# The Origins of WBS & Management Charts [1]

**By Patrick Weaver**

## Introduction

The purpose of this paper is to consolidate the available information on the creation and evolution of the work breakdown structure (WBS). The introduction incudes a brief précis of a number of previous history papers developed by the author that set the starting point for the creation of various business charts[2]. The next section looks at three chart types for the early 20th century that appear to lay the foundations needed for the creation of the WBS. The final section looks at the initial documentation of the WBS. Where available, some of the more important original documents have been sourced and are now directly linked on the Mosaic website to retain direct access to the source over time. This is a work in progress, in particular there seems to be very little information on developments between the 1920s and 1950s and very little documentation from sources outside of the USA. Any help readers can provide in these areas will be appreciated.

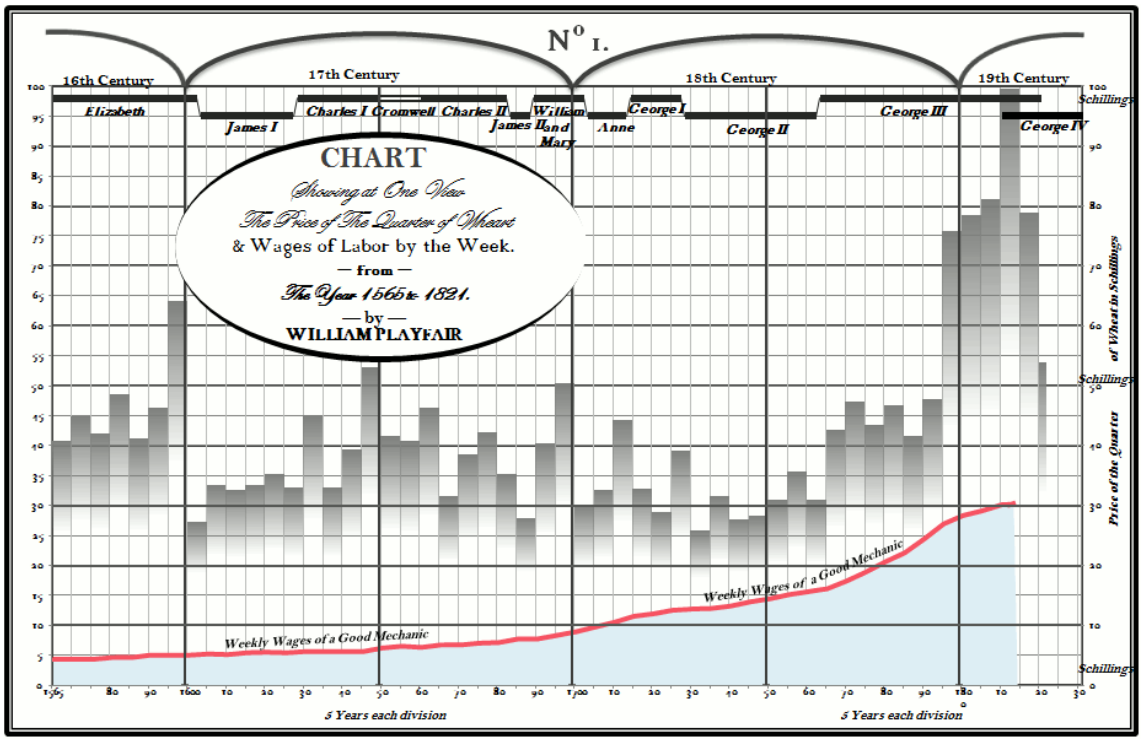
### Origins of business graphics

The use of charts to help understand business data and structures appears to have originated with the work of William Playfair (1759-1823). He is credited with developing a range of statistical charts including the line, bar (histogram), and pie chart[3].

[1] How to cite this paper: Weaver, P. (2021). The Origins of WBS & Management Charts; *PM World Journal*, Vol. X, Issue XII, December.

[2] To access the full collection of ***project management history papers*** developed and maintained by Mosaic Project Services, see: https://mosaicprojects.com.au/PMKI-ZSY.php

[3] Playfair originally published *The Commercial and Political Atlas* in London, in 1786. The chart above is from the 1821 edition of his Atlas. (source: Tufte, 1983, p. 34)

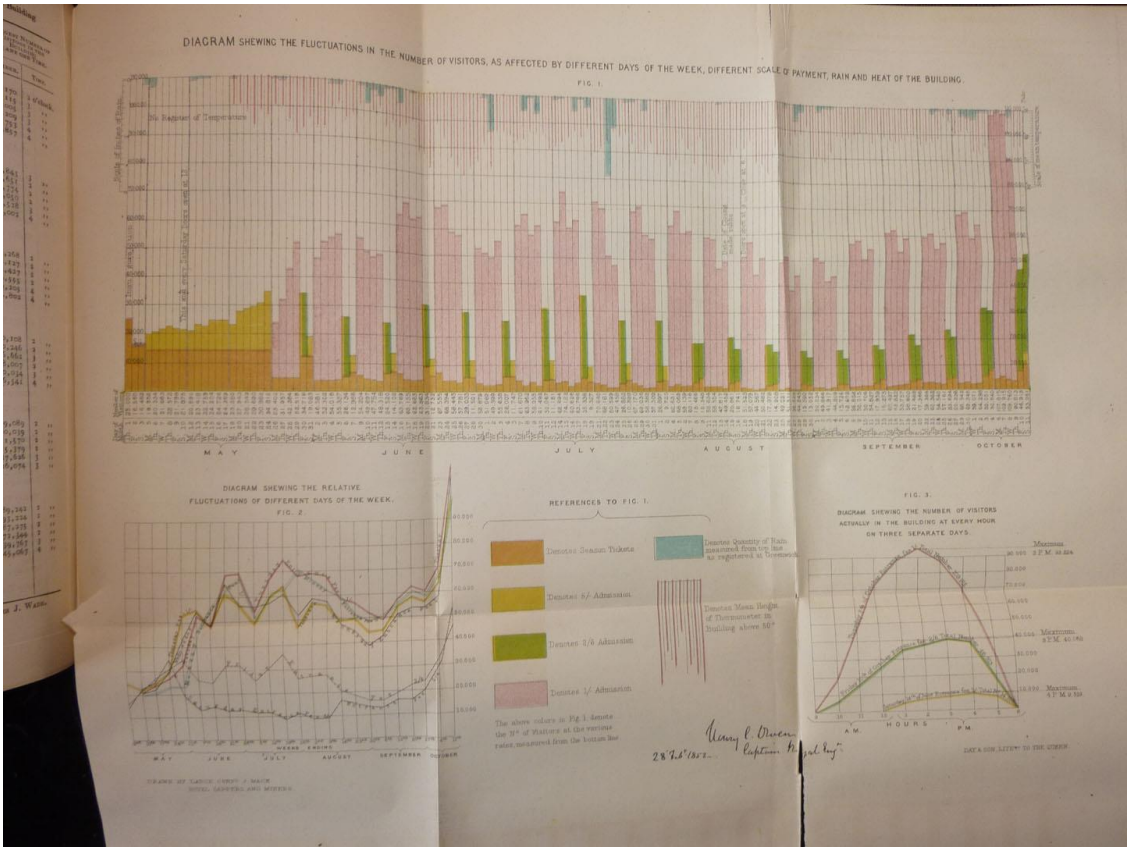



The data presentations invented by Playfair were primarily graphs and histograms designed to show and compare time-series data[4].

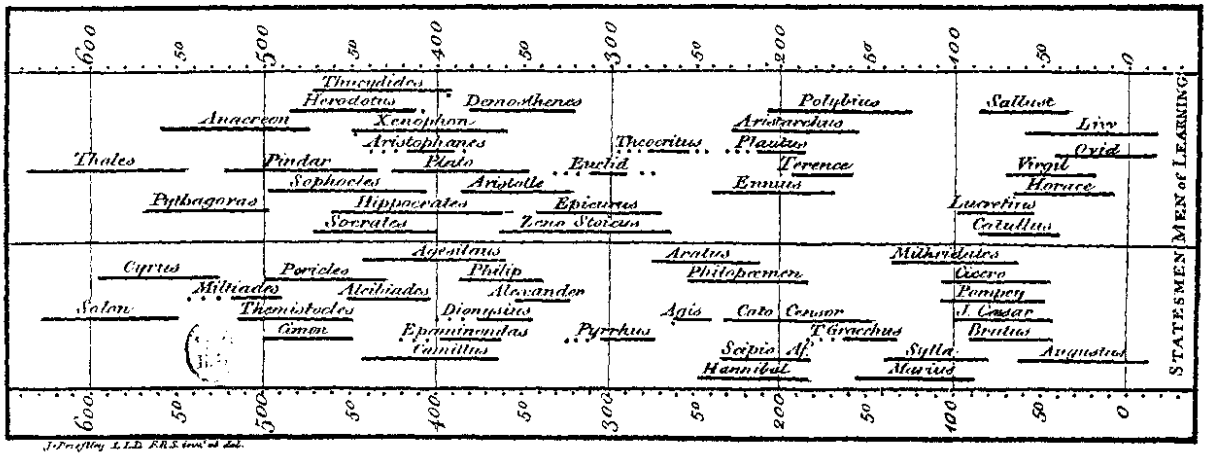
Charts similar to Playfair's are contained in the reports of the Royal Commissioners responsible for constructing the exhibition buildings and facilities, and staging the Great Exhibition in London in 1851[5]:

[4] For more on the development of this type of chart see ***The Origins of Schedule Management: the concepts used in planning, allocating, visualizing and managing time in a project***: https://mosaicprojects.com.au/PDF_Papers/P202_The_Origins_of_Schedule_Management.pdf

[5] For more on the 'Great Exhibition', and the building of the 'Crystal Palace' see ***Project Governance & Control, The Building of the Crystal Palace.*** Note: the very fragile nature of the report prevented a better image being captured: https://mosaicprojects.com.au/PDF_Papers/P180-Project_Governance-Building_the_Crystal_Palace.pdf




Playfair used the same graphical concepts that Joseph Priestley (England, 1733-1804) used in his 1765 *'Chart of Biography'*, a bar chart[6] that plots some 2000 famous lifetimes against a time scale, in which *"…a longer or a shorter space of time may be most commodiously and advantageously represented by a longer or a shorter line."*. This parallel development evolved into the project management bar charts of today.




[6] A redacted version of Priestley's Chart of Biography (1765), obtained from: https://upload.wikimedia.org/wikipedia/commons/9/98/PriestleyChart.gif

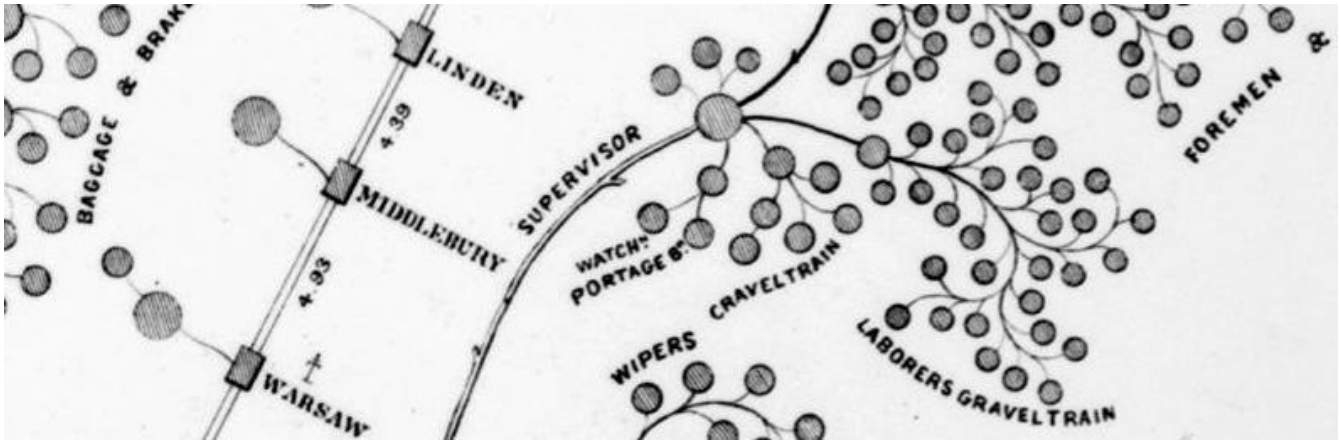
The general representation of statistics and data from the middle of the 18th century on would appear to be the underpinning for more the advanced charts discussed below. However, the charts discussed below have a different purpose, rather than simply making data visible, they seek to enhance understanding by showing the relationships between the different components or entities, that make up an organization, process, or function.

# Early Business Charts

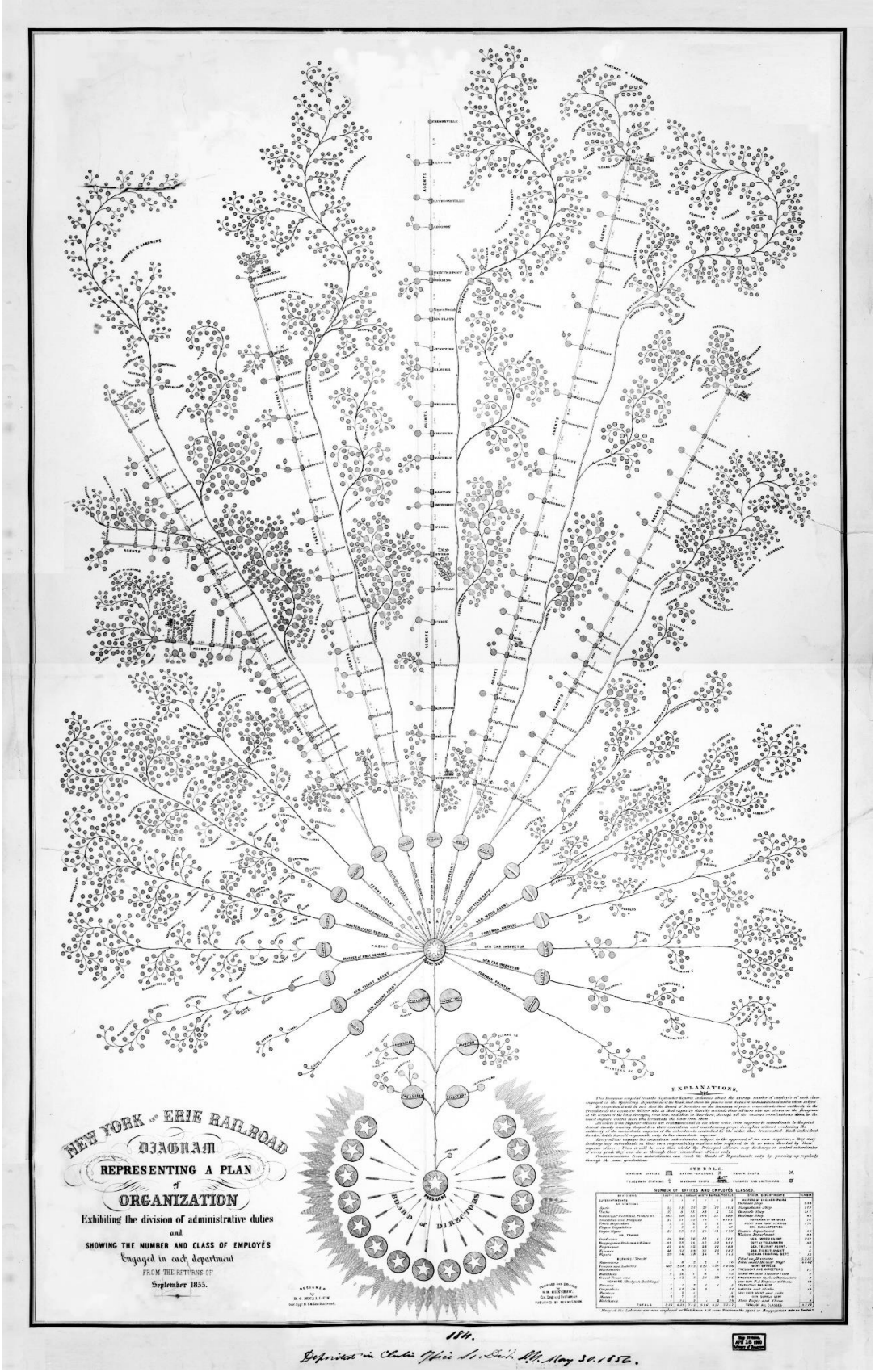
This section looks at the origins of three business charts that may have led to the creation of the work breakdown structure (WBS). It is generally accepted the concept of the WBS was not developed until 1957, which appears strange for a relatively simple concept supported by an equally simple diagram. The WBS is pre-dated by Organization Charts (1854), Cost Breakdown Structures (1909), and Flow Charts (1921).

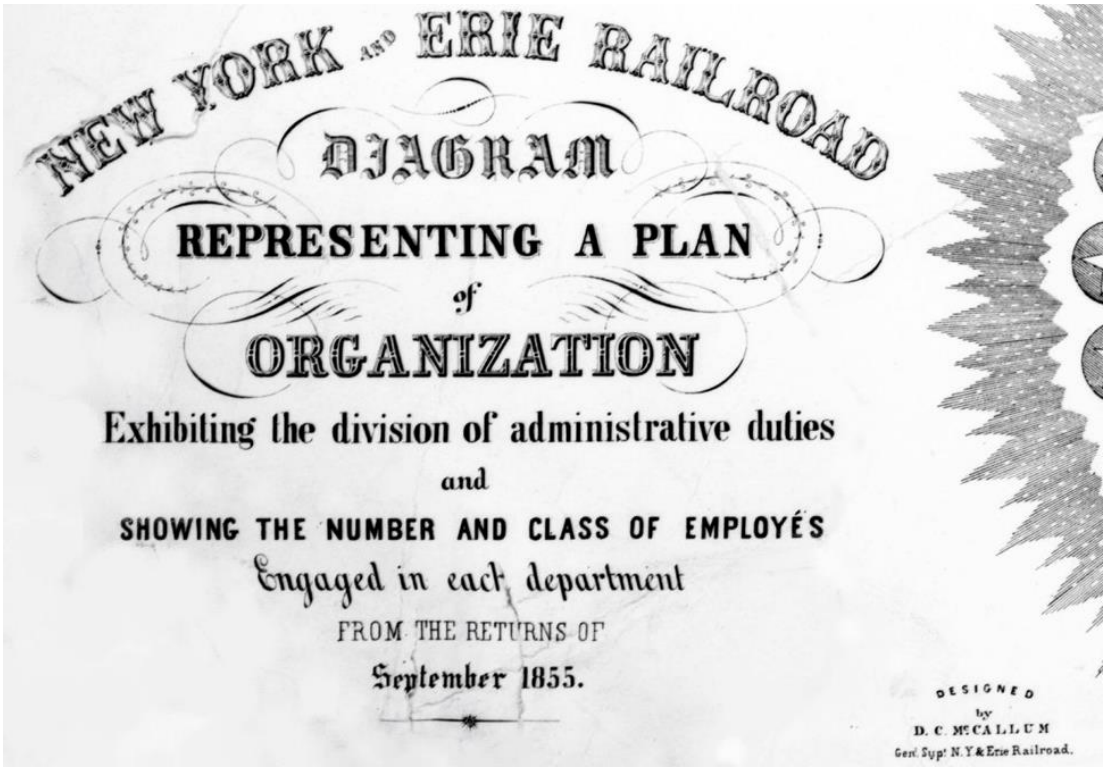
## Organization Charts

The Scottish-American engineer Daniel McCallum (1815–1878) is credited with creating the first organizational chart of an American business in around 1855 – details and full chart are reproduced below[7].

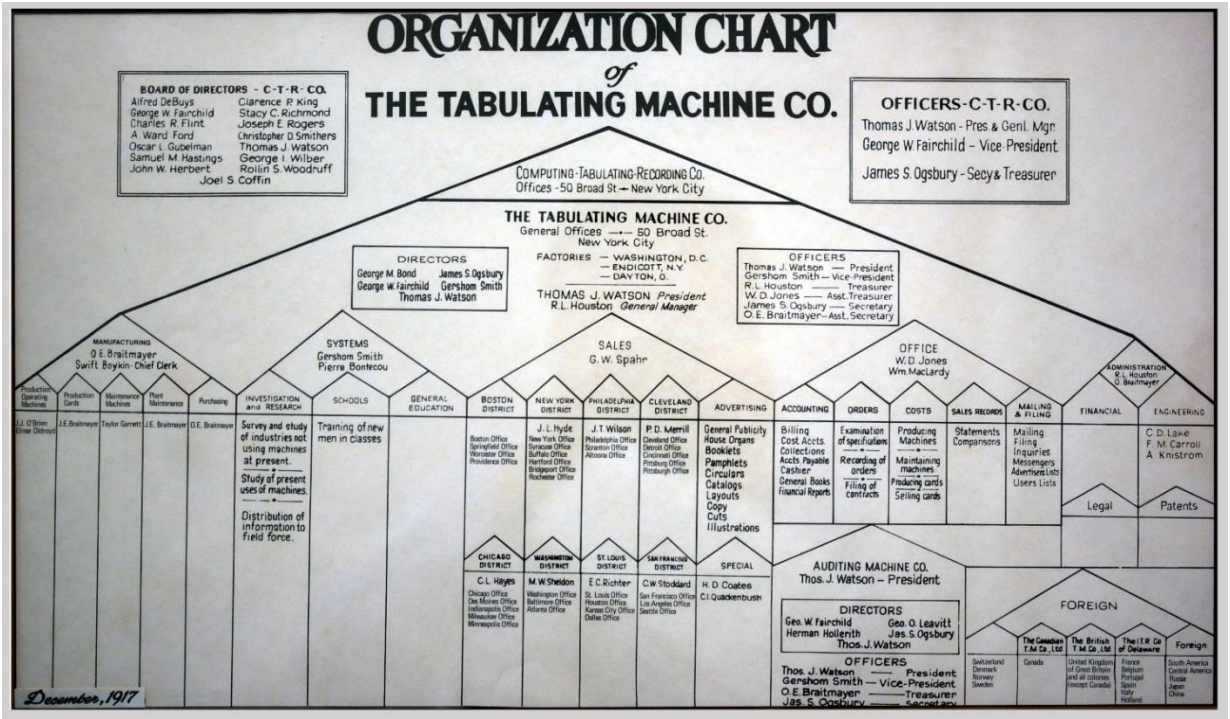



[7] Source of charts, Wikipedia. Full size versions of these charts are available on the Mosaic website at: https://mosaicprojects.com.au/PMKI-ZSY-020.php#WBS


NEW YORK AND ERIE RAILROAD
DIAGRAM
REPRESENTING A PLAN
of
ORGANIZATION
Exhibiting the division of administrative duties
and
SHOWING THE NUMBER AND CLASS OF EMPLOYÉS
Engaged in each department
FROM THE RETURNS OF
September 1855.
BOARD OF DIRECTORS
PRESIDENT
EXPLANATIONS.
SYMBOLS.
NUMBERS OF OFFICES AND EMPLOYES CLASSED.
1854.
Deposited in Clerks Office S. Dist. Mass. May 30. 1854.




While McCallum's diagram is rather artistic, more WBS like organization charts were developed early in the 20th century (although not widely used), such as the example below from December 1917 created by the Tabulating Machine Co. of New York.



The Tabulating Machine Co. was one of the companies that merged to become IBM[8], and its UK subsidiary, The British Tabulating Machine Co. Ltd., eventually became part of ICL Ltd.

The August 1939 report prepared for the Tennessee Valley Authority on the planning, design, construction and initial operations of *The Wheeler Project*[9] (dam) brings together a number of charts types discussed in this paper including a number of organizational breakdown structures, and extensive cost breakdown (discussed below) and the concept of a work breakdown structure embedded in a bar chart (discussed below). The Tennessee Valley Authority is an agency of the United States Government and the design and construction phases were assisted by the United States Army Engineers. This suggests the practices employed in diagramming and managing the works were standard USA government practice at the time.

The organizational breakdown structure (OBS) below, from page 265 in the report, is one of several and similar in style to modern OBS.

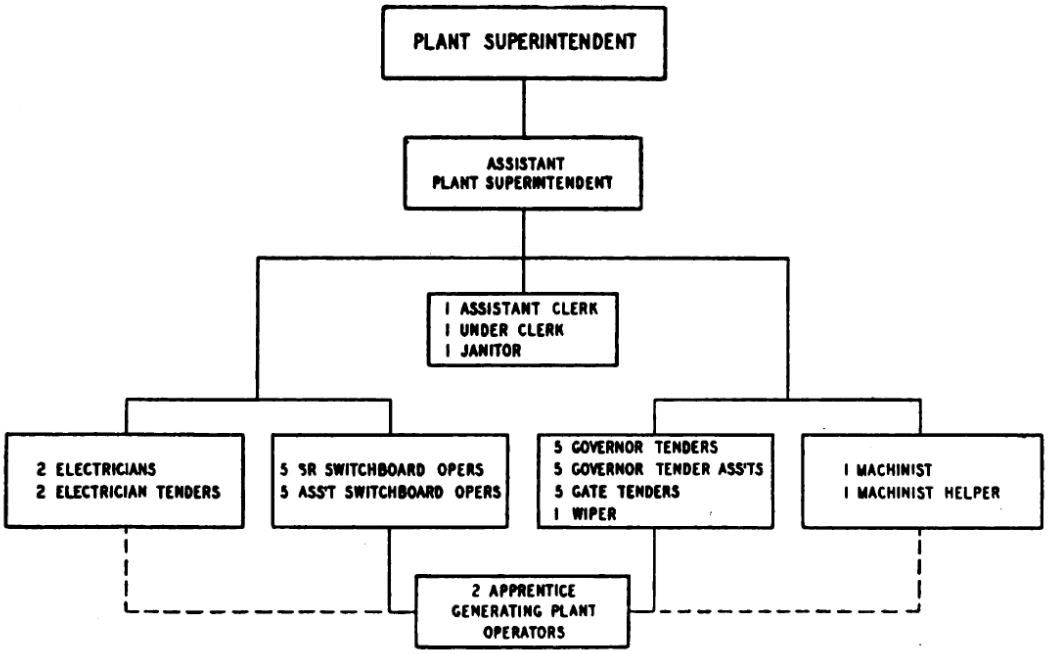



FIGURE 134.—*Organization chart—Operating staff.*

The personnel required to operate the Wheeler plant consists of 39 employees (see figure 134) classified as follows:

[8] Download a brief timeline of the companies that merged into IBM provided by Dr. Mihail Sadeanu https://mosaicprojects.com.au/PDF_Papers/P207_IBM_History.pdf

[9] Download the full report from: https://www.google.com/books/edition/The_Wheeler_Project/FFXVAAAAMAAJ?hl=en&gbpv=1&dq=wheeler+project+tva&printsec=frontcover

## Cost Charts

Cost engineering appears to be the direct antecedent of the WBS. Financial controls in both business and projects extend back into antiquity[10]. However, the reframing of accounting based financial control into an engineering management process seems to have been part of the scientific management school of the early 20th century. However, a discussion on the development of engineering as a profession through the 19th century, followed by the emergence of cost engineering as a core capability (initially focused on estimating and economic feasibility), is beyond the scope of this paper[11].

While financial efficiency was a core part of the approach to improving productivity developed by the 'Scientific Management School'[12], and was central to the work of Fredrick Taylor and Henry Gantt[13] in the early 1900s; the aspect of cost engineering that feeds into the emergence of the WBS was the charting of cost breakdowns within a business, or project.

Halbert Powers Gillette and Richard Dana's 1909 publication *Construction Cost Keeping and Management*[14] contains one of the earliest diagrams of a cost breakdown structure I've been able to find:

[10] An early example is a treatise that discusses engineering and capital investment in mining and metals in Latin entitled *'De Re Metallica'* by Agricola in 1556.

[11] For more on the ***development of cost engineering*** see: https://mosaicprojects.com.au/PMKI-ZSY-020.php#Process1

[12] The various 'schools' of management thinking are outlined in ***The Origins of Modern Management*** (pp10-15): https://mosaicprojects.com.au/PDF_Papers/P050_Origins_of_Modern_Management.pdf

[13] For more on ***the work of Henry Gantt*** see: https://mosaicprojects.com.au/PMKI-ZSY-025.php

[14] Gillette, H. P. and R. Dana, "Cost Keeping and Management Engineering", Myron C. Clark Publishing Company, 1909.

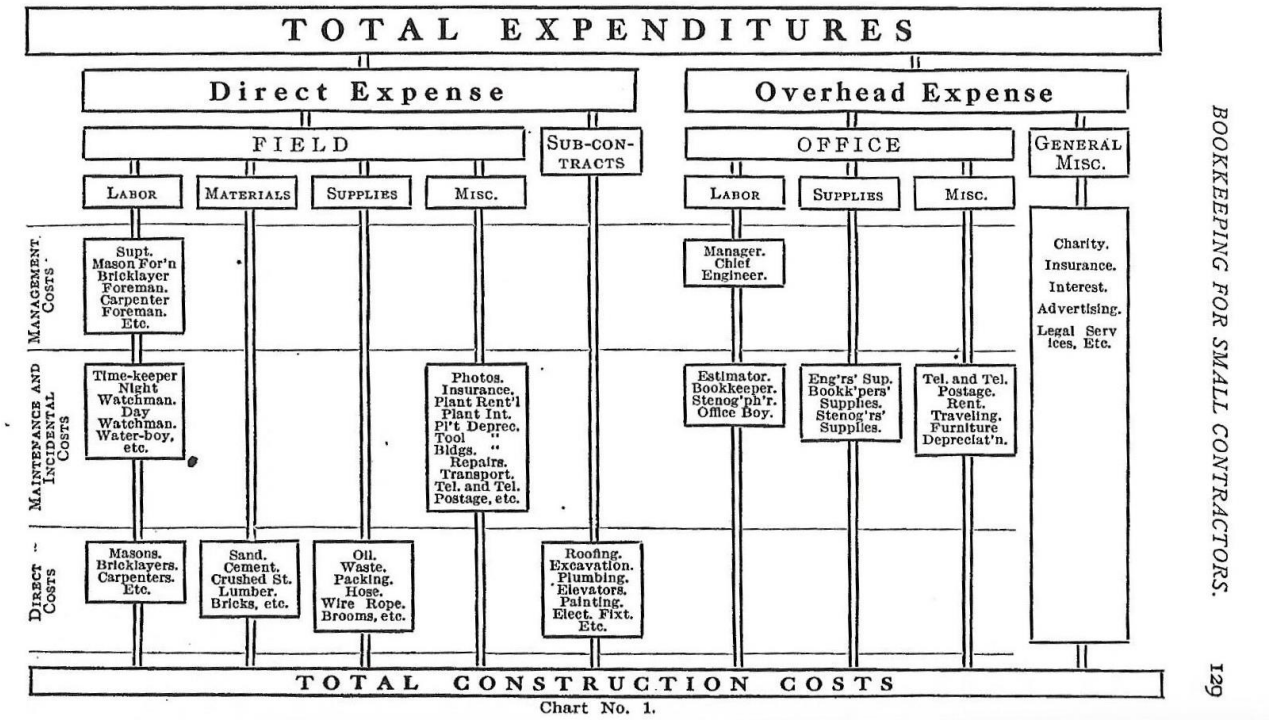


Chart No. 1.

The breaking of project costs down into categories and sub-categories would appear to have become standard practice by the early 1900s.

An abstract of a paper presented to the Electrical Section, Western Society of Engineers, on 16th November 1906, published in 'The Iron Age' on 22nd November 1906, titled *What is an Engineer-Constructor?*, sets out the cost breakdown structure for a major project (apologies for the poor quality of the reproduction):

With the general layout and the preliminary report and estimate approved, the next move is to prepare the plans and specifications. To indicate the scope of this work the following illustrative classification is shown, the numbers being the key which is placed in each drawing, specification, data sheet, report, or letter which may be originated as the work progresses:

CLASSIFICATION FOR BATTLE CREEK (MICH.) SHOPS, GRAND TRUNK RAILWAY SYSTEM.

*Contract No. 74.*

GENERAL INDEX.

*Sections of Classification.*

74000—Organization.
74100—Building structures.
74400—Track.
74600—General equipment.
74700—Power plant equipment.
74800—Tool equipment.

*Parts of the Work.*

A—Yard.
B—Power house.
C—Storehouse.
D—Oil house.
E—Office building.
F—Locomotive shop.
G—Forge shop.
H—Iron foundry.
I—Pattern shop.
J—Frog shop.
K—Car machine shop.
L—Truck shop.
M—Coach and paint shop.
N—Freight car shop.
O—Planing mill.
Q—Dry kiln.
R—Scrap platforms, sheds, &c.
S—Turntables.
T—Yard crane.
U—Pipe tunnel.

*Detail Classification.*

74000—ORGANIZATION.
74001—Contract.
74002—Home office fixed charges.
74003—Legal expense.
74004—Preliminary reports.
74005—Surveys.
74006—Engineering.
74007—Accounting.
74008—Construction Tools.
74009—Construction office supplies.
74010—Temporary construction.
74011—General construction labor.
74012—Superintendence.
74013—Insurance.
74014—Traveling and living expenses of representatives.
74015—Tests.
74016—Preliminary operation.
74100—BUILDING STRUCTURES.

The list of classifications continues, and of particular significance '*the numbers being the key which is placed in each drawing, specification, data sheet, report, or letter…*'.

The USA government *Manual of Financial and Accounting Procedure for Public Bodies*. March 1934, contains proformas for various cost reporting forms that are very similar to those used in PERT COST and EVM a few years later, and at page 61 sets out a breakdown structure for cost that is very similar (with indented numbering) to modern WBS tabulations:

**Item 4. Classification of work operations needed.**—A public body in deciding upon the particular cost accounts required should prepare a chart showing the features of work subdivided by work operations for which cost information will have value. This chart of accounts

**Item 5. Chart of construction cost accounts.**—The following chart illustrates some of the work operation cost accounts grouped by feature of work, commonly employed in street, sewer, and building construction of public-works projects.

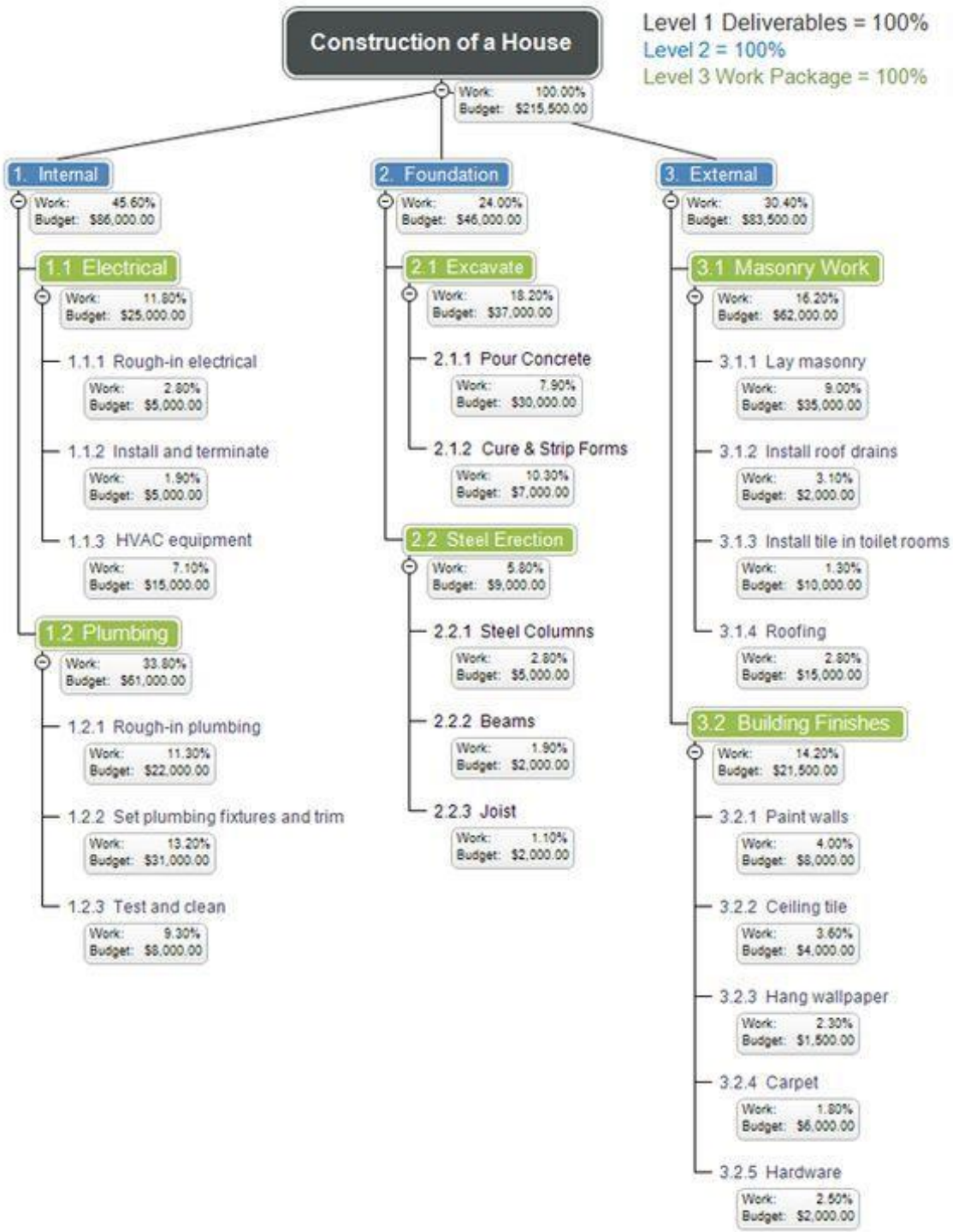
| | Standard Unit For Measuring Work |
|---|---|
| **100. Street Construction** (total costs measured by square yards): | |
| 110. GRADING (total cost measured by square yard top). | |
| 111. Machine excavation | Cubic yards |
| 112. Hand excavation | Cubic yards |
| 113. Moving | Cubic yards |
| 120. INLETS, CATCH BASINS, AND DRAINS (total cost by square yard top). | |
| 121. Excavation | Cubic yards |
| 122. Laying pipe | Lineal feet |
| 123. Building catch basins | Number of |
| 124. Moving | Square yard top |
| 130. CURB AND GUTTER (total cost by square yard top). | |
| 131. Setting forms | Lineal feet |
| 132. Pouring concrete | Lineal feet |
| 133. Finishing | Lineal feet |
| 134. Moving | Lineal feet |
| 140. BASE CONSTRUCTION (total cost by square yard top). | |
| 141. Unloading materials | Cubic yards |
| 142. Pouring and raking | Cubic yards |
| 143. Curing | Cubic yards |
| 144. Moving | Cubic yards |
| 150. SURFACE OR TOP (total cost by square yard top). | |
| 151. Hauling materials | Square yards |
| 152. Spreading and raking | Square yards |
| 153. Rolling | Square yards |
| 154. Moving | Square yards |
| 160. CLEAN UP (total cost by square yard top). | |
| 161. Grading curb to walk | Square yards |

*The Wheeler Project* report, extract from page 289 shows the application of the above concepts to a dam construction project in 1939:

| | | | | | |
|---|---|---|---|---|---|
| 213 | Powerhouse: | | | | |
| -0 | Exploration of foundation | | | | 4,775.42 |
| -1 | Diversion and care of water | | | | 198,871.12 |
| -2 | Excavation and backfill: | | | | |
| -23 | Rock excavation | 256,317 | Cubic yard | 1.81 | 465,074.92 |
| -3 | Foundation preparation and treatment: | | | | |
| -30 | Drilling grout holes | | | | 6,889.64 |
| -37 | Pressure grouting | 2,180 | Cubic foot | 5.56 | 12,125.72 |
| -39 | Gravel fill under service bay and control building. | 1,029 | Ton | 3.58 | 3,687.85 |
| -4 | Concrete: | | | | |
| -40 | Substructure concrete: | | | | |
| -400 | Concreting | 58,704 | Cubic yard | 9.39 | 551,287.42 |
| -401 | Forms | 439,753 | Square foot | 1.23 | 542,874.95 |
| -402 | Reinforcing steel | 4,576,669 | Pound | .046 | 209,104.74 |
| | Total substructure concrete. | 58,704 | Cubic yard | 22.20 | 1,303,267.11 |
| -42 | Gantry deck parapet and gover- | | | | 4,044.05 |

The indented numbering structure and sub-totals clearly show the intended breakdown of the work and its associated costs.

Modern versions of the cost breakdown structure tend to merge with the work breakdown structure:




## Flowcharts & Process Charts

Unlike the previous two charts which are hierarchic breakdowns and therefore directly related to the WBS, flow charts are focused on interdependence and sequence. Process Charts were

originally developed by Frank and Lillian Gilbreth, and publicized in their 1921 presentation to The American Society of Mechanical Engineers[15]; In their own words:

# PROCESS CHARTS

## FIRST STEPS IN FINDING THE ONE BEST WAY TO DO WORK

By Frank B. Gilbreth, Montclair, N. J.
Member of the Society
and
L. M. Gilbreth, Montclair, N. J.
Non-Member

*The process chart is a device for visualizing a process as a means of improving it. Every detail of a process is more or less affected by every other detail; therefore the entire process must be presented in such form that it can be visualized all at once before any changes are made in any of its subdivisions. In any subdivision of the process under examination, any changes made without due consideration of all the decisions and all the motions that precede and follow that subdivision will often be found unsuited to the ultimate plan of operation.*

PLACE OF PROCESS CHART IN MANAGEMENT

2 The process chart is a record of present conditions. It presents, in simple, easily understood, compact form, data which must be collected and examined before any improvement in existing conditions and methods is undertaken. Even if existing conditions are apparently satisfactory, the chart is useful as presenting much information in condensed form.

3 The process chart serves as an indicator of profitable changes. It assists in preventing "inventing downward," and stimulates invention that is cumulative and of permanent value. It is not only the first step in visualizing the *one best way to do work*, but is useful in every stage of deriving it.

4 This paper presents established working data used successfully in numerous installations for many years.

[15] Download the full publication: ***Process Charts: First Steps in Finding the One Best Way to do Work***. Frank & Lillian Gilbreth (1921) from https://mosaicprojects.com.au/PDF-Gen/Process_Charts_Gilbreth.pdf

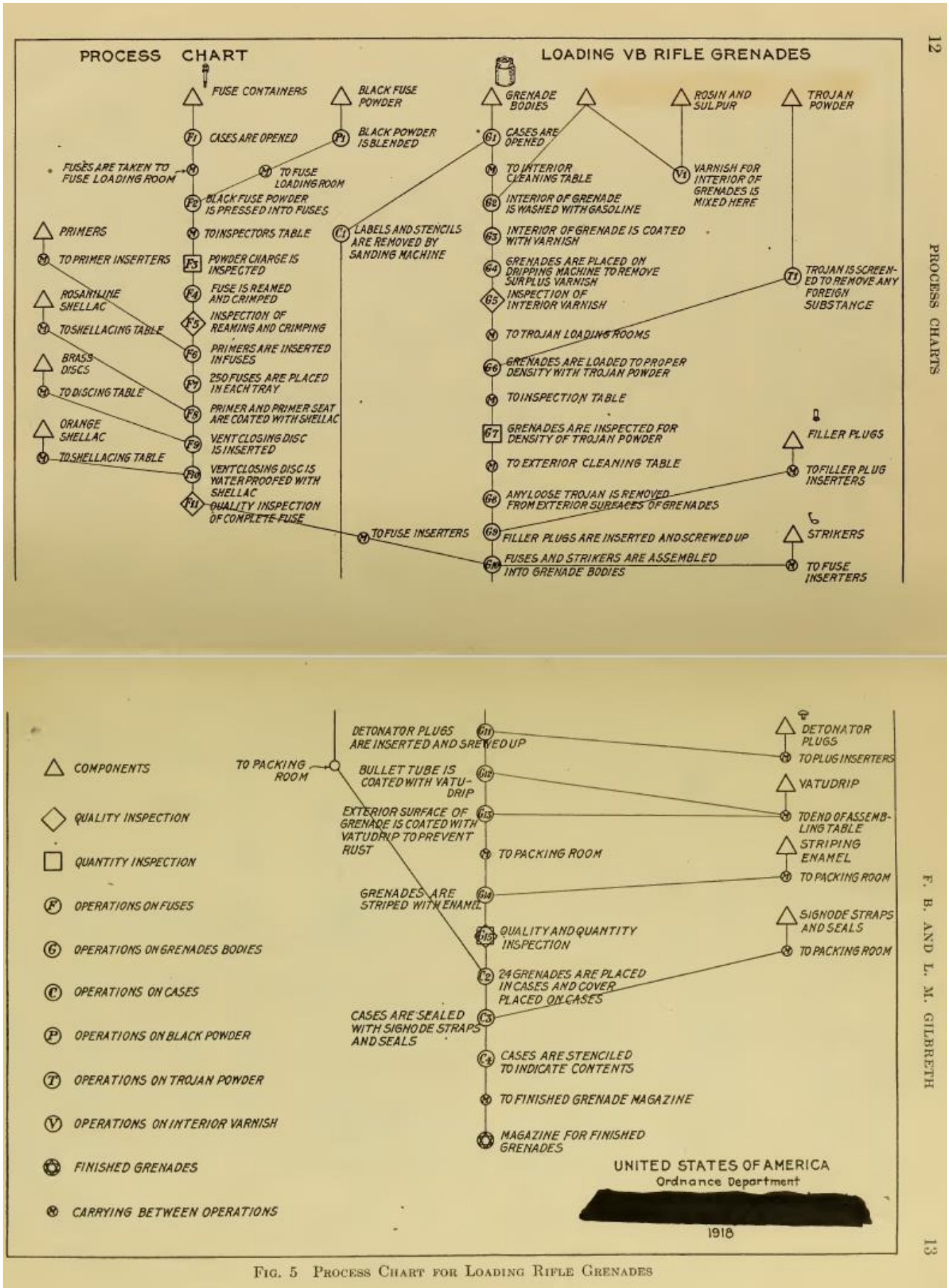
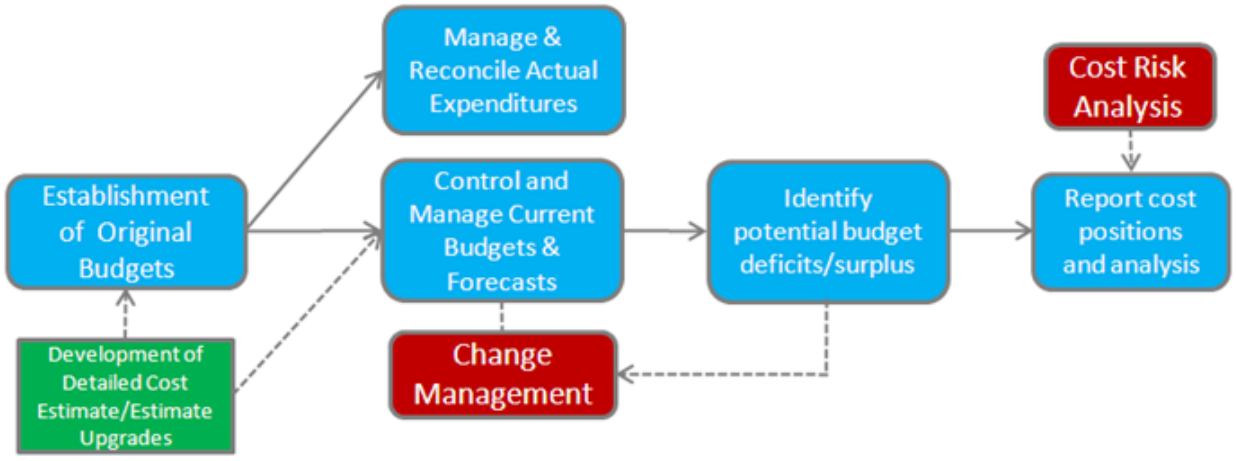



FIG. 5 PROCESS CHART FOR LOADING RIFLE GRENADES

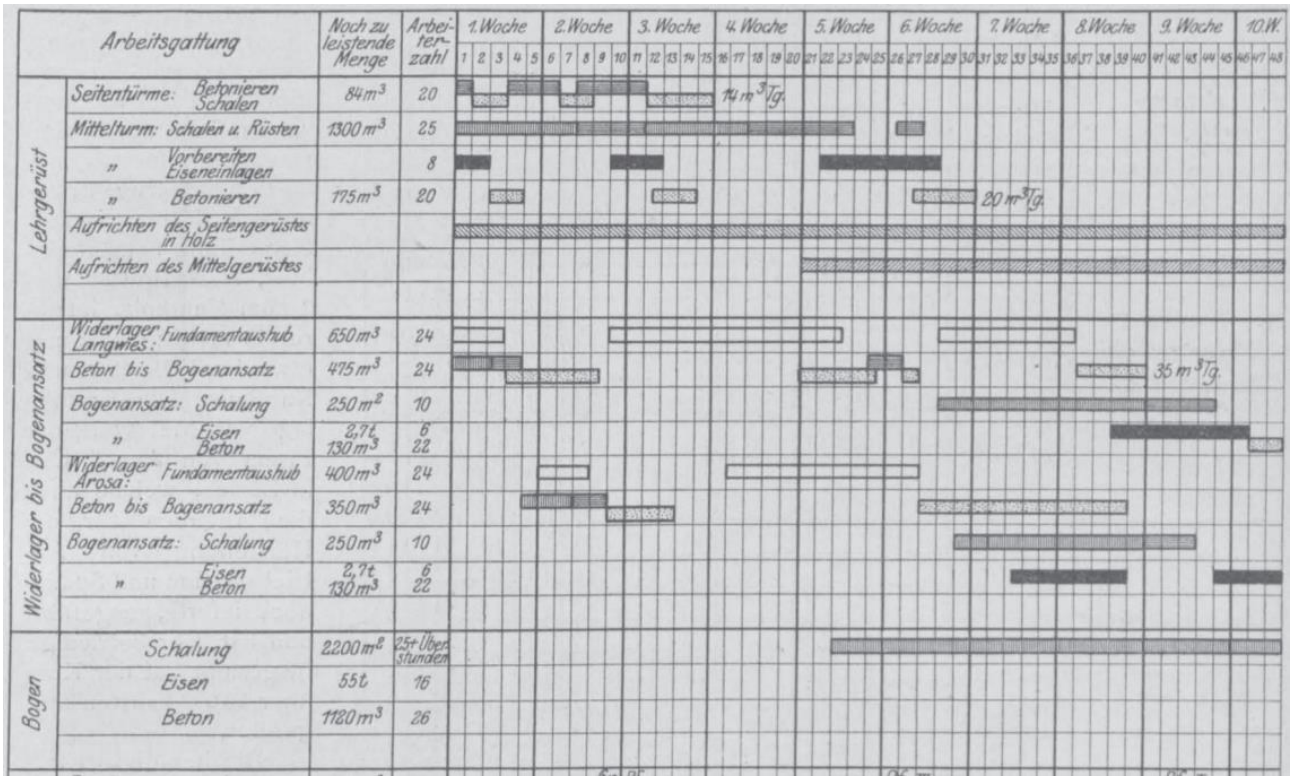
Process charts morphed into flow charts relatively quickly and were considered normal business diagrams well before the concept of a 'flow chart' was used to underpin the PDM network notation developed by Dr. John W Fondahl in 1962[16]. A typical example is the cost-management flowchart below:




## Project Bar Charts

The idea of breaking the work of a large project into its component parts can also be seen in various bar charts.

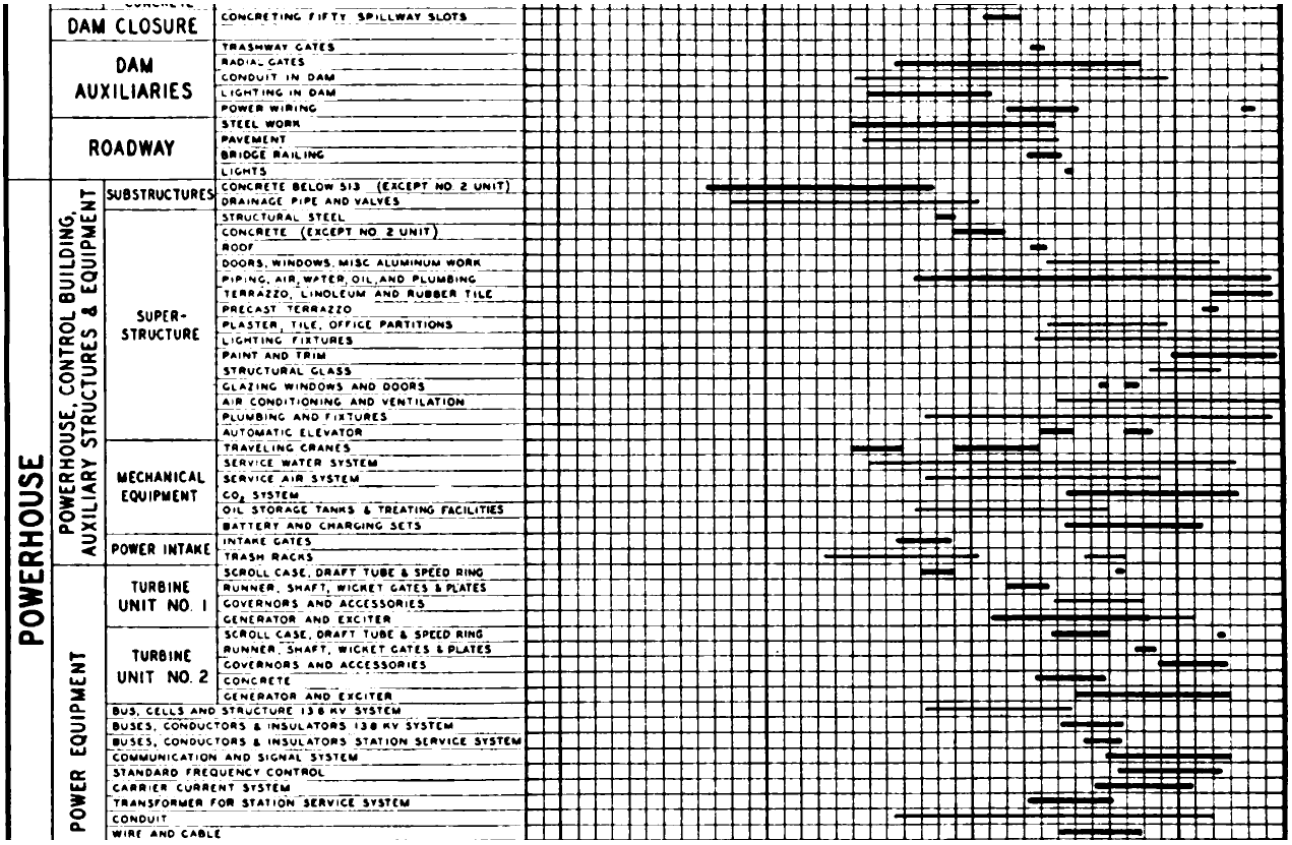
[16] For more on the ***development of PDM networks*** see: https://mosaicprojects.com.au/PMKI-ZSY-030.php#Process1




The bar cart above is for the construction of a section of the Chur–Arosa narrow gauge railway (the "Arosabahn") around the Langwies GR railway station, in Switzerland. The chart is divided into sections based on the geography and nature of the work[17]. The project included the station (buildings, sidings, etc.) and, at the time, the longest and highest reinforced concrete railway bridge in the world as well as other mainline trackwork.

The construction schedule for *The Wheeler Project*, (from page 110) shows a three-level breakdown of the works and appears to reflect the intended management structure of the project.

[17] Download the full article on the Langwies project from: https://mosaicprojects.com.au/PMKI-ZSY-020.php#Overview




Neither, of the projects above describe the way the project activities are drawn as a 'work breakdown', the style of drawing may simply be for convenience of presentation. However, it appears far more likely given the contents of each section, and sub-section of the charts, the intention of the project management was to allocate responsibility to the various engineers and foremen working on the project along similar lines in effect creating a WBS arrangement of project based on the type and location of the work.

## The Evolution of the Work breakdown structure (WBS)

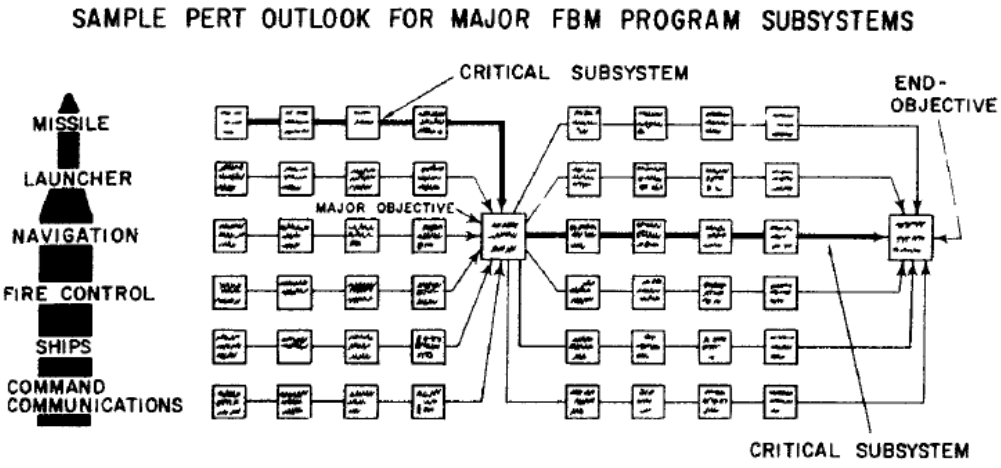
While the roots of a WBS chart can be found in various forms chart described above, the development of the WBS concept[18] in its modern form appears to have occurred after 1957 as part of the Program Evaluation and Review Technique (PERT) developments, and in particular PERT COST.

PERT was created in 1957 and from the outset appears to have organized the schedule activities into product-oriented categories as shown in the diagrams below[19]. The stated purpose of the

[18] When discussing the WBS, it is important to remember the decomposition is based on deliverables (products); the ISO 21511 standard definition is the: ***'decomposition of the defined scope of the project or programme into progressively lower levels consisting of elements of the work'***. Emphasis added.

[19] The diagrams in Fig. 14 on page 665 of the 1959 PERT paper by Malcolm, Roseboom, Clark & Fazar: *Application of a Technique for Research and Development Program Evaluation*; clearly show a breakdown into systems,

'breakdown by components' was to provide summary level reporting for senior management (backed up by the detailed analysis).



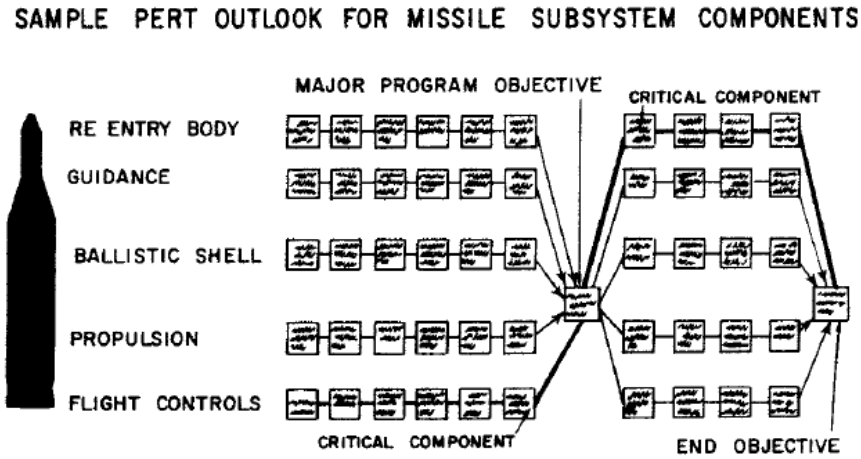



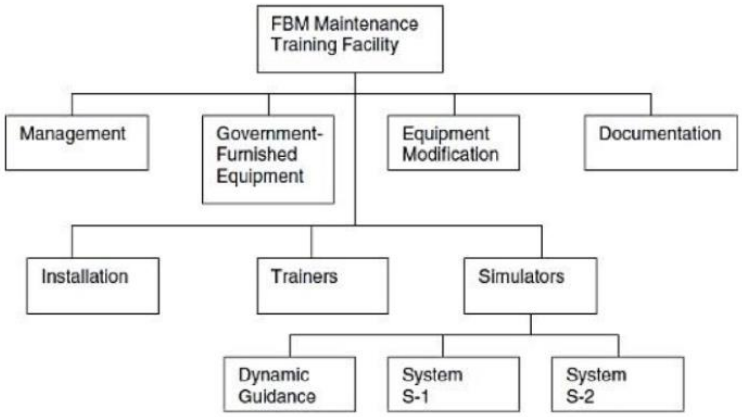

**Fig 14 Integrated outlook**

The ability to generate summary activities appears to be a PERT innovation, however, the concept of organizing the work into logical components and sub-components was part of the way bar charts were drawn and organized from at least 1910 onwards. The three-level decomposition of the *Wheeler Project* bar chart discussed above would appear to be a direct antecedent to the PERT concepts (and both were 'government projects').

While its precise origin is unclear, the term *work breakdown structure* appears to have been in common use by 1961. At that time a sample WBS was included in an article published within General Electric Corporation focused on the importance of a WBS in developing effective

subsystems and components. Download the full paper from: https://mosaicprojects.com.au/PMKI-ZSY-030.php#Process2

management control systems[20]. Part of this WBS for the Fleet Ballistic Missile Maintenance Training Facility is shown below[21]:




The next few months formalized the WBS concept. The *AFSC PERT Policies and Procedures Handbook* was published in January 1962. Then in June 1962 the *DOD and NASA Guide, PERT Cost System Design* was published describing the PERT/COST system and the use of a WBS. In October 1962, NASA published its *PERT and Companion Cost System Handbook* (NASA NPC 101), stressing the WBS was a top-down structure.

The PERT COST report formats and WBS were later standardized in ***Supplement No.1 to DOD and NASA Guide, PERT COST Output Reports***, March 1963[22].

Work Breakdown Structure

A family tree subdivision of a program, beginning with the end objectives and then subdividing these objectives into successively smaller end item subdivisions. The work breakdown structure establishes the framework for:

- defining the work to be accomplished;
- constructing a network plan;
- summarizing the cost and schedule status of a program for progressively higher levels of management.

[20] Warren F Munson. *A Controlled Experiment in PERTing Costs*. POLARIS PROJECTION, GE Ordinance Department November 1961. Quoted in: *Work Breakdown Structures for Projects, Programs, and Enterprises,* Gregory T. Haugan. Management Concepts, Vienna, VA. 2008.

[21] Source: Haugan, G.T., *Work Breakdown Structures for Projects, Programs, and Enterprises*. 2008, Management Concepts Inc. Figure 1-11.

[22] Source: ***Supplement No.1 to DOD and NASA Guide, PERT COST Output Reports***, March 1963, Page 67 (Glossary). Download from: https://mosaicprojects.com.au/PDF-Gen/DOD_and_NASA_Guide_PERT_Cost_Output_Reports.pdf

This description of the WBS remains fundamentally unchanged through to the present time.

In the same general timeframe, the ***USAF PERT-TIME System Description Manual***, September 1963[23] formally integrated the WBS into the PERT schedule development processes ***Chapter VII Development of the Plan*** states:

> B. Program Work Breakdown Structure
>
> As the objectives are developed in greater detail they form the program work breakdown structure which establishes a common framework for the accomplishment of all the work to be performed. It provides a basis for uniform planning and program visibility, enables assignment of responsibilities, and delineates objectives for monitoring progress. Additionally, it establishes the basis for constructing networks at any desired level of detail by identifying the end items to be accomplished at that level.
>
> The work breakdown structure is developed downward by proceeding from the major program end items (hardware, services, equipment, or facilities) to successively lower levels, until manageable units for planning and control are derived. A top-down approach is used to guide planning rather than allowing detailed plans to be generated outside of a common framework. It is apparent that networks can readily be constructed without the use of a work breakdown

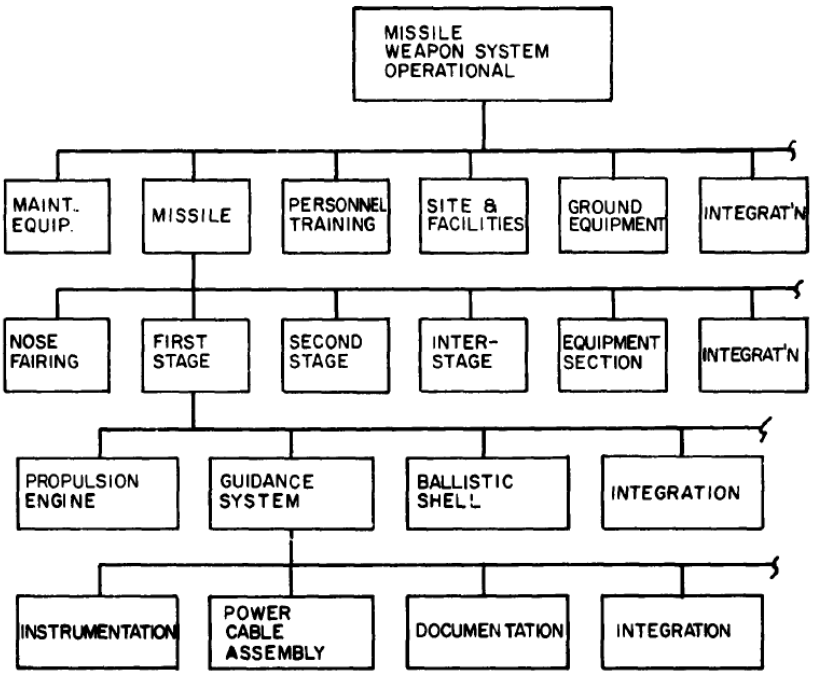
[23] Download the ***USAF PERT-TIME System Description Manual, September 1963*** from: https://mosaicprojects.com.au/PDF-Gen/PERT_Time_System_Manual_1963.pdf

structure, but quite possibly such networks will be incomplete or inconsistent with program objectives.

Briefly, the work breakdown structure establishes the basis for:

- defining the work to be performed in successively greater detail;
- determining how the various end items of work are related to one another;
- constructing networks at any desired level of detail;
- identifying the organizational element(s) responsible for accomplishing the work at each successive level of work definition;
- summarizing actual status and forecasted progress of the program for progressively higher levels of management.

A partial work breakdown structure is shown in Figure VII-1. A complete work breakdown structure is shown in Appendix A.




These complimentary approaches were formalized by the publication of *MIL-STD-881* on 1 November 1968 by the USA Dept. of Defense. This initial release was followed by ***MIL-STD-881A***

on 25 April 1975[24]; and this standard has been progressively updated since. The current version is *MIL-STD-881E* - dated October 6, 2020.

Numerous other standards for the creation and use of WBS followed, including:

- DEF(AUST)5664 in 1995,
- PMI's *Practice Standard for WBS* in 2001 (WBS was a core component of the PMBOK for many years prior), and
- ISO 21511 *Work breakdown structures for project and programme management* in 2018.

In summary, the WBS concept described in 1961 has evolved into the modern use of the WBS, where on larger project where the WBS chart is linked to the WBS Dictionary (usually a database) to enhance project control[25]. However, none of these later developments have changed the basic concepts that were formally documented in 1962.

# Conclusion

A consistent theme in the Scientific Management School's approach to understanding how organizations function was breaking the aspect being studied down into smaller parts to understand and optimize each part in turn. As improvements were implemented at the detail level, a corresponding improvement (or level of control) was expected on the overall system performance. This approach is consistent across the Organization Chart, the Cost Breakdown Chart, the Process Chart, and the bar charts described above.

The importance of these types of 'breakdown chart' in the lead up to the invention of the WBS is in part the increasing use of diagrams to help create a better understanding of an aspect of a business or project. Plus, the 'scientific' approach to management and control typified by the use of breakdown structure to separate a larger entity into its components to facilitate problem solving.

There appears to be a clear lineage between the concept of a cost breakdown structure and the WBS as used in the PERT COST systems, similarly, the way bar charts were drawn and evolved in the early part of the 20th century would appear to feed into the original PERT development in 1957.

We cannot know for sure what the people involved in developing PERT and PERT COST actually knew, or had seen, but on the available evidence, the WBS appears to be an evolutionary development of USA Government practice in the 1930s rather than a radical departure from previous management processes and charts.

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[24] Download a copy of ***MIL-STD-881A*** from: https://mosaicprojects.com.au/PMKI-ZSY-020.php#WBS

[25] For an ***overview of the WBS and WBS Dictionary*** suitable for distribution see: https://mosaicprojects.com.au/WhitePapers/WP1011_WBS.pdf

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## About the Author

**Patrick Weaver**

Melbourne, Australia

**Patrick Weaver**, PMP, PMI-SP, FAICD, FCIOB, is the Managing Director of Mosaic Project Services Pty Ltd, an Australian project management consultancy specialising in project control systems. He is a Fellow of the Chartered Institute of Building, Australasia (FCIOB) and a Fellow of the Australian Institute of Company Directors (FAICD). He is a member of the the PMI Melbourne Chapter (Australia), as well a full member of AIPM, and the Project Management College of Scheduling (PMCOS).

Patrick has over 50 years' experience in Project Management. His career was initially focused on the planning and managing of construction, engineering and infrastructure projects in the UK and Australia. The last 35 years has seen his businesses and experience expand to include the successful delivery of project scheduling services and PMOs in a range of government, ICT and business environments; with a strong focus on project management training.

His consultancy work encompasses: developing and advising on project schedules, developing and presenting PM training courses, managing the development of internal project control systems for client organisations, and assisting with dispute resolution and claims management.

In the last few years, Patrick has sought to 'give back' to the industry he has participated in since leaving college through contributions to the development of the project management profession. In addition to his committee roles he has presented papers at a wide range of project management conferences in the USA, Europe, Asia and Australia, has an on-going role with the PGCS conference in Australia and is part

of the Australian delegation to ISO TC258. Patrick can be contacted at patw@mosaicprojects.com.au or at www.mosaicprojects.com.au.