Decision Trees

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Can information science techniques help the intelligence analyst?

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It has become popular to speak of an "information explosion" as the prime cause of present-day indecision, delay, and error. One Soviet military leader* has observed that

> Soviet Armed Forces are now so well equipped with modern weapons and technology that fundamental changes are taking place in the military art. The number and variety of tasks being planned by commanders, consequently, are tremendously increased. ... The time to gather a complexity of data, analyze it, and react to changes is constantly shortened.

What is true of Soviet military, tactical, and policy decision making is equally true in the environment of the American Intelligence Community: the analyst and the policy maker are surrounded by a tremendous volume of information, they control sophisticated collection and reaction systems, and the time in which they may safely make the most profound decisions is being constantly shortened. Neither the policy maker nor the analyst can afford the luxury of unassisted intuitive decision making in a world of dwindling resources and awesome instant power.

Several thousand years ago the Greek discovered the concept of *modeling* when they noted that, while the *content* of a problem may vary, the *form* remains a constant. So it is possible, as one management analyst proposed, to express management problems in eight forms: inventory, queueing,** routing, competition, allocation, sequencing, replacement, and search. And it is possible to carry the process a step farther to observe that in the intelligence environment the rules of inventory analysis apply equally well to Order of Battle, queueing to enemy force resupply, and so on. In short, models can be constructed to assist the analyst and policy maker in an intelligence environment in making more accurate, more scientific decision, because while the content of intelligence problems varies greatly, their forms are few and constant.

To illustrate: intelligence requirements fall into four major categories:

1) places (geographic locations, physical resources) ;

2) people (their strength and attitudes) ;

3) organizations (that people form and belong to — an indication of their power) ; and

4) objects (that people make and possess — for example, cities or weapons systems.)

A nation gathers intelligence in these categories to help the policy makers in formulating tactical (timely) and strategic (long-range) decisions. The decision-making processes of both the national-policy maker and the intelligence analyst require projections of possible outcomes based on knowledge of present factors. In short, intelligence deals with *forecasting* and is a creature of uncertainty.

Consequently, the goal of the analyst is to produce his study within a framework of as much precision as uncertainty will allow, Caution often leads, however, to the overuse of what Sherman Kent called "words of estimative probability" (or "weasel words") such as *probable*, *possible*, or *suggests*. All of these can spell disaster, both for the analyst who uses them, and for the policy maker who ventures to rely on an assessment so framed. Not only is there uncertainty as to the degree of conviction such words connote, but the complete range of alternatives is not presented. What would be useful under such circumstances would be a model that would serve both to organize sizable amounts of data, and to communicate the degree of certainty relating to possible outcomes or the likelihood of the occurrence of specific events at some given time in the future.

Fortunately, there is such a model available to the intelligence analyst and the policy maker; it is called the decision tree. John F. Magee has claimed that

> Using the decision tree, management can consider various courses of action with greater ease and clarity. The interactions between present decision alternatives, uncertain events, and future-choices and their results become more visible.*

Logic diagramming is an information-handling technique used for graphic display of sequences, interrelationships, and the time-phased logic of a problem situation. The decision tree is a prototype for the preponderance of logic diagrams. It is a linear means of representing the alternatives, objectives, and consequences of a series of decisions. The decision tree, essentially, is an algorithm for the analysis of complex sequential decision problems.

Decision trees can be used to depict a series of true-false sequences, i.e., in a deterministic way; or to display subjective likelihoods and their relationships — a probabilistic use. The technique is deceptively simple:

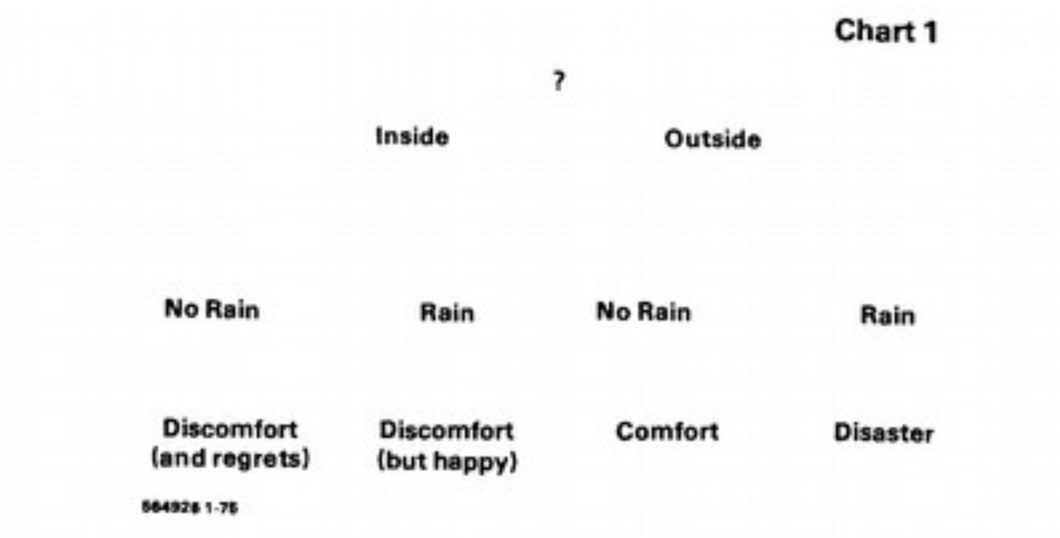
1. Identify the strategies available to you, and the possible states of nature (chance events) that might occur.

2. Draw the tree skeleton.

3. If probabilities are being expressed, enter the economic or statistical data and associated (subjective) probabilities.

4. Finally, analyze the tree to determine the best course of action.

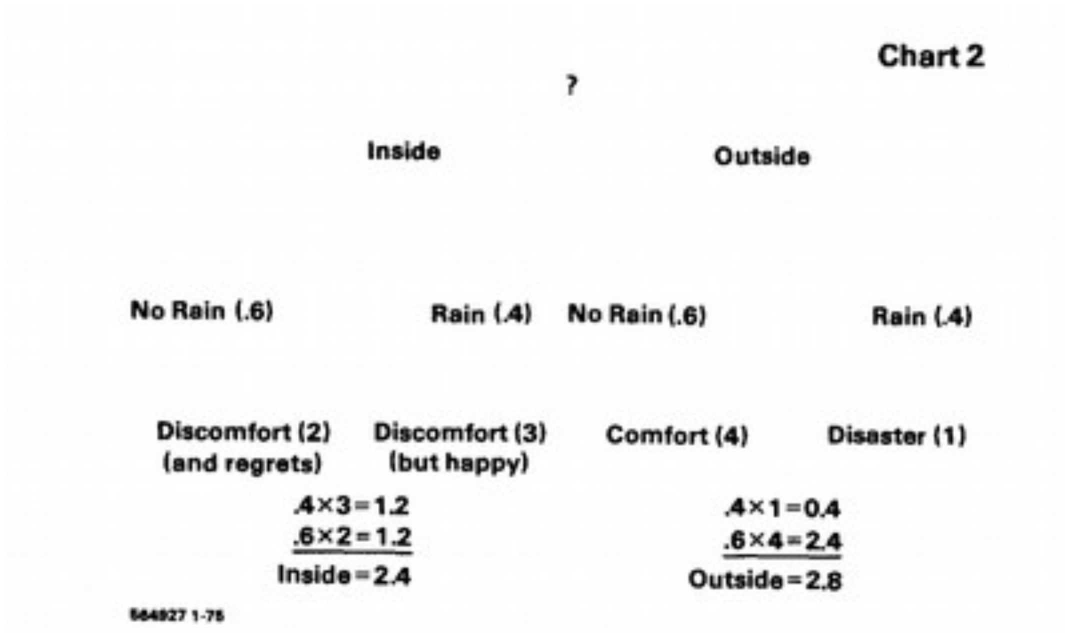
For a rudimentary example, suppose you would prefer to hold a party on your patio, but there is a 40 percent chance of rain and the party can not be moved once the decision has been made. You have only two strategies: *outside* and *inside*. The chance event is *rain* or *no rain*. The tree would look like this:



Note a few formalities: decisions are normally rendered as squares, and chance events as circles. The connecting lines, called branches, depict alternatives. Trees are normally drawn from left to right on the long axis, but where necessary have been rendered from top to bottom for easier presentation in this publication.

Now assess the *subjective* value of the ultimate alternatives: there are four, so on an ascending scale, *outside-no rain-comfort* would rate "4," while *outside-rain-disaster* is last and least.

You also have a quantified probability to crank into the chance event — if you believe your weather bureau, it's 60-40 against rain. When you have multiplied the subjective value by the probability of the alternative, the completed tree looks like this:



There is, then, a slight quantified edge (2.8 vs. 2.4) to holding the party outdoors. You, as decision maker, have been told something subjective by me as an analyst. By means of a simple graphic device, you not only know where I have been subjective, but what impact that subjectivity has had on the recommended outcome. In short, you have no misunderstanding about my reasoning and weighting processes.

Now let's consider a relatively complex intelligence situation in terms of some practical applications of the technique, both to understand the situation, and to outline the alternatives in priority order in a situation involving stress and a great deal of danger.

In the year 1290 B.C., a Jewish military leader, Moses, made two decisions which had far-reaching consequences, both in fact, and predictably *before* they were made. I use a historical precedent because there is a danger of bogging down in detail in current examples, and because the decisions of Moses afford multiple applications both to the practice of intelligence and the technique of the decision tree.

In about 1370 B.C., a three-month old boy, Moses, was adopted by the daughter of the Pharaoh, Seti 1. He was given the best Egyptian education — presumably including diplomatic and military training. He spent his first 40 years in the house of Pharaoh. But political tensions in Egypt in those days differed little from those of the 20th century, and Moses spent his next 40 years in exile in the grazing lands of Midian (near the Gulf of Aqaba) because of his involvement in a minority racial issue. In his 80th year, he returned, described as faithful, reluctant, slow of speech, and "the meekest man in Israel," to confront the new Pharaoh, and to lead the Israelites to freedom.

The key resource available to Moses was personnel, but the people of Israel had just achieved a freedom not all of them had necessarily sought; they were

=possibly not yet united in faith or motivation;

=untried in battle;

=untrained;

=not used to freedom or its responsibilities;

=superstitious;

=uneducated;

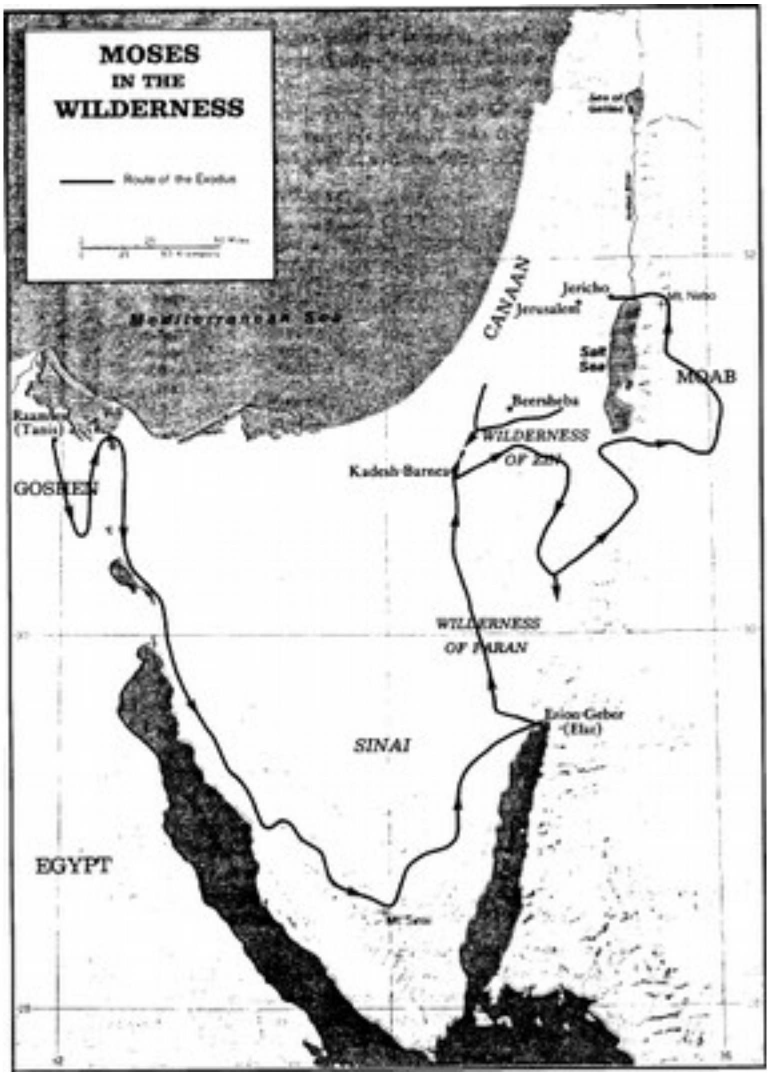
=poorly clothed;

=in need of basic necessities;

=the aggressors in a military situation in which they would not be assisted by any other nation;

=but — and possibly the only plus factor — they were used to an independent struggle for survival.

The Israelites spent two months traveling from the Egyptian treasure city of Rameses to Mount Sinai, where superstition and factionalism interfered with the efforts of Moses to unify them. He confronted the people and asked who would follow him. He had the Levites kill the 3,000 who refused. Within the year after their release from captivity, the Israelites — now instructed in both spiritual and secular law — were in the Wilderness of Paran (see map), just south of their goal. Moses prepared to move against the southern border of Canaan — "flowing with milk and honey" — the Promised Land from which Joseph had been taken generations earlier.



In the Wilderness of Paran, Moses arrayed 12 family-grouped units, or tribes, with some 603,550 adult Israeli males, and an additional 22,300 Levites, or priests, of all ages. The Scriptures give us their Order of Battle: (1290 B.C.)

TRIBE	STRENGTH	LEADER
	(males over 20)	
Reuben	46,500	Shammau
Simeon	59,300	Shaphat

Gad	45,650	Geuel
Judah	74,600	Caleb
Issachar	54,400	Igal
Zebulun	57,400	Gadiel
Ephraim	40,500	Joshua
Manessah	32,200	Gaddi
Benjamin	35,400	Palti
Dan	62,700	Aminiel
Asher	41,500	Sethur
Naphtali	53,400	Nahbi

	603,550	
Levi	22,300 (males over one month)	

	625,850	

It was here in the Wilderness of Paran, at Kadesh Barnea, that the Israelites refused to follow Moses into the Promised Land until he had the land and the situation checked out — the first recorded instance of a user-originated collection requirement!

The Intelligence Cycle

In response to user requirements of this nature, the process we call the Intelligence Cycle begins. For this analysis, the steps will be termed tasking, collection, processing, dissemination, and evaluation. A sixth (sometimes labeled estimation) precedes the tasking step, but need not be considered separately in this study.

Policy makers normally drive the cycle, setting it in motion. A request for data (intelligence information) necessary to make an assessment which would be couched in policy terms ("Is it wise to invade the Promised Land?") was met by management with a political response — the selection of representatives (spies) from each of the 12 tribes to collect the required data.

In this case study, the executive, judicial, and legislative branches of government, together with the reins of military and spiritual leadership, rested upon Moses and his tightly structured management organization. In the wilderness he had introduced the "modern" concept of span of control by designating captains over 10s, 50s, 100s, and 1000s. The people were the ultimate consumer — the user of intelligence information, the means of action, and the deciding vote on policy proposals. To win this vote, Moses selected the spies and the Intelligence Cycle began. We have a rather specific account[*] of what happened next:

Note that good tasking is succinct and unambiguous. Note also that although the Promised Land was to the north, Moses first had the spies go south up the mountain for a birds-eye view (overhead collection) of whether the Promised Land was worth the effort. This instruction produced the most yield at the least risk for his 12 valued leaders. Having satisfied the basic question of the land's overall worth, the spies came down and entered Canaan.

Even without a decision tree, the tasking as set forth by Moses was virtually perfect. It is perhaps shortsighted, however, to count on matching his perfection every time without recourse to modern techniques, and we can reconstruct his decision tree *ex post facto* to show how the tree helps the Intelligence Cycle. (See Chart 3.) This tree would have graphically linked each of the collection requirements to the specific decisions that the resultant data would affect. It also would have ensured at a glance that the essential "need-to-know" questions were being raised ahead of the secondary "nice-to-know" questions.

This particular tree and this Intelligence Cycle, incidentally, deal only with the state of affairs in the Promised Land. As we shall see, for a net assessment Moses would require yet another tree when disunity among his people placed the entire venture in question.

The last six lines, obviously, are Order of Battle data. Note the "moreover" reference to Anak's children, unqualified by any precise number they claimed to have seen. Note also that the processing step of the Intelligence Cycle has been omitted. I feel the omission was deliberate, as I shall suggest in more detail.

Once a collection requirement has set the Intelligence Cycle in motion, we really can't be sure of how successful the effort has been without some measure of user reaction. It is often user reaction, in fact, that causes the most measurable changes in our activity in support of the cycle. In this regard the Israelites were no exception. After the initial report, just cited, they became considerably exercised; it took both Caleb and Joshua to calm them down.

This is the leader of the largest tribe speaking — a man who had been to the Promised Land and returned. He and Joshua, to the consternation of the other 10 spies who did not share their optimism, apparently were making some headway with the Israelites.

Under any objective form of processing whatsoever, it is highly dubious that from the initial three known and observed "giants," the final report could arrive at an entire population "of great stature." We will pass over the concept that a competent processor might have pressed the spies for more precise specifications — say, in cubits or in axehandles — rather than accepting the grasshopper ratio.

There was also a bald appeal to superstition: with Moses the only Israelite of the past few generations who had ever been outside Egypt before, there was no experience to disprove the spies' claim that the land ate up its inhabitants. If true, however, there should have been no inhabitants left, giant or normal, and the spies themselves should never have returned.

The reaction to this gloomy follow-up report, however, was predictable. The Israelites were in virtual panic; when the dust had settled, they refused to move into the Promised Land, and it fell to Caleb and Joshua, 39 years later, to lead the next generation into the land these people had refused to seize.

Deterministic vs. Probabilistic Trees

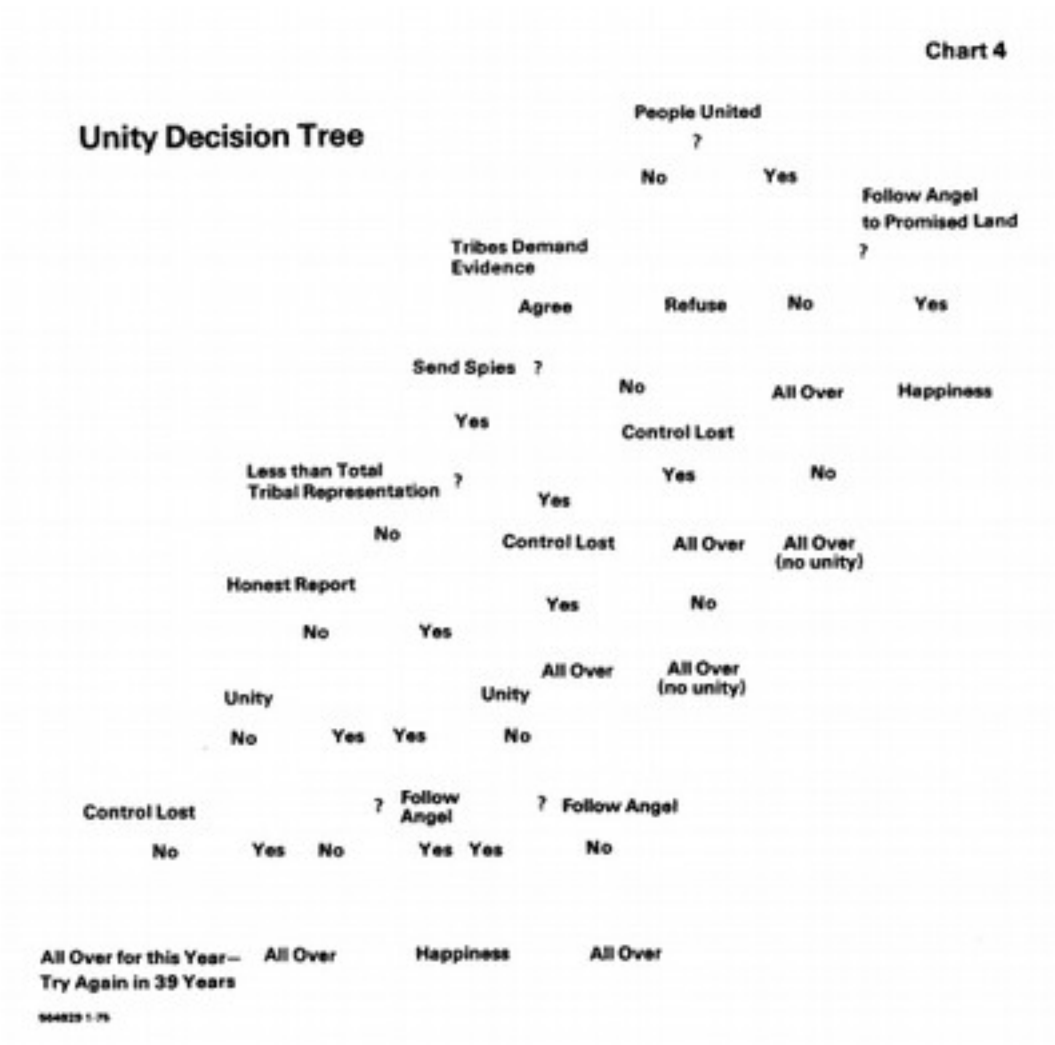
Managers are faced with both repetitive and non-repetitive situations. The repetitive ones are generally susceptible to "standard operating procedures" which both resolve specific recurring problems and contribute to the development of behavior patterns in an organization. It is the non-repetitive situation that causes problems — and it was such a situation that Moses faced. Non-repetitive situations involve new and significant incidents, changes in policies or procedures affecting probable outcomes, and usually emphasize the fact that no body of past experience is directly or comprehensively applicable. Stereotyped problem-solving procedures are recognizably inappropriate; the new situation is often ill-structured, and reliable information regarding it is often scarce. In such cases the conventional problem-solving approach (curing symptoms with readily available expedients) usually results in a new and completely unexpected symptom arising. It is in such situations that a workable model of the entire problem should be constructed and then manipulated as a substitute for costly trial-and-error experimentation with the actual resources. These, in other words, are cases for the decision tree.

A *deterministic* use of the decision tree as a problem-solving device can be effectively demonstrated by examining Moses' tasking of the spies. They were to discover a series of states of affairs — states that either existed or did loot — with no probability associated. (See Chart 3 again.)

In this particular tree I included an assumed instruction to return to camp if the initial observation from the mountaintop showed the land to be worthless. I also inserted a key decision the Israelites had to face — could the resident peoples in the Promised Land be overcome? — and a suggestion of the conversion of the tree into a similar device to help in the probabilistic assessment of an invasion's success.

As I mentioned earlier, another and quite powerful use of the decision tree is as a *probabilistic* tool in the decision process. One key question facing Moses as the leader of his people was whether they had sufficient unity and cohesiveness as a nation to accomplish the difficult task of invading occupied territory by force of arms to carry out "the will of the Lord." In retrospect, the decision that Moses was compelled to make in regard to that unity can be depicted as a probabilistic decision tree. (See Chart 4.)

The branches of this tree are easy to construct after the fact, and they again enable the student of the management of non-repetitive situations to obtain a clear perspective of the factors and possible consequences of alternate courses of action.



The development of such a tree *before the fact* is much more desirable, but correspondingly more difficult. There are few cut and dried means of assuring the inclusion of *all* alternatives, and the best advice seems to be to have demonstrated that a single course of action and its implications can have a profound effect on the weighting of the alternatives as to their attractiveness. With or without the canopy, you have actually succeeded in using the tree as a decision-making tool, for the modification is nothing more than an updated model.

Footnotes

*Lt. Gen. C. Zavision of the Armored Forces, in his introduction to P. G. Skachko, G. T. Volkov, and V. M. Kulikov, The Planning of Combat Operations and Troop Control Using Network Techniques.

**"Queueing" is an information-handling technique seeking the proper alignment of data to produce a solution of maximum effectiveness; for example, how many check-out lines should a supermarket have?

* "Decision Trees for Decision Making," Harvard Business Review, July-August 1964.

*The Bible, (King James Version), Numbers 13:1-33. In the following passages I have made no changes in sequence, context or phrasing, but I have used indentation to emphasize contextual order, and have inserted the appropriate Intelligence Cycle headings.

**A storehouse city of later Israel. The connotation is that of a hungry traveler chancing upon a supermarket offering free wares.

***I have put Anak's name in capitals and his three sons' in italics for emphasis — the reason will become apparent shortly.

*Emphasis supplied.

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