Novel Project Progress Monitoring and Delivery Date Forecasting Tool

NOSTRADAMUS 2.0

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LOB: Line of Balance, consists of a list of product's major components (or major tasks) and their expected completion dates (ECDs) along with an estimate of the fully-assembled product delivery date, all prepared by the manufacturer/ supplier.

Motivation

- **Project cost overrun closely follows the schedule delays.**
- **Manufacturing & testing phases are most at risk of incurring cost & schedule growth (by GAO).**
- **On-schedule availability of highly-reliable and complex new products is important, and only approved for use after a set of qualification and acceptance tests (conducted after product delivery) is successfully accomplished.**
  - Therefore, ***objective*** and ***unbiased*** assessment of progress status and estimate of **product delivery date** are paramount, especially when limited information is available.
- **Create a new & powerful tools to further empower the US Government (USG) with capabilities for project progress & schedule management in acquisition program.**

> **"There are two main causes of poor decision making: insufficient motivation and cognitive biases"**

Daniel Kahneman (2002 Nobel Memorial Prize in Economic Sciences).

Decision Making, Harvard Business Review, May 2015.

Leaders as Decision Architects, Harvard Business Review, May 2015

Nostradamus 2.0 – A Novel Monitoring & Forecasting Tool

- **Nostradamus 2.0 minimizes *cognitive biases* found in forecasting and provides *objective forecasts* of product delivery date†, and identifies tasks heavily contributing to delivery failure probability.**

- **Nostradamus 2.0 also provides progress state and speed for monitoring purposes during project implementation.**

- **Situation under which NOSTRADAMUS was developed and used:**
  - **Forecasting for a new product with no direct analog among products built in USA.**
  - **Departure from experience: High uncertainty in design, analysis, and manufacturing.**
  - **Manufacturing process improvements ("learning curve effect").**
  - **Early-stage application, implying high uncertainties.**
    - ❖ However, Nostradamus 2.0 can also be used at later stages when manufacturing reaches maturity.

Professor Daniel Kahneman is an Israeli-American psychologist and economist (Princeton University) known for his work on the psychology of judgment and decision-making, cognitive biases, as well as behavioral economics, for which he was awarded the 2002 Nobel Memorial Prize in Economic Sciences.

"The confidence people have in their beliefs is not a measure of the quality of evidence, but of the coherence of the story the mind has managed to construct."

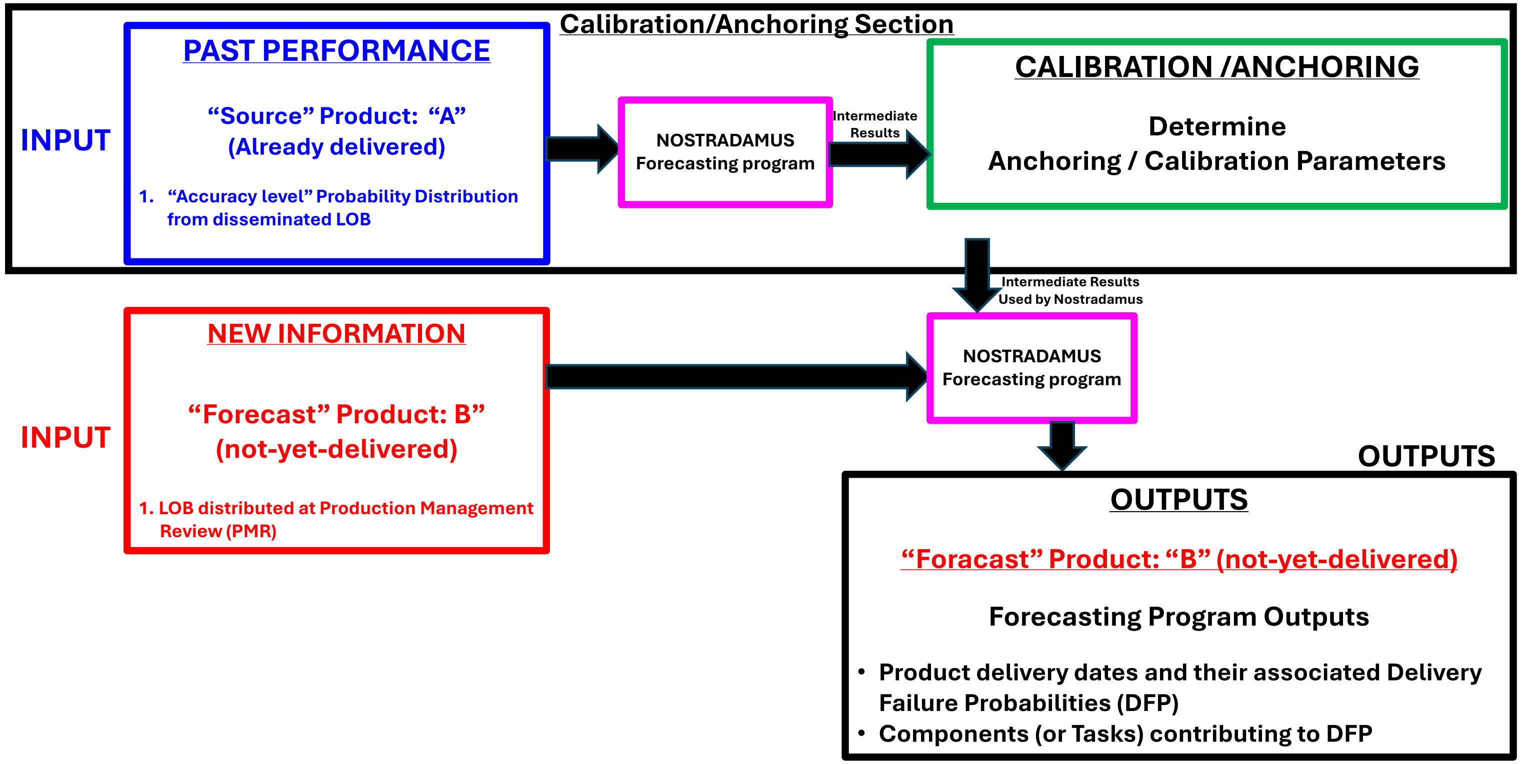
Daniel Kahneman

† *Chehroudi, et al., 2023. Novel and Evidenced-Based Project Duration Forecasting for Acquisition Programs Characterized by Low-Volume Highly-Complex New Product Development, NDIA I/ITSEC 2023 Conference (iitsec.org), Nov 27-Dec 1, Orlando, FL (Accepted). For Abstract see https://sites.google.com/site/brucechehroudi/news.*

Forecasting METHOD I: Use of Line-of-Balance (LOB) information

Input and Output of NOSTRADAMUS Schedule Forecasting

- **A probabilistic approach.**
- **A recently-delivered product was used for calibration/ anchoring to forecast delivery date for a not-yet-delivered product.**
- **<u>METHOD I</u> assesses the "accuracy level" of the supplier-provided information in the LOB of a recently-delivered product and combines it with updated information on a not-yet-delivered one to generate its delivery date forecasts.**
- **Quantifies extent to which each remaining task is contributing towards the delivery failure.**



Chehroudi, et al., 2023. Novel and Evidenced-Based Project Duration Forecasting for Acquisition Programs Characterized by Low-Volume Highly-Complex New Product Development, NDIA I/ITSEC 2023 Conference (iitsec.org), Nov 27-Dec 1, Orlando, FL (Accepted). For Abstract see https://sites.google.com/site/brucechehroudi/news.

<u>LOB</u>: Line of Balance, consists of a list of product's major components (or major tasks) and their expected completion dates (ECDs) along with an estimate of the fully-assembled product delivery date, all prepared by the manufacturer.

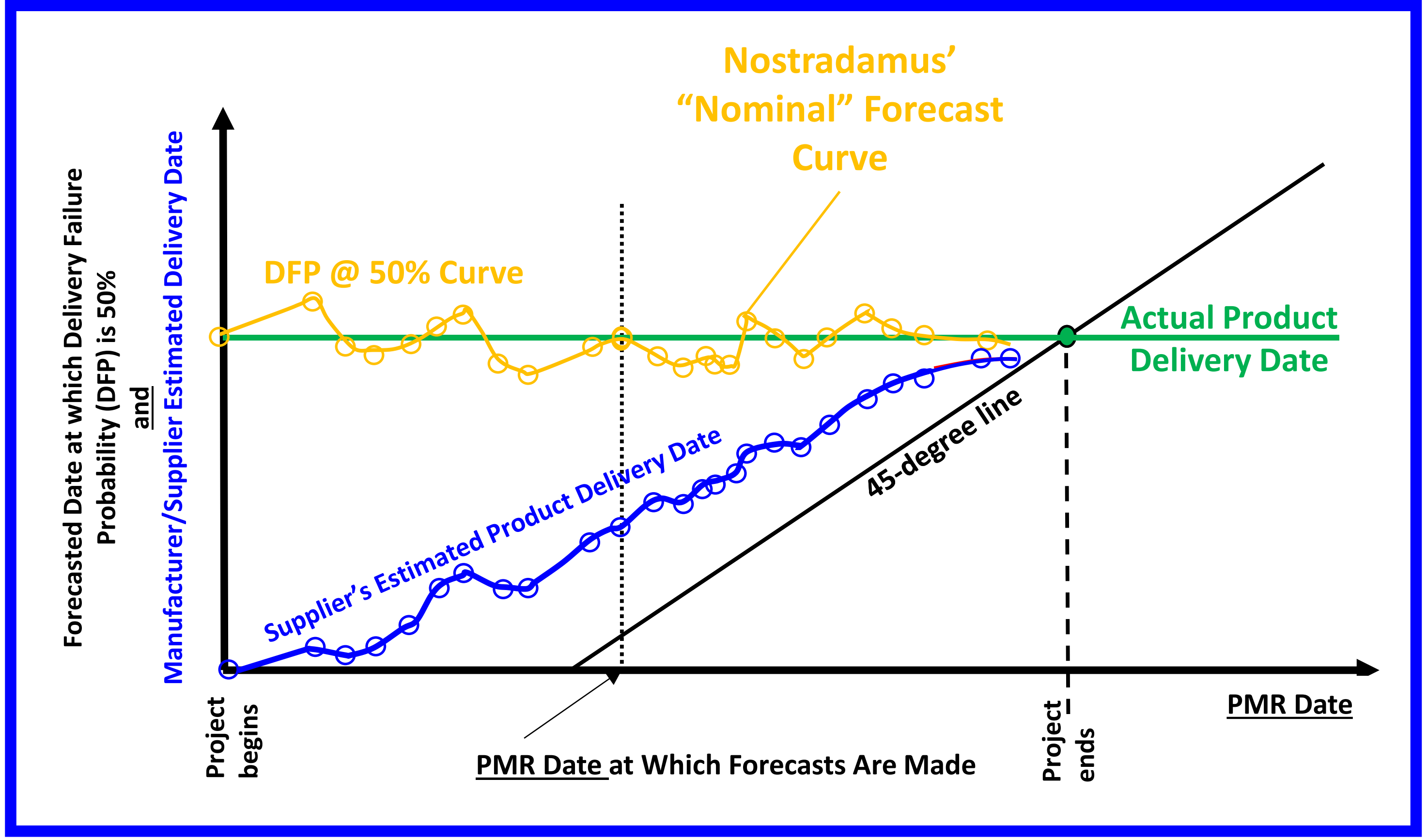
<u>A: "Source" product,</u> is a product that has already been delivered (usually the recently delivered).
<u>B: "Forecast" product,</u> is a not-yet-delivered product for which schedule forecasting is desired.

Forecasting METHOD I: Use of Line-of-Balance (LOB) information

How Good is the Nostradamus' Historical Forecasts?

- **Bottom blue-colored curve is the SEPDD at different PMR dates.**
- **Nostradamus forecasts (i.e., top curve) were made when the product was not yet delivered.**
  - For every future date from PMR date, Nostradamus determines a Delivery Failure Probability (DFP).
  - Date at DFP of 50% is the "nominal" forecast.
- **Nostradamus' forecasts along with Manufacturer's estimated delivery dates (i.e., SEPDD) converge to actual product delivery date, which is a point on the 45-degree line.**
- **IMPORTANT: even at the beginning of the project (in this case, over 2 years before actual delivery) Nostradamus "Nominal forecast" was impressively on target.**
- ***Time-averaged forecast imprecision:***
  - Nostradamus: 5 to 27%
  - Supplier/Manufacturer: 144%

Actual data from past USG Acquisition Program is used



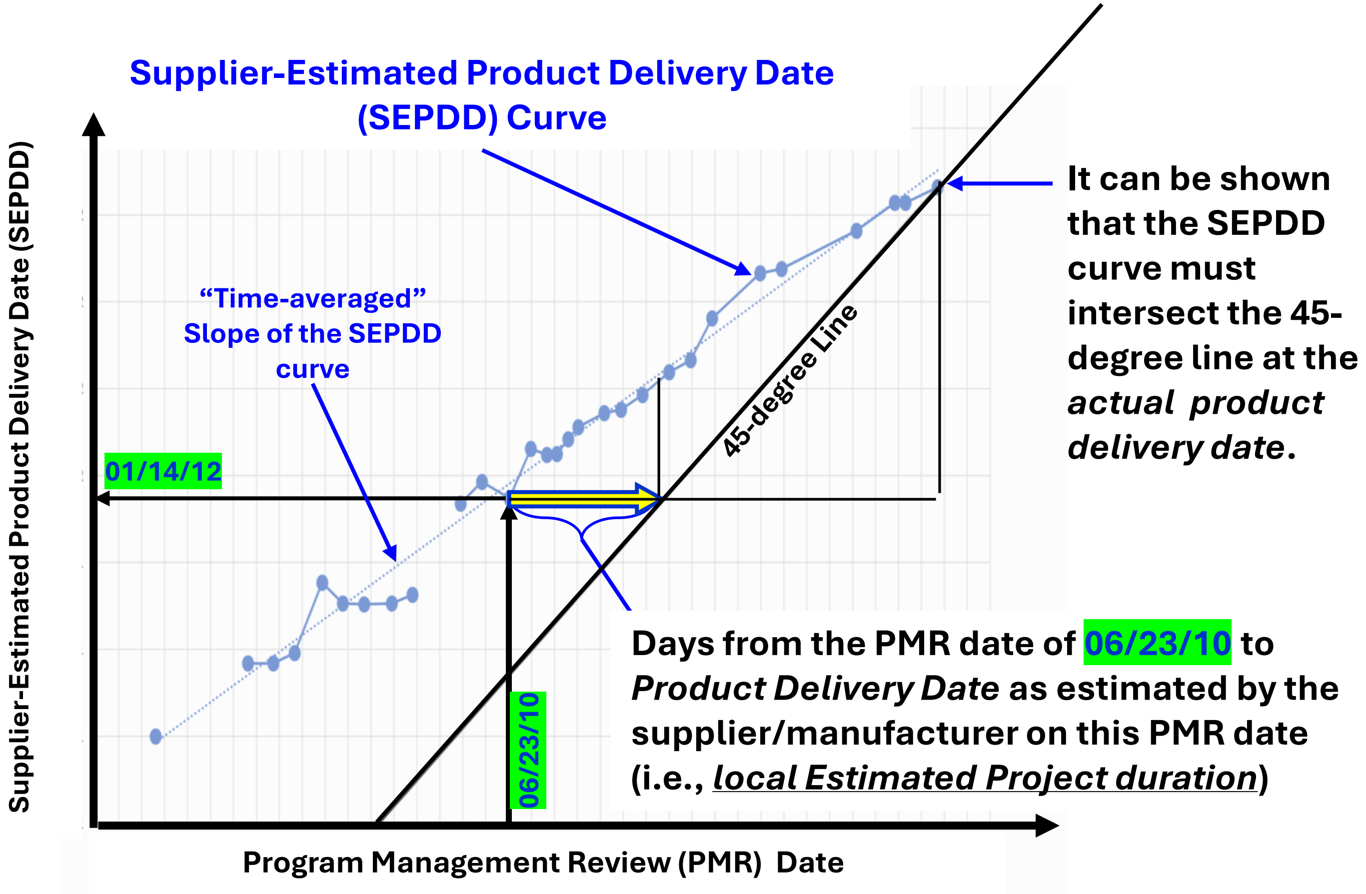
Note: X-axis and Y-axis scales are not the same

DFP: Delivery Failure Probability
PMR: Program Management Review
SEPDD: Supplier-estimated product-delivery date

Forecasting METHOD II: When Only the SEPDD Is Available (no LOB)

The Supplier-Estimated Product-Delivery-Date (SEPDD) Curve and the Concept of Progress Speed

- **Not a probabilistic approach.**
- **"<u>Progress Speed</u>" concept: Speed with which a project progresses to reach the finish line.**
  - For manufacturing projects, we refer to this as "Manufacturing Progress Speed (MPS).
- **"<u>Time-averaged</u>" Progress Speed = 1 – ("Time-averaged" Slope of the SEPDD curve) for the entire project. Used for delivery forecasting.**
  - *Time-averaged* MPS = *Average* number of days reduced from project's remaining duration per calendar day passed.
  - Progress speed limit = 1.
- **"<u>Local</u>" Progress Speed = 1 – ("Local" Slope of the SEPDD curve). Used for assessment & monitoring of local progress state.**
  - *Local* MPS = Days reduced from (if positive), or added to (if negative), the project's "*local*" remaining duration per calendar day passed.



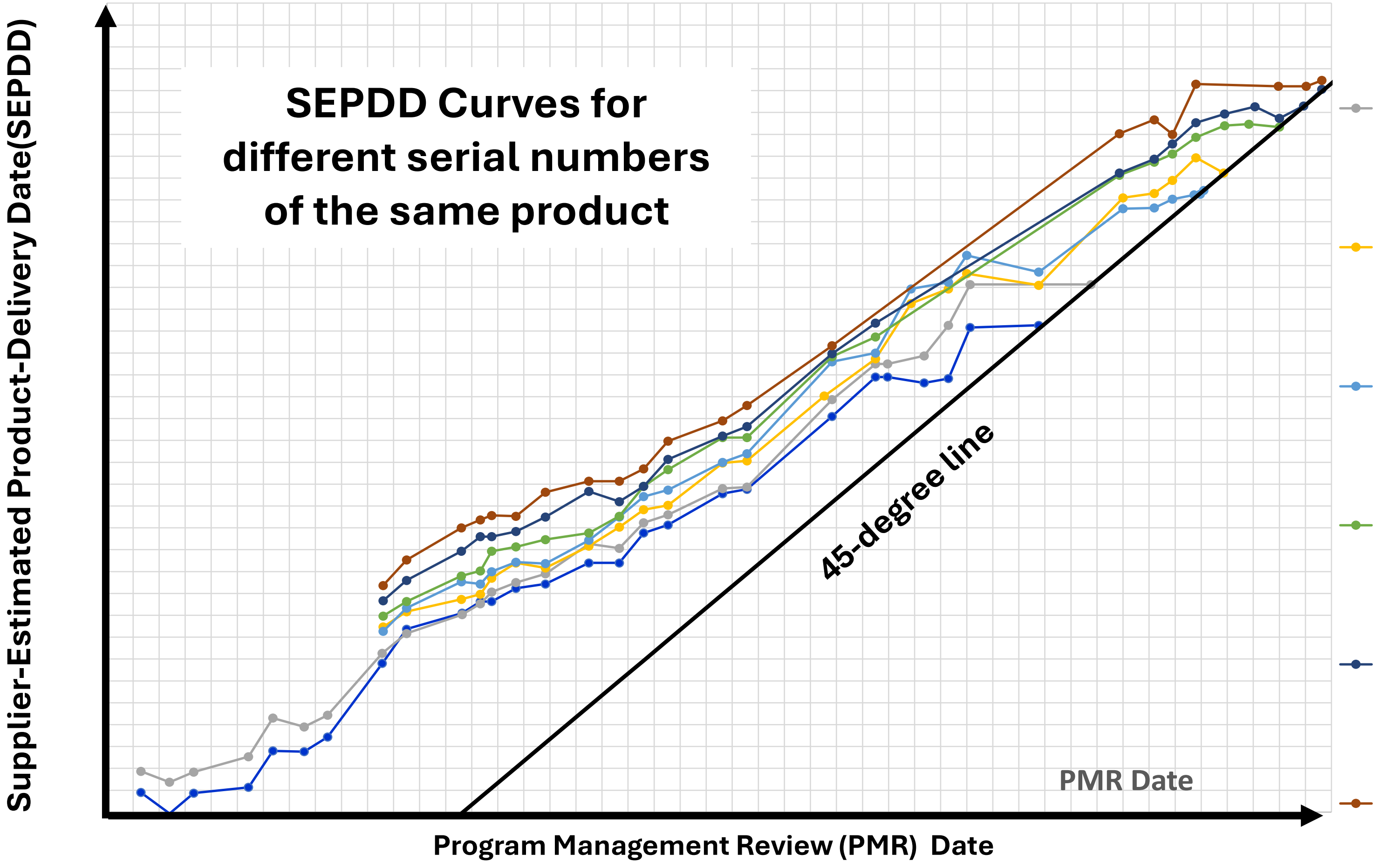
Note: X & Y axes scales are not the same

Forecasting METHOD II: When Only the SEPDD Is Available (no LOB)

Supplier-Estimated Product Delivery Date (SEPDD) for Different Serial Numbers

- **Historical changes of the Supplier-Estimated Product-Delivery Date (SEPDD) curve for different product serial numbers are shown.**

- **Similarities are observed amongst the SEPDD trajectories of different serial numbers delivered from the same manufacturing assembly.**



NOTE: X & Y axes scales are not the same.

SEPDD: supplier-estimated product-delivery date.
LOB: Line-of-Balance
PMR: Program or Production Management Review (monthly)

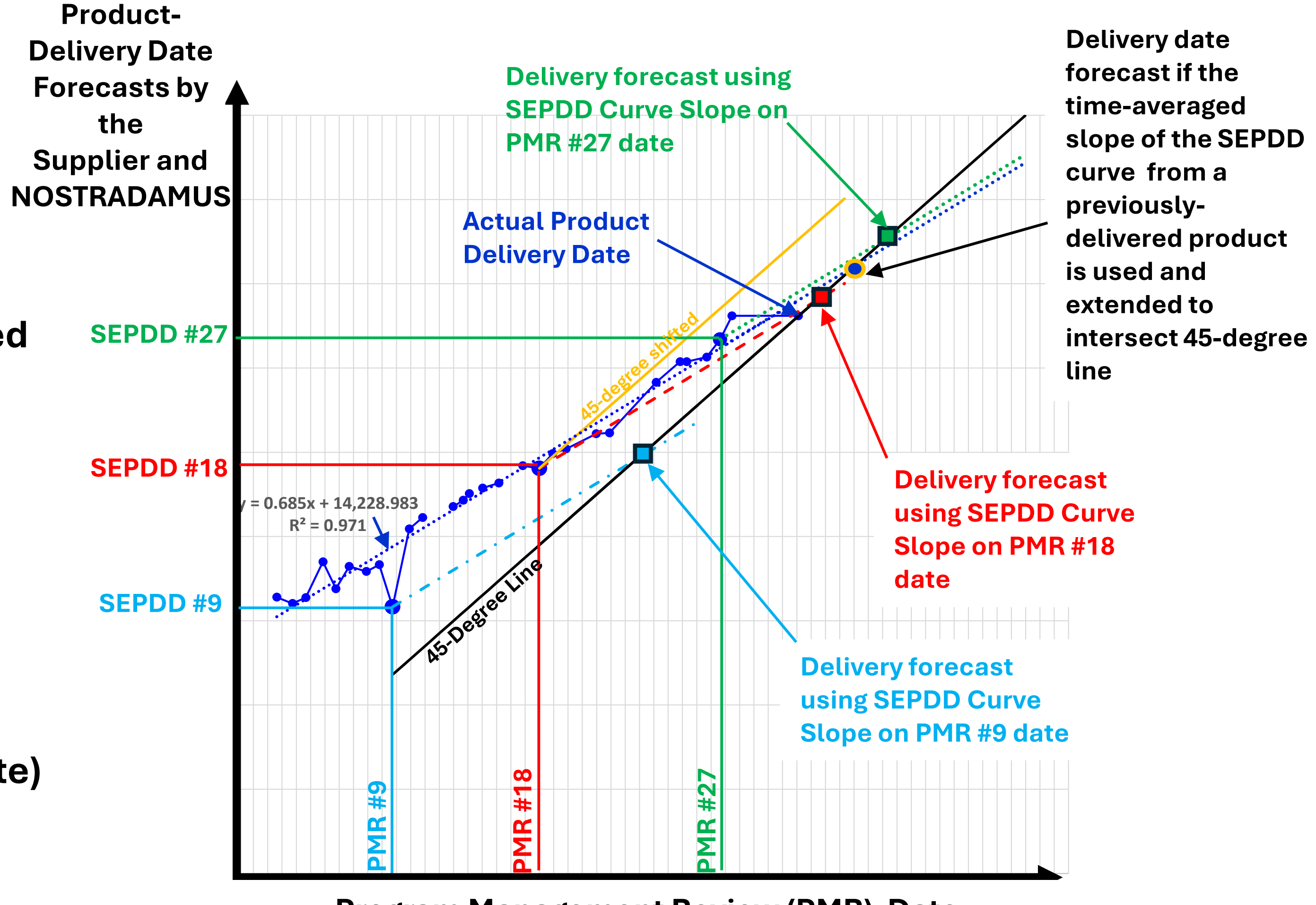
Forecasting METHOD II: When Only the SEPDD Is Available (no LOB)

Time-averaged Slope of the SEPDD Curve to Forecast Delivery Date – How Good Is it?

	Forecast Imprecision [%]	
PMR#	NOSTRADAMUS 2.0	MANUFACTURER
PMR#9	-39%	81%
PMR#18	6%	67%
PMR#27	107%	34%

Imprecision = (Forecasted Duration - Actual Duration) / (Actual Duration)
Note: Negative imprecision value implies that the forecast is earlier than the actual delivery date

- **Intersection point of a line possessing a time-averaged slope (determined from a recently-delivered product) with the 45°-line is NOSTRADAMUS delivery date forecast.**
- **Even when *only one delivery date* is provided by the supplier at a given PMR and *nothing else*, METHOD II produces forecasts with relatively good imprecision.**
- **Generally better imprecision values (i.e., more accurate) observed, earlier during a project (see Table).**
- **Recalling that Slope = (1 – MPS), adjustments in MPS is likely needed towards the end of the project (the *"project-end-effect"*).**



Note: All "dotted" and "dashed" lines are parallel because they use the same slope (i.e., 0.685) as that for the "time-averaged" slope of the SEPDD Curve determined from a recently-delivered product.

SEPDD: supplier-estimated product-delivery date.
LOB: Line-of-Balance
PMR: Program or Production Management Review (monthly)
MPS: Manufacturing progress speed = (1 – Slope of the SEPDD Curve)

Progress State Assessment and Monitoring of NOSTRADAMUS 2.0

Interpretation and Importance of the *Local* Slope of the SEPDD Curve

- **"Local" Progress Speed**: the speed with which a project progresses (from PMR1 to PMR2) to reach the finish line.
- **"Local" Manufacturing Progress Speed (MPS) = 1 – "local" Slope of the SEPDD Curve.**
  - Example: If local Slope = 0.68 → local MPS = 0.32. It means, per each calendar day passed, the project' remaining duration is reduced by 0.32 days.

- **Interpretations given below are supported in different and complementar**

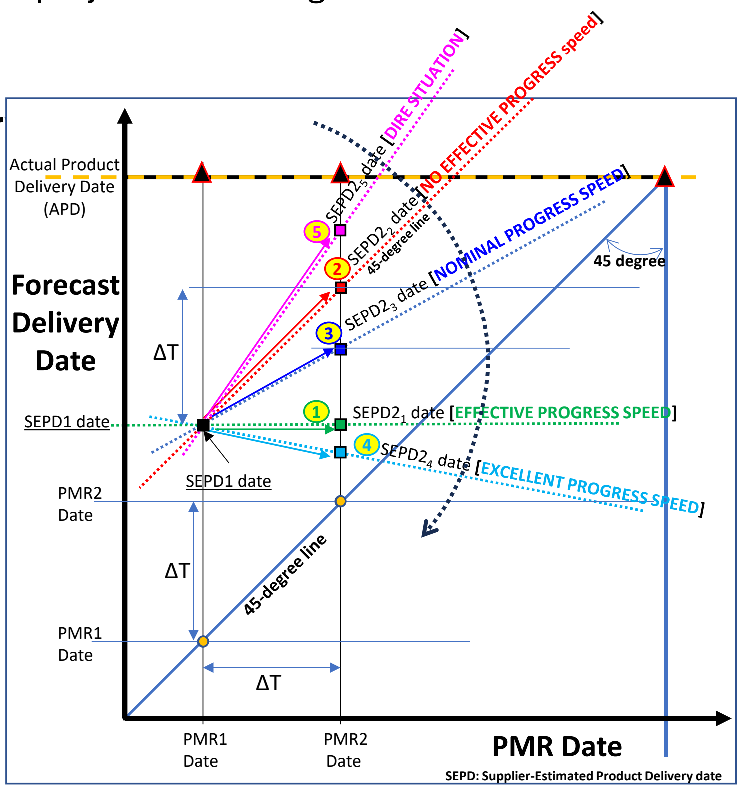
1. **Zero local slope: EFFECTIVE PROGRESS SPEED**
   (i.e., time lapse between the two PMRs is used effectively).

2. **45° local slope (slope = 1): NO EFFECTIVE PROGRESS SPEED**
   (from the product-delivery-schedule perspective only, it was not effective).

3. **Positive but less than 45° local slope (0<slope <1): NOMINAL PROGRESS SPEED.**

4. **Negative local slope: EXCELLENT PROGRESS SPEED.**

5. **Positive but higher than 45° local slope (slope >1): DIRE SITUATION.**

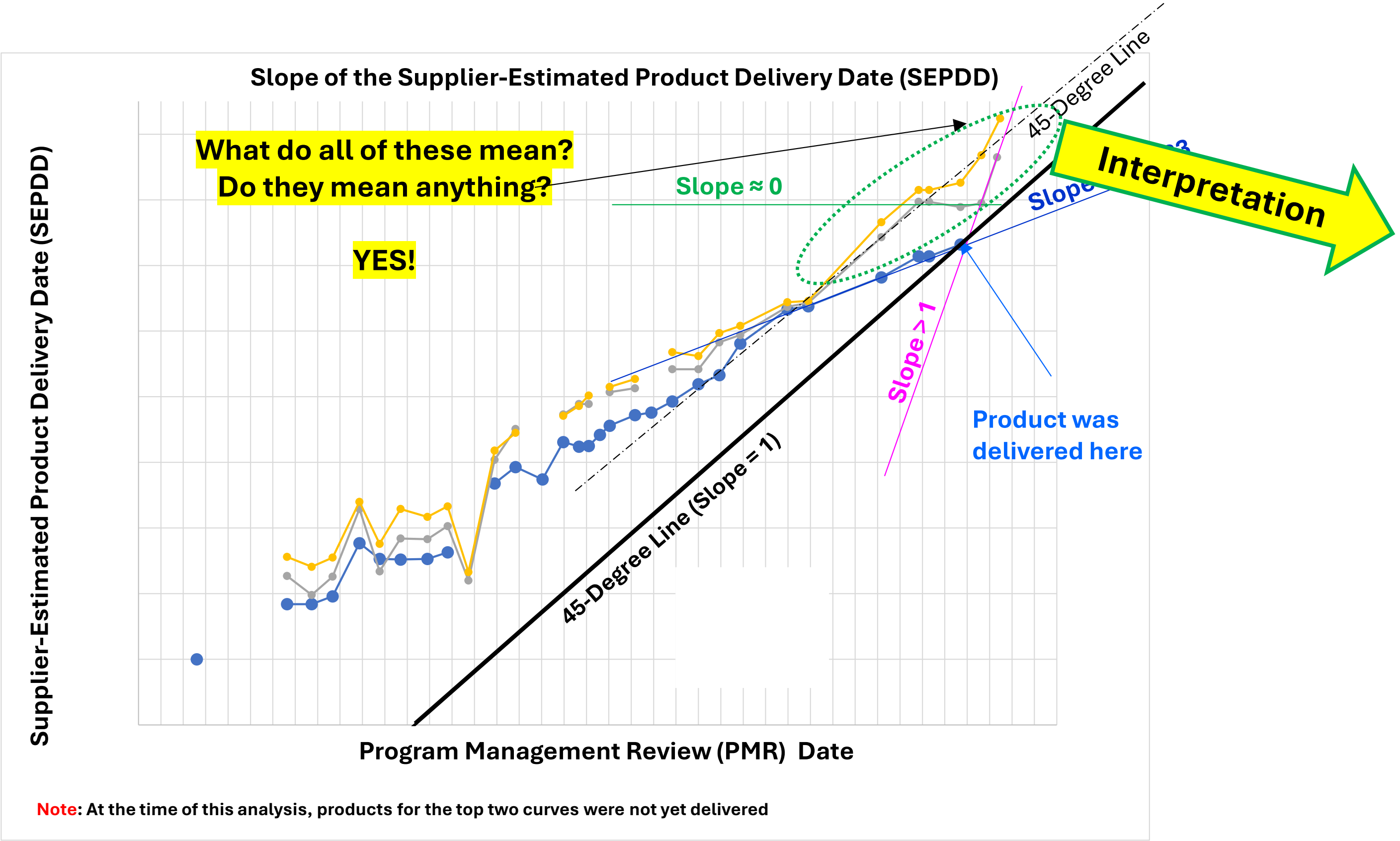


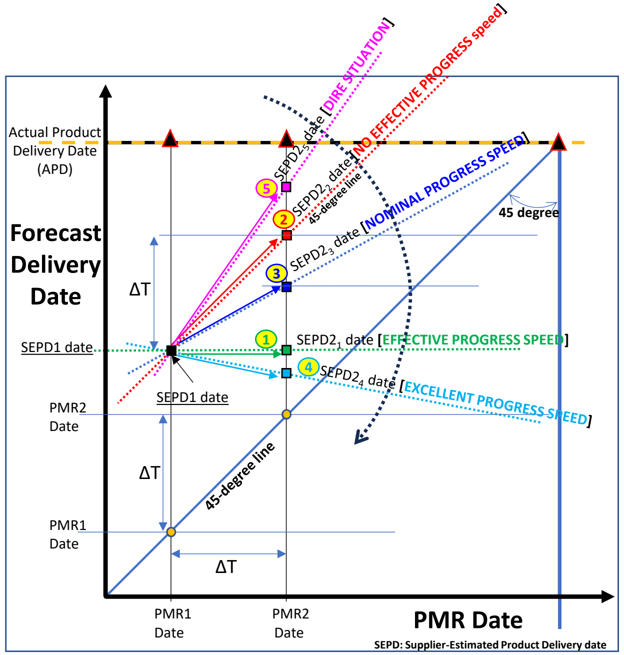
Note: Cases 2 and 5 are special cases for the Case 3.

SEPDD: supplier-estimated product-delivery date.
PMR: Program or Production Management Review (monthly)
MPS: Manufacturing Progress Speed = 1 – (Slope of the SEPDD curve)

Progress State Assessment and Monitoring of NOSTRADAMUS 2.0

Interpretation of *Local* Slope Variations Was Verified by Project Reports





Note: Cases 2 and 5 are special cases for the Case 3.

- **Can we extract some useful "progress" information from the "local" slopes? YES**

- **Interpretation of the Local Slope Variations was verified by detailed project reports.**
- **Several verification cases from a large-scale USG acquisition program are used.**

Summary and Conclusions I

- **Nostradamus Schedule forecasting tool uses both *past performance* and *current information* from the product manufacturer to provide accurate forecasts.**

- **Depending on the information provided by the manufacturer/supplier, NOSTRADAMUS 2.0 selects one of the following methods to forecast product delivery dates.**

    - **METHOD I: Line-of-Balance (LOB) is disseminated by the manufacturer/supplier.**

        - METHOD I assess the “accuracy level” of the information in the LOB of a recently-delivered product and combines it with updated information on a not-yet-delivered one to generate its delivery date forecasts.

    - **METHID II: only supplier-estimated product-delivery date (SEPDD) is shared (no LOB).**
        - METOD II is based on the concept of time-averaged *manufacturing progress speed (MPS)*. It determines “time-averaged” slope of the SEPDD curve from a recently-delivered product and combines it with updated information on a not-yet-delivered one to generate its delivery date forecasts.

        - “Time-averaged” Progress Speed = 1 – (“Time-averaged” Slope of the SEPDD curve).
            - It quantifies the average number of days reduced from the project’s remaining duration per calendar day passed.
            - “Time-averaged” Progress Speed Limit = 1.

- **When compared to manufacturer-estimated product delivery date, Nostradamus 2.0’s product delivery forecast has nearly *always been better and closer to the actual product delivery date*. This is true especially and consistently at early stages of the project.**

Questions?

Summary and Conclusions II

- **For project progress state and speed, the concept of "local" Progress Speed is used.**
  - "Local" Manufacturing Progress Speed = 1 – ("Local" Slope of the SEPDD Curve)
- **Depending on the "local" slope of the SEPDD curve, total of 5 cases are presented, characterizing the progress state of an acquisition project at the time when a Program Management Review (PMR) is held.**
- **It was demonstrated that different *"local"* slope values have different interpretations for the progress state of a project:**
  - Dire Situation (Slope >1),
  - No Effective Progress Speed (Slope =1),
  - Nominal Progress Speed (Slope <1),
  - Effective Progress Speed (Slope =0), and
  - Excellent Progress Speed (Slope <0).
- **Monitoring and characterization capabilities of the SEPDD curve's *local* slope were verified by actual data from a large-scale USG acquisition program.**

Questions?

Acknowledgements

- **Support of the following organizations are acknowledged:**
  - **US Space Force, for initial authorization, financial and human resource support of this innovation.**
  - **ManTech International, for continued support of this activity and further marketing at the USG level.**
  - **Astrion (formerly Axient), for support of this activity.**

Backup Slides

Dr. B. Chehroudi, accumulated years of technical/leadership experiences in different organizations. This includes, Mechanical Engineering Dept Head (Arkansas Tech Univ), Managing Director (Advanced Technology Consultants), Principal Scientist appointment at AFRL (ERCInc), Chief Scientist (Raytheon STX), Visiting Technologist (Ford's Advanced Manufacturing Technology Development center), tenured Professor of Mechanical Engineering (Kettering University and University of Illinois), and Senior Research Fellow (Princeton University). He directed numerous interdisciplinary projects in chemically-reacting flows, combustion and pollutants emissions in engines, sustainable/alternative energy sources, distributed fuel ignition, material/fuel injection, advanced pollution-reduction technologies, propulsion concepts, gas turbine and liquid rocket engines, combustion instability, laser optical diagnostics, spectroscopy, supercritical fluids with applications in environmental and propulsion, advanced composites, and nanotechnology in propulsion. He has won many merit/leadership awards from SAE (Arch. T. Colwell Merit Award (to only top 1%), Forest R. McFarland Award, Outstanding Faculty Advisor, Sustained Leadership in Professional Service), AIAA (Best Publication Award of the Year), AFRL (Outstanding Technical Publication Award, STAR Team Award), ILASS (Marshall Award), and has been a consultant for many organizations. He has PhD & MS in mechanical/aerospace engineering (Princeton Univ and SMU), MS in Finance/Management (Swiss Finance Institute), and is a senior AIAA Propellant/Combustion Technical Committee member and AIAA Associate Fellow. He delivered over 200 technical presentations, has over 150 publications with extensive experience in scientific, management, and finance areas.

Dr. Chehroudi's website: *https://sites.google.com/site/brucechehroudi/home*

Different Phases of a Project

- **In project management, one is always interested in project *progress* and *duration* (which affects *cost* & *resource distribution*).**

- **Distinction between *planning (or decision-making) phase* and actual *implementation phase* of a project.**

- **Objective forecasts of the project duration is paramount in both phases.**
  - **Planning phase: Interest is on *cost-benefit analysis* (helpful tool in public investment policy/planning).**
  - **Implementation phase: Interests are in,**
    - **Project's progress (compared to what was planned),**
    - **Cost overruns, and**
    - **Identification of possible measures to compensate for any project delays.**

Background (I): Cognitive and Other Biases in Forecasting

- **Cost-benefit analysis, if not practiced carefully, is of less value due to biases in its process.**
- **Biases in forecasting can be explained better through Psychological and political sources.**
  - Psychological source: "*optimism bias*, " a cognitive predisposition with most people to judge future events in a more positive manner than is warranted by actual experience.
  - Political source: comes from *strategic misrepresentation*.
- **Optimism bias explanation was developed by *Nobel prize winning work* of Daniel Kahneman.**
- **Kahneman, et al: Human judgement is generally optimistic because of "*overconfidence*" and "*insufficient regard to distributional information*."**
  - People will underestimate the project costs, completion times, and risks of planned actions, whereas they will overestimate the benefits of the same actions.
- **They referred to such a common behavior as the "*planning fallacy*" :**
  - It comes from people/forecasters who take an "*inside view*" by focusing on the constituents of the specific planned actions or tasks rather than on the *outcomes of similar actions or tasks* that have already been completed.

Professor Daniel Kahneman is an Israeli-American psychologist and economist (Princeton University) known for his work on the psychology of judgment and decision-making, as well as behavioral economics, for which he was awarded the 2002 Nobel Memorial Prize in Economic Sciences.

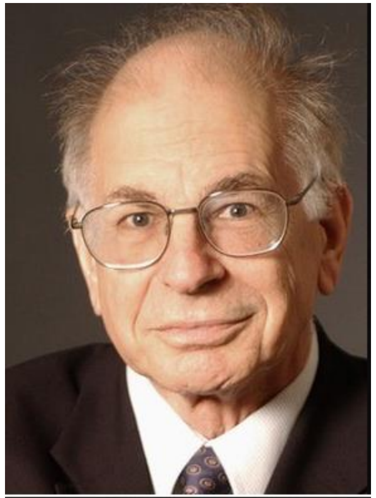
Background (II): Nobel Prize Winning Solution for Cognitive Biases in Forecasting

- **To compensate for the *cognitive bias* the "*reference class forecasting (RCF)*" approach was proposed (won Kahneman the 2002 Nobel Prize in economics).**

- **This approach/concept can bypass human bias.**

- **Experimental research: this method was shown more accurate than conventional forecasting methods.**

- **These same authors demonstrated that,**
  - Errors of judgement are often systematic and predictable than being random, suggesting *bias* rather than *confusion*.
  - Interestingly, such errors in judgment are shared by both laymen and experts alike and that errors remain compelling even when the actor or forecaster is fully aware of their nature.



"The confidence people have in their beliefs is not a measure of the quality of evidence, but of the coherence of the story the mind has managed to construct."

Daniel Kahneman

Nostradamus – A Novel Schedule Forecasting Approach

- **Nostradamus, while different in mechanics from RCF, maintains/implements the concept behind the reference class** (i.e., minimizing cognitive biases and provides an objective/accurate forecast of the project duration).

- **Nostradamus was born after realization that existing conventional forecasting approaches were not performing satisfactorily for <u>low-volume, highly-complex</u> new product development (NPD) efforts practiced under USG acquisition process.**

- **Situation we had to deal with:**
  - Forecasting for a new product that has not been built in USA.
  - Hence, departure from past experiences was sufficiently far (i.e., high uncertainty in design, analysis, and particularly manufacturing).
  - Manufacturing process improvements ("learning curve effect") are to be considered.
  - Early-stage application (i.e., high uncertainties)
    - ❖ However, Nostradamus 2.0 can also be used at later stages when manufacturing reaches maturity.

Michel de Nostredame (December 1503 – July 1566), usually Latinised as Nostradamus, was a French astrologer, apothecary, physician, and reputed seer, who is best known for his book Les Prophéties (published in 1555), a collection of 942 poetic quatrains allegedly predicting future events. Some of his prophecies appeared to be fulfilled, and his fame became so widespread that he was invited to the court of Catherine de Médicis, queen consort of Henry II of France, where he cast the horoscopes of her children.
Source: Wikipedia

Line-of-Balance (LOB)

Input Information from Manufacturer or Supplier

Production Monthly Review (PMR) date

Manufacturer's Estimated Product Delivery or Project Completion Date (ECD)

Task (or Component) #11

- Different "Components" of the product, assembly of which defines the final product.
- Different "Tasks" of the project, completion of which defines the end of the project.

#	Item	PMR1	PMR2	PMR3	PMR4	PMR5	PMR6	PMR7	....
	PMR Date -->	5/10/2010	6/8/2010	7/9/2010	8/3/2010		10/14/2010	....	....
	PROGRAM								
	Product Delivery Date	6/27/2010	10/25/2010						
	SECTION 1								
1	Component 1a	6/2/2010	10/6/2010						
2	Component 1b	4/10/2010	8/29/2010						
3	Component 1c	6/1/2010							
4	Component 1d								
5	Component 1e	6/1/2010	8/7/2010						
	SECTION 2								
6	Component 2a	5/15/2010	1/24/2011						
7	Component 2b		6/5/2010						
8	Component 2c	5/15/2010	5/22/2010						
9	Component 2d								
10	Component 2e		6/16/2010						
11	Component 2f		8/7/2010						
12	Component 2g								
13	Component 2h		4/7/2010						
14	Component 2i								
15	Component 2j		6/16/2010						
16	Component 2k		6/16/2010						
17	Component 2l		4/28/2010						
18	Component 2m								
19	Component 2n	5/14/1920	5/12/2010						
20	Component 2o								
	SECTION 3								
21	Component 3a	4/20/2010	5/18/2010						
22	Component 3b	5/30/2010	7/20/2010						
23	Component 3c	5/1/2010	6/29/2010						
24	Component 3d	5/10/2010	7/27/2010						
25	Component 3e	5/1/2010	7/7/2010						
	SECTION 4								
26	Component 4a	3/7/2010	3/27/2010						
27	Component 4b	5/8/2010	8/10/2010						
28	Component 4c	5/24/2010	10/4/2010						
29	Component 4d	5/4/2010	8/8/2010						
30	Component 4e	1/26/2010	5/24/2010						
31	Component 4f	12/8/2009	1/23/2010						
32	Component 4g	5/4/2010	1/23/2010						
	SECTION 5								
33	Component 5a	7/18/2010	9/13/2010						
34	Component 5b		6/30/2010						
35	Component 5c	5/15/2010	9/22/2010						
36	Component 5d		9/22/2010						
37	Component 5e	5/15/2010	6/9/2010						
38	Component 5f	5/29/2010	9/29/2010						
	SECTION 6								
39	Component 6a	6/13/2010	8/9/2010						
40	Component 6b								
41	Component 6c								

Estimated Completion Date (ECD) for the Task #11 (or Component #11) disseminated by the manufacturer on the PMR date of 6/8/2010 (i.e., PMR2).

Input and Output of NOSTRADAMUS Schedule Forecasting

Calibration/Anchoring Section

INPUT

Past performance

"Source" Product: "A"

Input data structure: List of major components (or tasks) of the product (or project) along with their Estimated Completion Dates (ECDs).
Input data provided by: Product manufacturer, project manager, or service provider.
Frequency: Once, and at the completion of the "first" product or project.
Input file format: Microsoft Excel.

NOSTRADAMUS Forecasting program

Intermediate Results

Anchoring/Calibration

Anchoring or Calibration parameters: These parameters are determined after delivery (or completion) of the "first" product "A" (or project). Or, parameters are determined by manufacturer's (or provider's) past performance, *if this "first" product is not yet completed*.
Parameters: Accuracy-level Probability Distribution Function (PDF) along with its curve-fit parameters, Lo-Limit, and High-Limit values.
Other information provided: Self-forecasting *imprecision* & *resolution*.

Intermediate Results Used by Nostradamus

INPUT

New Information

"Forecast" Product: "B"

Input data structure: List of major components (or tasks) of the product (or project) along with their ECDs.
Input data provided by: Product manufacturer, project manager, or service provider.
Frequency: Every 2 to 4 weeks, up to the product delivery or project completion date.
Input file format: Microsoft Excel.
Note: Applicable for the second and subsequent *not-yet-delivered* products or projects.

NOSTRADAMUS Forecasting program

Product: "B"

Forecasting program Outputs:

- Product or project *Delivery-Failure Probability (DFP)* at any desired future date.
- Delivery dates for not-yet-delivered product (i.e., "B") at any DFP values (standard DFP values: 95%, 50%, and 10%).
- List of components (tasks) ranked by the weight of contributions to the delivery failure probability.
- *Historical Forecast Curves* (HFCs).
- Visual presentation of each major component's (or task's) ECDs along with its Nostradamus' *forecast range*.
- Once the "B" product is delivered, the Nostradamus and manufacturer's *forecast imprecision* are determined as a function of time. The "B" product is then used as the "source product A" for all other not-yet-delivered products.

A: "Source" product, is a product that has already been delivered. This usually is the most recent product delivered.
B: "Forecast" product, is a not-yet-delivered product for which schedule forecasting is desired
LOB: Line of Balance, consisting of a list of product's major components and their ECDs along with an estimate of the product delivery date, all prepared by the manufacturer.

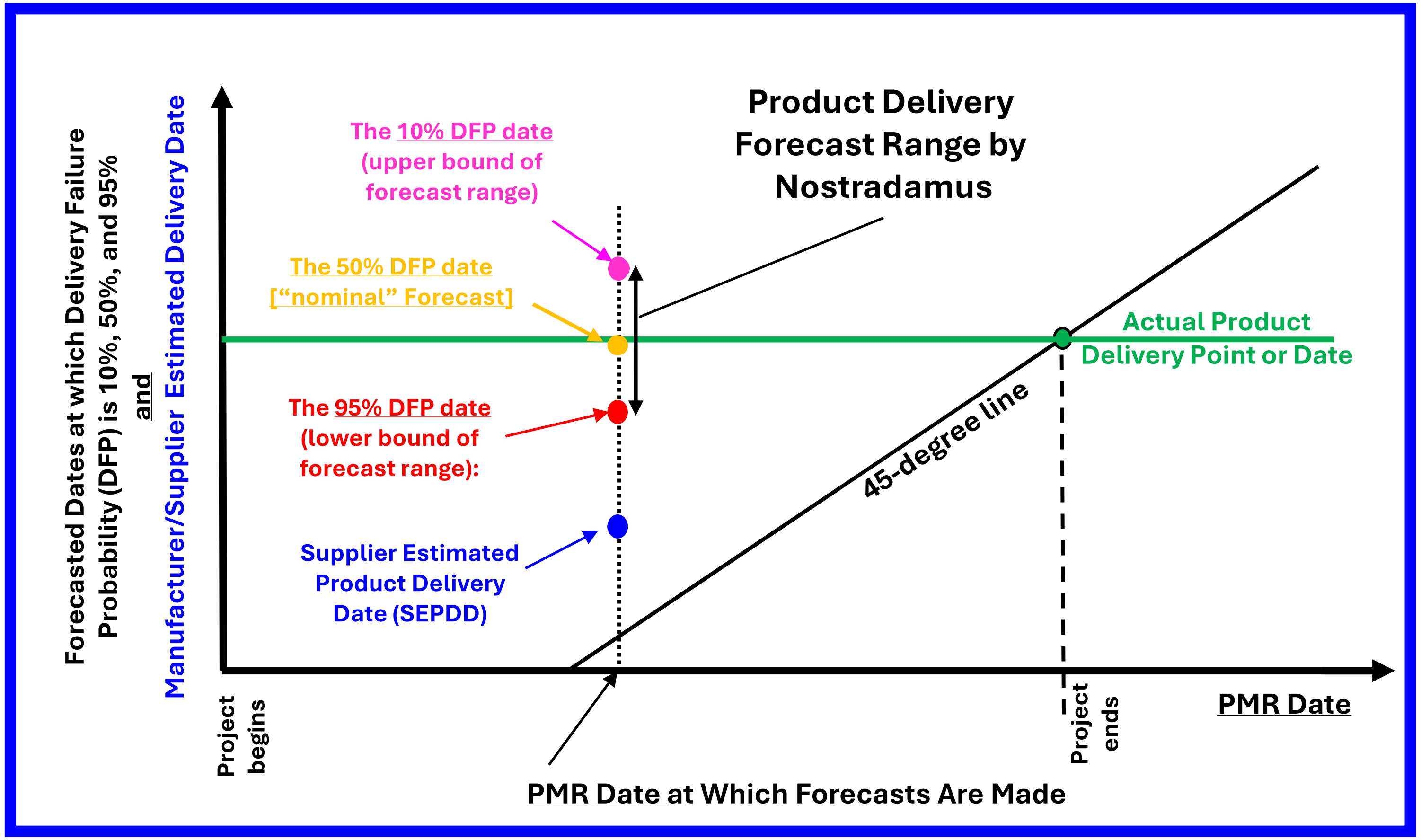
B. Chehroudi, PhD (https://sites.google.com/site/brucechehroudi/home)

Forecasting METHOD I: Use of Line-of-Balance (LOB) information

How Good is the Nostradamus' Historical Forecasts?

Actual data from past USG Acquisition Program is used

- **Nostradamus forecasts were made with no knowledge of when the actual product delivery was going to be.**
- **For every future date, Nostradamus determines a Delivery Failure Probability (DFP).**
- **Nostradamus' forecast range is better in the sense that it is closer to the actual product delivery date (the green horizontal line) than the Supplier-Estimated Product Delivery Date SEPDD).**



DFP: Delivery Failure Probability
PMR: Program Management Review

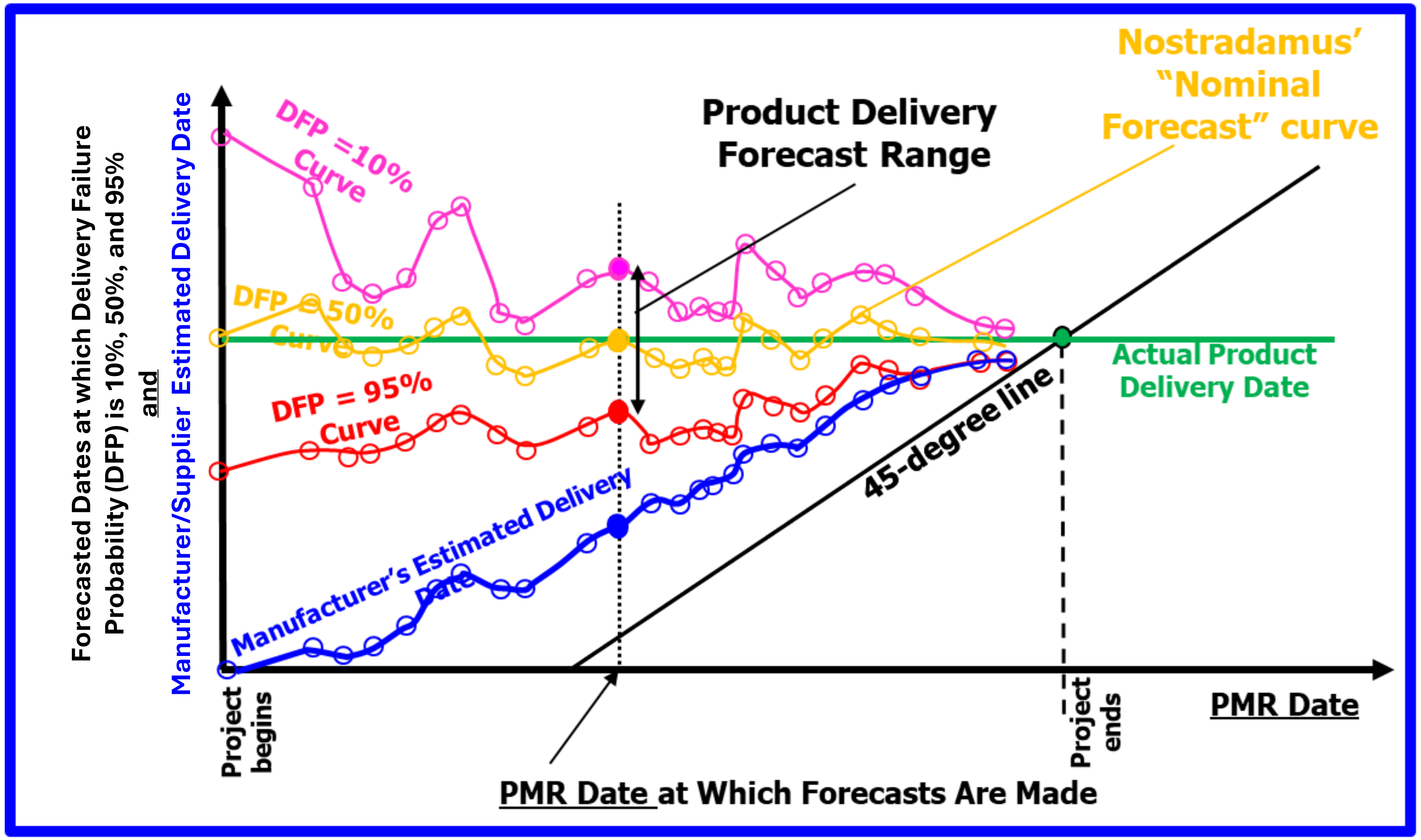
Note: X-axis and Y-axis scales are not the same

Forecasting METHOD I: Use of Line-of-Balance (LOB) information

How Good is the Nostradamus' Historical Forecasts?

- **Bottom blue-colored curve is the supplier-estimated product-delivery date (SEPDD) at different PMR dates.**
- **Nostradamus forecasts (i.e., top three curves) were made when the product was not yet delivered.**
  - For every future date from the PMR date, Nostradamus determines a Delivery Failure Probability (DFP).
- **IMPORTANT: even at the beginning of the project (in this case, over 2 years before actual delivery) Nostradamus "Nominal forecast" was impressing-ly on target.**
- **Nostradamus' forecasts along with Manufacturer's estimated delivery dates (i.e., SEPDD) converge to actual product delivery date, which is a point on the 45-degree line.**

Actual data from past USG Acquisition Program is used



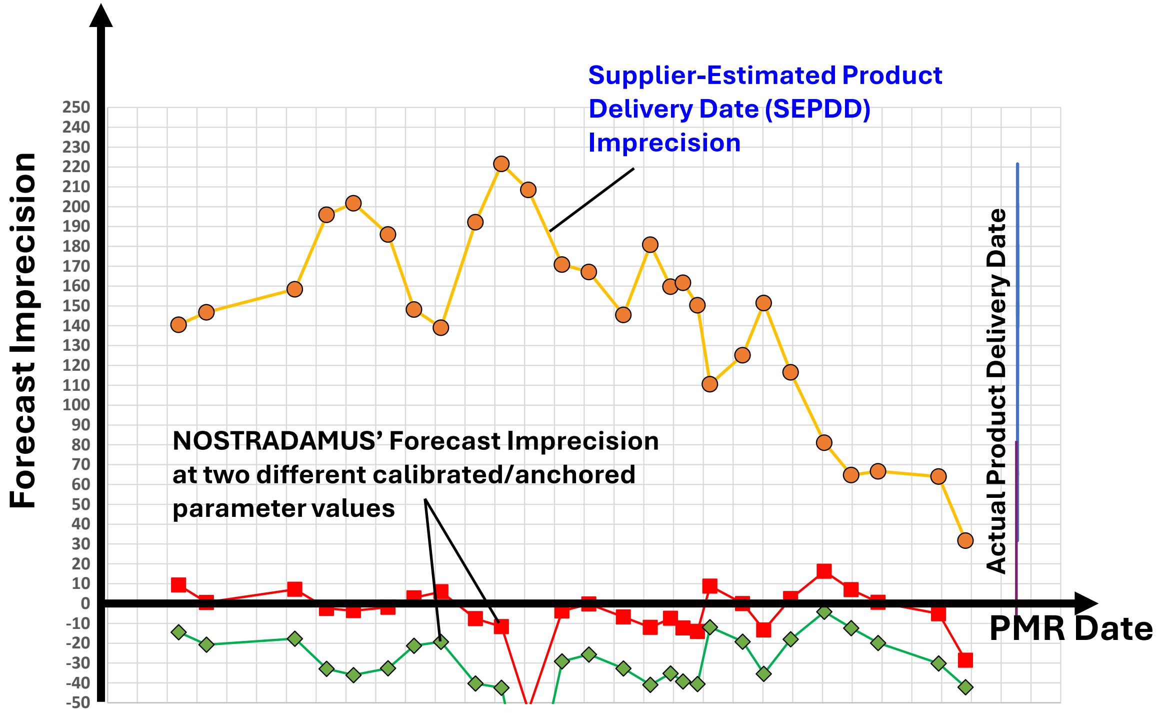
Note: X-axis and Y-axis scales are not the same

DFP: Delivery Failure Probability
PMR: Program Management Review
SEPDD: Supplier-estimated product-delivery date

Forecasting METHOD I: Use of Line-of-Balance (LOB) information

Nostradamus' & Manufacturer's <u>Forecast Imprecision</u> Compared

- **<u>IMPRECISION</u>: How far Nostradamus' past forecast was to the Actual Product Delivery date.**
- ***Time-averaged imprecision* of the Nostradamus' Nominal forecast for the product delivery date (at 50% DFP value):**
-
    - **-5% Nostradamus (with optimum calibration/anchoring parameter)**
    - **-27% Nostradamus (with off-optimum calibration/anchoring parameter)**
- **Time-average imprecision of the Product Delivery Date for manufacturer/supplier is 144%.**



NOTE: Imprecision value of zero means that the "forecasted delivery date" exactly coincides with the "actual" delivery date.