FoodChain INTELLIGENCE

Chain of Thought

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Welcome to our first quarterly newsletter!

I am pleased to present you with the inaugural issue of ‘Chain of Thought’, a regular commentary on the food supply chain industry. I hope the articles contained within, will provide you with valuable information, thought-provoking ideas and fresh perspectives on existing (and new) challenges related to your business.

In this first issue, we discuss the advantages of a collaborative approach to innovation between food suppliers, manufacturers and retailers. We also explore some temperature monitoring technologies used during the transport of perishable products. In addition, we review the top ten reasons why a cold chain may fail in maintaining an optimum product temperature.

If you have any comments about this newsletter, or suggestions for topics you’d like to see in our next edition, please send feedback to info@food-chain.com.au. May I finally wish you and your family a prosperous and rewarding 2008.

Regards,
Silvia Estrada-Flores

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Collaborative Supplier-Manufacturer-Retail Innovation

Cooperation has been defined as “similar or complementary coordinated activities performed by firms in a business relationship to produce superior mutual outcomes or singular outcomes with expected reciprocity over time” (Pelton et al., 1997).

In a cooperative framework, the relationship between partners is driven by the need of profitability and by strategies that are congruent within each company involved and within the relationship (Shaw and Gibbs, 1995).

Co-innovation is part of those strategies, where the success of a new product or service in the market means success for all the supply chain partners. It seeks to extend the scale and scope of external partnerships and alliances to access and exploit new technologies, knowledge, and markets.

Collaborative innovation requires early involvement of all chain players in the new product development (NPD) and the development of 'innovation networks', or clusters of collaborators working at every stage of the product cycle and at every link of the value chain.

The challenge of co-innovation is better understood if we take into account the balance of market power between food suppliers, manufacturers and retailers: in the Australian and UK environment, retailers (with emphasis on the supermarkets) are perceived as having more influence and control in the food chain (Bamford, 2001).

This influence received significant attention in the UK, which led to the introduction of a Supermarket Code of Practice in 2002. The Code outlines the nature of the relationship between retailers and their suppliers, and explicitly mentions that all supply chain participants would benefit if they worked together to expand the market for their products and develop a profitable and sustainable business (Fearne, 2005).

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Technology for Temperature Monitoring During Storage and Transport of Perishables

Although temperature is one of many factors affecting the safety of fresh foods, it is also true that it is the second most important factor leading to food borne illness outbreaks, only surpassed by the initial

contamination of foods as a causal factor. Therefore, temperature is normally monitored as part of the quality assurance systems of perishable products.

A temperature measurement system has essentially two elements: a sensor and an interface that translates the measured signal into a meaningful temperature scale. Some systems can store the temperature measured during a limited time.

Principles of temperature sensors

Temperature sensors may be based on physical or chemical properties. Examples of the properties used are:

- melting point
- thermal expansion
- emissivity
- diffusion
- solidification temperature, and
- viscoelastic properties.

Some temperature sensors rely on the development of chemical reactions such as electro-chemical corrosion, enzymatic reactions and polymerisation.

Platinum resistance thermometers (PRT's), thermistors and thermocouples are common examples of sensors that are based on physicochemical properties:

- PRT's change their electrical resistance according to temperature, which is calibrated by a well defined equation. PRT's are less sensitive to small temperature changes than thermistors and have a slower response time. However, thermistors have a smaller temperature range and stability. PRT's are often used as an accurate temperature standard and all temperature sensors are calibrated against a PRT reference.
- Thermistors function in a similar manner to a PRT, but encompass a ceramic or polymer which changes resistance with temperature. They can have a negative resistance/temperature coefficient (NTC), a positive one (PTC) or they can be a composite of both types.
- Thermocouples measure temperature using the voltage gradient that arises between two different conductors subjected to the same temperature gradient. The voltage difference is then correlated to the temperature difference being measured. Thermocouples are suitable for most cold chain applications, but if small temperature differences need to be measured with high accuracy (for example, in cooling or freezing experiments with ±0.1 °C accuracy), thermistors and PRT's are more suitable.

Common temperature monitoring systems

Two popular temperature measuring systems based on physical principles are:

1. Graphic recorders — used for monitoring air temperatures in containers, airplane holds, railcars and trucks. This device has a bimetal coil as a sensing element and the coil expands or contracts depending on the surrounding temperature. A stylus attached to the coil creates a 'temperature line' in the paper, which correlates with a range of temperatures, typically from −28.9 to +37.8 °C.
2. Electronic data loggers — now replacing graphic recorders. An electronic format of temperature data is more suitable for quality assurance analyses and records. Flexibility of electronic data loggers can accompany the product itself and are not necessarily part of the transport system. Electronic loggers have a sensing element which changes it's electric resistance in response to the temperatures sensed. The resistance is translated into temperatures by internally built software or by an external computer. The results are stored in an internal memory and data can be transferred afterwards to a computer for analysis.

Time-temperature indicators

Sensors based on chemical reactions are commonly represented by temperature indicators (TI) and time-temperature indicators (TTI) that use enzymatic hydrolysis processes. Basically, the sensor looks like a label that is attached to the surface of a food or pharmaceutical package. The label encompasses a compartment with two substances (an enzyme and a substrate) separated by a barrier. At activation, the barrier is broken (normally by pushing the compartment, in the form of a button) and the two compounds are allowed to mix. The activation is done at the start of the cold chain. From that point onwards, the mixed solution reacts in a similar manner to the food components that are used as indicators of freshness (for example, lipids). The solution changes it's colour as the reaction advances, and the rate of reaction is a response of temperature changes occurring during the product's cold chain. The higher the temperatures are during storage and transport, the faster food spoils and the faster the label's colour changes to a threshold signaling the end of the product's shelf-life.

A variety of temperature and time-temperature indicators/integrators (TI and TTI, respectively) as well as temperature data loggers are available from various suppliers. Some characteristics required from these systems for the transport industry are:sensitivity, satisfactory accuracy for the intended purpose, robustness to withstand harsh conditions (including vibration), traceability, ease of use, small space requirements and low unit and total cost per monitored shipment.

Wireless and RFID technologies — the future of temperature monitoring

Temperature sensors are undergoing substantial technological transformations. However, developments in the data logging and data transmission components of temperature monitoring systems may be the key to radically transform the fresh supply chains in future years. Deloitte Consulting (2007) names two technologies:

1. Wireless technologies that allow gathering of data and exchange of real-time information with supply chain partners. An example is the wireless 'mesh' network technology developed by Motorola Inc and licensed globally and exclusively to Ceebron Pty Ltd for cold chain applications.
2. Radio frequency identification devices. An RFID system generally encompasses a sensor, a tag and a reader that communicate with each other by means of radio transmission. Active RFID systems are battery powered, which allow them to be independent of a common energy source and therefore can be used for transport applications. The information collected by the tag, such as temperature or identification code, can be obtained real-time and sudden situations that endanger the integrity of the frozen goods can be addressed promptly. New developments in the field of time-temperature indicators include the combination of RFID technology and enzyme-based technologies, opening the possibility of tracking shelf life of perishable products remotely.

Top 10 Reasons Why A Cold Chain Fails

The Australia New Zealand Food Standards Code (2002) and the Australian Cold Chain Guidelines (1999) state that all perishable products should be maintained at 5 oC or below during transport. Apart from the need to ensure the foods on our table are safe to eat, and with the high standards of quality we all expect in Australia, maintaining a constant temperature during the storage and distribution of foods is not always achievable. Here are 10 common reasons:

1. **High initial product temperature**
   The extra-heat load generated by warm product entering a truck, container or coldstore can significantly impair the performance of the refrigerated equipment. During transport, temperature differences in boxes of product before truck loading, can persist until the end of the voyage. This is particularly true for mixed loads of products.

   For example, consider a truck that has been half loaded with boxes of green salads with leafy vegetables that have been kept in a cold store at 0 °C. The rest of the load encompasses bulk containers filled with salad dressing that has just been pasteurised and cooled to 15 °C. The overall cargo space temperature will be closer to that of the bulk containers. The leafy salads are items highly responsive to air temperature changes and will get warmer as a consequence.

   Remember, not all coldstores are designed to cool product! Some coldstores only maintain the existing temperatures of products that have been previously cooled in chillers, freezers or precoolers.

2. **Warm loading conditions**
Imagine that a refrigerated container or truck is loaded with chilled goods during a summer day in Sydney. Even though the cargo space was previously cooled to the recommended transport temperature, the simple act of opening the doors to load the product lets warm, humid air in. Additionally, the product being loaded will increase its temperature during loading. If the product happens to be fruit or vegetables, the extra degrees will accelerate the respiration rate, which in turn will demand more cooling capacity during the voyage. The use of a refrigerated loading dock would minimise the rise of product temperature and the entrance of warm air and humidity.

3. **Inadequate loading patterns**
The loading pattern should ensure an even distribution of air within the cargo. Good loading practices include uniform stowage, filling gaps between the end of the load, the doors and the gaps between pallets. This leaves sufficient air space between the top of the load and the ceiling and utilises vertical separations (dunnage) for respiring cargo. For frozen cargo, the pattern should be as

compact as possible, although spaces between: (a) the ceiling and top boxes; and (b) the sidewalls and the boxes closest to the walls, should let air flow circulate around the load.

4. **Excessive product handling**
In 1995, the Food Safety and Inspection Service and other US departments established a group that identified primary hazards associated with the transport of perishable products, and provided recommendations to ensure food safety during transport. The team found the following handling issues:

- Problems were more numerous with partial loads and mixed loads.than with single product loads.
- Issues were more frequently encountered with small carriers, which were more likely to haul smaller, mixed cargoes than larger shippers.
- Loading and unloading of cargo was also more frequent with mixed loads, thus contributing to temperature deviations.

The recommendations that followed included hauling products with similar temperature specifications, and maintaining the temperature between 0 °C to 4.4 °C during loading and unloading operations.

5. **Inefficient airflow management**
The most common air circulation pattern in refrigerated trucks is top-to-bottom air delivery; lengthwise from front-to-rear. In reefers, the cool air is delivered through floor channels towards the door, and then circulated back to the evaporator in the space created by the uppermost boxes and the ceiling. The performance of refrigerated transport can be greatly improved by generating adequate air movement within the cargo space. Recommended measures to achieve effective air circulation include:

- installing solid return air bulkheads
- providing uniform stowage
- securing the load away from doors and sidewalls, and
- providing space underneath the load to create effective return paths for the air.

Multiple compartments or partitions between very different types of products allow independent airflow patterns and temperature control within the cargo space. Plastic or air curtains for doors can greatly decrease the entrance of warm air during deliveries.

6. **Poorly designed packaging**
The design of the package will also determine the uniformity of temperatures within the cargo. Air circulation will be more effective with ventilated cartons for fruits and vegetables. However, aspects such as packaging, structural integrity and heat transmission from product through the package, carton and pallet stack need to be considered.

7. **Leaky door seals, damaged insulation and old insulated bodies**
The possibilities of water-damaged insulation and/or faulty door seals increase in old trucks and

containers when maintenance has been insufficient. High air leakage rates and high heat infiltration inevitably lead to loss of temperature control, unless the refrigeration unit has been sized to take these into account. The deterioration of the insulation materials due to aging is estimated to be about 5% of the insulating quality per year. This leads to uncertainty in the thermal performance of refrigerated transport systems that have been in service for more than five years.

8. **Inadequate selection of refrigeration capacity and control systems**
   The sizing of the refrigeration unit is critical to ensure the truck, container or coldstore can cope with extra heat loads usually encountered during the transport of fresh produce. Initial warming of both product and truck occurring during loading (in the absence of refrigerated loading facilities), product respiration (considering the higher rate found for fresh cuts), air exchange, infiltration through the insulated walls in diverse ambient conditions, defrosting, fans and door openings are all influential factors. Mechanical refrigeration systems coupled with thermostats sensing the air return or air delivery temperatures, are the most common means of temperature control for the transport of chilled products. The control system can vary from simple 'On/Off' strategies, to Proportional-Integral-Derivative controls. Regardless of the system, air temperature fluctuations and significant temperature differentials will occur lengthwise and along the height of the truck. The extent of these variations will depend on design features such as the location of the temperature sensor and the control strategy.

9. **Gaps in education and training**
   Operators in the cold chain require an understanding of the effect of temperature on foods, correct loading and unloading practices, quality assurance systems such as hazard plans and risk analyses, and a general knowledge of refrigeration systems, amongst other aspects. In the wider context, modern supply chains now underpin international perishable food distribution. Chain participants may come from a range of industries, roles and location in the value chain. Quite understandably, there will be varying levels of understanding on important cold chain aspects and collaboration with multiple supply chain players. Knowledge and skills gaps in the handling and transport of perishable products throughout the chain need to be attended to.

10. **Lack of supply chain vision and strategy**
   An integrated cold chain is the result of a careful selection of technology, the implementation of education and training required to raise the bar in quality over competitors, and an analysis of the

   market and trends in the distribution of perishable goods. An example described by Jude Barry, from Cornell University, is Earthbound Farm - the US largest grower shipper of organic produce. Amongst the external factors to the business (which are critical in the decision making of their distribution strategy), they include the changing models of distribution and transportation and the need to get business closer to the customer to ensure high quality product can be economically distributed.

   These factors have implications on the selection of distribution routes and the selection of storage and transport technologies. Other global trends that have far-reaching effects on the design of cold chains are the rise of the foodservice and convenience sectors, showing themselves as a market power to be reckoned with, and the consolidation of growers/shippers at the marketing level, increasing economies of scale and structuring year-round supply chains.

Perhaps you have stumbled upon other common reasons for cold chain failure that I have not discussed in this article. I will be happy to include your examples in a future article, so please feel free to forward me your views.

Collaborative Supplier-Manufacturer-Retail Innovation

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In view of these developments in the UK, the take home message for the Australian food industry is that creating the level of communication, trust, commitment and interdependence required for co-innovation does require significant organisational efforts.

Diversity of the Australian food industry

There are three major sub-chains that characterise most food industries:

- **Primary production.** In Australia, this sector encompasses a large number of relatively small firms, particularly upstream in the chain. In 2004, about 205,000 agricultural businesses (excluding services, forestry and commercial fishing) were accounted for by the Australian Bureau of Statistics (ABS). About 130,000 of these businesses were farm households or farming enterprises. A large proportion of the remaining businesses include harvesting, primary processors and small road transport units.

- **Food manufacturing**. This is a diverse sub-chain, ranging from SMEs to major multinational companies. In 2004, about 9,000 food beverage and tobacco manufacturing businesses were accounted for by the ABS. The food manufacturing industry worldwide tends to be dominated by large, multinational firms and Australia is no exception, with the largest 50 food and beverage global corporations producing close to 75% of the domestic industry's revenue (Short et al, 2006). The implications for NPD are that research and development activities do not necessarily take place in Australia, but in the global R&D centres of the company.

- **Food retailing**. This sector includes supermarkets, grocery stores, non-petrol sales of convenience stores at petrol stations, take-away food, and others (e.g. fresh meat, poultry and fish; fruits and vegetables; liquor; bread and cakes, and specialised food retailers). About 65,000 food retail businesses were accounted for during the 2004 survey of the Australian Bureau of Statistics. Food represents about 40% of the total retail sales and 70% of food sales are registered in supermarkets and grocery store retailing.

The innovation spheres of manufacturers and retailers

Innovation is a process that goes beyond theoretical conception, through technical invention to commercial exploitation (DAFF, 2001). Therefore, R&D is a sub-set of activities within the innovation process.

Most of the retail-led innovations in supermarkets have focused on improving supply chain aspects and ensuring that the shopping experience is enjoyable. This is hardly a surprise, as supermarkets are highly dependent on reliable and efficient supply chains that can deliver the products offered. Table 1 shows some of the retail-led innovations in the past years.

Innovations in the manufacturing side tend to gravitate towards new products, packaging and processes. Table 2 presents some manufacturing-led innovation initiatives in the past years.

In Table 2, the items in blue fonts highlight the most common areas of collaboration between manufacturers and retailers. It is evident that innovation in transport and distribution has significant synergies between these two parties. Nevertheless, little collaborative approaches in NPD take place currently.

Consumer-led innovation

Consumer-led product development arguably offers the best platform for co-innovative projects between suppliers, retailers and manufacturers. The aim of consumer-led product development is to create product differentiation, leading to higher consumer satisfaction, increased levels of consumption of specific products, or increased overall value of the given level of consumption (Grunert and Valli, 2001).

In a consumer-orientated approach, NPD begins with consumer and market research to identify the specific characteristics required by consumers. The next step is the organisation of the cooperative framework and information exchange among all the actors in the production chain.

An important aspect in this process is the translation of descriptive and qualitative terminology in which consumers express themselves into technological specifications for all the chain players participating in this form of co-innovation (Linnemann et al., 2006).

Consumer-led NPD also opens new doors of collaboration. Consider highly perishable NPD based on fruit and vegetables, which have a shelf life of sometimes days only. The shelf life of the product dictates the speed the supply chain should operate at. Therefore, for these products, some retailers plan their resourcing more than once a day, because the potential wastage cost exceeds the savings through economies of scale in transportation and warehousing activities.

In this case, the flow benefits of co-innovation can be captured simply with information sharing and forecasting collaboration.

For less perishable items, say, canned food, a highly efficient supply chain depends on low inventory levels and high capacity utilization. This makes data synchronization very attractive for supplier, manufacturer and retailer (Holweg et al., 2005).

In a co-innovative environment, sharing of information has more probabilities of success than in the case of a traditional, manufacturer-led NPD.

Figure 1 presents a co-innovation model proposed by Dr Andrew Fearne, the Director of the Centre for Supply Chain Research at the Kent Business School, United Kingdom. Dr Fearne recently toured the Asia-Pacific region to explain his views on co-innovation and food supply chains.

Fearne (2007) suggests that there are three drivers to undertake co-innovation:

1. It allows the development of new (value added) products/services for distinct customers and targeted consumer segments
2. Process improvement occurs for existing products/ services beyond organisational boundaries
3. Innovation at the interfaces in the value chain are much more difficult for others to copy, thus increasing the competitive advantage

Since co-innovation quite often requires global innovation networks, there are further advantages, such as:

- Supporting collaboration among geographically dispersed teams of suppliers, manufacturers and retailers
- Speeding time-to-market and reducing costs for all the parties involved in the NPD process (due to resource pooling and reduction of learning curve)
- Meeting customer expectations in a more close manner, due to the direct input of retailers into the main purchase drivers of products
- Enforce consistency and quality of brands and innovations
- Creating a compliance audit trail through sharing of quality documentation
- Most importantly, creating a repository of protected know-how and intellectual property, only available to the chain participants.

How can organisations achieve the right environment for co-innovation? Several authors agree that the following are key aspects to achieve this:

- Have a consumer focus and enforce collective responsibility
- Promote value chain visibility and information flows (vertical and horizontal) across the chain
- Promote the management of inter-personal and inter-organisational relationship
- Align the required resources (physical, financial and organisational) with the final demand and process integration.

Table 1. Past and current retail-led innovations (Sources: Dappiran and Hogarth-Scott, 2003;Keh ,1998).

Innovation	Outcome targeted
Air conditioning control	Comfort in supermarkets
Scanner systems	Efficient inventory
Bar codes	Traceability, supply chain management
Electronic cash register	Efficiency, shopping experience
Electronic data interchange	Paperless management of supply chain, reduced order lead time, fewer out-of-stick situations, lower inventory costs, reducing errors in ordering, shipping and receiving, reduction in labour costs, higher service levels
Category management	Vertical integration, matching of consumer's preferences by sellers offerings and growth of categories
Cross-docking	Cost efficiency in distribution
ECR	Efficiency gains in store assortment, promotion, new product introduction and replenishment, through constant flow of product and information between suppliers and retailers
CPFR	Coordination of supply-demand

Table 2. Past and current manufacturer-led innov ations (Sources: Linnemann et al.,2006;Keh, 1998).

Innovation	Outcome targeted
New product development (NPD)	▪ *'Me-too' products*: a product that replicates characteristics of existing successful products in the market, thus avoiding some NPD risks. The objective is to erode the market of a competitor ▪ *Line extensions*: variations of a well-known product (e.g. favours, colours, etc). The aim is to increase market share and improve product positioning with relatively little effort and development time, plus small changes in manufacturing processes, marketing strategy and storage and/or handling operations. ▪ *Repositioning of products*: changing the promotion strategy of current products in the market, to reposition these as products responding to current consumer's demands. The major efforts are, thus, in marketing. For example, repositioning of products as 'health' or functional products. The aim is to capitalize in niche markets. ▪ *New form/formulations for existing products*: these encompass products that have altered to another form (e.g. solved, dried, granulated, concentrated, spreadable, dried or frozen) or products that have been reformulated. For the former category, extensive R&D and development time may be required, plus changes in the supply chain operations. Formulation changes can have various impacts on the supply chain, according to the degree of variation in the product. The outcomes sought refer to: convenience, value addition, cost reduction, unreliable supply of some raw materials, or the availability of better/less costly ingredients. ▪ *Evolutionary innovative products:* substantial changes in an existing product, otherwise than described above. The changes must add value/functionality in a significant manner to the original version. R&D times, costs and risks are generally larger than for other modifications. Marketing can also be costly. ▪ *Radically innovative products:* a 'never seen before' product. These require extensive product development, have high R&D, marketing and capital (new equipment) costs and have the highest failure chance of all categories. Having said that, these products potentially offer greater rewards than others. The products can be potentially disruptive, but not all are.
New packaging development	Added functionality, better preservation of foods, variety in volumes/portions, more attractive designs for targeted consumer segments, labelling, convenience, retail-ready formats.
New processes	Cost reduction (e.g. less labour, energy efficient), OH&S compliance, reduction of environmental impact, requirement for manufacturing new product
New supply chains	Response to changes in client's (e.g. retail, foodservice, etc) business formats, supply chain initiatives, traceability (e.g. RFID).

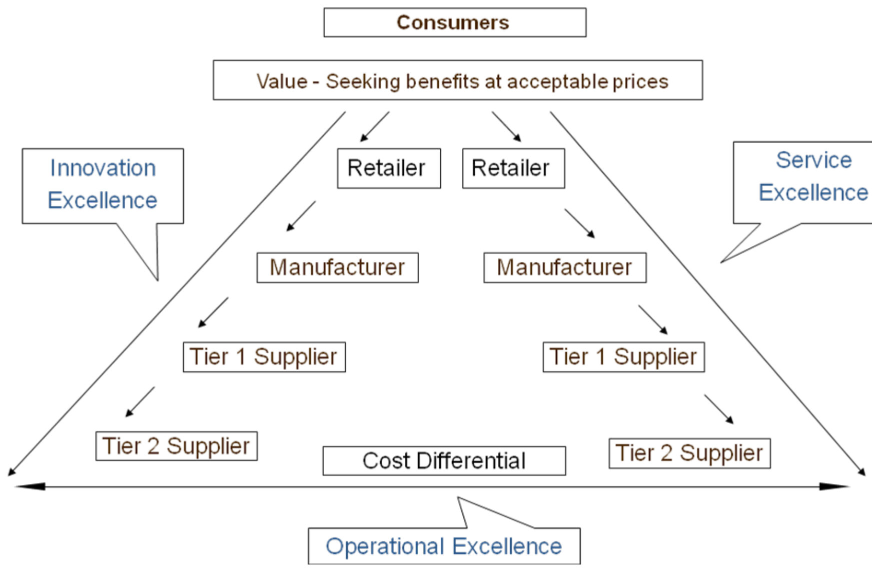

Figure 1. Co-innovation framework (Source: A. Fearne, 2007. Co-innovation for sustainable competitive advantage. ABARE Outlook conference 2007).

In Summary

- It has been long recognised that co-innovation, in the form of cooperation and integration of existing knowledge from different organisations across the chain, can lead to exciting new products, services and potentially new retail formats that could cross over the convenience sector.

- The pre-requisites for co-innovation include consumer focus, collective responsibility, value chain visibility, information flow, positive inter-personal and inter-organisational relationships and alignment of resources with final demand and process integration.

- Notwithstanding the obvious synergies in supply chain-related innovations, consumer-led product development arguably offers the bets platform for co-innovative projects between suppliers, manufacturers and retailers.

- Inter-organisational learning is a key part of the co-innovation process. Learning occurs across firms because each party normally brings different interpretations of the same data, as well as different and complementary data to the process.

- Encouraging occasions and opportunities for people from different organisations that are curious to learn from each other, involving the exchange of detailed and important information under the assumption of trust and mutual commitment, is a vital part of the co-innovation process.

Further reading

More information on the the topics mentioned in this newsletter can be found in the following resources:

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