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Managing for Quality in Ancient Israel

by

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1. Introduction

The holy land is an historic region on the east coast of the Mediterranean. It was the site of the ancient kingdoms of Israel and Judea and comprises areas of the modern states of Israel and Jordan. The borders of this region have fluctuated throughout history but have generally included the territory lying between the southeastern Mediterranean coast to the west, the Dead Sea Valley to the east, the Negev Desert to the south, and the Litani River to the north--an area of only about 280 km (175 mi.) long by 128 km (80 mi.) wide.

Four thousand years ago the holy land was inhabited by a hodge podge society of agricultural villagers, sheep- and goat-herding nomads, and urban artisans. These populations evolved under the influence of cultural currents flowing from Egypt, Hittite Anatolia, the Semite-populated deserts to the east, and the Minoan island of Crete. In the year 1250 Before the Common Era (B.C.E.) Moses lead the exodus of the ancient Hebrews from slavery in Egypt to freedom and sovereignty in the holy land, in Canaan. The Hebrews saw periods of extraordinary achievement, such as the building of Solomon's Temple, and periods of downfall such as the annihilation of their independent nation and the Babylonian exile. Throughout these years, oral and written laws were intensively studied and applied in jurisprudence and work regulations. Jewish laws set forth in the Old Testament, subsequent precedents, innovations and traditions were codified in the year 200 of the Current Era (C.E.) in a text entitled the Mishnah. Later commentaries on the Mishnah were compiled around 500 C.E. in another unique literary document - the Talmud[1].

The objective of this study is to provide, through a selective analysis of relevant texts, a perspective on the role of managing for quality in what has been labeled "The Cradle of Civilization." Three aspects of Quality Management have been emphasized:

[1] A. Steinsaltz, The Essential Talmud, Basic Books, Inc., New York, 1976.

quality improvement, quality planning and quality control. Quality improvement is the organized creation of beneficial changes in process performance levels. Quality planning, on the other hand, is the activity of determining customer needs and the development of products and processes required to meet those needs. Quality control is typically defined as the managerial process during which actual process performance is evaluated and actions are taken on unusual performance. A major feature of quality control is the establishment of self control where a party producing a product has the means and knowledge to determine compliance with specifications and, furthermore, is empowered to initiate corrective actions when needed (For more details on topics of Quality Management see Juran[2]). In particular, this chapter provides examples designed to demonstrate:

- Self control
- Organization of work
- Specifications and work-standards
- Applications of measures
- Procedures and regulations
- Warranties and consumer rights

The period covered begins with the description of the act of Creation in the book of Genesis and ends with the Omayyad caliphs' Arab conquest in 637 C.E. The material used consists of written texts, such as the Old Testament, the Mishnah and the Talmud, as well as archaeological findings. The contextual background of the quotations is succinctly presented and readers interested in more details are referred to the bibliographical list. The chapter is structured according to different facets of daily life, major projects and various industries. Material availability mostly determined the selected topics which include: laws and regulations, measures and weights, buildings and

[2] J. M. Juran, Juran on Leadership for Quality: an Executive Handbook, the Free Press, 1989.

dwellings, roads, tunnels, textiles and pottery. A final section reviews the examples in light of general Quality Management principles. The appendix consists of an annotated chronological list of events designed to put the chapter in an historical context.

2. Early examples from the Old Testament

The Act of Creation

Verses from the Old Testament, written over 2500 years ago, are surprisingly modern in their content. In fact, many of today's organizations are rediscovering concepts and methods described in these old scriptures. A key concept in the quest for improved competitiveness is to allow the individual performing the work to conduct the inspection of his product. Implementing self control implies a comparison of actual results to specifications. Such a process is evinced by God's daily inspection of his creation. When there was more than one creation, as on the third day, there were two acts of inspection for the earth and vegetation respectively.

On the sixth day the Creator completed his work and used self control to determine if further action was needed.

The thirty first verse of Genesis reads[3]:

Genesis I, 31 *And God saw every thing that he had made, and, behold, it was very good.*

Noah's Ark

The concept of product quality is present in the Old Testament in many forms. God periodically reassessed his creation and after initially finding it satisfactory, determined that it required rework. The decay of society's moral fabric led him to destroy all living creatures. Noah, a

[3] All quotations from the Old Testament are from The Holy Scriptures: A Jewish Bible According to the Masoretic Text (Hebrew and English), Sinai Publishing House, Tel Aviv, 1972.

worthy example of God's creation, survives the destruction. Exact specifications for the Ark that is to protect him from the deluge, along with a list of representative of other species, can be found as close as five chapters after the Act of Creation.

Genesis VI, 15 *And this is the fashion which thou shalt make it of: The length of the ark shall be three hundred cubits, the breath of it fifty cubits, and the height of it thirty cubits.*

Genesis VI, 16 *A window shalt thou make to the ark, and in a cubit shalt thou finish it above; and the door of the ark shalt thou set in the side thereof; with lower, second and third stories shalt thou make it.*

Modern scholars[4] assume that one cubit = 20.6 inches = 52 centimeters so that the dimensions of Noah's ark were 156 meters in length, 26 meters in width and 15.6 meters in height - an impressive construction project. Noah's story is a prime example where after several attempts, improvement efforts were abandoned for a new beginning. It also demonstrates that such an effort requires extensive planning and preparation.

After the deluge, a promise is made to Noah whereby total destruction of earth, God's creation, will not reoccur. A contract is established in very clear terms including a spectacular symbol of the implied warranty - the rainbow:

Genesis VIII, 21 *I will not again curse the ground any more for man's sake...neither will I again smite any more every thing living, as I have done.*

[4] E.W. Heaton, Everyday Life in Old Testament Times, C. Scribner's Sons, New York, 1956.

Genesis IX, 12 *And God said, this is the token of the covenant which I make between me and you and every living creature that is with you, for perpetual generations.*

Genesis IX, 13 *I do set my bow in the cloud, and it shall be for a token of a covenant between me and the earth.*

Sodom and Gemorrah

The concept of "product" is omnipresent in the Old Testament. It applies to the total creation, to Noah's Ark and also to cities such as Sodom and Gemorrah. As God has promised to never again destroy his creation, Abraham allows himself to bargain with God about the destruction of Sodom and Gemorrah. Since a standard has been established, meeting such a standard of excellence can be assessed in order to determine if the cities are to be spared. In this instance, the criterion is the existence of "a few good men" in sufficient numbers to compensate, in their virtue, for the sins of their fellow citizens.

Genesis XVIII, 23 *And Abraham drew near, and said, Wilt thou also destroy the righteous with thwicked?... and not spare the place for the fifty righteous that are therein?*

Genesis XVIII, 32 *... Peradventure ten shall be found there. And he said, I will not destroy it for ten's sake.*

The Ark of the Covenant

Another product which received much attention and detail is the Ark of the Covenant containing the stone Tables of the Law. The specifications for this holy place are given in much greater detail than for Noah's Ark. Its unique role warrants the extensive details on size and type of

materials to be used. Minute details such as outer dimensions, material for the Ark itself, the number and color of the vails and surrounding curtains are all described in the Biblical verses.

Exodus XXV, 10 *And they shall make an ark of shittim wood: two cubits and a half shall be the length thereof, and a cubit and a half the breath thereof, and a cubit and a half the height thereof.*

Exodus XXVI, 7 *And thou shall make curtains of goats' hair to be covering upon the tabernacle: eleven curtains thou shall make.*

Exodus XXVI, 31 *And thou shalt make a vail of blue, and purple, and scarlet, and fine twined linen with cherubims shall it be made of cunning work:*

Maintenance work

However, complying with specifications does not guarantee a product free from deficiencies or wear and tear. Defects, maintenance work and repairs are extensively documented in the Old Testament. In the second book of Kings one finds a dialogue between king Jehoash and Jehoiada, the priest, on the method of payment for maintenance work at the Temple:

II Kings XII, 8 *Then king Jehoash called for Jehoiada the priest, and the other priests, and said unto them, Why repair ye not the breaches of the house? Now therefore receive no more money of your acquaintance, but deliver it for the breaches of the house.*

In the second book of Chronicles one can learn how this maintenance work was eventually conducted:

II Chronicles XXIV, 12 *And the king and Jehoiada ... hired masons and carpenters to repair the house of the Lord, and also such as wrought iron and brass to mend the house of the Lord.*

II Chronicles XXIV, 13 *So the workmen wrought, and the work was perfected by them, and they set the house of God in his state, and strengthened it.*

In some cases the damage was beyond repair and there is not even a mention of attempts to make repairs:

II Chronicles XX, 37 *And the ships were broken, that they were not able to go to Tarshish.*

Workforce qualifications, training and rewards

Workforce needs and expectations is another issue dealt with in several parts of the Old Testament. In particular, the concept of qualifying and training the workforce is delineated.

Worker qualifications for priesthood jobs were partly determined by age and lineage:

I Chronicles XXIII, 24 *These were the sons of Levi ... that did the work for the service of the house of the Lord, from the age of twenty years and upward.*

Supervisors had to come from the Levite clan:

II Chronicles XXXIV,12 *And the men did the work faithfully : and the overseers of them were Jahath and Obadiah, the Levites...*

Educational and training needs of the workforce are also addressed:

Exodus XVIII, 20 *And thou shalt teach them the ordinance and the laws, and shalt shew them the way wherein they must walk, and the work that they must do.*

Exodus XXXI, 3 *And I have filled him with the spirit of God, in wisdom, and in understanding, and in knowledge, and in all manner of workmanship.*

Many Old Testament passages consist of descriptions of rewards and recognition for work well done:

Song of Songs VII, 2 *The joints of thy thighs are like jewels, the work of the hands of a cunning workman.*

II Chronicles XV, 7 *... and let not your hands be weak: for your work will be rewarded.*

Job VII, 2 *As a servant earnestly desireth the shadow, and as an hireling looketh for the reward of his work.*

Jeremiah L, 29 *recompense her according to her work.*

Lamentations IV, 2 *The precious sons of Zion, comparable to fine gold, how are they esteemed as earthen pitchers, the work of the hands of the potter!*

Another form of reward is to establish pride of workmanship as stated below:

Ecclesiastes II, 24 *man ... should make his soul enjoy good in his labor.*

Vision and knowledge

Finally, the Old Testament is very explicit on the need for vision and knowledge in organizations:

Proverbs XXIX, 18 *Where there is no vision, the people perish.*

Hosea IV, 6 *My people are destroyed for lack of knowledge.*

Job XXXVIII, 2 *Who is this that darkeneth counsel by words without knowledge?*

Perfection - the goal of many modern organizations - has a very early origin:

Deuteronomy XXXII, 4 *He is the Rock, his work is perfect.*

This section presented examples of inspection, self control, specifications, workforce needs and expectations and the visionary goal of perfection. Perfection is the ultimate goal of a six sigma company whose defect levels are measured in parts per billion. We are now ready to expand on specific topics supported by more elaborate examples. The next section deals with written laws and regulations.

3. Laws and regulations

Information on how people lived and worked 2000 years ago is difficult to collect. However, the written text provides us with surprisingly detailed clues.

Material durability

A procedure for testing the durability of materials is implicitly described in the following verses:

Jeremiah XIII, 4 *Take the girdle that thou hast got, which is upon thy loins, and arise, go to the Euphrates, and hide it there in a hole on the rock.*

Jeremiah XIII, 6 *And it came to pass after many days, that the Lord said unto me, Arise, go to Euphrates, and take the girdle from thence, which I commanded thee to hide there.*

Jeremiah XIII, 7 *Then I went to the Euphrates, and digged, and took the girdle from the place where I had hid it: and, behold, the girdle was marred, it was profitable for nothing.*

Wine

Another product for which explicit standards were set was wine. To have wine turn to vinegar was a problem of economic and ritualistic consequences since the benediction of wine could not be performed with vinegar. Thus, the Talmud offers a procedure for determining the stage at which wine becomes vinegar[5]:

Baba Bathra, VI, 96a *If one tested a [wine] jug for the purpose of taking from it, ... and, subsequently, it was found to contain vinegar... During t he first three days [after the test, it is regarded as] certain wine; after that, [as] doubtful. What is the reason?- [Because] wine[begins to] deteriorate from*

[5] All quotations from the Talmud are from The Babylonian Talmud: Tractate Baba Bathra, Hebrew-English edition. I. Epstein, editor, The Soncino Press, London, Jerusalem, New York, 1976.

above, and this [man] had tested it [and ascertained that] it had not deteriorated; [and] if it be assumed that it had deteriorated [immediately] after it had been tasted, [even then during the first three days], it had the odour of vinegar and the taste of wine, and whenever the odour is of vinegar and the taste is of wine, it is regarded as wine.

Leprosy

Consumer goods were not the only aspect of life for which standards were established. The procedure for diagnosing leprosy delineates criteria to be used by a priest who has to determine if an individual is free of disease or must be quarantined:

Leviticus XIII, 2 *When a man shall have in the skin of his flesh a rising , a scab, or bright spot, and it be in the skin of his flesh like the plague of leprosy; then he shall be brought unto Aaron the priest...*

Leviticus XIII, 3 *And the priest shall look on the plague in the skin of the flesh: and when the hair in the plague is turned white, and the plague in sight be deeper than the skin of his flesh, it is a plague of leprosy: and the priest shall look on him, and pronounce him unclean.*

Leviticus XIII, 4 *If the bright spot be white in the skin of his flesh, and in sight be not deeper than the skin , and the hair thereof be not turned white; then the priest shall shut up him that hath the plague seven days:*

Leviticus XIII, 5 *And the priest shall look on him the seventh day: and behold, if the plague in his sight he at a stay, and the plague spread not in the skin; then t he priest shall shuthim useven days more:*

Leviticus XIII, 6 *And the priest shall look on him again the seventh day: and behold, if the plague be somewhat dark, and the plague spread not in the skin, the priest shall pronounce him clean: it is but a scab: and he shall wash his clothes, and be clean.*

The Red Heifer

An example of Quality Levels in Parts Per Million from 200 C.E. is provided by the requirements for the Red Heifer (Red Cow) used in sacrifices. The requirement is that animals with only red hair are to be sacrificed. The Mishnah indicates very clearly the method of rework in case some black or white hair are found[6]:

Mishnah, Tehoroth, Parah, 5 *If it had two black or white hairs [growing] from within a single hole it is invalid. R. Judah says: Or even from within a single hollow. If they grew from within two hollows that were adjacent, it is invalid. R. Akiba says: Even though there were four or even five but they were dispersed, they may be plucked out. R. Eliezer says: Or even fifty. R. Joshua b. Bathyra says: Even though it has but one on its head and one on its tail, it is invalid. If there were two hairs with their roots black but their tips red, or their roots red but tips black, all is according to what is the more manifest. So R. Meir. But the Sages say: According to the root.*

Municipal regulations

As society became more urbanized, municipal regulations were formulated to address relevant concerns:

[6] All quotations from the Mishnah are from H. Danby, The Mishna (Translated from the Hebrew with introduction and brief explanatory notes), Oxford University Press, London, 1933.

Baba Bathra, II, 27b *If a tree overhangs a public thoroughfare the branches should be cut away to a height sufficient to allow a camel to pass underneath with its rider.*

Baba Bathra, VI, 99a *He who owns a cistern within another man's house, goes in when it is usual for people to go in, and goes out when it is usual for people to go out... One of them may make for himself a lock, and the other may [also] make for himself a lock. Where [is] the lock [to be attached]?- R. Jonathan said: Both to the cistern. This is right [in the case of] the owner of the cistern, [for] he has to protect the water of his cistern; but for what purpose does the owner of the house [require a lock]?- R. Eleazar said: In order [to avert] suspicion from his wife. (By affixing a lock to the cistern he prevents the other from using the water in his absence and, consequently, deprives him of the excuse of entering his house while his wife is alone.)*

These laws and regulations are a reflection of the period's quality of life.

Consumer's rights

A similar level of detail is given to regulating customer and suppliers' rights in commercial transactions:

Leviticus XXV, 14 *And if thou sell ought unto thy neighbour, or buyest ought of thy neighbour's hand, ye shall not defraud one another:*

Leviticus XXV, 29 *And if a man sell a dwelling house in a walled city,then he may redeem itwithin a whole year after it is sold; within a full year may he redeem it.*

Baba Bathra, V, 83b *Four [different] laws [are applicable] to sales. [If] onehas sold wheat as good, and it turns out to be bad, the buyer may withdraw [from the sale]. [If sold as]*

bad, and it turns out to be good, the seller may withdraw. [If as] bad, and it was found to be bad; [or as] good, and it was found to be good, neither may withdraw.

These regulations define service levels to be expected, they almost look like modern warranty statements.

4. Measures and weights

Many business transactions described in the Old Testament relied on barter where the exchange of goods or services did not require measurements. However, tracking how measurements were used provides another perspective on the period.

Abraham purchased the cave of the Machpelah with silver:

Genesis XXIII, 16 `*... and Abraham weighed to Ephron the silver, ... four hundred shekels of silver, current money with the merchant.*

The "shekel" was the basic unit of weight and the term means "to weigh" in all Semitic languages. Researchers have established that one shekel = 0.4 ounce = 11.4 grams so that the famous cave in Hebron cost Abraham about 4.5 kg. of silver.

Other examples of measures of distance, angles and volume used in the Old Testament include:

Genesis XXX, 36 *And he set three days' journey betwixt himself and Jacob:*

II Kings XX, 9 *...the shadow hath gone forward ten degrees:*

Isaiah V, 10 *Yea, ten acres of vineyard shall yield one bath, and the seed of an homer shall yield an ephah.*

where one bath = 5 liquid gallons and one ephah = 5 gallons.

The practical need to have several units of measurement lead to a standardization of the pound, half pound and quarter pound:

Baba Bathra, V, 89a *Our Rabbis taught: If one asked him for a pound, a pound must be weighted. [If] half a pound, half a pound must be weighted. A quarter of a pound, a quarter of a pound must be weighted. What does this teach us?- That weights must be provided in these [three] denominations.*

The Talmud also provides clear regulations on how length, volume and weight measurements should be carried out:

Baba Bathra, V, 89b *Our Rabbis taught: ... **In meteyard** relates to the measuring of ground; one should not measure out for one person in the hot season (when the measuring rope is dry and unyielding) and for another in the rainy season (when the rope is moist and capable of extension). **In weight**, [means] that one shall not keep one's weights in salt (salt reduces the weight), **In measure**, that one shall not cause [liquids] to froth (by pouring rapidly from a certain height, foam is generated and, c consequently, less liquid enters the measure).*

Baba Bathra, V, 89a *Our Rabbis taught: If he ordered from him ten pounds, he shall not say, 'Weigh out for me each [pound] separately and allow overweight [for each].' But all are weighted together and one overweight is allowed for all of them.*

Baba Bathra, V, 89b *Rab Solomon said in the name of Rab: A person is forbidden to keep in his house a measure [which is either] smaller or larger [than the nominal capacity] even if [it is used as a] urine tub (even if not intended to be used for measuring purposes; since others may use it as a measure, by mistake).*

The Old Testament is very explicit in requiring honest measurement:

Leviticus XIX, 35 *Ye shall do no unrighteousness in judgement, in meteyard, in weight, or in measure.*

Leviticus XIX, 36 *Just balances, just weights, a just ephah, and a just hin, shall ye have.*

The corruption at the end of the First Temple era, as described by Amos, is also apparent in the use of measurements:

Amos VIII, 5 *... making the ephah small, and the shekel great, and falsifying the balances by deceit?*

Measuring devices need maintenance and calibration. The proper maintenance procedure for scales is widely debated in the Talmud. The following quotation sounds like a dialogue between two contemporary engineers:

Baba Bathra, V, 88a *A wholesale dealer must clean his measures once in thirty days, and a producer once in twelve month. R. Simeon B. Gamliel says: The statement is to be reversed. A shopkeeper must clean his measures twice a week, wipe his weights once a week and cleanse the scales after every weighing.*

The use of measures also requires an organizational structure for traceability to assure that measures are comparable. The Levites were assigned this responsibility and it is written that, as part of their duties as priests, they will oversee measurements:

I Chronicles, XXIII, 28 *...their office was to wait on the sons of Aaron for the service of the house of the Lord, in the courts, and in the chambers, and in the purifying of all holy things, and the work of the service of the house of God.*

I Chronicles, XXIII, 29 *...and for all manner of measure and size*

5. Buildings and dwellings

The Temple of Solomon

The most renowned temple at the time was the Temple of Solomon in Jerusalem. It was completed around 950 B.C.E., with the aid of Phoenician artisans, and was destroyed in 586 B.C.E. Most of present-day knowledge about this Temple comes from the Old Testament and from evidence supplied by other contemporary temples. Apparently the Temple faced east and had three main room disposed axially with the entrance. The anteroom, or Ulam, was a rectangular space entered through one of the short sides; flanking the Ulam were square rooms that led to the small storage rooms, or Yasiya, that surrounded the Temple on the other three sides. Beyond the Ulam was the main sanctuary, or Hekal, and beyond that, a flight of stairs that led to the Holy of Holies, or Debir, where the Ark of the Covenant was kept. The Temple was built out of stone and had a flat wooden roof made from imported cypresses and cedar. Bronze pillars known as Yakhin and Boaz, which may have symbolized the relationship between the monarchy and the Temple, stood in front of the edifice.

Specifications for The Temple of Solomon

Specifications for the Temple of Solomon are given in such details that modern scientists are able to prepare reconstructed models of a temple erected 2500 years ago[7]:

I Kings VI, 2 *And the house which king Solomon built for the Lord, the length thereof was threescore cubits, and the breatthereof twenty cubits, and the height thereof thirty cubits.*

I Kings VI, 3 *And the porch before the temple of the house, twenty cubits was the length thereof, according to the breath of the house; and ten cubits was the breath thereof before the house.*

I Kings VI, 7 *And the house, when it was in building, was built of stone made ready before it wasbrought thither: so that there was neither hammer nor axe or any tool of iron heard in the house, while it was in building.*

The relationship between king Solomon and Hiram of Tyre

A major supplier to the Temple builders was Hiram of Tyre who provided Cedar trees. These trees are still world-famous for their quality and strength. The customer-supplier relationship between king Solomon and Hiram of Lebanon is described in an almost journalistic style. It appears that they were able to establish a win_win relationship:

I Kings V, 20 *Now therefore command thou that they hew me cedar trees out of Lebanon;...for thou knowest that there is not among us any that can skill to hew timber like unto the Sidonians.*

[7] See for example the article by K. Ritmeyer, and L. Ritmeyer "Reconstructing Herod's Temple Mount in Jerusalem", *Biblical Archaeological Review*, pp. 23-42, 6, November/December 1989.

I Kings V, 22 *And Hiram sent to Solomon, saying, I have considered the things which thou sentest to me for: and I will do all thy desire concerning timber of cedar, and concerning timber of fir.*

I Kings V, 23 *My servants shall bring them down from Lebanon unto the sea: and I will convey them by sea in floats unto the place that thou shalt appoint me, and will cause them to be discharged there, and thou shall receive them: and thou shalt accomplish my desire, in giving food for my household.*

I Kings V, 24 *So Hiram gave Solomon cedar trees and fir trees according to all his desire.*

I Kings V, 25 *And Solomon gave Hiram twenty thousand cors of wheat for food to his household, and twenty cors of pure oil: thus gave Solomon to Hiram year by year.*

Organization of Solomon's workforce

Organizing the workforce needed to build the Temple of Solomon was no trivial task. Most workers were drafted by royal decree. The book of Kings describes the hierarchical structure of the workforce as well as their employment conditions:

I Kings V, 27 *And king Solomon raised a levy out of all Israel; and the levy was thirty thousand men.*

I Kings V, 28 *And he sent them to Lebanon, ten thousand a month by courses: a month they were in Lebanon, and two months at home: and Adoniram was over the levy.*

I Kings V, 29 *And Solomon had threescore and ten thousand that bare burdens, and fourscore thousand hewers in the mountains;*

I Kings V, 30 *Beside the chief of Solomon's officers which were over the work, three thousand and three hundred, which ruled over the people that wrought in the work.*

I Kings V, 31 *And the king commanded, and they brought great stones, costly stones, and hewed stones, to lay the foundation of the house.*

I Kings V, 32 *And Solomon's builders and Hiram's builders did hew them, and the stone squarers: so they prepared timber and stones to build the house.*

The Temple of Herod

Solomon's Temple was destroyed by Nebuchadnezzar II, 340 years after king Solomon's death. Five hundred and fifty years later, Herod rebuilds the Temple on a grandiose scale. Not satisfied with the size of the Temple Mount that Solomon had built, Herod doubles its span by lengthening the eastern wall and by building a new wall on the other three sides. Herodian masonry has a characteristic fine finish with a flat, slightly raised, center boss and typical flat margins around the edges. The stones were cut with such precision that mortar was not used to get a good fit between the stones. The stonecutters first straightened the face of the stone by chiseling the rock in such a way as to produce a flat vertical surface and a flat surface on the top. Quarrymen than inserted dry wooden beams into grooves cut at right angles. They would hammer them tightly into place and pour water over them. The water would cause the wood to swell, and under the consequent pressure the stones separated from the lower rock layer. Some of these stones weigh over 50 tons and required special transportation techniques. The quarries were located uphill, about one mile from the Temple. Using the force of gravity, cranes and ropes, the stones were positioned according to the architects' plans. All these activities required proper quality planning and quality control. The

precision of the stones implies strict compliance with specifications. In the heart of modern Jerusalem there still are 50-foot-long columns attached to the bedrock. These are the scrap from the stone cutting process. The workmen simply stopped work and left the damaged columns in place[8].

Specifications for a partition wall

On a more mundane level, the Talmud provides specifications of raw materials to be used in a partition wall put together by ordinary citizens.

Baba Bathra, I, 2a *If joint owners agree to make a Mehizah (a 'partition' or 'division') in a courtyard, they should build the wall in the middle. In districts where it is usual to build of Gebil, Gazith, Kefisin or Lebenim (names of various bricks), they must use such materials, all according to the custom of the district. If Gebil is used, each gives three hand breaths (because a wall of Gebil usually was six hand breaths thick.)...*

Traditional dwellings

Hirschfeld[9] extensively studied Roman and Byzantine dwellings in the area by also interviewing Arab house builders who are still using traditional methods. These master builders have carried their trade for generations using pre-industrial technologies that can be traced to the first century of the common era. Stone houses built hundreds of years ago are securely holding heavy cement constructions which were added in modern times to accommodate larger families. Building a traditional stone house typically involves only one paid master builder. All other construction workers are members of the family for whom the house is built. The master builder is in charge of building the house

[8] For more details see L. Ritmeyer "Quarrying and Transporting Stones for Herod's Temple Mount", *Biblical Archaeological Review*, pp. 46-48, 6, November/December 1989.

[9] Y. Hirschfeld, Dwelling Houses in Roman and Byzantine Palestine (in Hebrew), Yad Yzhak Ben-Zvi, Jerusalem, 1987.

from start to finish. He prepares the house plans, marks the plot of land under construction and supervises the construction itself. The master builders rely on experience and good construction practices for meeting their customers' requirements. This expertise is passed on from fathers to sons, as a family secret. Even though houses have kept a common external appearance, their insides are designed to meet specific customer needs. The house plans themselves are rarely put on paper. A one-meter stick is used to measure lengths, especially of openings in the walls. Standardization of the size of doors and windows is needed in order to meet the carpenter's requirements. Once the walls are completed the most crucial step in the house building process begins. It involves putting the roof on the top of the house. One method of constructing a roof is to lay wooden beams across the side walls and cover them with leaves and mud. The drawbacks of this method are that such a roof requires yearly maintenance and that the beams' length pose a restriction on the size of the rooms. Stone arcs and cross vaults are a major improvement to the roofing method. They eliminate the need for maintenance and allow for bigger rooms to be constructed. Hirschfeld concludes his study by stating that a big improvement in Byzantine construction standards was achieved by recognizing the master builders as professionals who are in charge of a turnkey construction project. Traditional stone houses are therefore examples of quality planning, quality control and quality improvement.

6. Roads and tunnels

This section focuses on examples of civil engineering projects. The first example is a famous tunnel constructed 26 centuries ago. The other examples are derived from an exhaustive study of Roman roads in Israel.

The Tunnel of Siloam

In the city of Jerusalem, at the entrance of the Siloam tunnel, there is an inscription by an unknown author who lived in 700 B.C.E., during the reign of Hezekiah, king of Judea. It states:

"This is the boring through. This is the story of the boring through: whist the miners lifted the pick each towards his fellow and whilst three cubits yet remained to be bored through, there was heard the voice of a man calling his fellow, for there was a split in the rock on the right hand and on the left hand. And on the day of the boring through the miners struck, each in the direction of his fellow, pick against pick. And the water started flowing from the source to the pool twelve hundred cubits. A hundred cubits was the height of the rock above the head of the miners."[10]

One can only admire the skills of these workers who began digging a tunnel from two opposing ends and achieved incredible accuracy without modern technology.

The books of Kings and Chronicles mention many other hydraulic engineering projects accomplished by king Hezekiah:

II Kings XX, 20 *And the rest of the acts of Hezekiah, and all his might, and how he made a pool, and a conduit, and brought water into the city, are they not written in the book of the chronicles of the kings of Judea?*

II Chronicles, XXXII, 30*This same Hezekiah also stopped the upper watercourse of Gihon, and brought it straight down to the west side of the city of David.*

[10] E.W. Heaton, Everyday Life in Old Testament Times, C. Scribner's Sons, New York, 1956.

Roman roads

An impressive indication of the high level of cultural and commercial activity in Roman times is provided by the Roman road network throughout the province of Judea. About 1000 Roman miles (1500 km.) of major roads were gradually built with accompanying bridges, supporting terraces and land leveling operations, as well as many ancillary constructions such as caravanserai, reservoirs, guard stations, milestones and other official structures. The earliest milestone found in Israel is from 69 C.E. It was discovered in the outskirts of the city of Afula near Mount Tabor. The milestone inscription testifies to roadlaying work undertaken by soldiers of the tenth legion on the Caesarea-Scythopolis road, under the care of its commander, Marcus Ulpius Traianus (Emperor Trajan's father). During wartime, the roads were under the responsibility of the military authorities. However, in times of peace, the roads were under the jurisdiction of the provincial administration. An example of roadbuilding in Judea during a military campaign can be found on Tarjan's column in Rome[11].

What where the Roman techniques of roadlaying, and how did they choose and plan the proposed routes? In the valleys and flatlands, the Romans chose as straight a route as possible. However, Roman engineers did not hesitate to circumvent areas that would make roadlaying difficult. Roll and Ayalon[12] studied construction methods of Roman roads in western Samaria and found adherence to standards enforced throughout the Roman Empire. In particular, the builders first cleared the future roadway down to bedrock, to provide a firm base for the fill, they then proceeded to lay a filler consisting of larger stones which was eventually covered with a layer of smaller stones and earth. This roadlaying process gives some elasticity to the road and prevents damage from earth movements and traffic vibrations. Finally a pavement consisting of large rough stones was laid

[11] For more on Roman roads in Judea see I. Roll, "The Roman Road System in Judea", in The Jerusalem Cathedra: Studies in the History, Archeology, Geography and Ethnography of the Land of Israel, volume 3. Edited by L.I. Levine, Yad Izhak Ben-Zvi Institute, Jerusalem. Wayne State University Press, Detroit, 1983.

[12] I. Roll and E. Ayalon, "Roman Roads in Western Samaria", *Palestine Exploration Quarterly*, pp. 113-134, July-December 1986.

closely with the flat sides up so as to make a reasonably smooth surface for traffic. In later periods roads were paved with fairly small stones. The roads were completed with either a single row of large curbstones or a supporting wall. Planning and execution of such a network of roads required extensive knowledge in quality planning and quality control. Some of the Roman roads in Judea and Samaria are still in use today, an impressive tribute to Roman quality achievements.

7. Textile and pottery

Dyes

The Jewish prayer shawls have, at their corners, strands dyed in blue:

Numbers, XV, 38 *Speak unto the children of Israel, and bid them that they make them fringes in the corners of their garments throughout their generations, and that they put upon the fringe of the corners a thread of blue.*

According to Biblical and Talmudic sources these blue strands must be colored with a particular blue, *tekhelet*, which is a dye derived from a snail. However, the process of making *tekhelet* has been forgotten since the eighth century. Modern researchers have uncovered three species of gastropod snails from which blue pigments found in ancient cloth were painstakingly extracted. The same blue dye can be extracted more economically from an herb named Indigofera of the pea family. Talmudic authorities describe tests to distinguish dyes extracted from snails from those of plant origin. These tests are inconclusive since the chemical structure of the two dyes is the same. A fascinating account of dyes used in Old testament times is given in Krauss[13]. The history and chemical properties of the color blue are reviewed in Hoffman[14].

[13] S. Krauss, The Talmudic Antiquity (Kadmoniut Ha-Talmud, in Hebrew), Dvir Press, Tel Aviv, 1945.

[14] R. Hoffman, "Marginalia: Blue as the Sea", *American Scientist*, 78, pp. 308-309, 1990.

The Phoenicians, who piloted King Solomon's ships on the Mediterranean and Red Sea, had a monopoly on a purple dye derived from shellfish. These ancient mariners and merchants sailed without compass or sextant through uncharted seas even into the Atlantic. The Phoenicians have even been credited as having discovered Britain, or at least traded with Britain. Some clue to this is provided by pre-Bronze Age shell dumps of the particular kind yielding the purple dye found on the Cornwall and Devon coasts. Lord Leighton, president of the British Royal Academy, who was commissioned to paint a mural depicting "Ancient Commerce" on the walls of the Royal Exchange in London, painted black-bearded Phoenicians spreading out purple cloth before avid Britons who offer hides and ingots of tin in exchange[15].

Yigael Yadin published a scientific study of textiles from the Bar-Kokhba period found in the "Cave of the Letters"[16]. The composition of dyes and colors on several pieces of first century woolen cloth were tested by two independent laboratories in England and the U.S.A. using optical, chemical and infrared techniques. Their findings are meticulously reported by Yadin including their spectrophotometric profiles. This detailed analysis enabled researchers to reconstruct the dye and color preparation processes which included the addition of special components for achieving stability over time. It appears that customers have always resented having their clothes change color with usage.

[15] B.W. Tuchman, Bible and Sword: England and Palestine from the Bronze Age to Balfour, Ballantine Books, New York, 1956.

[16] Y. Yadin, Judean Desert Studies: The Finds from the Bar-Kokhba Period in the "Cave of Letters" (in Hebrew), Keren Bar-Kokhba, Jerusalem, 1963.

Cloth

Sheep's wool was the main raw material used in ancient textiles. After shearing, the wool was washed and combed to be ready for spinning. In most homes one could find women spinning wool into yarn by using a simple hand spindle. Several verses of the Old Testament refer to spinning:

Proverbs, XXXI, 19 *She layeth her hands to the spindle , and her hands hold the distaff.*

Job, VII, 6 *My days are swifter than a weaver's shuttle, and are spent without hope.*

A yarn has an **S**-twist if, when held in a vertical position, the spirals conform in direction of slope to the central portion of the letter '**S**', and a **Z**-twist if the spirals conform in direction of slope to the central portion of the letter '**Z**'. Unlike linen, who has a natural S-twist, and cotton, who has a natural Z-twist, wool has no natural twist in any direction. The actual twist in woollen yarn is therefore determined by spinning traditions and habits. By studying the direction of the , Yadin was able to identify different sources for the woollen yarn. The researcher's findings even indicate that the cloth found by Yadin is made of wool from a medium-wooled type sheep which produced the same wool as that present in the Dead Sea Scrolls.

There were many methods of weaving. The most primitive method is little more than plaiting with the "weft" going over and under the "warp". Other methods practiced by the ancient weavers include canvas weave and twill. Overall, Yadin identifies 10 weaving methods. Each of these methods requires some planning and documentation so that the work can be performed repeatedly and homogeneously by different weavers.

Cloth used in the Temple required special weaving by virgins. Weaving in general was done by women with looms that were of two kinds - horizontal and vertical. In a most famous example Delilah used an horizontal loom to weave Samson's hair[17].

Pottery

Pottery is easy to break but difficult to destroy. There is therefore more evidence of the potter's craft than of any other trade in Old Testament times. Archaeologists have traditionally used pieces of jars and jugs to date the various strata of excavated sites. Indeed, diggings in the holy land have revealed pottery as old as any known in the world.

The potters of the Old Testament produced everyday articles for everyday life such as storage jars, house lamps, cooking pots, pitchers and children toys. They used mass-production methods using the fast-spinning potter's wheel. The wheel was fixed to the top of a spindle which ran through the center of another wheel below. The lower wheel was heavier to give momentum as the potter spun it by hand. Evidence of foot-operated mechanisms dates from 200 B.C.E. In order to satisfy demand various mass-production methods were applied. For example, a great cone of clay would be worked on the wheel and articles would be shaped and pinched off from the top until it was all used up. Using a similar concept, modern machines for automatic placement of electronic components on printed circuit boards carry cartridges of individual components.

Standardized shapes and sizes were fixed so that the various manufacturing stages could be divided between different workers. Young apprentices were responsible for making handles of jars. Indeed, their inexpert fingers have left traces which are still visible. Apprentices would also rough out articles which were then handed to skilled craftsmen to finish. There is evidence from stamps and trade-marks that potters worked together in cooperative enterprises consisting of families or guilds.

[17] S. Krauss, The Talmudic Antiquity (Kadmoniut Ha-Talmud, in Hebrew), Dvir Press, Tel Aviv, 1945.

The clay used was usually a red variety taken from just below the surface of the soil. Before it was ready to be placed on the wheel it had to be cleaned from chemical impurities and broken up into an homogeneous dough of clay. Leaving the clay in the sun, rain and frost, before it was kneaded by treading, was adequate preparation for most items. If a clay of better quality was required an additional filtering was performed using large vats. This is reminiscent of modern attempts at improving quality by additional testing and inspection. For example, higher quality components for military systems are undergoing additional testing steps over and beyond their civilian counterparts. Special applications required certain additives to be mixed with the clay. For example, crushed limestone was added to prepare clay for heat-resistant cooking-pots.

After the clay was turned into a vessel that was shaped on the wheel it was left to dry and harden. The vessel was then returned to the wheel for finishing operations using cutting tools. The final step consisted of baking in a furnace. Quality deficiencies of amphoras used for storage have been abundantly reported and studied in the Mishnah and Talmud. Brand has investigated the causes of poor quality in pottery and the methods for repairing these deficiencies using tar[18].

8. Discussion

This last section reviews and discusses the overall picture drawn in the previous seven sections. The first lesson learned is that inspection is a natural complement to creation. Moreover, the book of Genesis also demonstrates, with Noah's story, that improvement efforts do not always succeed and sometimes there is a need for planning a new beginning. The warranty embodied by the rainbow, that God will not destroy civilization again is leading Abraham to bargain for the survival of Sodom and Gemorrah. Standards and warranties often lead to such discussions. The Old Testament also

[18] Y. Brand, Klei Haheres Besifrut Hatalmud (Ceramics in Talmudic Literature, in Hebrew), Mossad Harav Kook, Jerusalem, 1953.

demonstrates that important projects, such as the Ark of the Covenant and Solomon's Temple, require detailed specifications. The references to the Temple bring out the point that maintenance work has to be budgeted and that there is a need to develop trustworthy suppliers and organize the workforce. The Talmud and Mishnah provide detailed examples of procedures in economic, medical and religious applications. Such detailed descriptions of procedures have made these ancient processes accessible to our modern days. The scientific studies of Yigael Yadin have shown that much can be learned about undocumented procedures with modern scientific technology. The chapter provides several examples on the need for standardization, for example in buildings and pottery.
Finally, it is worth noting that the concept of special orders has a long history. Examples of this include the virgins weaving special cloth for the Temple in Jerusalem and the requirements for red cows to be used in sacrifices.

Godfrey[19] lists seven milestones that delineate a road map for the top management of organizations planning their journey towards continuous quality improvement. These milestones provide, with some modifications, an excellent frame of reference for discussing some of the examples presented earlier in this chapter. The milestones are:

1) **Awareness** of the competitive challenges and current competitive position: Competitive challenges were practically non existent in ancient times. The Phoenicians had a monopoly on purple dye, and so did Hiram of Lebanon with the supply of Cedar trees. The quality of these products was essential to uphold the suppliers' reputation but no efforts had to be invested in "beating the competition."

2) **Understanding** of the definition of quality and of the role of quality in the success of the organization: Major projects require quality of execution. The Siloam tunnel is one such example. Another example is provided by the Temple of Solomon. However,

[19] A. Blanton Godfrey, "Buried Treasures and Other Benefits of Quality", The Juran Report, 9, Summer 1988.

defects in ancient storage vessels seemed to be the norm, and fixing these defects appears to have been an acceptable practice.

3) **Vision** of how good the organization can really be: The Old Testament is very explicit on the need for a vision. Clearly king Solomon had a vision for his kingdom and so did Bar-Kokhba who rebelled against the Romans in order to let his people practice their religion. A far reaching example of the power of a vision is provided by the Jewish people in exile, who, for over two thousand years, kept alive the vision of their return to their homeland.

4) **Planning** for action with clearly defined steps needed in order to achieve the vision: Very few examples of large scale planning exist in written form. The Arab master builders are planning in detail the construction of the traditional house but do not put anything in writing. The Old Testament is providing very elaborate details on specifications of various construction projects - completing these projects required planning and control, but, again, there is no records of such plans.

5) **Training** of the people so as to provide the knowledge, skills and tools needed to make the plan happen: The need for training of workers is clearly recognized in the Old Testament. Training is also necessary for individuals to properly comply with religious laws and regulations.

6) **Support** actions taken to ensure that changes are made, problem causes are eliminated and gains are held: Records of actual improvements are scarce. However, indirectly, one can observe improvements such as in the construction of traditional houses. The color *tekhelet* is an example where lack of documentation has resulted in a process being forgotten - apparently no one cared.

7) **Rewards and recognition** of achievements to make sure that quality improvements spread throughout the organization and become part of the business plan: Master craftsmen are recognized in several verses of the Old Testament. In another example

Roman milestones carry the names of the troops' commanders, thereby making them famous throughout human history.

In sum, the history of ancient Israel provides examples that demonstrate most of the basic principles of Quality Management. Quoting again from Juran[20]: "For most companies and managers, annual quality improvement is not only a new responsibility; it is also a radical change in style of management - a change in culture... ." This chapter is demonstrating that the concepts of managing for quality are deeply rooted in "The Cradle of Civilization." Managers interested in performing such a "radical change in style of management" might get inspired by going back to these sources.

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[20] J. M. Juran, Juran on Leadership for Quality: an Executive Handbook, the Free Press, 1989.

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Appendix

Chronology of main events

2000 B.C.E. Abraham enters the holy land after migrating from Ur on the Persian Gulf to Haran in Mesopotamia and from there to the land of Canaan. Eventually the Hebrews migrate to Egypt and settle in the fertile eastern part of the Nile called the land of Goshen.

1250 B.C.E. Moses leads the exodus of Hebrews to the holy land from Egypt.

1020 B.C.E.-926 B.C.E.Kingdoms of Saul, David and Solomon, divided into 12 administrative districts, undergo rapid development. The period is characterized by heavy taxation and grandiose projects. King Solomon indubitably puts Israel on the international map.

950 B.C.E.-586 B.C.E.First Temple era. Solomon's glorious forty years are followed by chaos. After his death in 926 B.C.E. the kingdom is split into two: Israel (in the north) and Judea (in the south). The prophets Amos, Hosea, Isaiah and Micah provide first hand evidence of the corruption, collapse of justice and greed of the period.

721 B.C.E. Sargon II of Assyria conquers and liquidates northern Israel deporting 27000 prisoners.

586 B.C.E. Fall of Jerusalem to Nebuchadnezzar II followed by a second deportation of thousand of Judeans to Babylon.

586 B.C.E.-536 B.C.E. Babylonian captivity.

539 B.C.E. Cyrus of Persia topples Babylonian Empire and frees Jerusalem.

539 B.C.E.-332 B.C.E. Persian rule.

520 B.C.E. Zerubbabel begins rebuilding the Temple.

515 B.C.E. Rebuilt Temple inaugurated.

332 B.C.E.-140 B.C.E.Greek rule.

167 B.C.E.-162 B.C.E. Maccabean revolt.

140 B.C.E.-63 B.C.E. Hasmonean dynasty.

63 B.C.E. Pompey conquers Jerusalem.

37 B.C.E.-4 B.C.E.	Herod is crowned by the Romans as King of the Jews.
20 B.C.E.	Herod begins reconstructing the Temple.
4 B.C.E.	Death of Herod.
30 C.E.	Crucifixion of Jesus Christ.
66 C.E.-70 C.E.	First Jewish Rebellion repressed by Gesius Florus.
70 C.E.	Destruction of Herod's Temple by Titus.
73 C.E.	Fall of Massada.
132 C.E.-135 C.E.	Bar-Kokhba's rebellion repressed by Hadrian.
200 C.E.	Codification of the *Mishnah* by Rabbi (R.) Judah Ha-Nassi who succeeded in classifying and organizing oral laws into a fundamental document of great importance and sanctity to the Jewish people.
200 C.E.-500 C.E.	The Amoraim interpret the *Mishnah*.
499 C.E.	Codification of the *Babylonian Talmud* (R. Ashi) and the *Palestinian JerusalemTalmud* (R. Yohanan). The *Talmud* is an uncompleted summary of discussion and elucidation of the *Mishnah* that evolved through centuries of scholarly efforts by sages who lived in Palestine and Babylonia.
324 C.E.-640 C.E.	The Byzantine era.
632 C.E.	Death of the Prophet Muhammad
637 C.E.	Arab conquest by the Omayyad caliphs.