

# Evaluating Effects of RFID Introduction Based on CO2 Reduction

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## Abstract

In this paper, the effects of RFID introduction will be discussed with respect to the Carbon dioxide (CO<sub>2</sub>) reduction effect based on a case of Wal-Mart Stores. Companies eagerly introduce RFID technologies to improve supply chain management (SCM). Information and communication technology (ICT) is believed to improve environmental problems, such as creating sustainable society. The Kyoto Protocol requests the countries ratified to archive each CO<sub>2</sub> emission target, and companies are aware of the target. However, it is not proposed the method to evaluate the reduction of CO<sub>2</sub> emission by employing RFID technologies. The method to calculate the reduction effect of CO<sub>2</sub> emission will be developed, and estimated the effect in a case of Wal-Mart Stores, and also evaluated its economic effect in SCM. In conclusion, the methods based on CO<sub>2</sub> emission reduction effect can be successfully developed to evaluate the effect of RFID.

Keywords: SCM, RFID, sustainable society, CO<sub>2</sub> emission, Wal-Mart Stores

## 1.

Recently, Companies eagerly introduce RFID technologies to improve supply chain management (SCM). In demand forecasting of RFID, According to the RFID demand forecast provided by Yano Economic Research Institute (2007), the demand is estimated to be 1,884 million sheets in 2010 while it was 44 million sheets in 2005 (125% over previous fiscal year). This is a tremendous increase. It is estimated that distribution (retailers) and physical distribution (transportation and warehousing) fields will occupy 90% of the demand in 2010. Judging from these facts, it can be said that IT applications applied by RFID technology have already rushed into the time for actual utilizations.

According to Hotta (2004), it is often said that SCM (Supply Chain Management) in Japan has better quality in its efficiency compared with the one in Europe and the United States and that the efficiency by RFID is so limited in the SCM. One of the reasons of the limitation in retailer area (from shipping to retailers), he pointed that retailers have average one month inventory. To solve the limitation, he stated that it is necessary to discuss ROI of RFID applications for SCM enhancement from corporate management view points.

On the other hand, on present business, according to the monthly material flow's writer (2006), makers (supplier) including Hewlett-Packard Inc. who has delivered Wal-Mart Stores have to stick with a RFID tag for Wal-Mart Stores' distribution centers at the time of the shipment from the sales company warehouse of the U.S., and have to pay expense, for the time being. However, the makers (suppliers) can

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hardly receive the merit by the RFID. It was reported "there is no investment merit for suppliers who attach and supplies a RFID tag to major upstream retail stores although some merit can be afforded to the major downstream retailers chain. Judging from this fact, it is general that the makers (suppliers) can hardly receive without solving the RFID tagging expense issue.

But RFID introductory effect can exist in some fields, but it depends how RFID applications can be constructed.

Information and communication technology (ICT) is believed to improve environmental problems, such as creating sustainable society. The Kyoto Protocol requests the countries ratified to archive each CO<sub>2</sub> emission target, and companies are aware of the target. According to Miyashita (2005), the environment involving distribution systems are changing a lot in recent years. While consumption demand matures, concentration and globalization of distribution structure are progressing and public changes, such as deregulation, the innovation and spread of IT, are progressing. At the same time, CO<sub>2</sub> reduction in distribution processes is strongly demanded to cope with the global environmental issues. The major companies have come to release their "environmental report" from the CSR (Corporate Social Responsibility) standpoint. Considering those circumstances, when RFID was introduced to SCM, I calculated "the presumed value of the rate of CO<sub>2</sub> emissions reduction effects" as an introductory effect item, and thought that it was necessary to adopt as one of evaluation criteria.

In this paper, it inquires with the SCM

introduction example by RFID among Wal-Mart Stores (U.S. major retail store) and the suppliers.

## 2. Effects of RFID introduction in Wal-Mart Stores

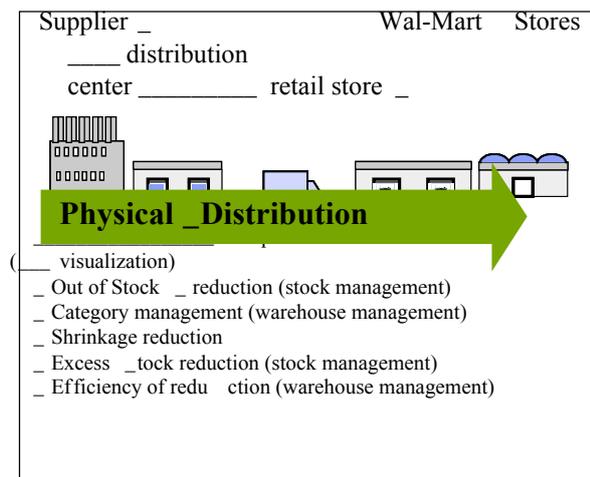
A supplier and Wal-Mart Stores are building the physical distribution network efficiently through respective distribution centers using RFID (refer to Fig.1). It is important to feed back demand information in physical goods movement on a real time basis to the upstream suppliers to increase a process improvement in productivity in returns process...etc. That is the big effect through the improvement from the physical distribution to fund recovery processes is by visualizing information.

Mitani (2003) stated ['informational visualization reforms a supply chain'] and defined that it could be done by coordinating the information among the different systems and different part codes by corporate organization and made the information consistent.

In order to deploy a supply chain with much efficiency,

It would be a key to obtaining information, namely, events on a real time basis, which would be a turning point for a success or a loss. In this point, RFID tag, namely RFID, could be a useful tool to identify automatically the status by simply putting goods, foldable containers, and pallets vehicles with RFID through both starting point and arrival point. That process would be big help to grasp the real time status such as inventory, shipping transportation...etc. Therefore, he expects that RFID will be a practical tool rather than a current bar code system and asserts that RFID introduction is a new method to visualize information in SCM.

The sales amount of Wal-Mart Stores is 256,300 million dollars in 2003 (source:Fortune500). According to Ohya (2005), although reduction of labor costs and out of stock have been accomplished. And the further cost reduction of 8,300 million dollars is planned over five years.



\_ Claim reduction of returned-goods

## Demand Information

Fig.1 \_Effects of RFID introduction in Wal-Mart Stores

According to Funamoto (2005), it is assumed that the associated costs of RFID introduction comes to 1 billion dollars from 2003 to 2005. Compared with the suppliers who paid the tag for Wal-Mart Stores, as tag introduction was made for nothing. It can be regarded as quite advantageous conditions.

The investment vs. effect for five years of Wal-Mart Stores was summarized in Fig. 2. 2006, 2007 after Fortune500 were predicted using 1.1% of sales growth rates in 2005 to 2006 from 2003 of sales, and it asked for the sales sum total of about 1,600 billion dollars for five years.

Year/	2003	2004	2005	2006	2007	
	2586	2974	3420	3933	4523	Fig2:
The Wal-Mart Stores sales transition						
(Unit: 100M\$)						

Among RFID introduction expense, the average ratio during 2003- 2005 (1 billion dollars) was applied, which resulted in 1,700 million dollars investment from 2003 to 2007 as an assumption. The RFID introduction effects in Wal-Mart Stores are summarized in Fig3.

Since the reduction effect is estimated to be 8,300 million dollars to the investment amount-of-money 1,667 million dollars for five years, it can be found that the investment effect is around 1,327 million dollar on an annual average basis. On calculation, total 5 years investment can be recovered in less than one year. RFID investment ratios are about 0.1% of sales also for the sales for five years because Wal-Mart Stores of 1,600 billion dollars. From these results, Wal-Mart Stores as a major retail company can enjoy the investment effect of RFID. However, I said in Chapter 1, we can find no positive effect as for suppliers because there is no concrete number released.

Investment vs. Effect (unit: 100M\$)	
Sales Amount(2003 _2007_	16,040.93
Introduction Cost(2003 _2007_	16.67
Reduction effect_5years_	83.00
_ Warehouse Management	67.00
_ Stock Management	6.00
_ Shrinkage	5.75
_ Visualization	4.80
Fig.3 _Effects of RFID introduction in Wal-Mart Stores	

On the other hand, RFID introduction of retail trade companies is very prudent in Japan. The reason is simple. One is the unit price of the RFID tag per sheet is high and the other is the difficulty among makers and whole sellers to clarify the responsibility, namely, which side should owe RFID cost. From SCM viewpoint, I could build the highly complete distribution system in SCM, and think that it is possible. However, many companies are going to discern the trend of a tip company like Wal-Mart Stores from a viewpoint of the RFID investment effects vs. RFID introduction. Considering such circumstances, I think that there is an important meaning to study the U.S. Wal-Mart Stores case.

### 3. CO2 Reduction Ratio

The whole physical distribution in cooperation with suppliers like U.S. Wal-Mart Stores presumes the effect of 'environmentally harmonized physical distribution efficiency' by reduction of CO2 emission by construction of RFID introduction in the SCM. The coefficient of the reduction effect by RFID is created from the example of Wal-Mart Stores. Although the composition of physical distribution expense means the thing of all the expense generated in relation to physical distribution activity, generally we can consider transportation expense, warehouse expense, management expense, etc. Here, it can be defined as all the expense of the physical distribution activity between Wal-Mart Stores and suppliers. Generally, transportation expense is obtained by the following formula.

Transportation expense = transportation (weight t) x transportation distance (km) x K (transportation company sets up uniquely)

This formula explains that the transportation costs decrease when transportation goods are cut down as transportation itself is reduced.

Amount of the energy used, such as a truck, is proportional to transportation weight (t) and transportation distance (km) (refer to figure 4-(1)).

I can say that transportation expense and the amount of the energy used has a positive correlation.

Since carbon-dioxide emission (tCO2) are proportional to the amount of the energy used (GJ) (refer to figure 4-(2)), if energy is reducible, it can be said that CO2 emission is also reducible. This means that CO2 emission can be reduced by transportation expense decrease in the transportation with positive correlation between energy reduction and CO2 emission. If we can grasp the percentage of the physical distribution expense of Wal-Mart

Stores, the rate of CO2 emission reduction can be obtained.

$$\begin{aligned}
 & (1) \text{ The Amount of Energy Used (GJ)} \\
 & \quad : \text{ Revision ton km method} \\
 & = [\text{Transportation (Weight T)} \times \\
 & \quad \text{Transportation Distance (Km)}] \times \text{Fuel Use} \\
 & \quad \text{Field Unit Price (L/t/Km)} \times 1 / 1,000 \times \\
 & \quad \text{Unit Calorific Value (GJ/ Kl)} \\
 \\
 & (2) \text{ Carbon-dioxide-emission (tCO2)} \\
 & \quad : \text{ The calculation method from fuel} \\
 & = \text{used energy (GJ)} \times \text{CO2 emission} \\
 & \quad \text{K (tCO2/kWh)}
 \end{aligned}$$

Fig. 4: Energy / CO2 calculation formula

According to Sasaki (2003), physical distribution expense ratio is the sales of 2% or less. As I stated in Section 2.1, the sales sum is about 1,600 billion dollars for five years, an average annual sales is 320 billion dollars (the number about Wal-Mart Stores will use an average below for five years).

$$\begin{aligned}
 (1) \text{ Wal-Mart Stores Physical Distribution} \\
 \text{Expense} &= \text{Sell (320 Billion Dollars)} \times 2\% \\
 &= 6,400 \text{ million dollars}
 \end{aligned}$$

Utilizing RFID introductory effect of Wal-Mart Stores expectation, I explained the item and the amount of money of the reduction effect, a shrinkage and SCM visualization. By those items, I judged that it was the most effective in energy cost reduction, i.e., CO2 emission.

Transportation expense can be reduced since shrinkage becomes lower unless loss and theft happens. Moreover, SCM visualization will also be conjectured that the amount of physical distributions becomes less so much, and transportation expense also decreases if stock decreases in number. Although it was expected that other items were effective in energy cost reduction, since which item of warehouse management or inventory management was effective or the numerical value was not clear.

$$\begin{aligned}
 (2) \text{ Transportation Expense Reduction (5year} \\
 \text{average)} &= \text{shrinkage} + \text{SCM visualization} \\
 &= 211 \text{ million dollars}
 \end{aligned}$$

This is calculated by regarding as a rate of CO2 emission reduction by making the introductory effect of RFID into the rate of physical distribution expense reduction.

$$\begin{aligned}
 (3) \text{ Rate of the Amount of CO2 Emissions} \\
 \text{reduction} \\
 &= \text{Rate of Energy reduction (Transportation} \\
 & \text{Relation)} \\
 &= \text{Rate of Transportation Expense reduction} \\
 &= (2) \text{ Transportation Expense Reduction} / (1) \\
 & \text{Wal-Mart Stores Physical Distribution Expense} \\
 &= 3.2\%
 \end{aligned}$$

If it takes into consideration that transportation in multi-frequency small quantity will be introduced when inventory is cut down in recent years, it will be indicated that there is a difficulty in connecting CO2 emission with a simple assumption to expense a little. In this paper, argument was advanced on the assumption that the rate of loading had it and it did not take multi-frequency little transportation into consideration with the meaning of this paper, since actual data was obtained and it did not necessarily ask for the data of the rate of CO2 reduction itself with things about the rate of loading, or multi-frequency little transportation.

### 3.1 Calculations of CO2 reduction method

When it is necessary to convert "the amount reduction effect of CO2 emission" into the amount of money, if the amount of CO2 emission is multiplied by the original unit price, it can ask concretely like the following formula.

Amount of CO2 Emission Cost = Field Unit Price (dollar / tCO2) X CO2 emission amount

There are three original unit prices for converting greatly. Although collected into Fig. 5 as a whole, I want you to refer to the following about the source of each original unit price.

(1) According to the data of [right cost to emit CO2]: "the Ministry of Economy, Trade and Industry Industrial Structure Council environmental sectional meeting market mechanism special committee (11th time)", it deals with by per 12US dollars from about 7 US dollar per 1 t-CO2 in the trade-in-international-permits market by CDM (Clean Development Mechanism).

(2) CO2 emission cost: according to IPCC (2001), per 1 t-CO2 and from about 21 US dollar, the trial calculation of expense (a dollar / tCO2) required in order to cut down CO2 is made in the U.S. as they are 1 12US dollars.

(3) CO2 carbon tax: IPCC (2007), As plan expense, since it is a trade in international permits and a carbon tax, the plan which asks a company for the burden of 100 dollars has been adopted.

- (1) Right Cost to emit CO2 = Field Unit Price (Dollar / tCO2) x CO2 Emission Field Unit Price = \$7 / t - \$12 / t  
 (2) CO2 Emission Cost = Field Unit Price (Dollar / tCO2) x CO2 Emission Field Unit Price = \$21 / t - \$1 12 / t  
 (3) CO2 Carbon Tax = Field Unit Price (Dollar / tCO2) x CO2 Emission Field Unit Price = \$100 / t

Fig. 5 Amount cost conversion method of CO2 emission

Thus, although three were proposed as the amount cost conversion method of CO2 emission, it depends on judgment by which method amount-of-money conversion are carried out in this of the person in charge who introduces RFID on SCM.

generally, multiplying by it and asking the amount of the energy used (GJ) for CO2 emission coefficient has come out as Fig4-(2) shows carbon-dioxide emission (tCO2). However, in this Wal-Mart Stores example, although the rate of the amount reduction of CO2 emission and the transportation expense reduction amount of money have been guessed, since neither the amount of CO2 emission reduction nor data required for a guess has come to hand, amount-of-money conversion have not been carried out.

### 3.2 CO2 Emission-Convert by Transportation Charge.

In this Wal-Mart Stores example, although the rate of the amount reduction of CO2 emission and the transportation expense reduction amount of money have been guessed, since neither the amount of CO2 emission reduction nor data required for a guess can come to hand, exact amount-of-money conversion cannot be performed.

Then, in order to obtain a certain amount of feeling of a scale, in the "environmental harmony type logistics investigation outline" which the Ministry of Economy, Trade and Industry (2003) has published, its CO2 emission-calculation by the transportation charge indicated by the calculation formula of an environmental load total amount at (4) (reference), and the following formula was used.

CO2 emission (kg-CO2) = Transportation-charges (yen) x CO2 emission field unit (kg-CO2/yen)

The environmental load unit price field unit data book by the National Institute for Environmental Studies "inter-industry-relations table" is mentioned to CO2 emission field unit as reference. From this original unit-price data file (2000 producer-price base) to retail: 1.320 (t-CO2/1 million yen) was obtained.

Freight-charge money converted the RFID introduction effect (21.1 million dollar) into the Japanese yen (115 yen/dollar).

However, since the calculation formula which is here is premised on Japan, it is necessary to convert as the U.S.

For conversion work, Japan-U.S. comparison of a transportation cost ratio was

performed from "transition of the physical distribution functional option top quantity physical distribution cost ratio in Japan and the U.S." (Refer to Fig. 6).

As a result of comparing the 6-year average in 2000 to 2005, the result that a transportation expense ratio of U.S. is 1.16 times as high as Japan was obtained.

Year	2000	2001	2002	2003	2004	2005
Japan	3.17	3.13	2.95	2.77	2.93	2.82
USA	3.54	4.38	3.34	2.63	3.28	3.36

Fig. 6 Japan-U.S. physical distribution cost ratio (unit: %)

Source: Japan institute of logistics systems (2005)

CO<sub>2</sub> emission (t-CO<sub>2</sub>) = Transportation-charges (211 million dollar x 115 yen) x CO<sub>2</sub>emission field unit (tCO<sub>2</sub> / million yen (1.320) x Japan-U.S. transportation expense ratio (1.16) = 37,000t

It was able to substitute for the CO<sub>2</sub> emission cost conversion formula, and the 0.3 - 4.1million dollars was able to be obtained as transportation reduction trial calculation of the RFID introduction effect of Wal-Mart Stores (refer to Fig. 7)

(1) Right Cost to emit CO <sub>2</sub> = Field Unit Price (Dollar / tCO <sub>2</sub> ) x CO <sub>2</sub> Emission Field Unit Price = \$7 / t - \$12 / t Transportation reduction trial : 0.3 - 0.4M\$
(2) CO <sub>2</sub> Emission Cost = Field Unit Price (Dollar / tCO <sub>2</sub> ) x CO <sub>2</sub> Emission Field Unit Price = \$21 / t - \$12 / t Transportation reduction trial : 0.8 - 4.1M\$
(3) CO <sub>2</sub> Carbon Tax = Field Unit Price (Dollar / tCO <sub>2</sub> ) x CO <sub>2</sub> Emission Field Unit Price = \$100 / t Transportation reduction trial : 3.7M\$

Fig. 7 CO<sub>2</sub> emission cost trial calculation

#### 4. Consideration

Although "rate of the amount reduction of CO<sub>2</sub> emission in connection with transportation" 3.2% was obtained as a RFID introduction effect of Wal-Mart Stores in the chapter, the validity of this calculation method was considered.

(1) Although the trial calculation is made with 8,300 million dollars, is this all considered to be the introductory effect of RFID as an

introductory effect of RFID?

A bar code is also arranged in parallel and used in case -RFID application is built. It is necessary to associate the information on this bar code and a RFID tag. The newly introduced RFID tag output printer performs simultaneously the writing to bar code printing and a RFID tag. That is, since it will reconstruct from the existing bar code system to new RFID application, it is appropriate to all also of investment and an effect to consider the expense in connection with RFID

(2) The validity of

Rate of the Amount of CO<sub>2</sub> emission reduction

= Rate of Energy reduction (Transportation Relation)

= Rate of Transportation Expense reduction

It can be said that the transportation with correlation positive in energy reduction and CO<sub>2</sub> emission reduction has cut down CO<sub>2</sub> emission as transportation expense decreased. If it asks for whether it is what% of the physical distribution expense of Wal-Mart Stores about the reduction amount of this transportation expense, the rate of CO<sub>2</sub> emission reduction in connection with the transportation cost of the Wal-Mart Stores model can be drawn (refer to Chapter 3).

(3) The reason why using Shrinkage and SCM Visualization" as the Transportation Expense Reduction Amount of Money

If loss and a theft decrease, it will become unnecessary to deliver a basis and a Shrinkage using "a Shrinkage and SCM visualization" as the transportation expense reduction amount of money by the decrease in income. Moreover, by SCM visualization, if stock decreases in number further, the amount of delivery of goods becomes less so much, and the traffic related to energy cost can be cut down directly. Although it was expected that other items (warehouse management and stock management) were effective in relation with energy cost, in the operation of warehouse management or stock management, the numerical value which influences energy cost directly judged that there was no direct influence in not being clear and transportation cost. If transportation expense decreases, I will surmise that tracks decrease in number so much, and will think that energy also decreases so much.

(4) When it takes into consideration that transportation in multi-frequency small quantity will be introduced if stock is cut down in recent years, there is a difficulty in connecting CO<sub>2</sub> emission with a simple assumption to expense a little.

In this Wal-Mart Stores example, since neither the amount of CO<sub>2</sub> emission reduction nor data required for a guess could come to hand, exact amount-of-money conversions were not completed. Then, from the transportation charge, in order to calculate a certain amount of feeling of a scale, the trial calculation was made on the assumption that a CO<sub>2</sub> emission calculation formula.

As the RFID introduction effect amount of money in connection with transportation of Wal-Mart Stores, a feeling of a scale about 0.3 - 4.1million dollars was able to be obtained. However, about accuracy, since this method is substitution when the revision ton.km method, a fuel method, etc. cannot be used as shown in Fig. 4, if compared with other three methods, it is not so good. Furthermore, since it is converting for the U.S. also about CO<sub>2</sub>emission field unit (kg-CO<sub>2</sub>/yen), there is a certain amount of limit about accuracy.

It depends on judgment whether these amount of money is adopted as an item of the concrete investment effect of the person in charge who introduces RFID on SCM.

As considered above, there is a limit in the numerical value which can come to hand about the number of 3.2% of calculation basis of "the rate of the amount reduction of CO<sub>2</sub> emission in connection with transportation", and there is a limit which is the grade with which the actual result value is not taken out from Wal-Mart Stores. However, when RFID is introduced on SCM, I think that it was employable as evaluation criteria by showing how calculating "the presumed value of the rate of CO<sub>2</sub> emission reduction" as an introductory effect item.

Furthermore, if the amount of CO<sub>2</sub> emission can be obtained when it is necessary to convert "the amount reduction effect of CO<sub>2</sub> emission" into the amount of money, a concrete amount of money can be obtained by multiplying by the original unit price.

That is, I think that "the amount conversion amount of money of CO<sub>2</sub>\_emission" is employable as evaluation criteria.

Wal-Mart Stores which is major company retail cannot say that it is about the investment effect in the position of a supplier, although there is the investment effect of RFID. If it is made amount-of-money conversion by making the evaluation criteria of an SCM total into the CO<sub>2</sub> reduction effect about this subject was proposed. However, construction of the social system about "the subject of whom or whose pays concretely and accepts as an economic effect" serves as a future subject in the expense squeezed out by the "amount reduction of CO<sub>2</sub> emission" in connection with environment.

## 5. Conclusion

When RFID was introduced among Wal-Mart Stores and suppliers in SCM, I calculated the rate of CO<sub>2</sub> emissions reduction in physical distribution costs with paying attention to the energy reduction by traffic reduction. "Rate of the amount reduction of CO<sub>2</sub> emission related to transportation" was 3.2% as a RFID introduction effect item. This became possible to adopt "the rate of the amount reduction of CO<sub>2</sub> emission related to transportation" as an introductory effect item before RFID introduction. Furthermore, the method of converting into concrete CO<sub>2</sub> emission cost also became possible by proposing a calculation formula as the amount cost conversion method of CO<sub>2</sub> emission.

## 6. Future Research

As RFID introduction evaluation criteria, adoption of "the rate of the amount reduction of CO<sub>2</sub> emission with regard to transportation" was proposed in environmental costs view point. In this paper, the "rate of the amount reduction of CO<sub>2</sub> emission" between a major company retail store (Wal-Mart Stores) and suppliers was studied. From now on, I will plan to study a rate of the amount reduction of CO<sub>2</sub> emission as an introductory effect of RFID in transportation tracking system" and "warehouse management system... etc." Furthermore, I will study the structure for maintaining and managing rate of the amount reduction of CO<sub>2</sub> emission in SCM, as well. introduction evaluation criteria, adoption of "the rate of the amount reduction of CO<sub>2</sub> emission in connection with transportation" was proposed in environmental cost. In this paper, the "rate of the amount reduction of CO<sub>2</sub> emission" between a major company retail store (Wal-Mart Stores) and a supplier was studied. From now on, it guesses a "physical distribution tracking system" and "it being a rate of the amount reduction of CO<sub>2</sub> emission as an introductory effect of RFID at warehouse management system" etc." Furthermore, the structure for maintaining and managing rate of the amount reduction of CO<sub>2</sub> emission" on SCM is also due to be studied.

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