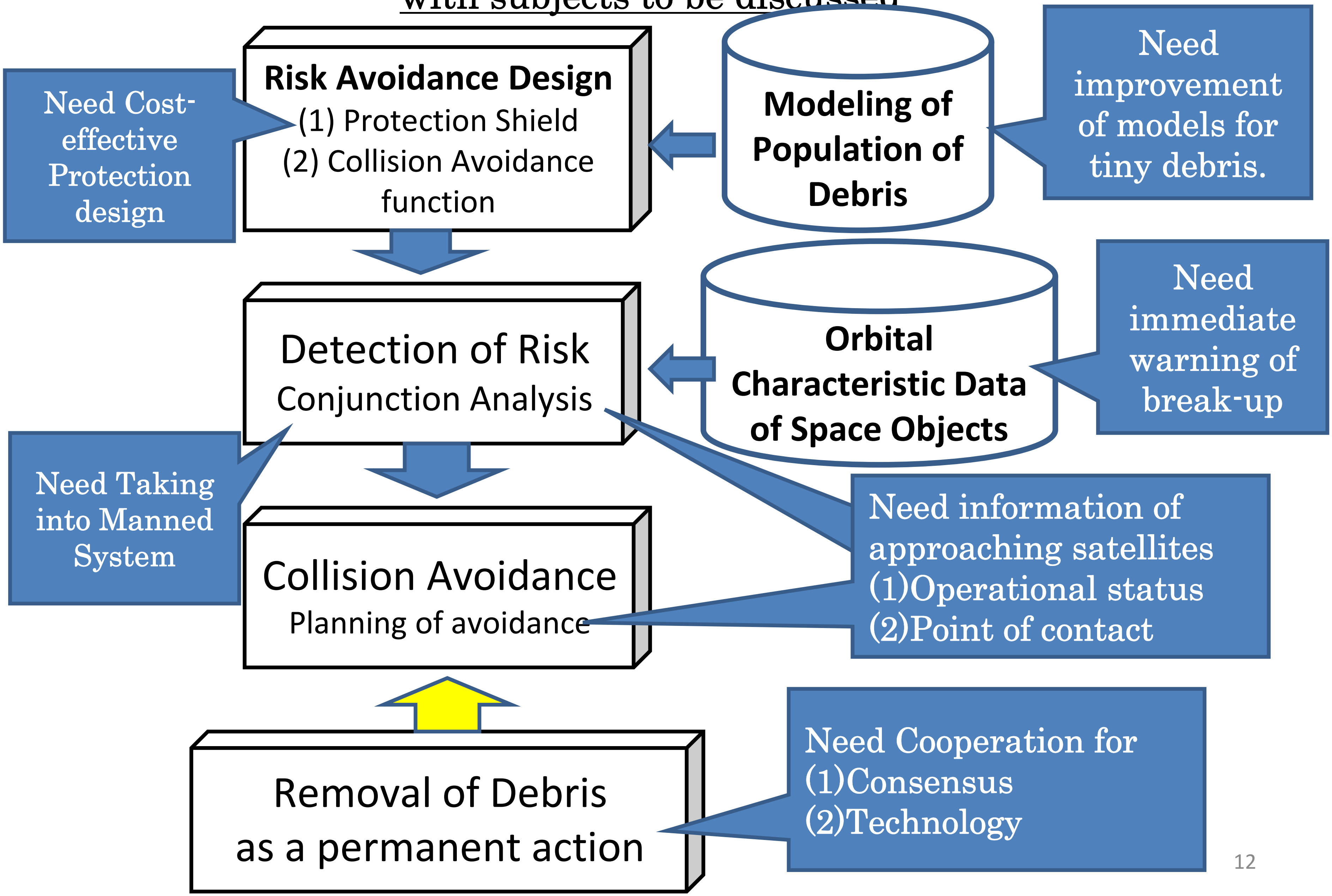
(1) Confirmation of Risk, and Risk Analysis
(2) Determination for Immediate and Adequate Action



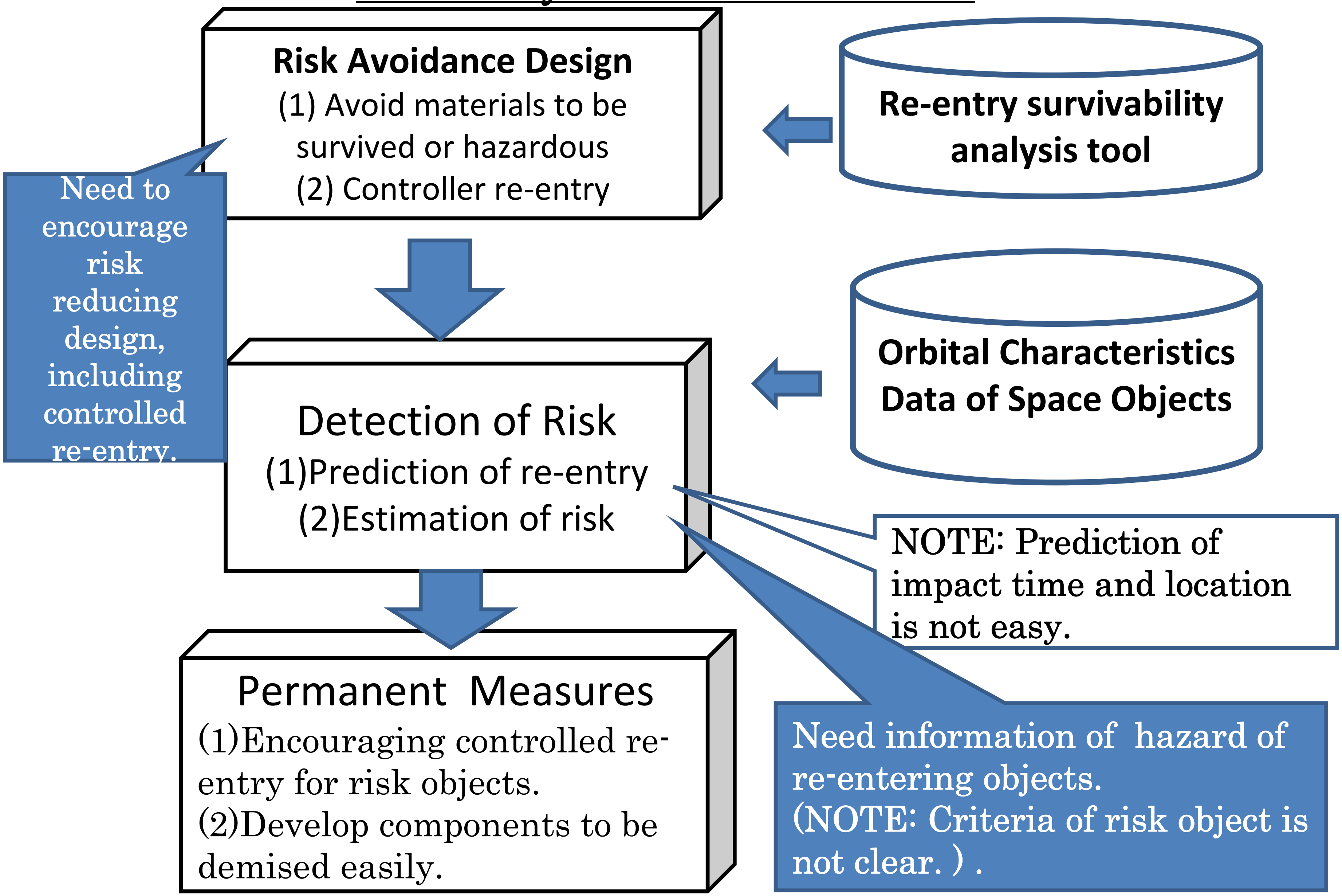
Permanent Actions

Removal of large objects from protected orbital regions

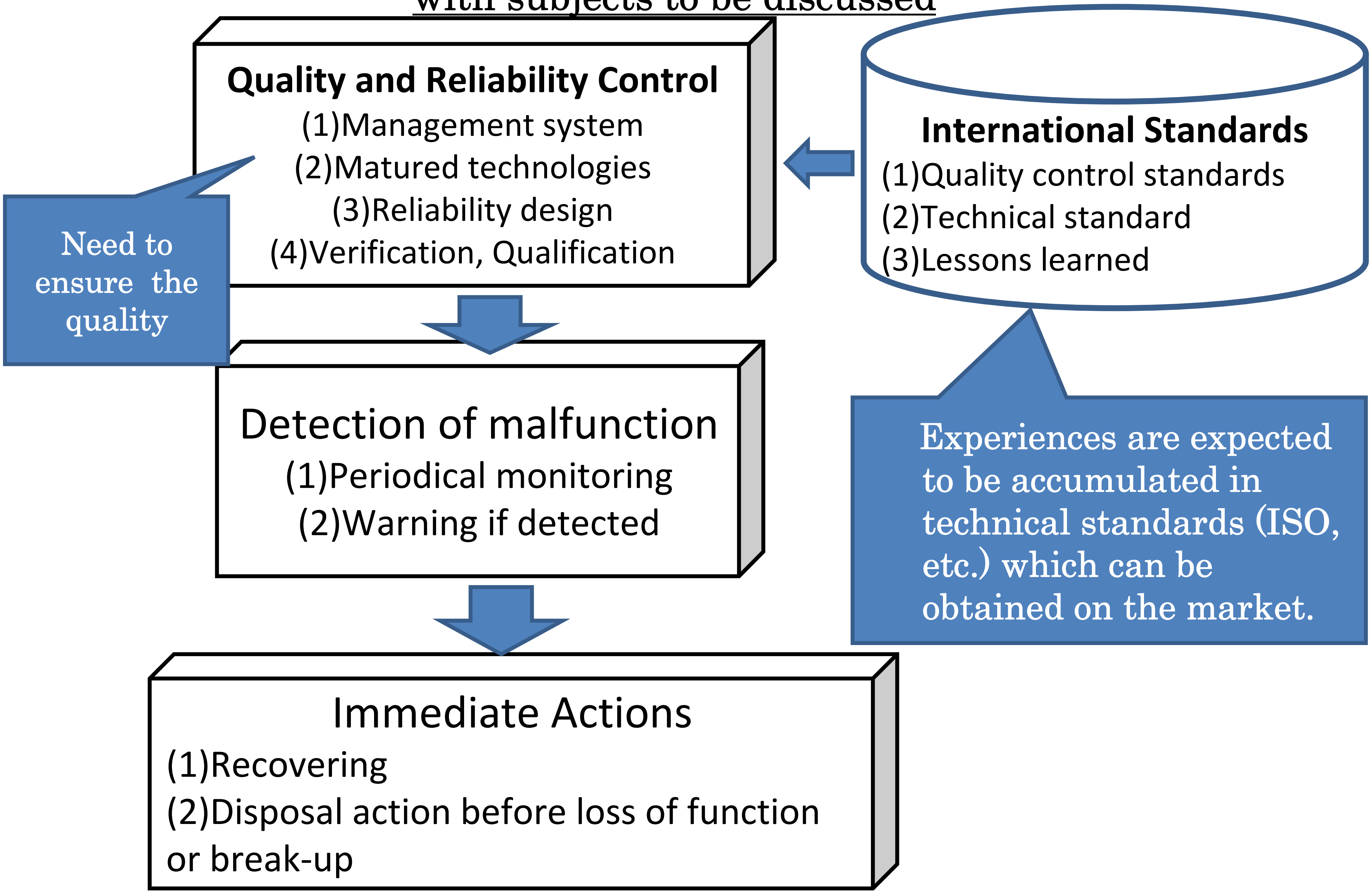
3.4 Typical Contingency Planning for Collision Risk with subjects to be discussed



3.6 Typical Contingency Planning for Re-entry Risk with subjects to be discussed



3.7 Typical Contingency Planning for Lack of Quality
with subjects to be discussed



3.8 Subjects and Candidates for Best Practices for Debris Issue

Subjects identified

Collision with large objects

(1) The operational status shall be reported according to the international treaty, and it shall be registered immediately on the web site.

Impact of tiny debris

(1) Survey tiny debris, and improve the models.

(2) Cost-effective protection design method should be established.

Collision with manned systems

(1) Launch windows should be controlled to avoid collision with manned space systems at the least.

Debris cloud

(1) Immediate warning when detecting break-up.

(2) Debris distribution data should be provided timely.

(3) Prevention of a chain reaction of collisions (in future)

Re-entry hazard

(1) Encouraging a risk reducing design for safe re-entry.

(2) High risk object shall be opened for its characteristics

Lack of Quality and Reliability

(1) Encouragement of quality control.

(2) It should be encouraged that matured technologies are shared through the international standards (ISO, etc.).

Best Practices

Information Sharing

a) operational situation

b) risk of re-entry

c) environment information

International Contribution

a)notification of break-up

b)orbital data of fragments

International Cooperation

a)collision avoidance at new launch

b)re-entry safety

c)improvement of statistical debris model

d)quality control

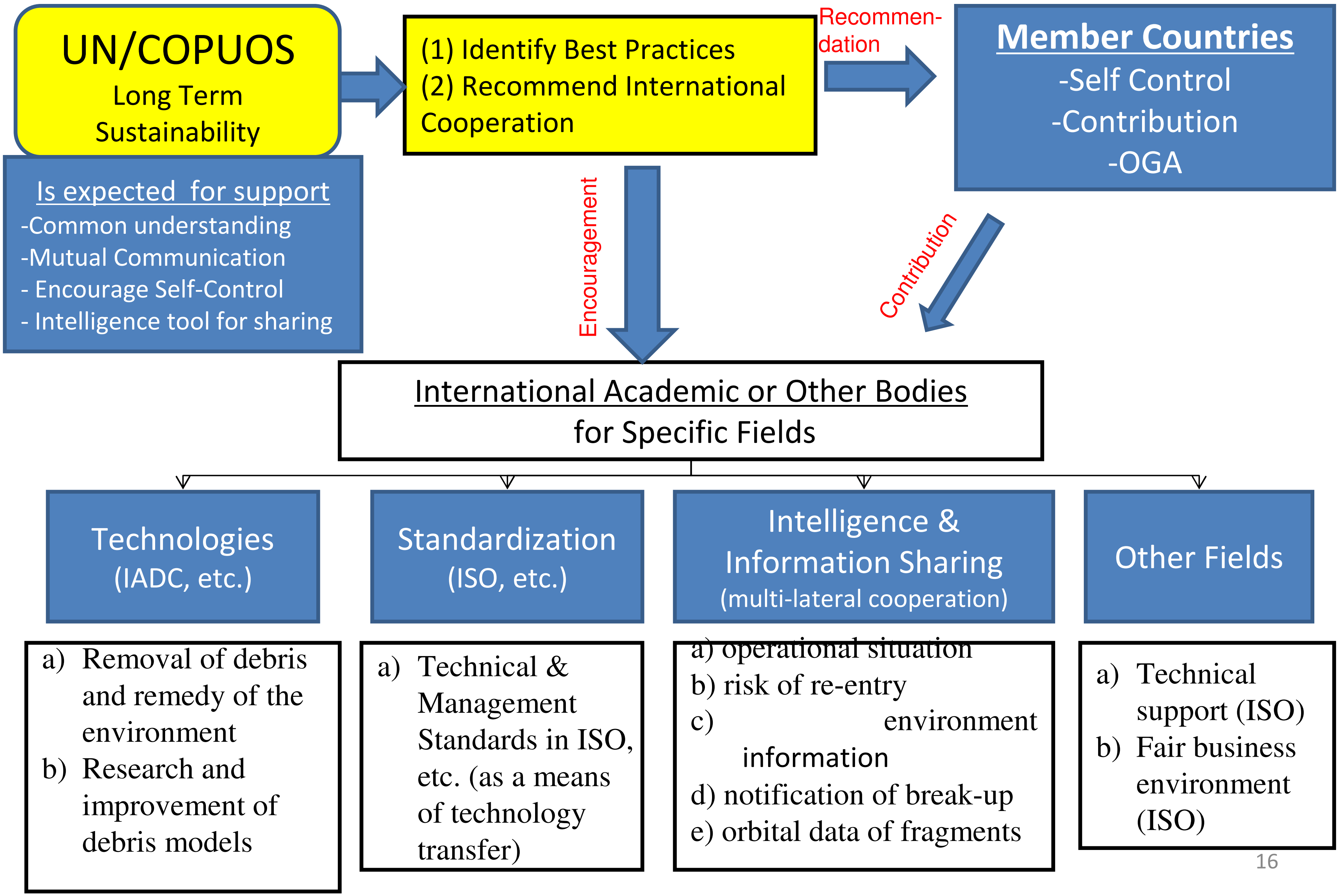
e)removal of existing large objects

International Standards

a)Technical & Management Standardization in ISO, etc.

3.9 Prospected Work Sharing after the LTS activities

to be considered presently



3.10 Conclusion for EG-B

A)Considering the current and future situation in the orbital environment, which can not be recovered with existing debris mitigation standards, 6 items *(collision avoidance in orbit and during launch , protection from impact, debris cloud, re-entry safety, quality control)* were identified to be discussed.

B) The discussion to remove existing large debris can't be avoided. If the WG identifies its significance, it can be transferred to other bodies for the next step to improve the situation.

C) Identified subjects should be submitted to the next discussion in EG-B to develop Best Practices.

Appendix-A

Contingency Plan for

①Fig.-A-1 Collision with Large Objects

②Fig.-A-2 Collision with Tiny Debris

③Fig.-A-3 Collision during Launch

④Fig.-A-4 On-orbit Break-up

⑤Fig.-A-5 Re-entering Objects

⑥Fig.-A-6 Lack of Quality and Reliability

Preventive Actions	Identification of Objects	Large objects are catalogued, and being provided to the world.
	Design & Operation Measures	Function and resources for avoidance maneuver will be prepared to the systems.
Detection of risk	Monitoring & Warning	Warning will be sent to both sides of operators.
	Risk Assessment	Operator shall assess the risk of collision. The status of objects (operational or not) should be cleared.
		State shall report the operational status according to the international treaty. The information shall be registered immediately on the web site.
Corrective Action	Risk Avoidance	Conduct collision avoidance maneuver coordinating with counter part, and return to the original orbit.
Permanent Action	Remove Large Objects	Remove large debris which are the source of chain reaction of collision.

Subject to be Discussed in EG-B

(1) State shall report the operational status (operational or not, etc.) according to the international treaty.
(2) Above information shall be registered immediately in web site.

Fig.-A-1 Contingency Plan for Collision with Large Objects

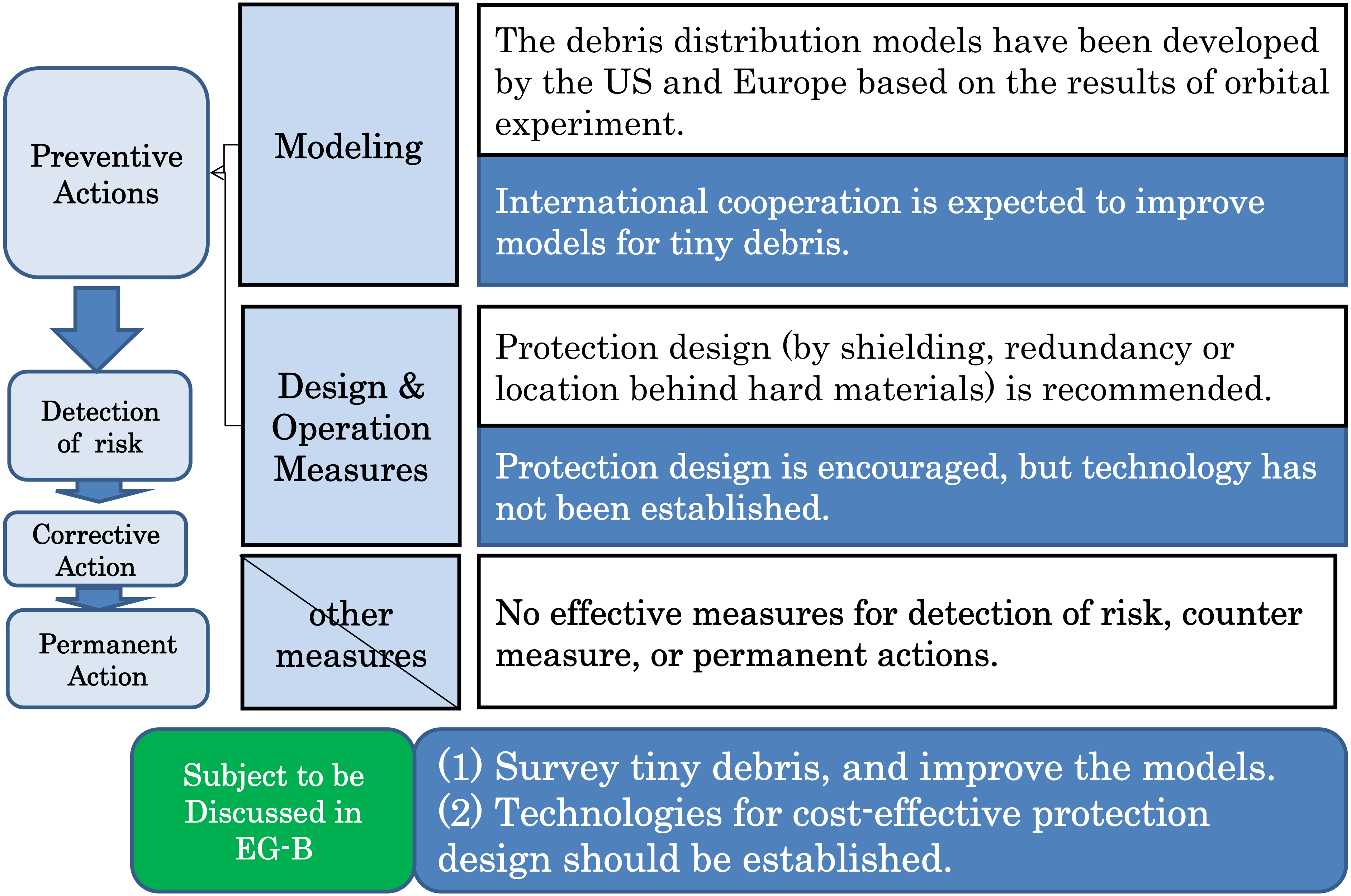


Fig.-A-2 Contingency Plan for Collision with Tiny Debris

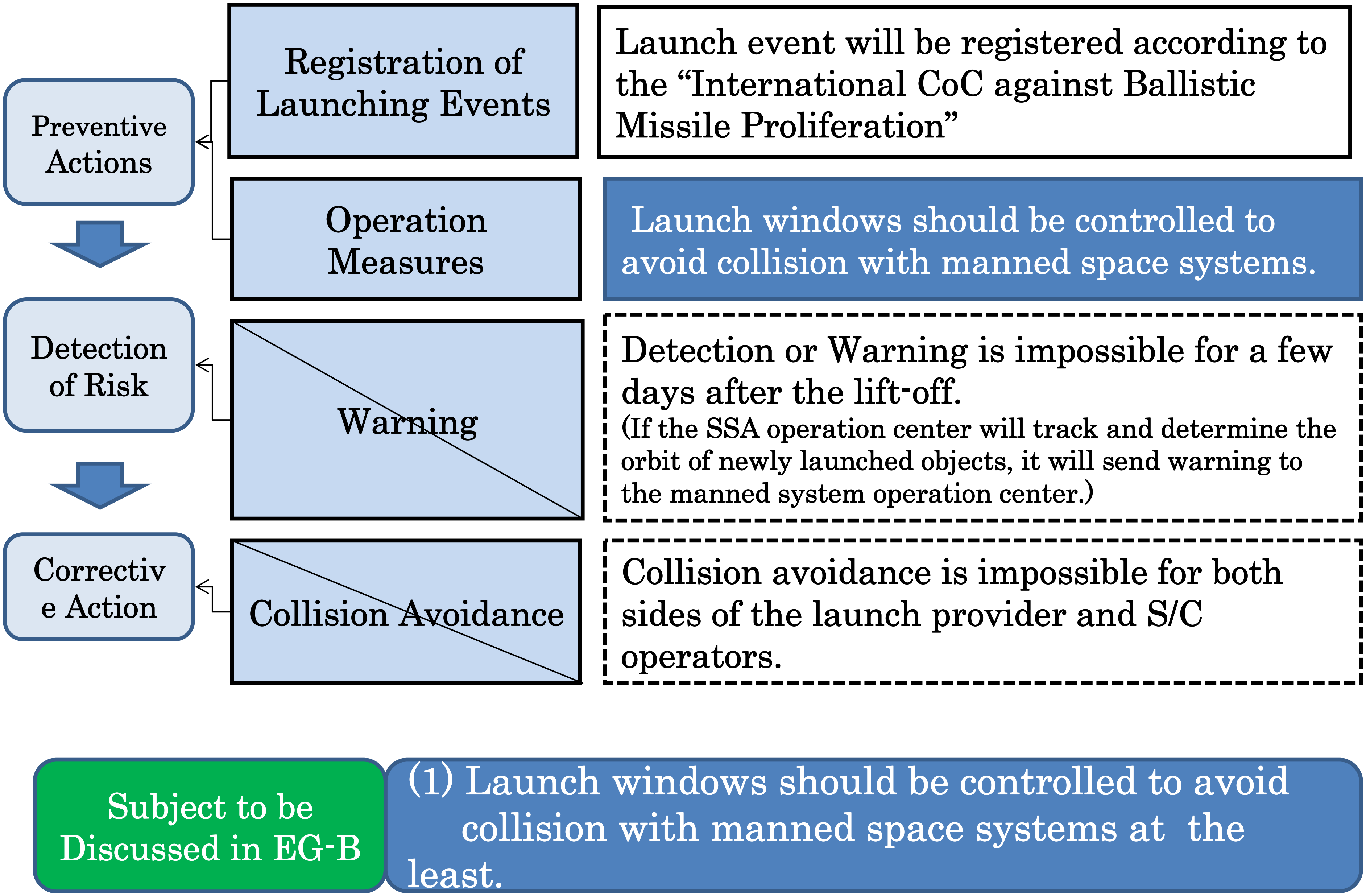


Fig.-A-3 Contingency Plan for Collision during Launch

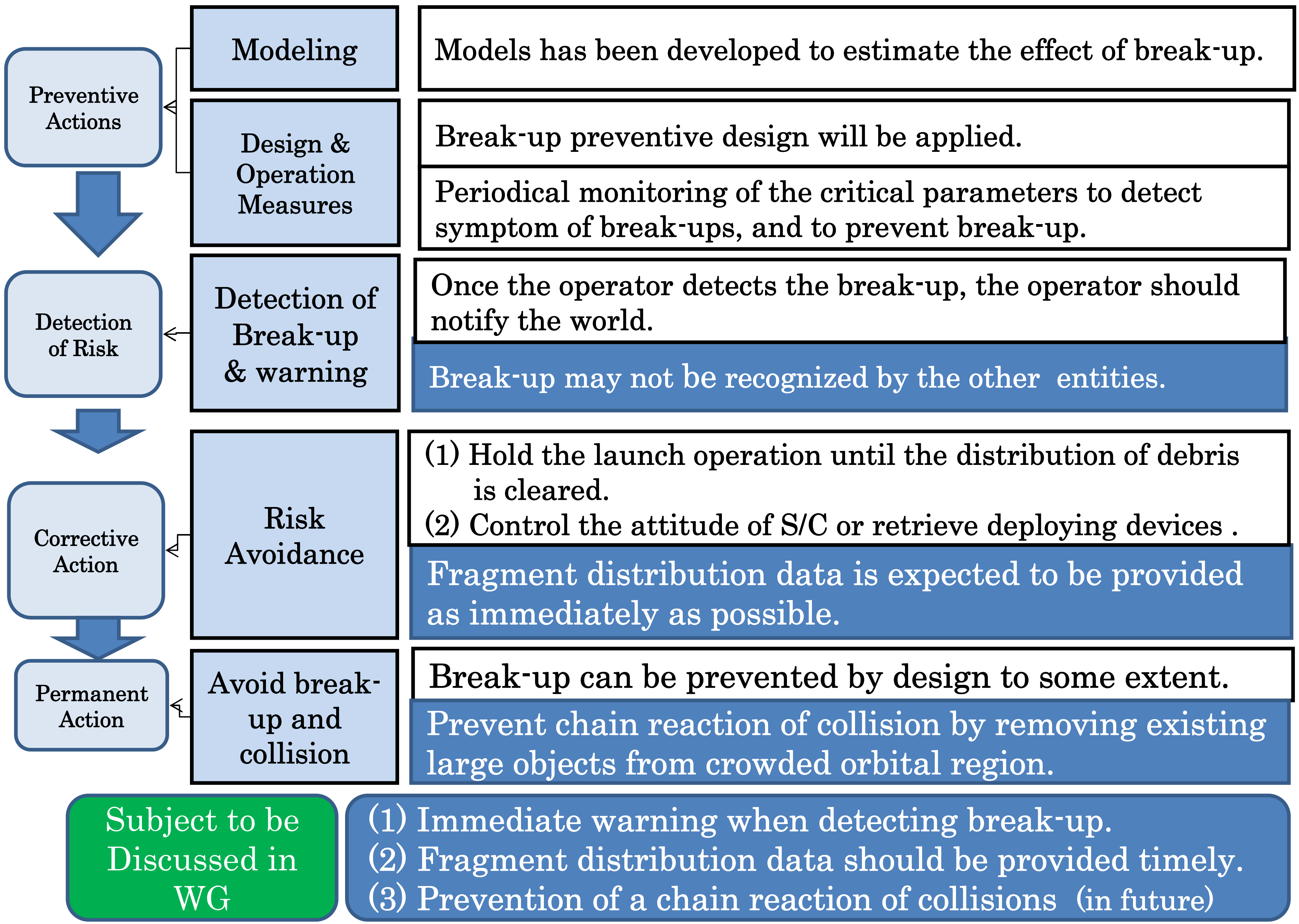


Fig.-A-4 Contingency Plan for On-orbit Break-up

Preventive Actions	Survivability Analysis	Survivability of re-entering object is analyzed, and casualty expectancy is assessed.
	Design & Operation Measures	Risk reducing design to prevent ground casualty (controlled re-entry, selection of adequate material, etc.) is expected to be applied. Risk reducing design should be encouraged.
Detection of Risk	Estimation of Risk	Re-entry time and location will be estimated. Impact footprint will be estimated. Ground pollution will be estimated.
	Warning	Responsible organization should open the situation for its re-entry event, if the risk is large. High risk object (atomic powered S/C, etc.) shall be opened for its orbital characteristic
Permanent Action	Permanent Action	Encouraging controlled re-entry for risk objects. Develop components to be demised easily.

Subject to be Discussed in EG-B

(1) Encouraging a risk reducing design for safe re-entry.
(2) High risk object shall be opened for its characteristics

Fig.-A-5 Contingency Plan for Re-entering Objects

Preventive Actions	Design & Operation Measures	The most principle measure for debris mitigation is to ensure the quality and reliability. [Matured technologies are being opened with international standards.]
Detection of Risk	Review system	(1) A national government is expected to review, control or authorize its domestic activities. (2) A spacecraft with low reliability could be limited in its altitude to lower than 600km.
Corrective Action	Operation Measures	In case of malfunction, disposal measures and break-up prevention measures will be taken.
Permanent Action	Feedback to Design with Design Standards	(1) Experiences are expected to be accumulated in technical standards (ISO, etc.) which can be obtained on the market.

Subject to be Discussed in EG-B & D	Encouragement of quality control. It should be encouraged that matured technologies are shared through the international standards (ISO, etc.).

Fig. –A-6 Contingency Plan for Lack of Quality and Reliability