Work Breakdown Structures (WBS)

WBS

➤ Technique originally developed by financial specialists to track spent money on a program or track the anticipated a need to spend money
  ➤ A control mechanism to make sure project cost estimates covered everything
  ➤ A control mechanism to make sure they understood where all the money went or was going
➤ This mechanism has been appropriated by project engineers and system engineers to make sure that **all** effort required for program or project has been accounted for and tracked
  ➤ A great way to find out if a project is in trouble when the actual effort projected in area of the WBS is exceeding projections

What is a WBS ?

➢ A Work Breakdown Structure (WBS) is a fundamental project management tool for defining and organizing the total scope of a project, using a hierarchical tree structure.

What's a WBS ?

➢ A hierarchical breakdown (level 1 thru n) of the work to be executed by the program team

➢ Typically in a tree format

➢ The first two levels of the WBS (Level 1 and Level 2) define a set of planned outcomes that collectively and exclusively represent 100% of the project scope.

➢ At each subsequent level, the children of a parent node collectively and exclusively represent 100% of the scope of their parent node.

What is a WBS ?

➢ A well-designed WBS describes planned outcomes instead of planned actions.

➢ Outcomes are the desired ends of the project, and can be predicted accurately

An easy way to think about a work breakdown structure is as an outline or map of the specific program

WBS Dictionary

➢ A WBS dictionary is a document that has a paragraph or two describing the technical content of each element of the WBS

➢ Because WBS element numbering and names can be cryptic, it is a good way to understand what exactly is in the WBS
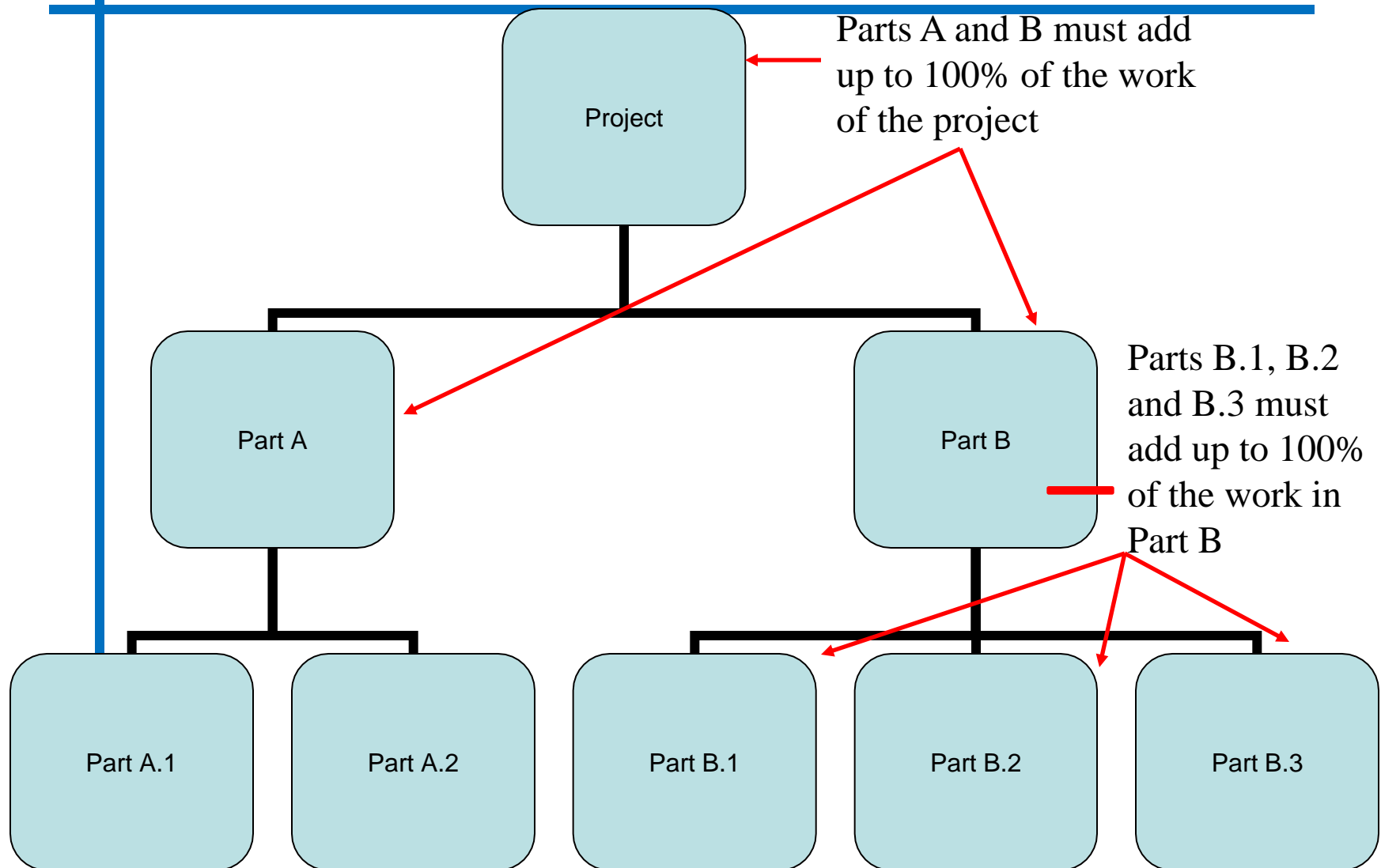
100% Rule

➢ ***The 100% Rule***...*states that the WBS includes **100% of the work defined** by the project scope and **captures all deliverables** – internal, external, interim – in terms of the work to be completed, including project management (and systems engineering).*

100% Rule

➢ *The 100% rule is one of the most important principles guiding the development, decomposition and evaluation of the WBS.*

➢ *The rule applies at all levels within the hierarchy: the sum of the work at the "child" level must equal 100% of the work represented by the "parent" and the WBS should not include any work that falls outside the actual scope of the project, that is, it cannot include more than 100% of the work…*
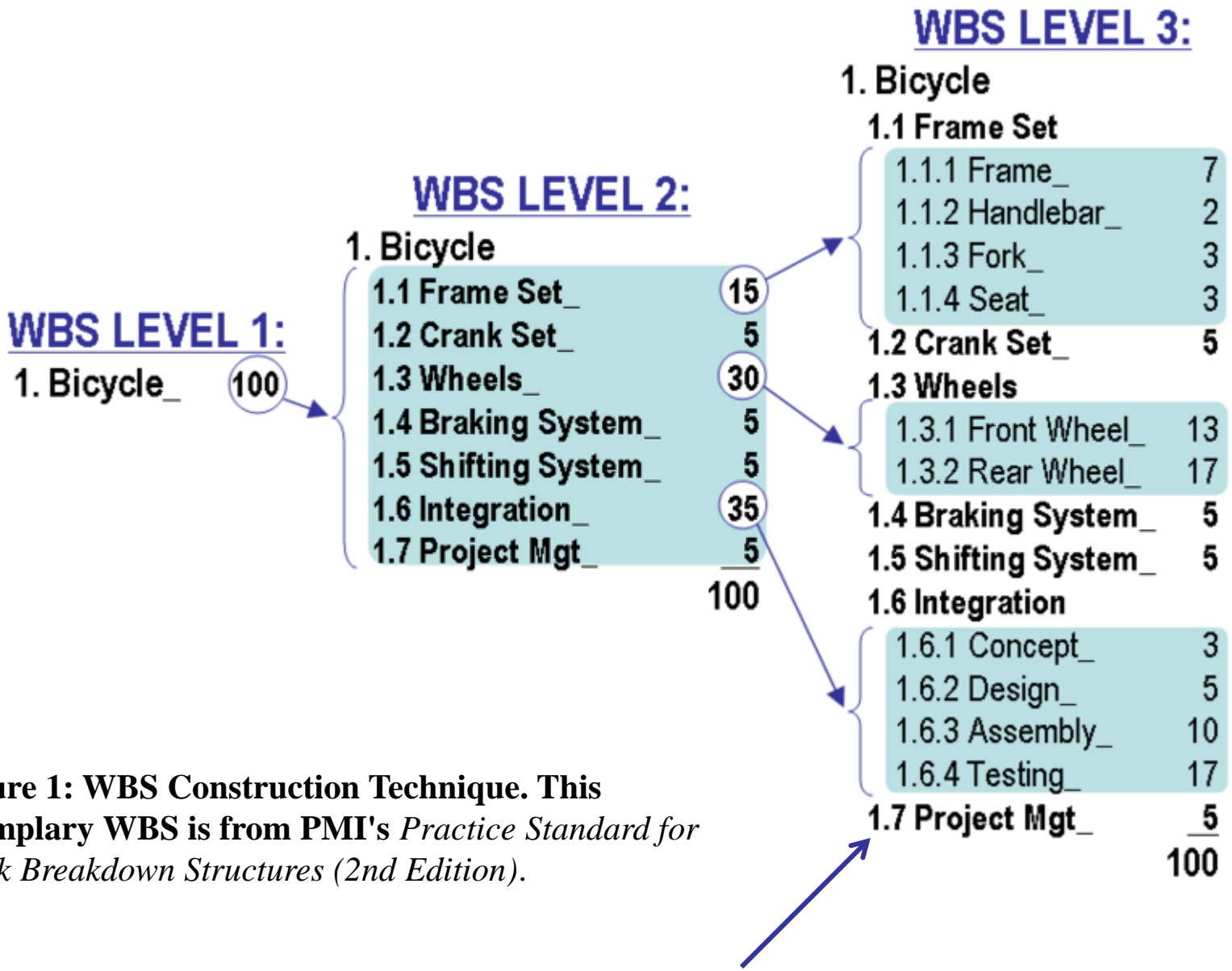
100% Rule Example

Project — Parts A and B must add up to 100% of the work of the project

Part A

Part B — Parts B.1, B.2 and B.3 must add up to 100% of the work in Part B

Part A.1 Part A.2 Part B.1 Part B.2 Part B.3

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WBS LEVEL 3:

1. Bicycle
1.1 Frame Set
1.1.1 Frame_	7
1.1.2 Handlebar_	2
1.1.3 Fork_	3
1.1.4 Seat_	3

1.2 Crank Set_   5
1.3 Wheels
1.3.1 Front Wheel_	13
1.3.2 Rear Wheel_	17

1.4 Braking System_   5
1.5 Shifting System_   5
1.6 Integration
1.6.1 Concept_	3
1.6.2 Design_	5
1.6.3 Assembly_	10
1.6.4 Testing_	17

1.7 Project Mgt_   5
               100

WBS LEVEL 2:

1. Bicycle
1.1 Frame Set_	15
1.2 Crank Set_	5
1.3 Wheels_	30
1.4 Braking System_	5
1.5 Shifting System_	5
1.6 Integration_	35
1.7 Project Mgt_	5
	100

WBS LEVEL 1:

1. Bicycle_   100

Figure 1: WBS Construction Technique. This exemplary WBS is from PMI's *Practice Standard for Work Breakdown Structures (2nd Edition).*

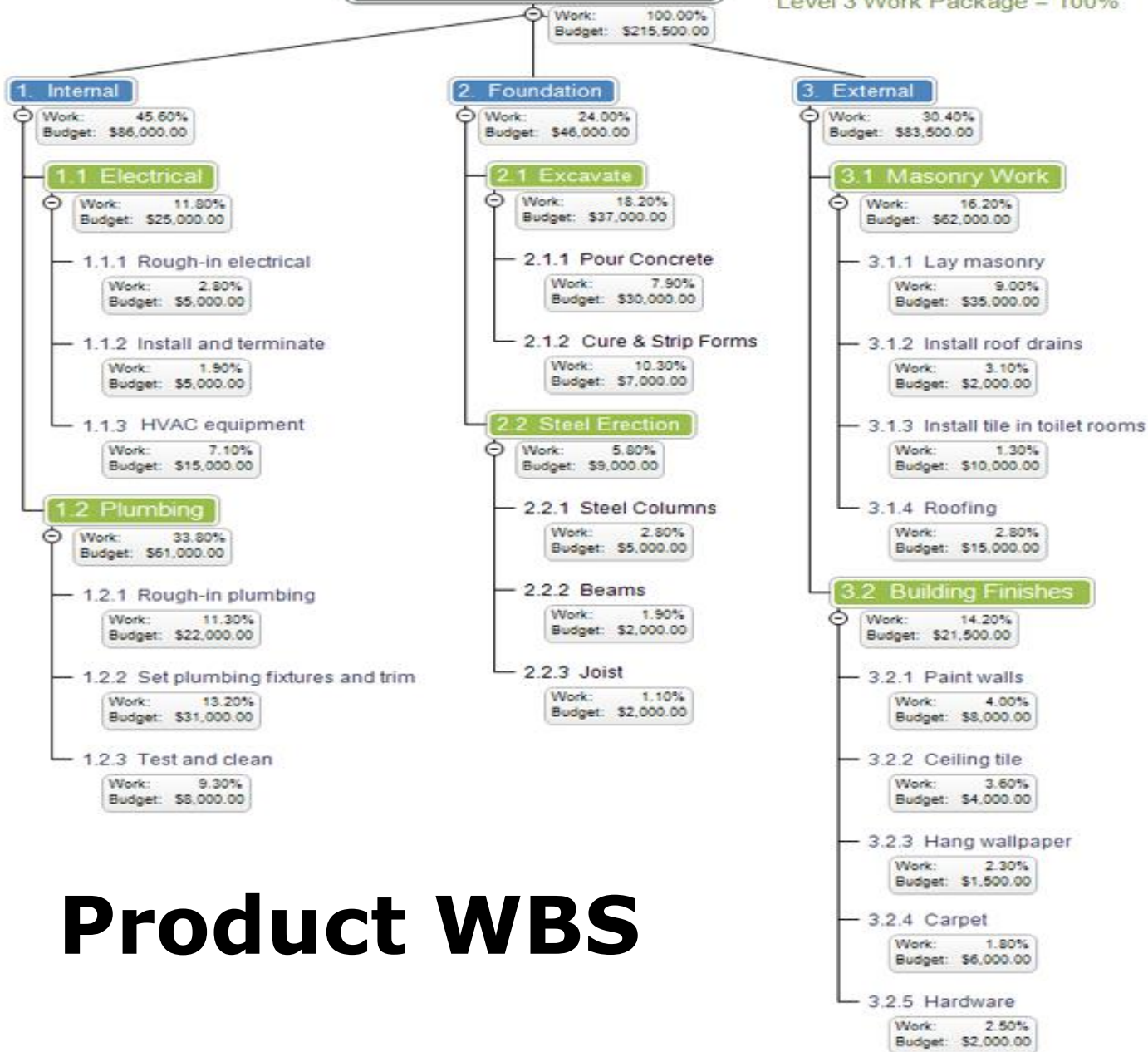**SE may or may not be included
In project management**

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Examples of WBS
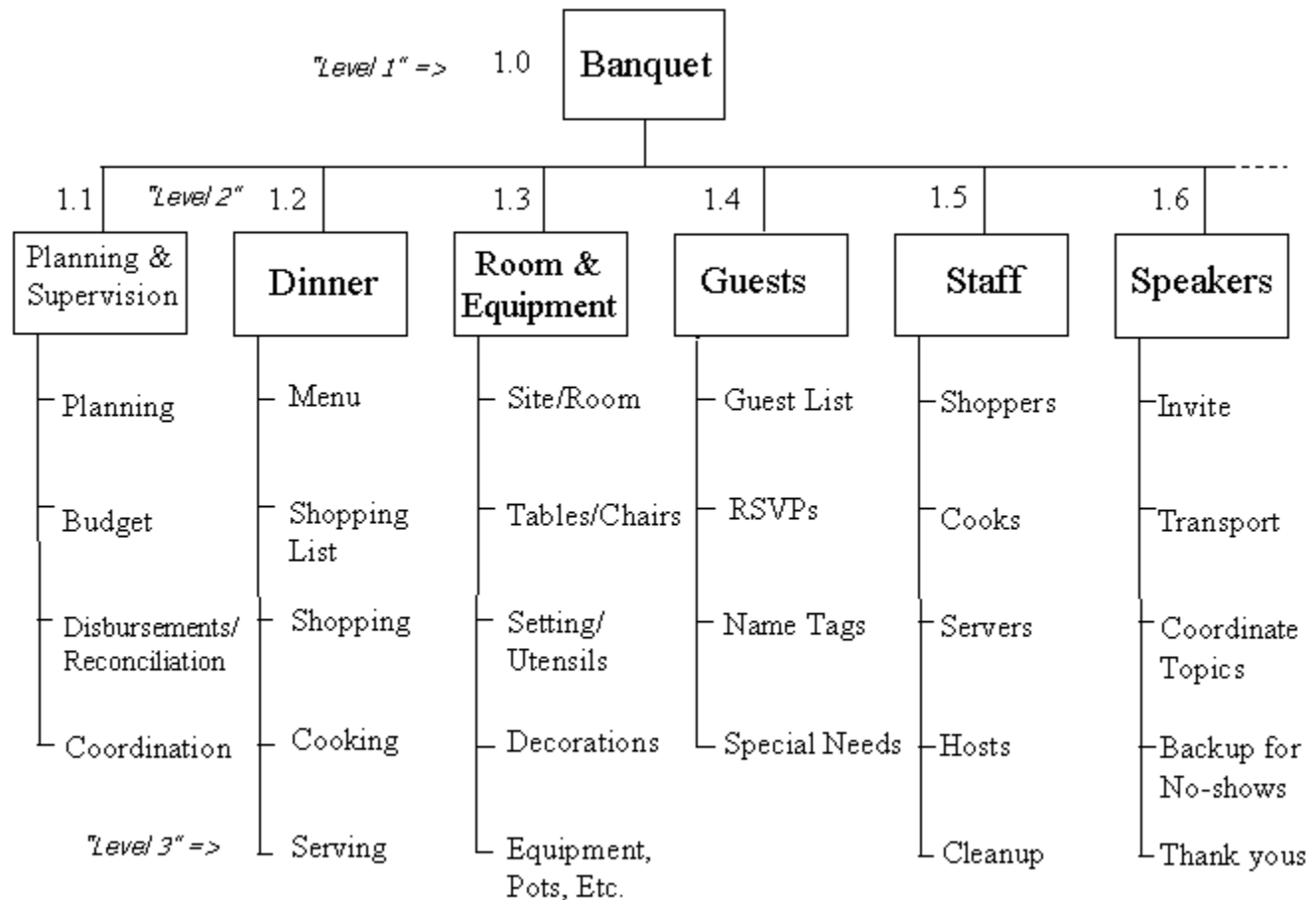
Construction of a House

Level 1 Deliverables = 100%
Level 2 = 100%
Level 3 Work Package = 100%

Work: 100.00%
Budget: $215,500.00

1. Internal
Work: 45.60%
Budget: $86,000.00

1.1 Electrical
Work: 11.80%
Budget: $25,000.00

1.1.1 Rough-in electrical
Work: 2.80%
Budget: $5,000.00

1.1.2 Install and terminate
Work: 1.90%
Budget: $5,000.00

1.1.3 HVAC equipment
Work: 7.10%
Budget: $15,000.00

1.2 Plumbing
Work: 33.80%
Budget: $61,000.00

1.2.1 Rough-in plumbing
Work: 11.30%
Budget: $22,000.00

1.2.2 Set plumbing fixtures and trim
Work: 13.20%
Budget: $31,000.00

1.2.3 Test and clean
Work: 9.30%
Budget: $8,000.00

2. Foundation
Work: 24.00%
Budget: $46,000.00

2.1 Excavate
Work: 18.20%
Budget: $37,000.00

2.1.1 Pour Concrete
Work: 7.90%
Budget: $30,000.00

2.1.2 Cure & Strip Forms
Work: 10.30%
Budget: $7,000.00

2.2 Steel Erection
Work: 5.80%
Budget: $9,000.00

2.2.1 Steel Columns
Work: 2.80%
Budget: $5,000.00

2.2.2 Beams
Work: 1.90%
Budget: $2,000.00

2.2.3 Joist
Work: 1.10%
Budget: $2,000.00

3. External
Work: 30.40%
Budget: $83,500.00

3.1 Masonry Work
Work: 16.20%
Budget: $62,000.00

3.1.1 Lay masonry
Work: 9.00%
Budget: $35,000.00

3.1.2 Install roof drains
Work: 3.10%
Budget: $2,000.00

3.1.3 Install tile in toilet rooms
Work: 1.30%
Budget: $10,000.00

3.1.4 Roofing
Work: 2.80%
Budget: $15,000.00

3.2 Building Finishes
Work: 14.20%
Budget: $21,500.00

3.2.1 Paint walls
Work: 4.00%
Budget: $8,000.00

3.2.2 Ceiling tile
Work: 3.60%
Budget: $4,000.00

3.2.3 Hang wallpaper
Work: 2.30%
Budget: $1,500.00

3.2.4 Carpet
Work: 1.80%
Budget: $6,000.00

3.2.5 Hardware
Work: 2.50%
Budget: $2,000.00

Product WBS

WBS Example - Banquet

"Level 1" =>   1.0   **Banquet**

"Level 2"
1.1 **Planning & Supervision**
1.2 **Dinner**
1.3 **Room & Equipment**
1.4 **Guests**
1.5 **Staff**
1.6 **Speakers**

Planning & Supervision	Dinner	Room & Equipment	Guests	Staff	Speakers
Planning	Menu	Site/Room	Guest List	Shoppers	Invite
Budget	Shopping List	Tables/Chairs	RSVPs	Cooks	Transport
Disbursements/ Reconciliation	Shopping	Setting/ Utensils	Name Tags	Servers	Coordinate Topics
Coordination	Cooking	Decorations	Special Needs	Hosts	Backup for No-shows
	Serving	Equipment, Pots, Etc.		Cleanup	Thank yous

"Level 3" =>   Serving

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WBS Levels for SOFIA

- Project (or System level) - integrating all of the systems of the project

- Observatory System (Subsystem) – integrating all of the parts of the observatory – instruments and facility

- Airborne Facility (Segment level) – integrating all of the parts on the aircraft

- Telescope Element (Element level) - Integrating the parts of the telescope

Note – Systems
Engineering at
4 different levels
▪Project - integrating all
of the systems of the
project
▪Observatory System –
integrating all of the
parts of the observatory
– instruments and
facility
▪Airborne Facility
Segment – integrating
all of the parts on the
aircraft
▪Telescope Element
▪- integrating the parts
of the telescope
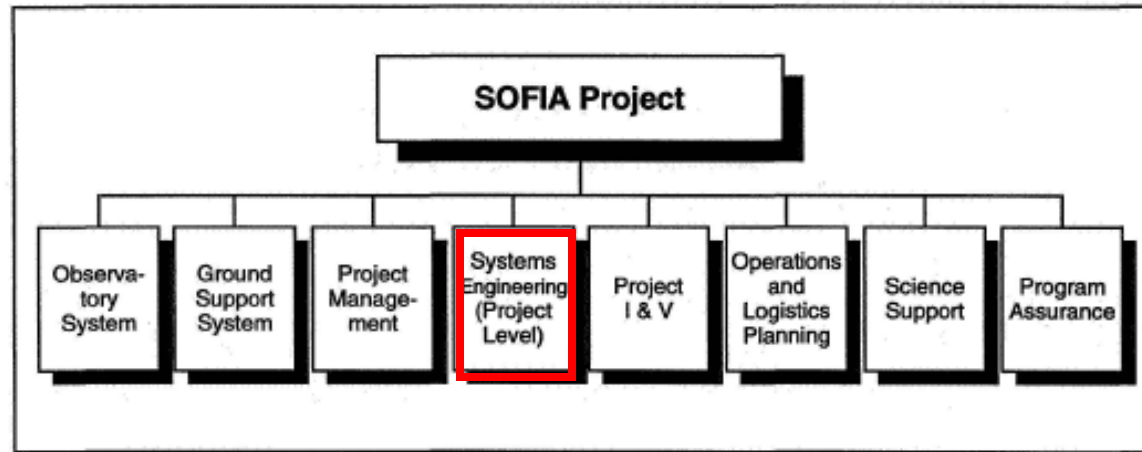
Figure B-2 — SOFIA Project WBS (*Level 3*).
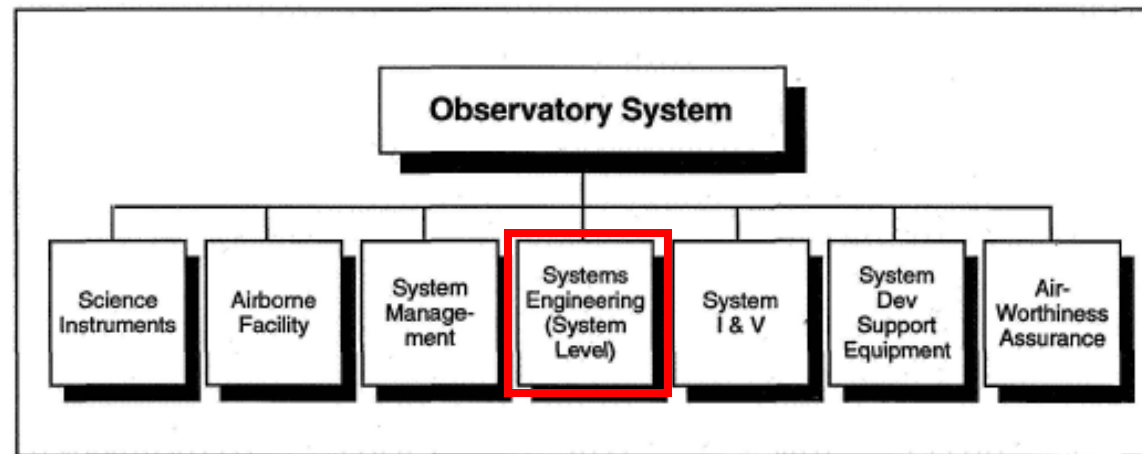
Figure B-3 — SOFIA Observatory System WBS (*Level 4*).

SOFIA
Stratospheric Observatory for Infrared Astronomy
Managed for NASA by the Universities Space Research Association (USRA)

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Figure B-4 — SOFIA Airborne Facility WBS (*Level 5*).
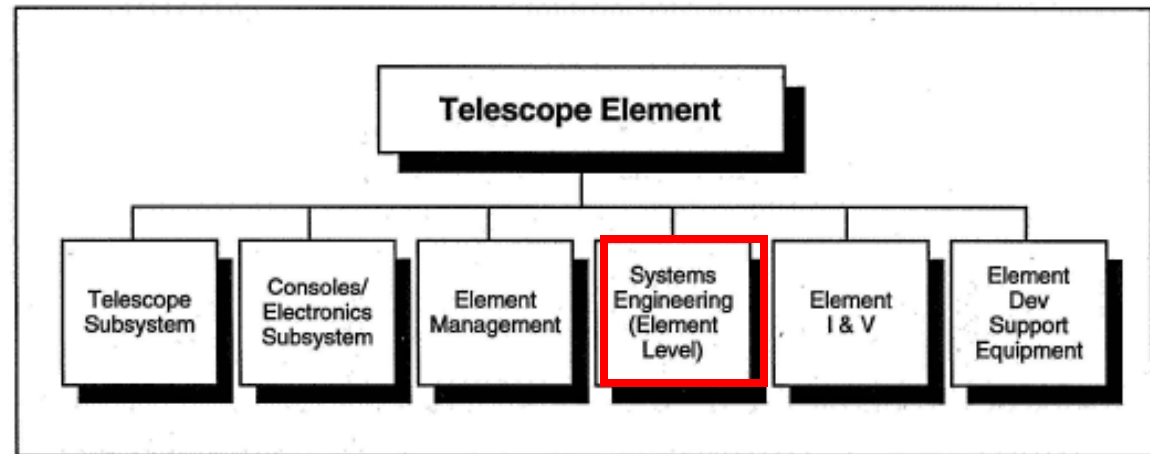
Figure B-5 — SOFIA Telescope Element WBS (*Level 6*).

A view through the partially open telescope cavity door showing the aperture assembly (brown), telescope assembly structure (black) and cover over the primary mirror (red). February 3, 2006

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Why is a WBS Important to a Systems Engineer ?

1. **Budgeting**: The proper way to get effort budgeted in a big project is to get it into the WBS – so if you want systems engineering to have a budget, need to understand the WBS

2. **Systems Engineering View:**   effort may exist at many levels in the project, examining the WBS allows you to see where you need to insert Systems Engineering efforts

3. **Integration View**: If Systems Engineering is going to integrate a project, it needs to know what is going on. The budgeted effort is reflected in a WBS. The WBS is the place to see where effort is being expended that may require integration.

Why is a WBS Important to a Systems Engineer ?

4. **Technical Performance Budgeting**: It is a good place to start for building technical performance budgets, like weight, electrical power, pointing accuracy

5. **Cost Estimating and Scheduling**: Systems Engineers are always heavily involved in cost estimating and scheduling and the WBS is a good tool for both of these efforts

Rules for WBS

➢ A WBS is **not** a project plan **nor** a project schedule and it is **not** a chronological listing.

  ➢ It is considered poor practice to construct a project schedule before designing a proper WBS.

  ➢ This would be similar to scheduling the activities of home construction before completing the house design.

  ➢ Without concentrating on planned outcomes, it is very difficult to follow the 100% Rule at all levels of the WBS hierarchy.

➢ A WBS is **not** an organizational hierarchy.

  ➢ Some practitioners make the mistake of creating a WBS that shadows the organizational chart.

  ➢ While it is common for responsibility to be *assigned* to organizational elements, a WBS that shadows the organizational structure is not descriptive of the project scope and is not outcome-oriented.

Rules for WBS

➢ **WBS updates**, other than progressive elaboration of details, require **formal change control**.

  ➢ This is another reason why a WBS should be outcome-oriented and not be prescriptive of methods.

  ➢ Methods can, and do, change frequently, but changes in planned outcomes require a higher degree of formality.
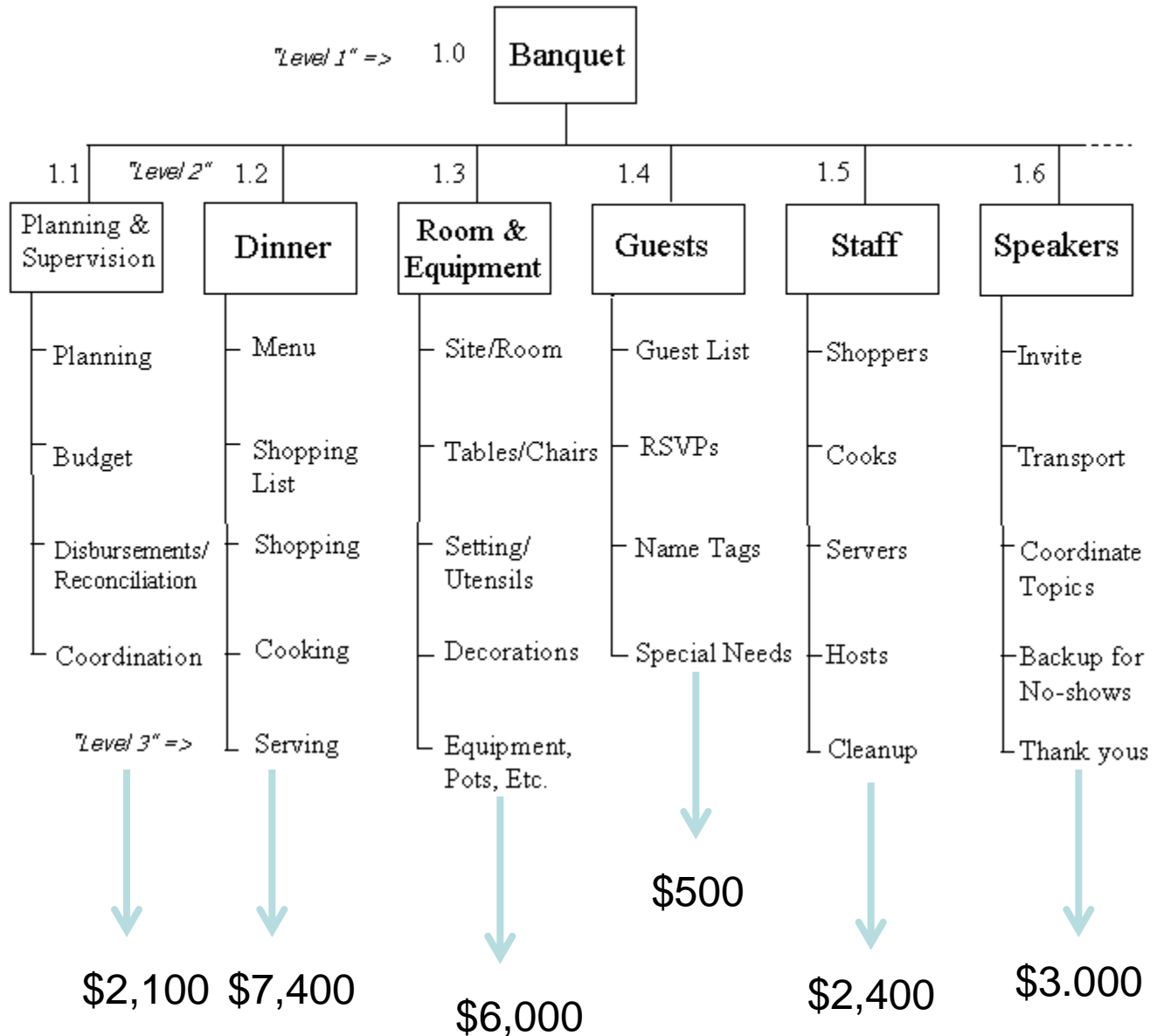
Once you have the WBS

➢ If you make each element a row in a spreadsheet
  ➢ Don't forgot the non-hardware items such as software, analysis, test, integration and project management
➢ And make each column the appropriate unit of time (month, year) that you use for accounting/budgeting
➢ Then you can fill in each cell with your method for estimating cost for that item for that year
  ➢ Called a Cost Estimating Relationship (CER)
  ➢ CER's can also include the escalation due to inflation
➢ Then if you sum columns, you get yearly budget
➢ If you sum rows, you get total estimated cost for each item in the WBS
➢ Once you have a WBS, you have the elements to build a schedule
  ➢ There should be a schedule with milestones for every item in the WBS

Cost Estimation Relationship - Example

	Jan	Feb	Mar	Apr	May	Total
Planning	$500	$500	$500	$300	$100	$2,100
Dinner	$100	$100	$100	$100	$7,000	$7,400
Room	$0	$0	$1,500	$4,000	$500	$6,000
Guests	$100	$100	$100	$100	$100	$500
Staff	$100	$100	$100	$100	$2,000	$2,400
Speakers	$100	$100	$100	$3,000	$100	$3,400
Total	$900	$900	$2,400	$7,600	$9,800	$21,800

Banquet is scheduled for May 15th

WBS Example - Banquet

	"Level 1" =>	1.0	**Banquet**		
1.1 "Level 2"	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**
Planning & Supervision	Dinner	Room & Equipment	Guests	Staff	Speakers
Planning	Menu	Site/Room	Guest List	Shoppers	Invite
Budget	Shopping List	Tables/Chairs	RSVPs	Cooks	Transport
Disbursements/ Reconciliation	Shopping	Setting/ Utensils	Name Tags	Servers	Coordinate Topics
Coordination	Cooking	Decorations	Special Needs	Hosts	Backup for No-shows
"Level 3" =>	Serving	Equipment, Pots, Etc.		Cleanup	Thank yous

$2,100 $7,400

$6,000

$500

$2,400

$3.000

Why Use a WBS

- The work breakdown structure has a number of benefits in addition to defining and organizing the project work.
- A project budget can be allocated to the top levels of the work breakdown structure, and department budgets can be quickly calculated based on the each project's work breakdown structure.
- By allocating time and cost estimates to specific sections of the work breakdown structure, a project schedule and budget can be quickly developed from the WBS.
- As the project executes, specific sections of the WBS can be tracked to identify project cost performance and identify issues and problem areas in the project.

Why Use a WBS

- Project WBSs can also be used to identify potential risks in a given project.
- If a WBS has a branch that is not well defined then it represents a scope definition risk.
  - These risks should be tracked in a project log and reviewed as the project executes.
- By integrating the WBS with an organizational breakdown structure, the project manager can also identify communication points and formulate a communication plan across the project organization.

Why Use a WBS

- When a project is falling behind, referring the WBS will quickly identify the major deliverables impacted by a failing work package or late sub-deliverable.
- The WBS can also be color coded to represent sub-deliverable status.
- Assigning colors of red for late, yellow for at risk, green for on-target, and blue for completed deliverables is an effective way to produce a heat-map of project progress and draw management's attention to key areas of the work breakdown structure.

WBS Guidelines

- The top level represents the final system deliverable
- Sub-deliverables contain work packages that are assigned to a organization's unit
- All elements of the work breakdown structure don't need to be defined to the same level
- The work package defines the work, duration, and costs for the tasks required to produce the sub-deliverable
- Work packages should not exceed an agreed to period
- Work packages should be independent of other work packages in the work breakdown structure
- Work packages are unique and should not be duplicated across the work breakdown structure

Homework

- For EE 461 Class
  - As a team, build a Level 3 WBS for you project.

- For EE590 and IE590
  - Write a 1 page paper on the importance of a Work Breakdown Structure.