The 2016 Perception Survey on the Technology Cooperation of

China-Korea-Japan

"Advanced Maintenance"

- Results of the Survey -

1 September 2016

The Chinese Academy of Engineering

The National Academy of Engineering of Korea

The Engineering Academy of Japan

I. China-Japan-Korea Technology Cooperation Index

	Number of Respondents	Very necessary	Necessary	Unnecessary	Very Unnecessary	No answer	Total
China	(109)	43.1	52.3	2.8	0	1.8	100.0
Korea	(130)	79.2	20.0	0.7	-		100.0
Japan	(98)	24.5	64.2	3.1	0	8.2	100.0

1. Do you think technology cooperation is necessary among China, Japan, and Korea?



Three countries agree that technology cooperation among China, Korea and Japan is necessary. Korea indicates a stronger recognition of the need.

	Frequency	Very much mutually beneficial	Somewhat mutually beneficial	Not very much mutually beneficial	Not mutually beneficial at all	No Answer	Total
China	(109)	15.6	69.7	10.1	0	4.6	100.0
Korea	(130)	72.7	27.3	0	0	0	100.0
Japan	(98)	23.5	62.2	14.3	0	0	100.0

2. Do you think technology cooperation among China, Japan and Korea would be mutually beneficial?



Three countries agree that technology cooperation among China, Korea and Japan is beneficial. Compared to China, Korea and Japan indicate a higher satisfaction level.

3. <u>In terms of quantity</u>, how do you evaluate the level of technology cooperation among China, Japan, and Korea?

	Number of respondents	Very high	High	Low	Very low	No answer	Total
China	(109)	7.3	54.1	33.9	0	4.6	100.0
Korea	(130)	7.7	34.6	53.8	4.6	0	100.0
Japan	(98)	4.1	32.7	48.0	15.3	0	100.0



China indicates a relatively high satisfaction level with the number of technology cooperation. Korea and Japan find that it is rather low, or potentially improvable.

4. <u>In terms of quality</u>, how do you evaluate the level of technology cooperation among China, Japan, and Korea?

	Number of respondents	Very high	High	Low	Very low	No answer	Total
China	(109)	6.4	61.5	27.5	0	4.6	100.0
Korea	(130)	2.3	28.5	59.2	11.9	0	100.0
Japan	(98)	2.0	29.6	61.2	2.1	0	100.0



The result of Q.4 shows a similar trend to that of Q.3 regarding the number of technology cooperation. China shows a relatively high satisfaction level both in the number and quality of cooperation while Korea and Japan find potential for improvement.

5.	What is your opinion on future prospect and potential for technology cooperation among China, Japan	,
	and Korea?	

	Frequency	Very positive	Positive	Negative	Very negative	No answer	Total
China	(109)	18.3	62.4	16.5	0	2.8	100.0
Korea	(130)	3.8	69.2	26.1	0.9		100.0
Japan	(98)	4.1	64.3	27.6	4.1	0	100.0



Three countries show a similar trend and agree that the future for technology cooperation among the three countries may not be rosy, but would be bright.

6. Transition of cooperation index by year

Based on the continuous survey carried out every year, transitions of cooperation index is clarified.



The indices of technical cooperation were obtained from 5 sub-surveys, which were respectively necessity of technical cooperation (Factor 1), benefits of technical cooperation (Factor 2), quantity level of technical cooperation (Factor 3), quality level of technical cooperation (Factor 4), and potential of technical cooperation (Factor 5). By calculating the means of scores on these 5 sub-items, the expected values of technical cooperation indices are obtained (the calculation formula is as shown below):

Expected value of technical cooperation index =

$$\frac{Factor1 + Factor2 + Factor3 + Factor4 + Factor5}{5}$$

In the five categories, a "very positive" response, "mildly positive" response, "mildly negative" response and "very negative" response were given 100, 67, 33 and 0 points respectively and Index is calculated on the basis of average.

	Necessity of Technical			Be	Benefits of Technical			Quantitative Level of Technical				
	Cooperation		Cooperation			Cooperation						
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
China	79.3	82.5	76.5	80.5	69.4	81.1	73.1	68.8	56.7	62.3	54.2	57.4
Japan	81.8	78.2	68.0	74.7	79.9	76.3	64.8	69.9	42.9	43.5	47.9	41.8
Korea	96.3	93.8	90.0	92.9	92.6	89.8	87.4	90.9	44.8	43.9	43.0	48.7

	Quality L	evel of Te	chnical Co	operation	Potential of Technical Cooperation				
	2013	2014	2015	2016	2013	2014	2015	2016	
China	56.0	61.5	51.7	59.4	62.4	73.6	64.0	67.5	
Japan	41.3	43.0	38.7	42.1	62.4	58.6	56.7	56.2	
Korea	38.3	39.4	38.3	40.9	62.6	59.9	59.5	58.9	

II. Personal Information

1. Have you participated in any technology cooperation with Korea, China, and Japan during the recent five years? If yes, how many cases?

If you are from Japan, please fill in the below.

- 1. China () case(s)
- 2. Korea () case(s)
- 3. China-Japan-Korea () case(s)

If you are from China, please fill in the below.

1. Japan () case(s)	
2. Korea () case(s)	
3. China-Japa	an-Korea () case(s)

If you are from Korea, please fill in the below.

- 1. China () case(s)
- 2. Japan () case(s)
- 3. China-Japan-Korea () case(s)

	Number of cases in 1	Number of cases in 2	Number of cases in 3	
China	38	37	14	
Korea	76	86	29	
Japan	85	61	16	

The average number of cooperation per respondent:

Japan

with China: 0.87, with Korea: 0.62, among three countries: 0.16

China

with Japan: 0.35, with Korea: 0.34, among three countries: 0.13

Korea

with China: 0.58, with Japan: 0.66, among three countries: 0.22

Compared to bilateral cooperation, trilateral cooperation is limited and potentially improvable.

2. Your profession (

- 1. University lecturer
- 2. Researcher
- 3. Business owner or employee
- 4. Government official or public sector employee

)

)

5. Others (

	University lecturer	Researcher	Business owner or employee	Governmental official or public sector employee	Others	Total
China	46.8	36.7	8.3	1.8	6.4	100.0
Korea	59.2	11.5	27.7	1.5	0	100.0
Japan	41.8	13.3	13.3	8.2	23.5	100.0



University lecturer is the largest group of respondents.

3. Your industry / sector ()

- 1. Civil and environmental engineering
- 2. Mechanical engineering
- 3. Technology management
- 4. Material and energy resources engineering
- 5. Electric and electronic engineering & ICT $% \left({{{\rm{E}}_{{\rm{E}}}}} \right)$

)

6. Chemical and biomedical engineering

7. Others (

	Civil & environmental engineering	Mechanical engineering	Technology management	Material & Engineering, resources engineering	Electric and electronic engineering	Chemical & biomedical engineering	Others
China	22.9	14.7	2.8	13.8	17.4	10.1	14.7
Korea	26.2	26.2	2.3	13.8	9.2	17.7	4.6
Japan	14.3	18.4	9.2	20.4	17.3	7.1	19.4



Respondents are sectorally balanced. It can be said that "Maintenance" is an issue of great concern.

4. For how many years have you been engaged in your research area? ()

- 1. Less than 5 years
- 2.5 10 years
- 3.10-20 years
- 4. More than 20 years

	Number of respondents	Less than 5 years	5-10 years	10-20 years	More than 20 years	No answer	Total
China	(109)	0.9	0.9	8.2	87.2	2.8	100.0
Korea	(130)	4.6	1.5	4.6	89.2	0	100.0
Japan	(98)	5.1	2.0	9.1	81.6	0	100.0



Three countries again show a similar trend curve. The largest group of respondents have more than twenty years of research experiences.

5. Your age ()

- 1.40-49
- 2.50-59
- 3.60-69
- 4.70-79
- 5.80 or older

	Frequency	40-49	50-59	60-69	70-79	80 or older	Total
China	(109)	11.9	18.3	33.9	33.0	2.8	100.0
Korea	(130)	0.8	32.3	53.8	13.1	0	100.0
Japan	(98)	7.2	11.2	44.9	21.4	2.0	100.0



In each country, the largest group of respondents is in their 60's and senior.

III. Fact finding survey

1. As to the idea "Scrap & Build" is better than maintenance," what do you think about it?

)

- 1. Scrap & Build is better
- 2. Scrap & Build is somewhat better
- 3. Maintenance is somewhat better 4. Maintenance is better

B(10) (

A(100) ()

C(1) () D(<0.1) (

)

	Number of respondents		Scrap & Build is better	Scrap & Build is somewhat better	Maintenance is somewhat better	Maintenance is better	No answer	Total
		Α	14.1	2.4	2.8	74.1	3.5	100.0
China	05	В	4.7	12.9	58.8	12.9	10.6	100.0
China	85	С	10.6	57.6	17.6	3.5	10.6	100.0
		D	76.5	1.2	1.2	9.4	11.7	100.0
	120	Α	22.3	16.9	30.8	30.0	0	100.0
Varma		В	5.4	39.2	46.2	9.2	0	100.0
Korea	150	С	16.2	43.8	30.8	9.2	0	100.0
		D	49.2	20.8	10.0	20.0	0	100.0
		Α	14.3	4.1	13.3	65.3	3.1	100.0
Ionon	08	В	0.6	15.3	46.9	27.6	4.1	100.0
Japan	98	С	16.3	46.9	21.4	10.2	5.1	100.0
		D	68.4	13.3	4.1	9.2	5.1	100.0



Three countries basically agree that "maintenance" better fits for longer life-span technologies and "scrap & build" for short life-span. In Korea, however, there is smaller difference between "maintenance" and "scrap & build" in 100-year life-span technologies.

2. Significance of maintenance is adequately understood in your country?

- 2-1. Central dogma of maintenance (maintenance should be prioritized over new products and facilities if equivalent level of performance and reliability can be ensured by maintenance) is established?
 - 1. Not at all established 2. Under discussion
 - 3. Almost established 4. Established

A(100) () B(10) () C(1) () D(<0.1) ()

	Number of respondents		Not at all established	Under discussion	Almost established	Established	No answer	Total
		А	36.5	12.9	16.5	22.4	11.8	100.0
China	05	В	30.6	24.7	16.5	8.2	20.0	100.0
Cnina	85	С	29.4	22.2	17.6	11.8	18.8	100.0
		D	47.1	7.1	3.5	21.2	21.2	100.0
	120	Α	23.8	26.9	32.8	15.4	0	100.0
Varias		В	15.4	36.9	41.5	6.2	0	100.0
Korea	150	С	16.9	46.9	32.3	3.8	0	100.0
		D	34.6	31.5	22.3	1.5	0	100.0
		Α	23.5	35.7	27.6	8.2	5.1	100.0
Ionon	08	В	10.2	40.8	36.7	6.1	6.1	100.0
Japan	98	С	17.3	23.5	46.9	4.1	8.2	100.0
		D	33.7	24.5	19.4	13.3	9.2	100.0



In China, significance of "maintenance" has not yet been well understood overall. In Korea and Japan, it has been under discussion or somewhat understood for longer life-span technologies, but not for ultra-short life-span technologies.

2 -2. The budget for maintenance and/or renewal is sufficient compared to that for introducing new products and equipment?

- 1. Insufficient
- 2. Somewhat insufficient

4. Sufficient

3. Somewhat sufficient

	Number of respondents		Insufficient	Somewhat insufficient	Somewhat sufficient	Sufficient	No answer	Total
		А	49.4	15.3	14.1	10.6	10.6	100.0
China	05	В	32.9	28.2	15.3	5.9	17.7	100.0
	83	С	29.4	25.9	20.0	7.1	17.6	100.0
		D	32.9	14.1	7.1	27.1	18.8	100.0
	130	А	40.8	42.3	10.0	6.9	0	100.0
Vora		В	24.6	46/1	16.1	3.1	0	100.0
Notea		С	30.0	46.9	20.0	3.1	0	100.0
		D	34.6	33.8	23.8	7.7	0	100.0
		А	58.2	27.6	8.2	1.0	5.1	100.0
Ionon	00	В	35.7	43.9	15.3	0	5.1	100.0
Japan	98	С	14.3	48.0	27.6	3.1	7.1	100.0
		D	21.4	32.7	23.5	13.3	9.1	100.0





Three countries agree that the budget for "maintenance" is not sufficient, in particular for longer life-span technologies, however, China is divided over ultra-short life-span technologies.

2-3. Technologies to realize advanced maintenance (IoT, management of big data, hardware technologies such as drones and robots, advanced sensing, MEMS sensors) are sufficiently developed?

- 1. Not at all developed
- 2. Under development
- 3. Fairly developed
- 4. Developed

	Number of respondents		Insufficient	Somewhat insufficient	Somewhat sufficient	Sufficient	No answer	Total
		Α	43.1	35.3	16.5	5.9	8.2	100.0
d .	05	В	28.2	35.3	15.3	4.7	16.5	100.0
China	65	С	23.5	32.9	23.5	5.9	14.1	100.0
		D	31.7	23.5	8.2	18.8	17.6	100.0
	130	Α	30.0	60.0	4.6	5.4	0	100.0
Varias		В	18.5	66.2	13.8	1.5	0	100.0
Korea		С	16.9	60.0	20.8	2.3	0	100.0
		D	23.8	46.2	23.1	6.9	0	100.0
		Α	39.8	48.0	6.1	1.0	5.1	100.0
Ionon	00	В	22.4	57.1	13.3	2.0	5.1	100.0
Japan	98	С	8.2	48.0	38.8	0	5.1	100.0
		D	15.3	38.8	27.6	10.2	8.2	100.0





In each country, efforts for "advanced maintenance" have been made, but still need to be stepped up. For 1-year and less life-span technologies, Japan indicates more positive responses than the other two countries.

2-4. Maintenance professionals are sufficiently secured?

- 1. Insufficient
- 2. Somewhat insufficient
- 3. Somewhat sufficient
- 4. Sufficient

	Number of respondents		Insufficient	Somewhat insufficient	Somewhat sufficient	Sufficient	No answer	Total
Ţ		А	56.5	22.4	9.4	3.5	8.2	100.0
	05	В	38.8	29.4	10.6	3.5	17.6	100.0
Chillia	83	С	31.8	17.6	25.9	8.2	16.5	100.0
		D	31.8	14.1	9.4	27.6	17.6	100.0
	130	А	35.4	41.5	18.5	4.6	0	100.0
Vora		В	25.4	51.5	2.3	0.8	0	100.0
Notea		С	22.3	51.5	26.2	0	0	100.0
		D	30.8	38.5	26.2	4.6	0	100.0
		Α	53.1	33.7	6.1	0	7.1	100.0
Ionon	08	В	39.8	40.8	11.2	1/0	7.1	100.0
Japan	98	С	19.4	53.1	19.4	1.0	7.1	100.0
		D	23.5	38.8	23.5	5.1	9.2	100.0



Three countries basically agree that maintenance professionals are not sufficiently secured, especially for longer lifespan technologies. China is divided over 1-year and less life-span technologies showing a different trend curve.

2-5. What should be most valued for sustainable maintenance?

- 1. Central dogma (as 2-1)
- 2. Budget (as 2-2)
- 3. Technologies (as 2-3)
- 4. Maintenance professionals (as 2-4)

	Number of respondents		Central dogma	Budget	Technologies	Maintenance professionals	No answer	Total
China		А	50.6	21.1	12.9	7.1	8.2	100.0
	05	В	24.7	25.9	20.0	14.1	15.3	100.0
China	85	С	10.6	21.1	25.3	18.8	14.1	100.0
		D	12.9	10.6	37.6	23.5	15.3	100.0
	130	А	22.3	36.9	16.9	23.8	0	100.0
Varias		В	13.8	45.4	11.5	29.2	0	100.0
Korea		С	8.5	32.3	44.6	14.6	0	100.0
		D	15.4	24.6	36.2	23.8	0	100.0
		А	31.6	26.5	21.4	14.3	6.1	100.0
Ionon	09	В	10.2	26.5	35.7	21.4	6.1	100.0
Japan	98	С	10.2	26.5	35.7	21.4	6.1	100.0
		D	10.2	22.4	19.4	34.7	7.1	100.0



Three countries show a similar trend curve for long and 1 year life-span technologies. For long life-span technologies three countries agree that central dogma and budget are two major issues for sustainable maintenance. For 10-year life-span technologies, besides budget, China, Korea and Japan respectively value central dogma, maintenance professionals and technologies besides budget. For ultra-short life-span, China and Korea consider that technology is the key and Japan values maintenance professional most.

3. Sustainable maintenance is adequately understood by the government and society?

- 1. Inadequate
- 2. Somewhat inadequate
- 3. Somewhat adequate
- 4. Adequate

	Number of respondents		Inadequate	Somewhat inadequate	Somewhat adequate	Adequate	No answer	Total
		А	47.1	28.2	8.2	5.9	10.6	100.0
China	05	В	25.9	44.7	9.4	2.4	17.6	100.0
China	85	С	23.5	24.7	25.9	8.2	17.6	100.0
		D	24.5	17.3	7.1	19.4	13.3	100.0
	130	А	43.1	40.0	12.3	4.6	0	100.0
Varias		В	32.3	50.8	15.4	1.5	0	100.0
Notea		С	23.1	56.2	18.5	2.3	0	100.0
		D	28.5	42.3	19.2	10.0	0	100.0
		А	49.0	32.7	12.2	1.0	5.1	100.0
Ionon	00	В	33.7	40.8	17.3	3.1	5.1	100.0
Japan	98	С	17.3	50.0	22.4	3.1	7.1	100.0
		D	24.5	41.8	16.3	9.2	8.2	100.0



For longer life-span technologies, three countries indicate a similar trend curve that the government and society show little understanding about sustainable maintenance. For 10-year and less life-span technologies, while Korea and Japan indicate a similar trend, China is divided.

4. How should the budget for sustainable maintenance be financed?

- 1. by maintenance fees, explicitly from beneficiaries
- 2. by charges for use, implicitly from beneficiaries
- 3.by taxes
- 4. No financial arrangement, no maintenance planned

	Number of respondents		Maintenance fees, explicitly from beneficiaries	Charges for use, implicitly from beneficiaries	Taxes	No financial arrangement, no maintenance planned	No answer	Total
		А	36.7	12.2	29.6	2.0	13.3	100.0
China	95	В	35.3	23.5	23.5	3.5	14.1	100.0
China	85	С	43.5	14.1	22.4	5.9	14.1	100.0
		D	25.9	9.4	15.3	34.1	15.3	100.0
		А	22.3	32.3	37.7	7.7	0	100.0
	120	В	23.1	56.1	16.1	4.6	0	100.0
Korea	150	С	43.1	46.9	7.7	2.3	0	100.0
		D	48.5	36.9	6.9	7.7	0	100.0
		А	35.7	18.4	36.7	3.1	6.1	100.0
Ionon	09	В	40.8	44.9	8.2	0	6.1	100.0
Japan	98	С	52.0	35.7	1.0	3.1	8.1	100.0
		D	41.8	22.5	2.0	24.5	9.1	100.0



For long life-span technologies, maintenance fees and taxes are the strong potential sources of funds in each country. For 10-year and less life-span technologies, maintenance fees and charges are the two major potential sources of funds, but China focuses more on taxes compared to Korea and Japan.

IV. Discussions and Summary

According to the results of the fact-finding survey, three countries overall show a similar trend about long life-span technologies. About 10-year and less life-span technologies, China indicates a different trend curve from Korea and Japan.

The points to be focused on are as follows:

- 1. The significance of maintenance has been gaining a wider recognition in three countries, especially for long lifespan technologies.
- 2. Korea and Japan tend to follow a similar trend line.
- 3. China tends to be divided in opinion about shorter life-span technologies.
- 4. Three countries share that advanced maintenance is increasingly important for long life-span technologies.

5. For development of advanced maintenance, stepped up efforts are needed for social understanding, government support, budget, technologies and professionals.

Regardless of the differences in individual answers to the questions, the results of the survey show that importance of maintenance is commonly agreed by three countries, not only for long life-span technologies but also for shorter life-span technologies. Although the stage of social development is different in each country, there is common understanding that the maintenance of such newly built social infrastructures and soon, can be a problem in future. In order to maintain recently built social systems along with the construction and renewal of new infrastructure in future, much more budget, professionals and other resources will be necessary. Without planning how to maintain such social systems properly, the construction will be a big debt for future. The survey was useful in making identical recognition that how-to-make should be always considered with how-to-maintain and how-to-stop.