ARTICLE

.13

Footprints of the Future: Timelines and Exploratory Forecasts in Futures Research

Peter von Stackelberg
Social Technologies
USA

Abstract

The presentation of time-oriented data can provide significant insights into both the past and future. The use of timelines that integrate disparate quantitative time series data and other time-oriented information into a unified visual presentation can reveal patterns, causes, probabilities, and possibilities across complex social, technological, economic, and political systems. Cycles, waves, logistics curves, and other archetypal patterns, when laid over historical data, can provide a deeper understanding of the dynamics of change. Timelines and these archetypal change patterns can also be used in the field of futures studies as key components in a "hypothesis-to-forecast" (exploratory forecast) process to identify potential long-term patterns of change and make long-range (25+ years) forecasts.

Keywords: timeline, exploratory forecast, futures studies, cycles, logistics curves, change, long-range forecast, time series, historical data, time-oriented data, past, future, discontinuity

The development of forecasts, trends, scenarios, and other forms of analysis about the future requires the study of a complex interplay of social, technological, economic, environmental, and political factors. A variety of tools and methodologies have been developed to structure and formalize the processes used in futures studies. Few of these, however, make use of visualization techniques in analyzing and communicating complex information.

The use of timelines as a visualization tool for analyzing events across a long period of time – both in the past and future – provides significant opportunities for the identification of patterns and interrelationships involving a broad range of factors. Identification of patterns is particularly important when attempting to look at the future of complex social, technological, economic, and other systems. Timelines can also be highly effective at provoking thought and discussion about the future.

Timelines and Visualization of Temporal Information

The representation of historical information in written form has been uncritically adhered to by professional historians despite the fact that the written word, when laid down sequentially, is a poor method for communicating the complexity of historical events. The representation of complex historical phenomena – the genesis of revolutions, wars, or major cultural shifts, for example – can be far more effective when visual (Staley, 2003).

In fact, the visual representation of complex social, technological, economic, environmental, and political events can be as effective for those studying future events as it is for those studying historical events.

Timelines have been a useful tool for the temporal visualization of events for more than 250 years. The earliest modern timeline, a 54-foot scroll that provided an annotated–but not illustrated–history since Creation, was created in 1753 by French philosopher Jacques Barbeu-Dubourg. Joseph Priestley's *Chart of Biography* (published 1765) and *Chart of History* (published 1769) were the first attempts to depict historical events graphically. Charles Minard's visual history of Napoleon's Russian campaign, publishing in 1869, was a notable for its pioneering use of a two-dimensional image to display several variables including time, geography, and the size and movement of Napoleon's army. Around 1932, John B. Sparks used vertical strips of varying width to show the proportional influence of various civilizations on his *Histomap of World History: The Story of Civilization in a Single Timeline* (Friendly, n.d.).

Correlated histories, in which parallel timelines show events in multiple domains, are comparatively new. Andreas Nothinger's *The Synchronoptic History Chart* (first edition published in 1989) and Paul Janke's *A Correlated History of the Universe* (published in 2002) are examples of such correlated histories (Friendly, n.d.).

Timeline of Major Trends and Events: 1750 A.D. – 2100 A.D. (first edition published in 1994 with subsequent editions published in 1998, 2006, and 2008), appears to be unique in its use of both quantitative and qualitative data across social, technological, economic, environmental, and political (STEEP) domains. Another unique feature of the timeline is that it provides both a historical and futures perspective. Whereas timelines typically plot only historical events, a key feature of the *Timeline of Major Trends and Events* is its display of graphs of statistical time series data, individual historical events, and archetypal patterns of change, all plotted on a common time scale extending both into the past and the future (von Stackelberg, 1998).

The timeline makes extensive use of idealized graphs of cyclical behavior, providing visual cues to long-term patterns of change involving global leadership, wars, energy use, social and political movements, and a number of other variables. In addition, an idealized Kondratieff cycle (K Wave) is included, both to determine its correlation with major technological and economic events dating back to 1750 and to test Schumpeter's (Schumpeter, 1939) theories on capitalism and cycles of "creative destruction".

Another key feature of the timeline is the inclusion of idealized S-curves representing the emergence, growth, and maturity of six successive waves of lead technologies. These S-curves are used to tie together historical data on major technological developments, enabling a comparison of the timing of those developments across broad categories of technologies.

The depiction of both historical data and archetypal change patterns in parallel allows a comparison of actual events with theoretical patterns. Laying cycles, waves, logistics curves, and other archetypal patterns over historical data enables a deeper understanding of the dynamics of change and the potential future states of technological, social, political, and other systems. Using timelines as an integrative tool in conjunction with a "hypothesis-to-forecast" (exploratory forecast) process makes possible the identification of long-range (25+ years) patterns of change.

Archetypal Patterns of Change

Trends, when quantified and charted, typically display just a few archetypal patterns: linear, exponential, or asymptotic growth or decline; S-curves; cycles; and chaotic change. These archetypal patterns could be considered the "footprints" left by complex systems as they change over time.

Linear change (either growth or decline) is typically the result of a relatively short-term perspective; when one takes a longer view, the change dynamics are often anything but linear (Figure 1). Exponential (Figure 2) and asymptotic growth (Figure 3) are typically not sustained over time; rather the system's dynamics begin to slow its growth or, if growth continues to accelerate, a growth-and-collapse pattern (Figure 4) occurs as the system reaches a particular limit.

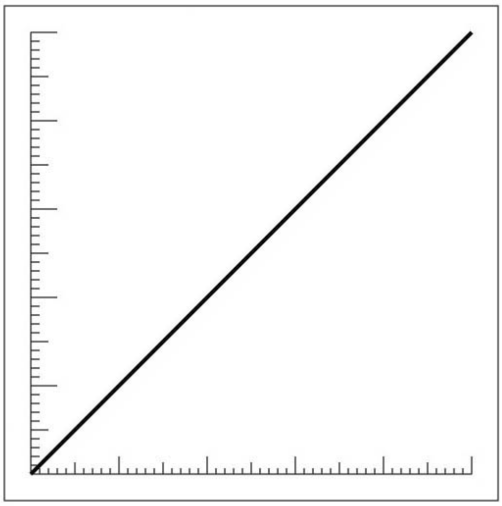

Figure 1. Linear growth

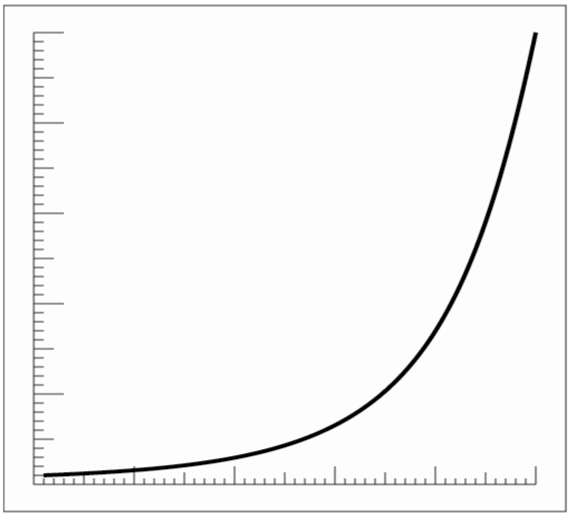

Figure 2. Exponential growth

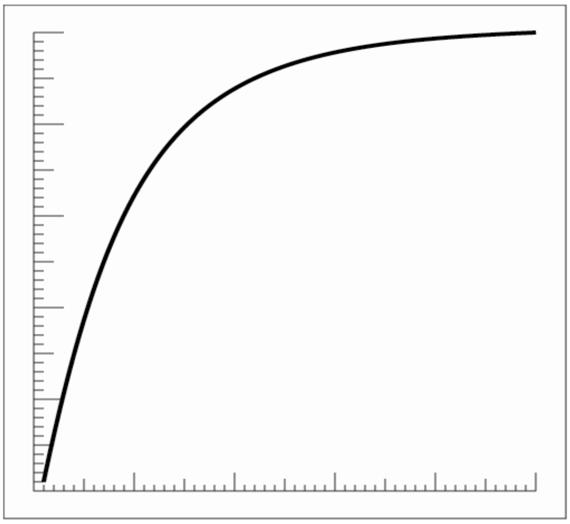

Figure 3. Asymptotic growth

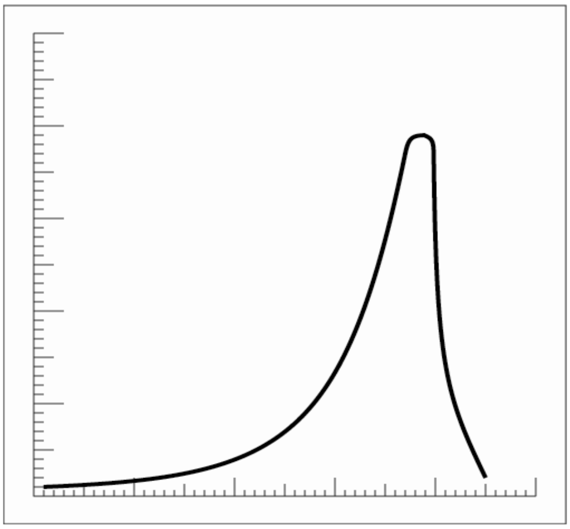

Figure 4. Growth-and-collapse

The remaining three archetypal patterns – S-curves (a range of curves that include logistics curves, Fisher-Pry substitution models, Gompertz curves, and others), chaotic change, and cycles – are the most interesting from a futures studies perspective.

- Variants of the S-curve (Figure 5) have been used to model the behavior of a wide variety of complex systems, including predator-prey relationships (Modis, 2007), the substitution of one technology for another (Modis, 1994), and the spread of innovations in music (Modis, 2007). The study of chaotic behavior in complex systems such as weather, a beating heart, insect populations, and economics began as early as the 1960s (Gleick, 1987), and by the 1990s was a hot field of study. Periods of chaotic behavior (Figure 6) can accompany the transition of a system from one state to another (Modis & Debecker, 1992).
- Cycles and waves (Figure 7) are the most controversial of these elements, from a futures perspective. Several kinds of cycles are relevant in this context: cycles in natural systems, economic cycles of various durations – among them the Kitchin inventory cycle (3 to 5 years), the Juglar fixed investment cycle (7 to 11 years), and the Kuznets infrastructure investment cycle (15 to 25 years), and the Kondratieff long wave (50 to 60 years) – have been also been documented. (Schumpeter, 1939) A variety of cycles, including a peak war cycle of roughly 50 years (Goldstein, 1988) and a global hegemony cycle of 100 to 150 years (Modelski & Thompson, 1996) have also been documented.

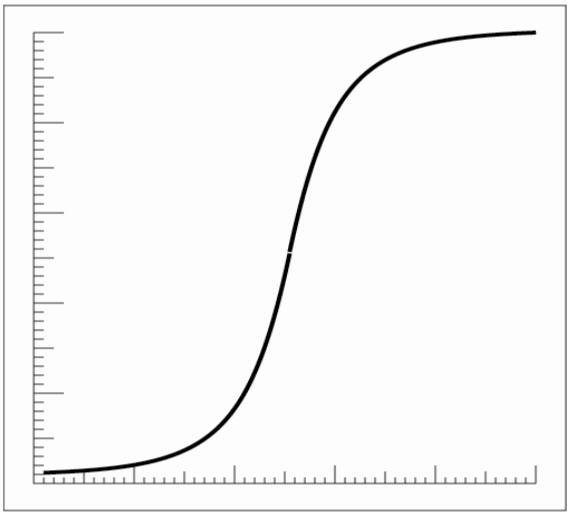

Figure 5. Logistics curve/S-Curve

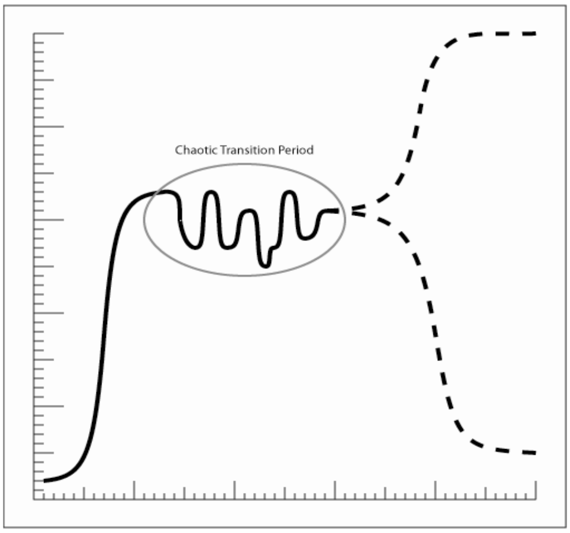

Figure 6. Logistics curve/S-Curve with chaotic transition

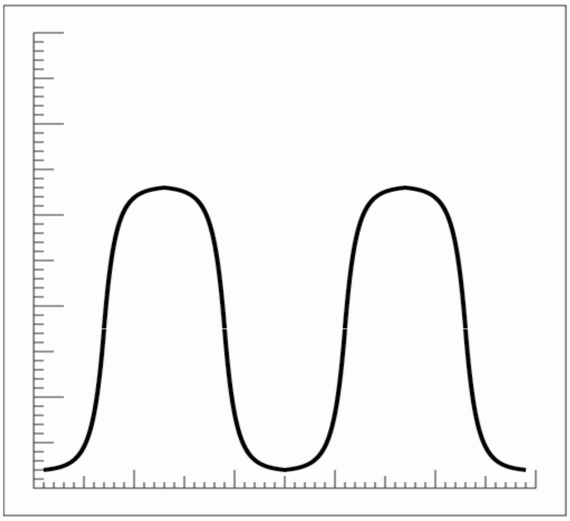

Figure 7. Cycle/Wave

Discussion of cycles in the context of the serious study of history or futures has sometimes been met with fierce criticism.

> *Cycles are viewed with skepticism if not downright distaste by many social scientists. They presume it to mean something mechanistic or even mystical, beyond scientific inquiry, and unproven if not unprovable. Social systems...are not only enormously complex but self-directing and continually evolving. The word cycle, for some, evokes images of clockwork mechanisms exhibiting strict periodicity and the regularity of a type ill-suited for describing social processes. (Goldstein, 1988)*

However, the notion of complex systems exhibiting cyclical behavior is not at all farfetched. The adaptive cycle model, developed from the study of ecosystem dynamics and extended to include social systems, proposes a cyclical pattern of behavior that includes four phases:

1. Growth – a period of rapid change as the system(s) exploit available resources to organize itself and grow.
2. Conservation – a period of slower change and higher stability as the system(s) accumulate and store resources.
3. Collapse or release – a period of rapid change as one or more existing system(s) break down.
4. Reorganization – a period of rapid change as the remaining systems reorganize. (Gunderson, Holling, & Ludwig, 2002)

Numerous computer models of complex systems–systems that typically contain feedback loops, time lags, limited information available to decision makers, and self-limiting and self-reinforcing processes–have also demonstrated cyclical behavior. The System Dynamics National Model, for example, shows "inherent oscillatory tendencies" (Sterman, 1985).

"Real-World" Examples of Archetypal Patterns of Change

The collapse of the American housing market, which is at the heart of the economic crisis of 2008-2009, is a classic example of a growth-and-collapse pattern. (Figure 8) The S&P/Case-Shiller U.S. National Home Price Index shows a two-decade long pattern of escalating home prices beginning in 1985. The price index peaked in 2005, then collapsed, continuing its fall through the end of 2008 (the latest data available as this paper was written) as housing prices collapsed, taking down banks and other financial institutions, and then the economy as a whole.

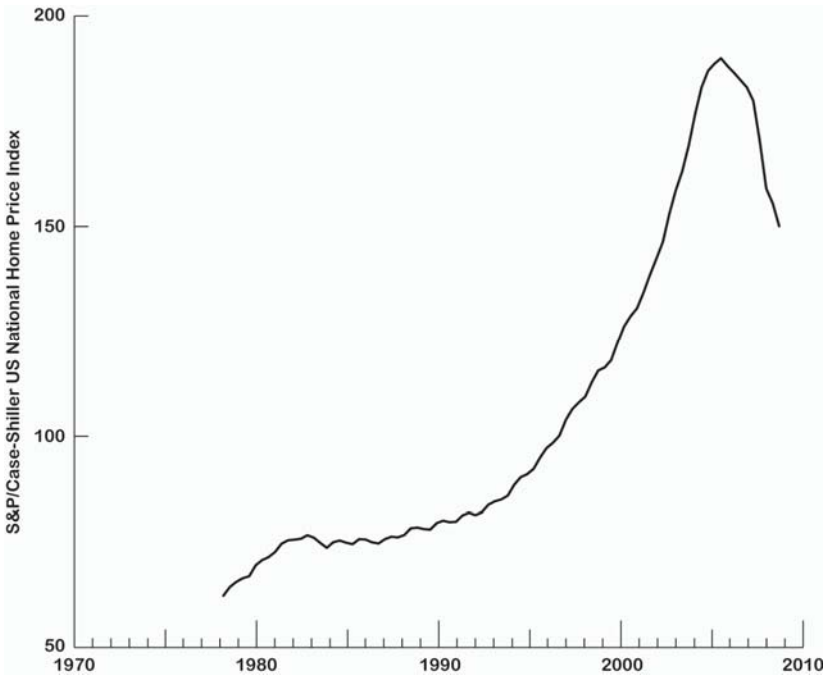

Figure 8. US housing prices – A classic growth-and-collapse pattern
Note. Statistical data on U.S. home prices from S&P/Case-Shiller Home Price Indices, U.S. National Values (Q1, 1987 to Q3, 2008), Standard & Poor's, http://www2.standardandpoors.com/portal/site/sp/en/us/page.topic/indices_csmahp/0,0,0,0,0,0,0,0,0,1,4,0,0,0,0,0.html.

Where the U.S. housing market collapse demonstrates a single pattern of change, the dynamics of the nuclear arms race between the United States and Soviet Union/Russia between 1945 and 2003 is an almost perfect example in which real-world data fits several archetypal patterns of change–a pair of S-curves (growth and decline) with a chaotic transition period between them and a growth-and-collapse pattern (Figure 9).

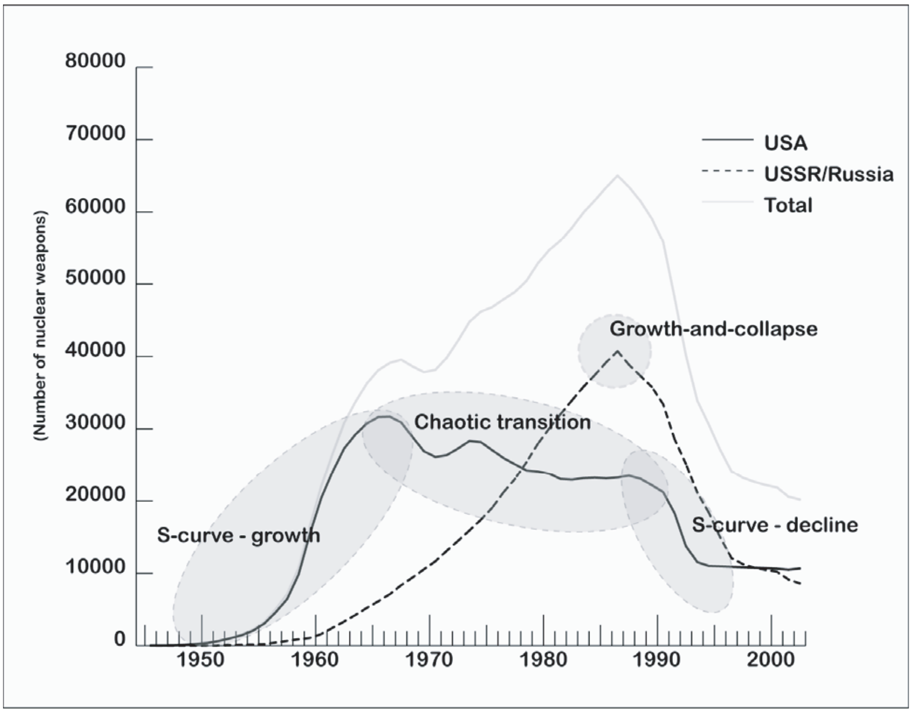

Figure 9. Arms Race & Archetypal Change Patterns
Note. Statistical data on nuclear weapons from Table of Global Nuclear Weapons Stockpiles, 1945-2002, Natural Resources Defense Council, http://www.nrdc.org/nuclear/nudb/datab19.asp.

By identifying these archetypal patterns and laying them on a timeline along with the actual data, it is possible to get a deeper understanding the arms race between 1945 and the early 21st century and, from a futures research perspective, two critical transition points during that period:

- The mid- to late-1960s, when the US nuclear arsenal declined dramatically, transitioning relatively rapidly from a classic growth curve to a chaotic transitional period.
- The late 1980s and early 1990s, when the USSR's nuclear arsenal exhibited a growth-and-collapse pattern and the US arsenal a declining S-curve.

While not all real-world situations fit as cleanly as these particular examples, many do and applying archetypal patterns of change to them can provide significant opportunities for foresight through the development of exploratory forecasts.

Developing Exploratory Forecasts

Once archetypal patterns and historical data are plotted on a multi-band timeline such as the *Timeline of Major Trends and Events*, a seven-step process may be used to develop and assess exploratory forecasts.

A forecast is a predictive description of the future state of a physical, social, political, technological, or other system. Data supporting a forecast may be quantitative (i.e. time series data), qualitative (i.e. a series of related events), both, or neither (i.e. an individual's statement of what they believe the future will be like) (von Stackelberg, 2007).

Unlike traditional forecasts, exploratory forecasts are not intended to be predictions of the future, but rather hypotheses of possible futures. Once an exploratory forecast has been created, indicators of its validity (or lack thereof) can be monitored and assessed using environmental scanning, trend analysis, and other futures research methods. Examples of exploratory forecasts derived from von Stackelberg's *Timeline of Major Trends and Events* are:

- The transformative role of information technology will diminish between 2010 and 2040.
- American society will experience a shift from right of the political center to the left between 2005 and 2030.
- The possibility for US involvement in a major war will increase significantly between 2030 and 2040.
- The full social, economic, and political impacts of molecular technology (biotech and nanotech) will materialize between 2035 and 2065.
- Social tensions will increase in the US between 2010 and 2030. Crime, alcohol and drug use, and social unrest will increase.
- Interest in spiritual experiences will increase between 2005 and 2030, while participation in traditional religions will decline.
- The social and political power of religious fundamentalism will decline between 2005 and 2030.

A seven-step process is used to develop exploratory forecasts using timelines and assess their validity and potential impact.

1. Plot events and time series data on the timeline

Wars, inventions, emergence of new social or political movements, and other events are plotted on the timeline. Charts of time series data can also be laid on the timeline. The information plotted can provide clues to potential relationships between events, as well as leads for further research.

Assuming that we are interested in looking at the future of energy, we might use a timeline to lay out global and American petroleum production, events involving OPEC, and wars (Figure 10). The wars and OPEC events are kept on separate bands, providing a clearer visualization of different types of events. However, because they are on the same timescale, it is possible to scan vertically on the timeline to identify events that happened at the same time.

In 1973, for example, the Yom Kippur War appears on the "War" band and the Oil Crisis of 1973 on the "OPEC" band. Moving up to the graph of global petroleum production, a sharp drop appears at the same time, disrupting the smooth upward curve of the previous dozen years.

Moving further along the global petroleum production graph, a second sharp drop occurs in 1979. This is identified in the "OPEC" band of the chart as the Oil Crisis of

1979. This information, however, does not necessarily explain the drop in production. Although not noted on this sample timeline, a band of events covering revolutions would reveal that in 1979 the Iranian Revolution, which overthrew the pro-American Shah, helped pave the way for the Iran-Iraq War and caused a breach in Iranian oil production.

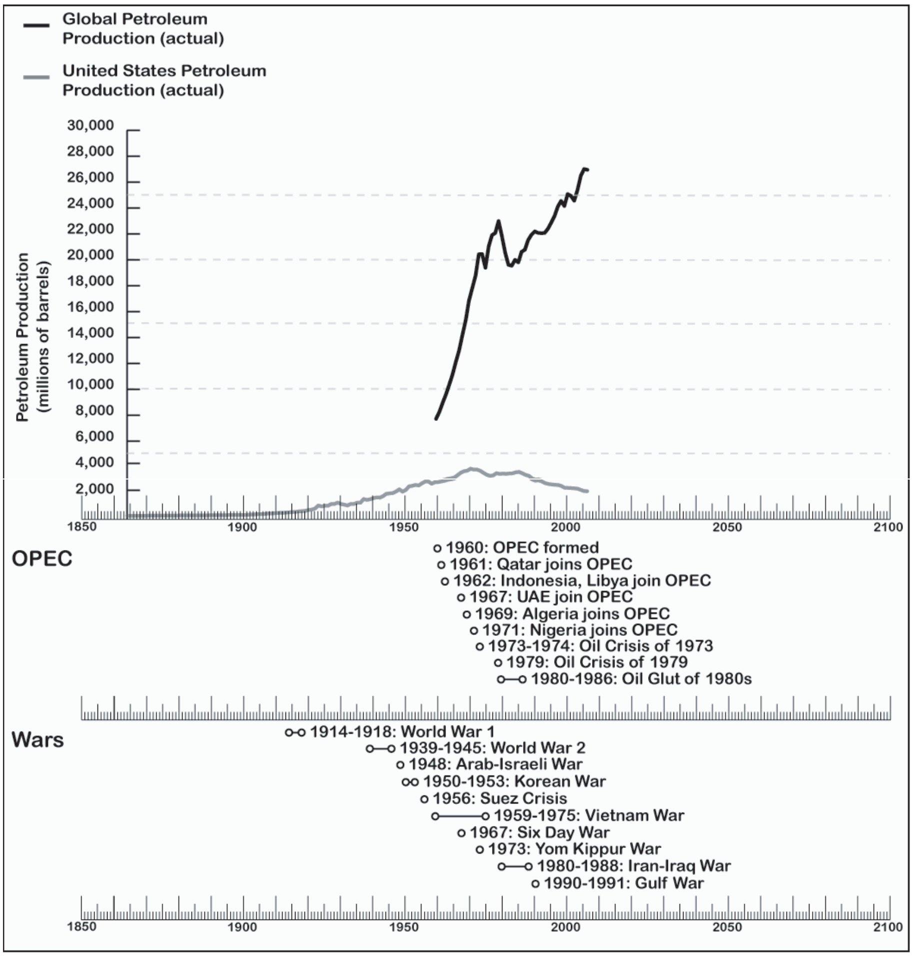

Figure 10. World and US petroleum production and related events
Note. Petroleum production statistical data from US Energy Information Administration.

2. Plot archetypal patterns of change

Plotting archetypal patterns of change (e.g., S-curves, cycles, exponential growth, etc.) on the chart is the second step in developing an exploratory forecast, and can provide additional insights into past and current events. Typically, these patterns are laid on the timeline using trial-and-error to determine the best fit.

In this example, a pair of S-curves representing idealized growth and decline patterns are fitted to both the global and American petroleum production figures. The peak of the curves from American production is centered on 1970, when American production actually peaked. (Figure 11)

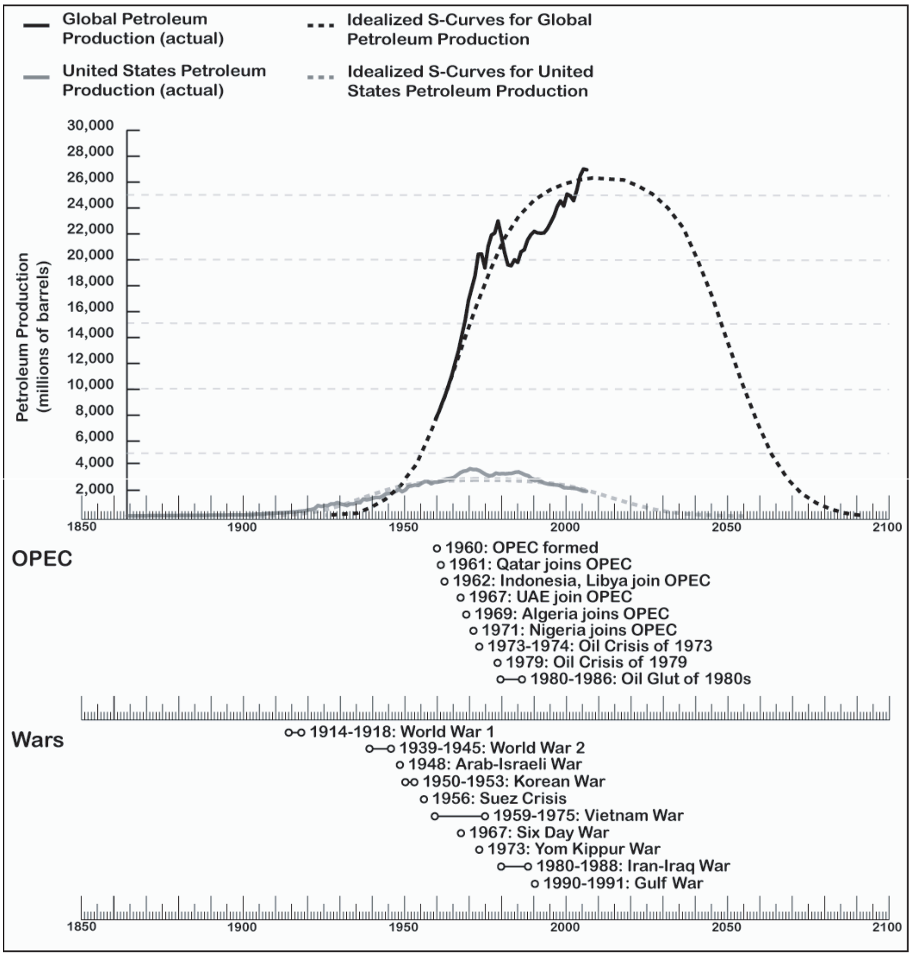

Figure 11. Idealized archetypal S-curves fitted to petroleum production

The peak for global production is set at 2010, based on some estimates of when actual global petroleum production might peak. There is currently disagreement over when "peak oil" will occur. Some place peak oil production in the early 2000s, while others place it around 2020 or later. Any or all of these peak dates can be plotted on the timeline using the idealized S-curves, providing alternative views of various forecasts. This ability to plot and visualize multiple forecasts and scenarios is a key benefit of timelines.

3. Identify and investigate potential significant relationships and anomalies

Presenting actual data and idealized patterns of change together on the same timeline is a valuable way to identify potentially significant relationships. In Step 1 of the process, relationships between various *events* were identified. In Step 2, idealized or archetypal change patterns were added to provide further insight into the background of events and allow for development of forecasts. At this stage of the process, these timeline elements can be analyzed further to identify significant relationships among them.

Equally important, possible anomalies might be identified. For example, the period between the mid-1960s and early 1970s showed that actual global petroleum production was higher than would be predicted by the idealized S-curve (Figure 12). On the other hand, between 1980 and 2000 (Figure 13), global petroleum production was below the idealized S-curve. While the causes of these possible anomalies are not readily evident from the information laid out on this sample chart, the anomalies do highlight areas worthy of further examination–another benefit of multiple-band timelines.

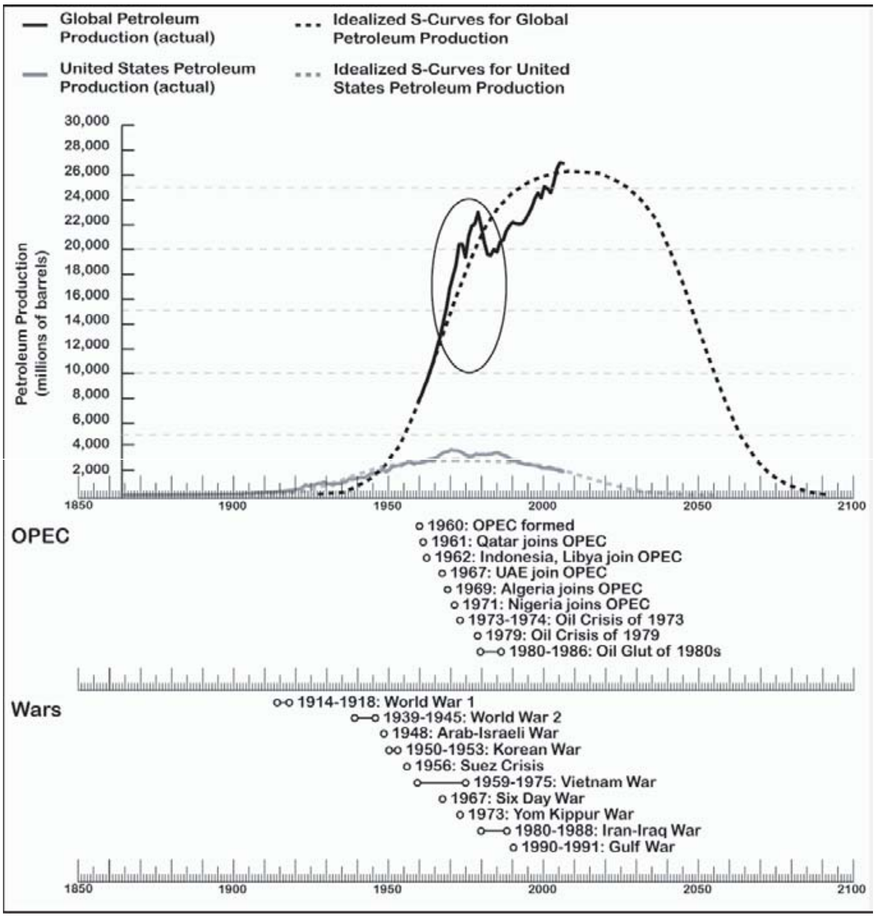

Figure 12. Anomaly between actual production and idealized curves (pre-1980)

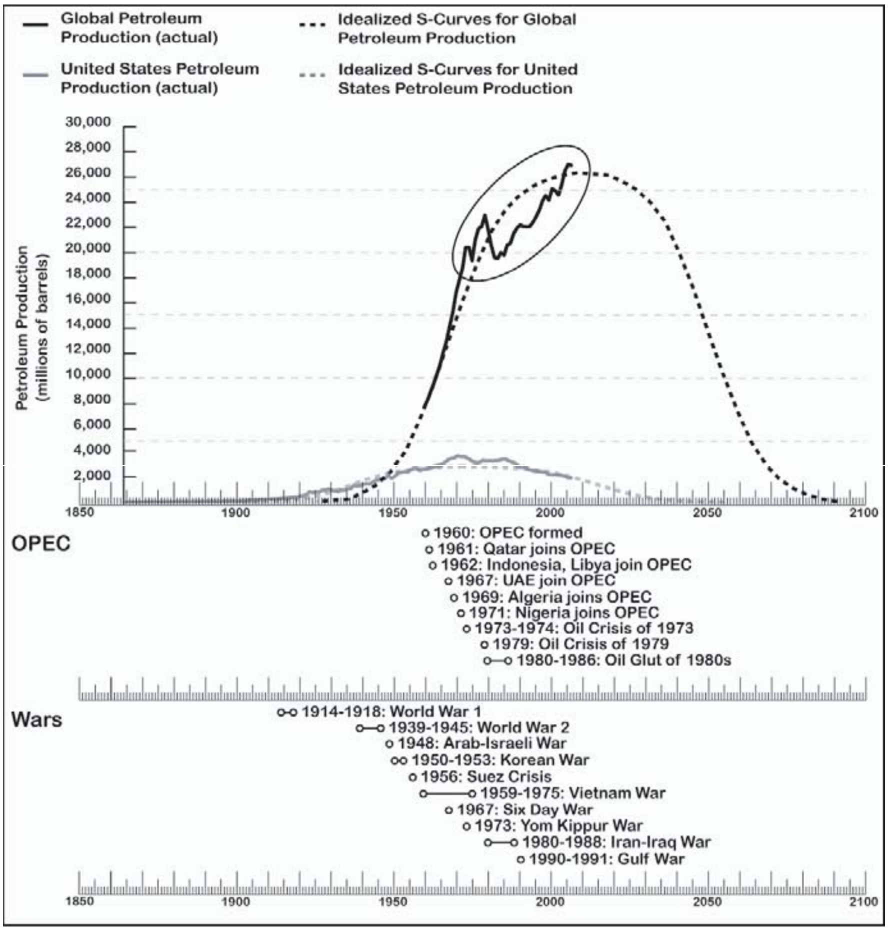

Figure 13. Anomaly between actual production and idealized curves (post-1980)

This sample timeline highlights an even more subtle anomaly. The slope of the growth trend in petroleum production between 1960 and 1980 is steeper than the slope of the growth trend between 1985 and 2005. The data presented on the timeline so far do not provide enough clues to fully explain this, so additional information can be added to the timeline – in this case a graphical representation of the Kondratieff long economic wave (K-wave) (Figure 14).

The K-wave, an economic wave of 50 to 60 years, is named after Russian economist Nikolai Kondratieff, who first brought the wave to international attention with a report published in German in 1926 (Kondratieff, 1926) and translated into English in 1935 (Kondratieff, 1935). The K-wave and its relationship to a variety of social, technological, economic, and political changes has been extensively studied since the mid-1930s.

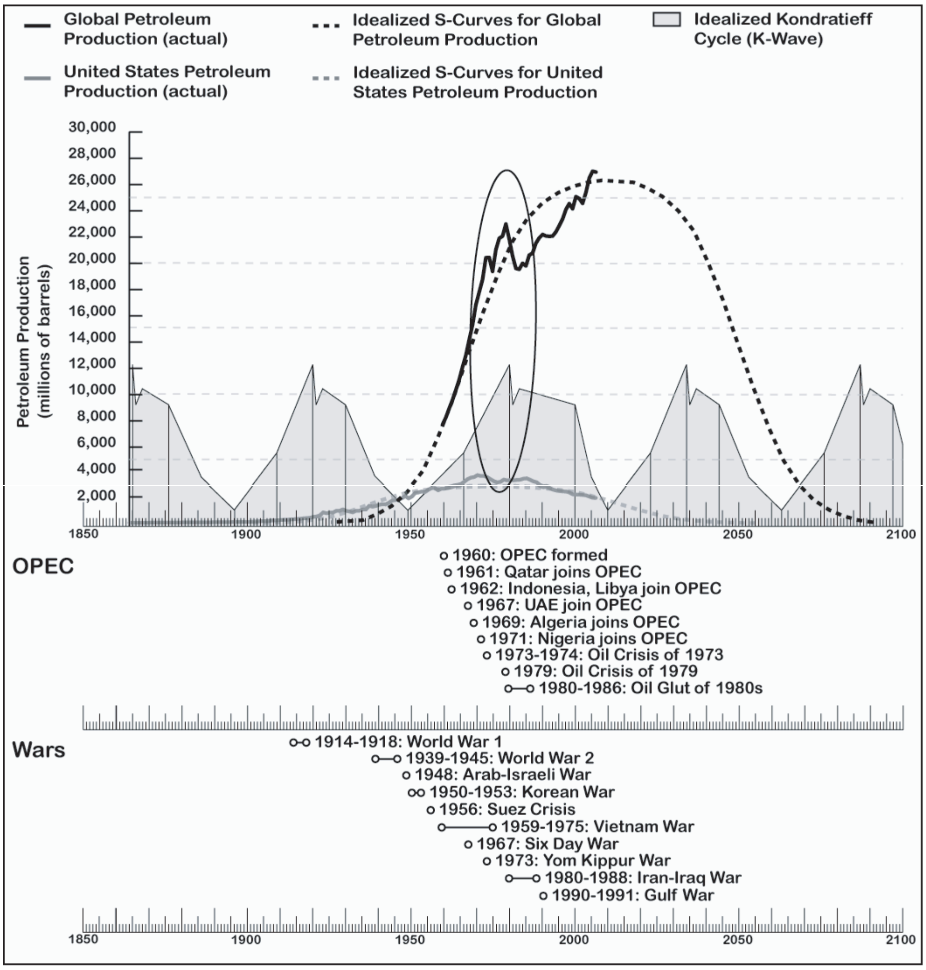

Figure 14. Potential correlation of pre-1980 anomaly to economic cycle.

The relationship between changes in petroleum production and the K-wave is striking. The peak in production in 1979 corresponds to the timing of the Oil Crisis of 1979, while the sharp drop in production corresponds to the Oil Glut of the 1980s. Both peak production and the subsequent drop correspond very closely to the peak of the K-wave in 1980 and subsequent slowing of economic growth. As noted earlier, the slope of production growth trends from 1960 to 1980 differs from the trend slope from 1985 to 2005, raising interesting questions about how petroleum production and the K-wave might be related. Because this paper is not intended as an examination of the merits of any particular relationship, we will not delve deeper into this here. Suffice to say that visualization of the K-wave on the timeline alongside other data provides a strong indication there are potential correlations worthy of further investigation.

Investigation of relationships between the K-wave and historical events may be at two levels:

1. Temporal relationships – these are relationships in the timing of events across two or more domains. For example, the 1979 peak and subsequent sharp drop in global petroleum production corresponds to the peak and decline in the K-wave. We've also noted the 1973 Yom Kippur War and 1980-1988 Iran-Iraq War as having occurred at the same time as significant changes in petroleum production.
2. Causal relationships – these are relationships that attempt to identify cause-and-effect across two or more domains. A hypothetical example of such a relationship might be that changes in energy demand are synchronized with the economic changes that occur as the K-wave progresses.

While temporal relationships are easy to establish with timelines – a key strength of this approach – identifying causal relationships is much more difficult. Great caution should be exercised when examining potential causal relationships identified from a timeline, as the systems represented are enormously complex. When looking for causal relationships, timelines should be used as an exploratory tool, while other approaches (i.e. causal diagrams and systems dynamics models) are best suited for gleaning causal relationships.

4. Extrapolate identified patterns and relationships

Step 4, extrapolating archetypal patterns, time series data, and temporal or causal relationships into the past and future, can provide insights in both directions.

For example, Modis and others have shown a long-term wave pattern in energy use. This energy cycle – the deviation of actual energy demand above or below the long-term trend – appears remarkably consistent over time.

When charted on a timeline with an archetypal cycle (Figure 15), the energy cycle consistently appears to lead the K-wave peak. The use of an idealized cycle makes visual interpretation of the timeline easier, but long-term time series data on energy use and data on the deviation from long-term trends can also be included on the timeline for a more comprehensive presentation.

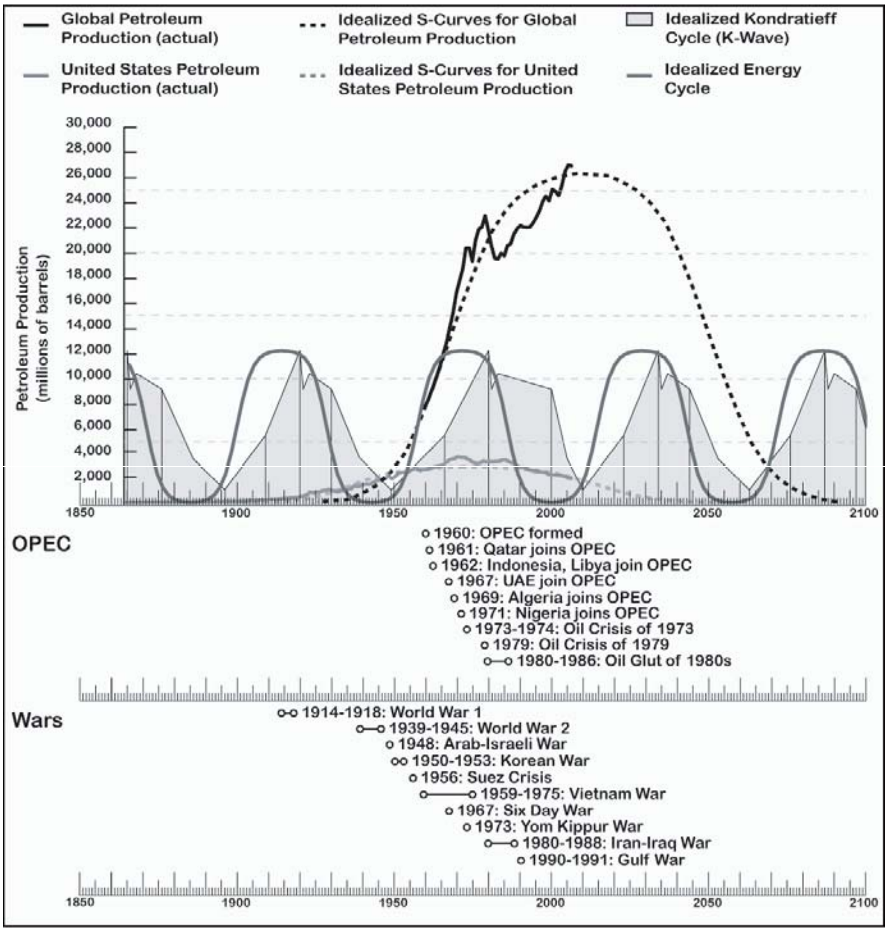

Figure 15. Energy cycle added to timeline

Preliminary and verified temporal or causal relationships should also be noted. For example, the apparent relationship between rising global petroleum production (and presumably, energy demand) and the upswing in both the energy cycle and K-wave should be noted for the period from about 2010 through 2035 (Figure 16).

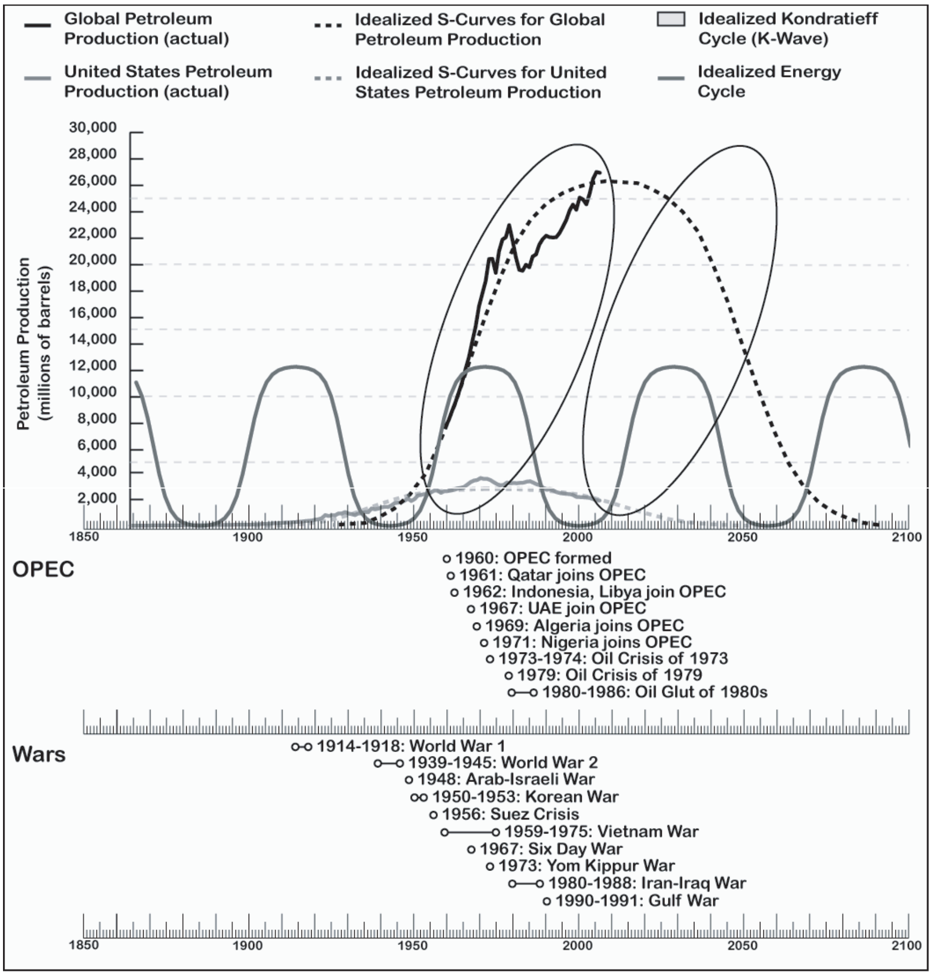

Figure 16. Analogous periods from 1960-2000 and 2010-2055

5. Create exploratory forecasts

The creation of one or more exploratory forecasts is the next step in the process. An exploratory forecast is a hypothesis about the future based on the events, trends, archetypal patterns, and temporal and causal relationships identified on a multi-domain correlated timeline. Typically, an exploratory forecast would consist of a statement that includes:

1. A future date or range of dates
2. The system or part of the system that is the subject of the forecast
3. A brief description of the future state of that system

The forecast may be for a single event (e.g., "In 2020, X will happen...") or a broader forecast of how the system may change (e.g., "Between 2020 and 2030, X will begin to rise...") A more detailed explanation may be developed that further clarifies the reasoning behind and potential implications of the exploratory forecast. A hypothetical example of an exploratory forecast based on the timeline that accompanies this article is:

> Between 2020 and 2030, petroleum supplies will decline while demand for energy peaks.
>
> Rising economic activity associated with an upswing in the K-wave from about 2010 through 2030 will result in increasing demand for energy. An upswing in the energy cycle will peak between 2025 and 2030.
>
> Based on historic growth patterns in global production of petroleum between 1960 and 2005, and assuming production peaks around 2010, we can expect to see global production begin to decline between 2010 and 2020.

A less obvious example of an exploratory forecast based on the timeline and historical information about wars is:

> International tensions will rise between 2010 and 2030, resulting in a significantly higher probability of the United States being involved in a major armed conflict.
>
> Going back as far as the American Revolution, the United States has been involved in a major war during every upswing of the K-wave and energy cycle.
>
> Given the anticipated peak in petroleum production and rising global demand for energy, a conflict between 2010 and 2030 might involve access to energy supplies.

6. Identify tracking indicators and collect observations

It must be emphasized that exploratory forecasts are not predictions, but rather conjectures that must be further verified and validated. In Step 6, indicators for tracking changes in key areas associated with the exploratory forecasts are identified and monitored (for example, petroleum supply and demand, evidence of growing international tensions, and the commercialization of alternative forms of energy production).

Not all indicators are statistical in nature; look for both quantitative and qualitative indicators. Both types of data can be plotted on the timeline. (See Sidebar 1 Text for an example of an exploratory forecast and observations associated with it.)

Sidebar 1 Text

Exploratory Forecast: Religious fundamentalism will have a declining influence on American society between 2005 and 2030.

Observations

- 2000 – 50% of voters are uncomfortable with politicians who speak publicly about how religious they are.
- 2000 – The political visibility of Christian evangelicals has waned.
- 2004 – Evangelicals have split into traditionalist and modernist camps, with very different voting patterns.
- 2005 – Independents are more critical of the influence of religious conservatives on the Republican Party than they are about the influence of secular liberals on the Democratic Party.
- 2006 – There is a growing divide between highly religious voters and the rest of

American society.
- 2007 – Only 38% of Americans polled see moral issues as being important to their voting decisions.
- 2008 – Protestants are on the verge of becoming a minority in the United States.
- 2008 – The number of people who are not affiliated with a religious denomination is growing more rapidly than any religious denomination.

7. Analyze and assess validity of exploratory forecast

Once an exploratory forecast has been developed, an ongoing process of analyzing observations and assessing their impact on the forecast is essential to ensuring that the forecast is on track. In turn, using the exploratory forecast as a baseline offers rich insight into the process of change as it unfolds.

If the observations confirm the exploratory forecast, data collection should continue to ensure it stays on track over time.

If the observations contradict the exploratory forecast, the exploratory forecast might need to be adjusted. However, before adjusting the forecast, determine why it is contradicted by the observations. Among the possible causes for the deviation are:

a. The pattern/trend is wrong. Correct by repeating the process with a new pattern/trend.
b. Hidden factors are at play. Identify those factors and repeat the process.
c. Behavior of the system has shifted. Identify if there has been underlying change in the system.

Conclusion

Timelines, when used to lay out historical data and cycles, waves, logistics curves, and other archetypal patterns along a common temporal scale, can provide a far deeper, more nuanced understanding of the dynamics of change. Timelines and archetypal change patterns can be used in a "hypothesis-to-forecast" (exploratory forecast) process to identify potential long-term patterns of change and make long-range (25+ years) forecasts.

The difference between traditional forecasts and exploratory forecasts is analogous to the difference between an unguided rocket and a guided missile. The unguided rocket is pointed at a target and fired; it follows a trajectory determined at the moment of launch. Unguided rockets are accurate enough over short distances, but that accuracy degrades rapidly as the distance to target increases. A guided missile, on the other hand, adjusts its trajectory based on environmental conditions, including movement of the target, resulting in greater accuracy over longer distances and in more challenging environments.

Traditional and exploratory forecasts (like unguided rockets and guided missiles) both have their place and can be highly effective if used appropriately. Traditional forecasts are well suited for relatively short-term futures. Exploratory forecasts, with the feedback from an ongoing monitoring and assessment process, are better suited to forecasting longer-term futures.

Correspondence

Peter von Stackelberg
Futurist
52 High Street
Alfred, New York
USA 14802
E-mail: pvonstackelberg@stny.rr.com

References

Adaptive Cycle. (n.d.). Resilience Alliance. Retrieved March 24, 2008, from http://www.resalliance.org/570.php

Friendly, Michael. (n.d.). *Timelines and visual histories* (York University). Retrieved April 15, 2008, from Gallery of Data Visualization: http://www.math.yorku.ca/SCS/Gallery/timelines.html#past

Gleick, James. (1987). *Chaos: Making a new science.* New York: Viking Penguin.

Goldstein, Joshua. S. (1988). *Long cycles: Prosperity and war in the modern age.* New Haven and London: Yale University Press.

Gunderson, Lance H., Crawford Stanley, Holling & Donald Ludwig (2002). In quest of a theory of adaptive change. In Lance Gunderson, & Crawford Holling (Eds.), *Panarchy: Understanding transformations in human and natural systems.* Washington, DC: Island.

Kondratieff, Nikolai D. (1926). Die langen wellen der konjunktur. *Archiv für Sozialwissenschaft und Sozialpolitik, 56.*

Kondratieff, Nikolai D. (1935). The long waves in economic life. *Review of Economic Statistics, 16*(6).

Modelski, George, & William R. Thompson (1996). *Leading sectors and world powers: The co-evolution of global economics and politics.* Columbia: University of South Caroline Press.

Modelski, George., & William R. Thompson (1989). Long cycles and global war. In Manus I. Midlarsky (Eds.), *Handbook of war studies.* London: Routledge.

Modis, Theodore. (1994). Fractal aspects of natural growth. *Technological Forecasting and Social Change, 47*(1).

Modis, Theodore. (2007). Strengths and weaknesses of S-curves. *Technological Forecasting and Social Change, 74*(6).

Modis, Theodore, & Alain Debecker. (1992, March). Chaoslike states can be expected before and after logistic growth. *Technological Forecasting and Social Change, 41*(2).

Schumpeter, Joseph. (1939). *Business cycles.* New York: McGraw-Hill.

Staley, David J. (2003). Computers, visualization, and the representation of history. *Historically speaking: The Bulletin of the Historical Society , IV*(4).

Sterman, John D. (1985). An integrated theory of the economic long wave. *Futures, 17*(2).

The Sunspot Cycle. (2008). (National Aeronautics and Space Administration) Retrieved March 24, 2008, from Solar Physics: Marshall Space Flight Center: http://solar-science.msfc.nasa.gov/SunspotCycle.shtml von Stackelberg, Peter. (1998). Timeline of major trends and events (1750 A.D. - 2100 A.D.). *2nd Edition.* Applied Futures International. Retrieved May 15, 2008, from http://www.math.yorku.ca/SCS/Gallery/images/timelines/futureswatch-org.jpg

von Stackelberg, Peter. (2007). *Forecast type description.* Retrieved April 15, 2008, from Freebase: http://www.freebase.com/view/user/pvonstackelberg/Futures_Studies/forecast