



# Galaxy Charts

The 1,000-Light-Year View of the Data

Robert Nehring  
Katharine Mann  
Robert Jones

# Outline

---

- ▶ Problem Statement
- ▶ Example Data
- ▶ Review of Visualization Chart Types
  - Pie Charts
  - Pareto Charts
  - Comb Charts
- ▶ Galaxy Charts
- ▶ Insights
- ▶ Further Research and Enhancements



# Problem Statement

---

## ▶ Challenges

- Succinctly conveying estimates to decision makers
- Significant time spent poring over datasets
- Significant time spent discussing WBS elements with small costs or small deltas at the expense of more important elements

## ▶ Constraint

- Most cost data housed in a WBS

**Graphical Excellence:** “That which gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.”  
~ Edward Tufte

# Example Data

- ▶ Surface Combatant
  - Follow Ship
  - Derived from FY12 Budget

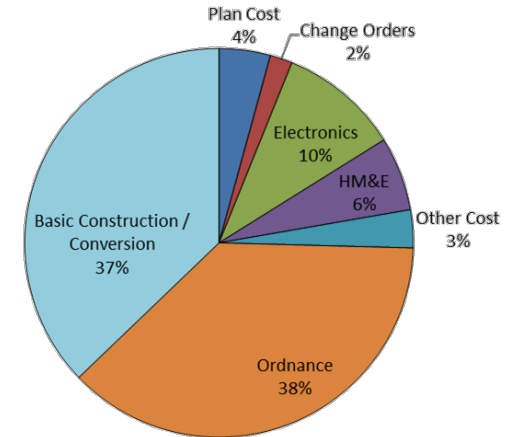


| Element | Name                                | Cost (FY13\$M) |
|---------|-------------------------------------|----------------|
| 1.0     | Surface Combatant                   | \$2,000        |
| 1.1     | Plan Cost                           | \$85           |
| 1.2     | Basic Construction/Conversion       | \$743          |
| 1.2.1   | Labor                               | \$379          |
| 1.2.2   | Material                            | \$253          |
| 1.2.3   | FCCM                                | \$15           |
| 1.2.4   | Fee                                 | \$97           |
| 1.3     | Change Orders                       | \$37           |
| 1.4     | Electronics                         | \$200          |
| 1.4.1   | SQQ 89 ASW                          | \$50           |
| 1.4.2   | SLQ-32 EW/MK 53 Nulka               | \$10           |
| 1.4.3   | USQ 82 GEDMS                        | \$16           |
| 1.4.4   | EXCOMM                              | \$48           |
| 1.4.5   | Navigation System                   | \$2            |
| 1.4.6   | MK-12 IFF                           | \$5            |
| 1.4.7   | SLQ 25 NIXIE                        | \$2            |
| 1.4.8   | SLQ 4 LAMPS III                     | \$2            |
| 1.4.9   | SSEE                                | \$15           |
| 1.4.10  | MIDS                                | \$3            |
| 1.4.11  | CEC BLK II                          | \$7            |
| 1.4.12  | Misc. Electronics                   | \$40           |
| 1.5     | HM&E                                | \$123          |
| 1.5.1   | STC 2 IVCS                          | \$7            |
| 1.5.2   | Main Reduction Gear                 | \$63           |
| 1.5.3   | Machinery Control System            | \$12           |
| 1.5.4   | Integrated Bridge Navigation System | \$9            |
| 1.5.5   | Misc. HM&E                          | \$32           |
| 1.6     | Other Cost                          | \$63           |
| 1.7     | Ordnance                            | \$748          |
| 1.7.1   | AEGIS Weapon System (MK-7)          | \$343          |
| 1.7.2   | VLS MK 41                           | \$85           |
| 1.7.3   | MK 45 LWG                           | \$24           |
| 1.7.4   | MK 37 Tomahawk                      | \$39           |
| 1.7.5   | Phalanx CIWS BLK 1B                 | \$6            |
| 1.7.6   | MK 32 SVTT                          | \$2            |
| 1.7.7   | Electro-optical System              | \$3            |
| 1.7.8   | MK 160 GFCS                         | \$9            |
| 1.7.9   | SPS 67 Radar                        | \$13           |
| 1.7.10  | Misc. Ordnance                      | \$224          |

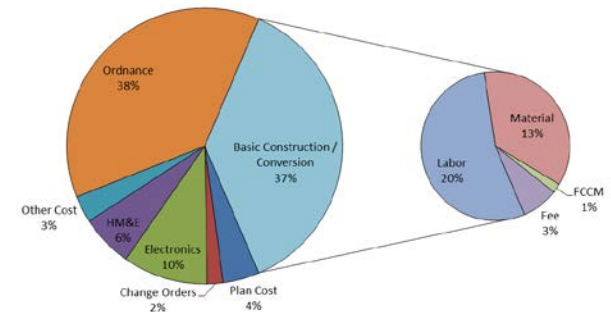
# Pie Charts

- ▶ Each slice's area is equal to a proportionate percentage of the whole
- ▶ Strengths:
  - Very familiar
- ▶ Weaknesses:
  - Only shows one or two levels of data
  - Lose sight of higher WBS levels

Surface Combatant Costs



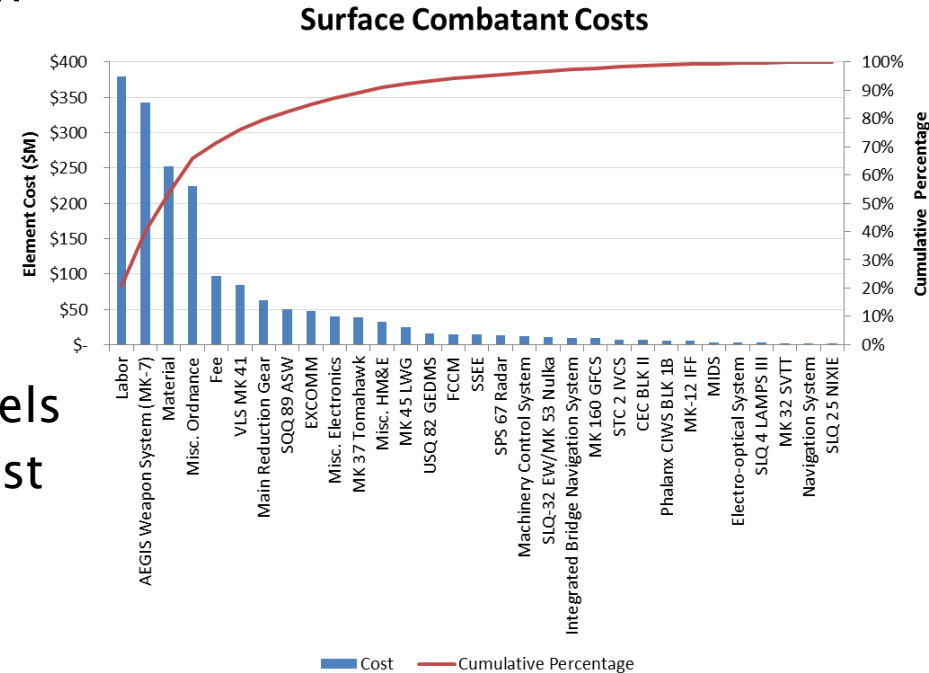
Surface Combatant Costs



**Conclusion:** Pie charts do not graphically capture the complexity of cost relationships that a WBS contains

# Pareto Charts

- ▶ Elements shown on a bar chart in descending order
- ▶ Strengths:
  - Focus on big-ticket items
- ▶ Weaknesses:
  - Difficult to show multiple WBS levels
  - Relationships and structure are lost
  - Lose sight of higher WBS levels



**Conclusion:** Pareto charts do not graphically capture the complexity of cost relationships that a WBS contains

# Comb Charts

- Costs broken out in tables from left to right

- Strengths:

- Shows multiple levels

- Weaknesses:

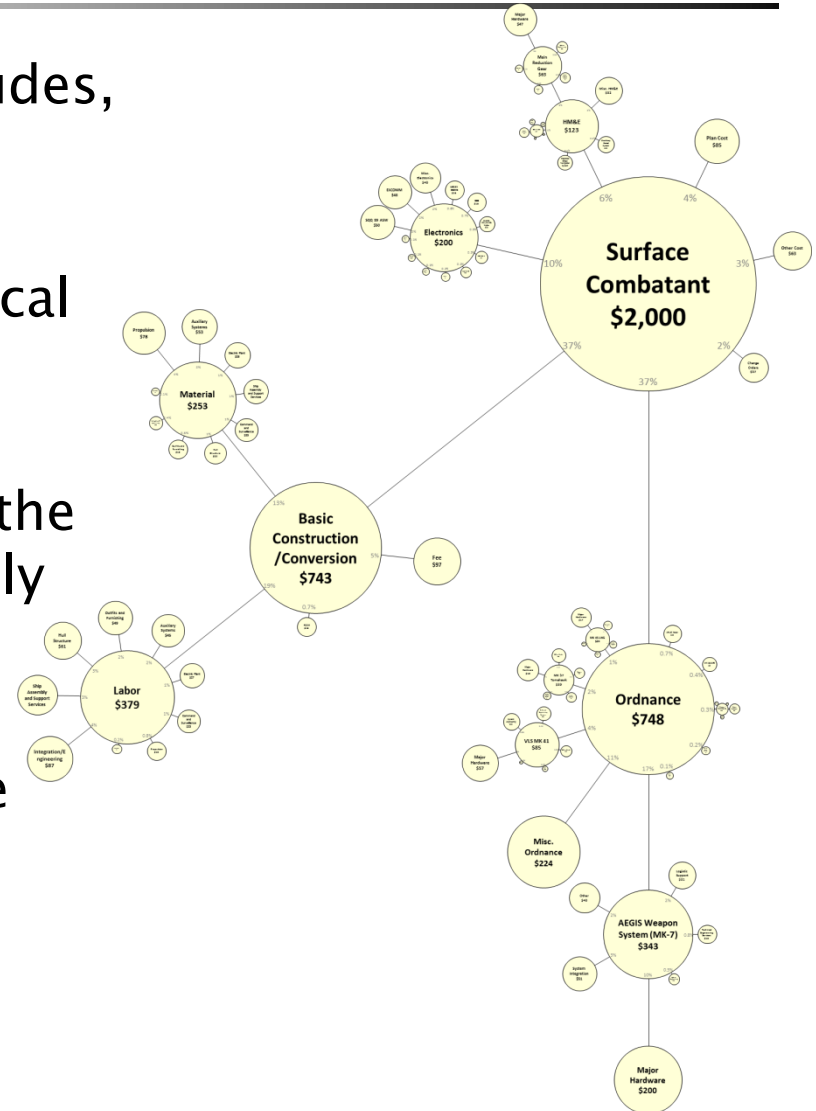
- Cost magnitudes are not readily apparent
- Multiple pages often needed to make text readable

|                   | FY10\$M | % of Total |                                     | FY10\$M   | % of Category |
|-------------------|---------|------------|-------------------------------------|-----------|---------------|
| Surface Combatant | \$2,000 |            | Plan Cost                           | \$85      | 4.3%          |
|                   |         |            | Basic Construction/Conversion       | \$743     | 37.2%         |
|                   |         |            | Change Orders                       | \$37      | 1.9%          |
|                   |         |            | Electronics                         | \$200     | 10.0%         |
|                   |         |            | HM&E                                | \$123     | 6.1%          |
|                   |         |            | Other Cost                          | \$63      | 3.2%          |
|                   |         |            | Ordnance                            | \$748     | 37.4%         |
|                   |         |            | Labor                               | \$ 379.16 | 51.0%         |
|                   |         |            | Material                            | \$ 252.77 | 34.0%         |
|                   |         |            | FCCM                                | \$ 14.87  | 2.0%          |
|                   |         |            | Fee                                 | \$ 96.65  | 13.0%         |
|                   |         |            | SQQ 89 ASW                          | \$ 50.34  | 25.2%         |
|                   |         |            | SLQ-32 EW/MK 53 Nulka               | \$ 10.16  | 5.1%          |
|                   |         |            | USQ 82 GEDMS                        | \$ 15.62  | 7.8%          |
|                   |         |            | EXCOMM                              | \$ 47.58  | 23.8%         |
|                   |         |            | Navigation System                   | \$ 2.17   | 1.1%          |
|                   |         |            | MK-12 IFF                           | \$ 4.96   | 2.5%          |
|                   |         |            | SLQ 25 NIXIE                        | \$ 2.16   | 1.1%          |
|                   |         |            | SLQ 4 LAMPS III                     | \$ 2.45   | 1.2%          |
|                   |         |            | SSEE                                | \$ 14.67  | 7.3%          |
|                   |         |            | MIDS                                | \$ 3.40   | 1.7%          |
|                   |         |            | CEC BLK II                          | \$ 6.77   | 3.4%          |
|                   |         |            | Misc. Electronics                   | \$ 39.64  | 19.8%         |
|                   |         |            | STC 2 IVCS                          | \$ 7.03   | 5.7%          |
|                   |         |            | Main Reduction Gear                 | \$ 63.05  | 51.3%         |
|                   |         |            | Machinery Control System            | \$ 11.66  | 9.5%          |
|                   |         |            | Integrated Bridge Navigation System | \$ 9.35   | 7.6%          |
|                   |         |            | Misc. HM&E                          | \$ 31.79  | 25.9%         |
|                   |         |            | AEGIS Weapon System (MK-7)          | \$ 342.62 | 45.8%         |
|                   |         |            | VLS MK 41                           | \$ 84.70  | 11.3%         |
|                   |         |            | MK 45 LWG                           | \$ 24.47  | 3.3%          |
|                   |         |            | MK 37 Tomahawk                      | \$ 38.85  | 5.2%          |
|                   |         |            | Phalanx CIWS BLK 1B                 | \$ 6.05   | 0.8%          |
|                   |         |            | MK 32 SVTT                          | \$ 2.35   | 0.3%          |
|                   |         |            | Electro-optical System              | \$ 3.07   | 0.4%          |
|                   |         |            | MK 160 GFCS                         | \$ 8.89   | 1.2%          |
|                   |         |            | SPS 67 Radar                        | \$ 13.36  | 1.8%          |
|                   |         |            | Misc. Ordnance                      | \$ 223.71 | 29.9%         |

**Conclusion:** Comb charts do not display the data in an easily readable graphical form

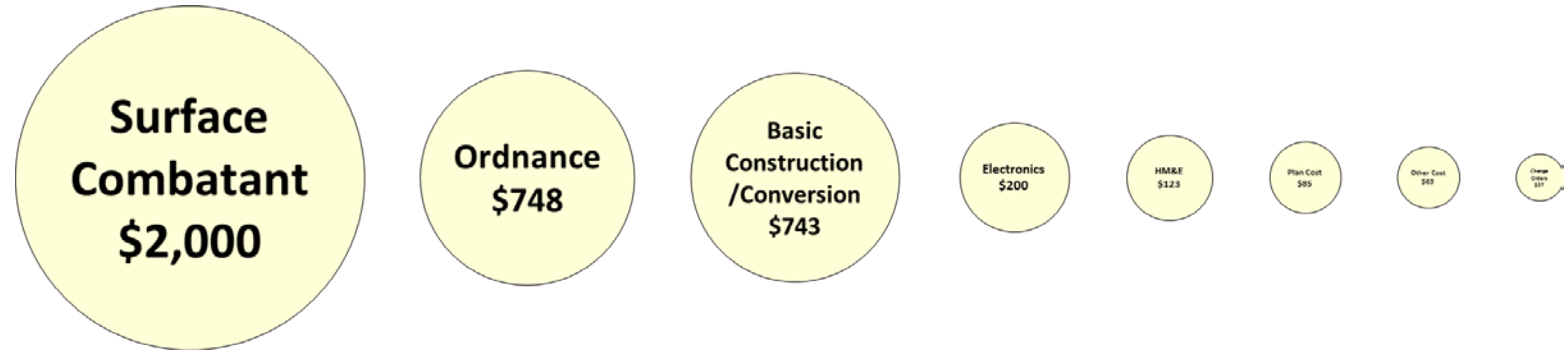
# Galaxy Charts

- ▶ Shows all WBS elements, magnitudes, and relationships
- ▶ Total Cost, i.e., the Sun, is the focal point
- ▶ Children, i.e., the Planets “orbit” the Sun; relative magnitudes are easily discernible
- ▶ Lines between elements illustrate relationships



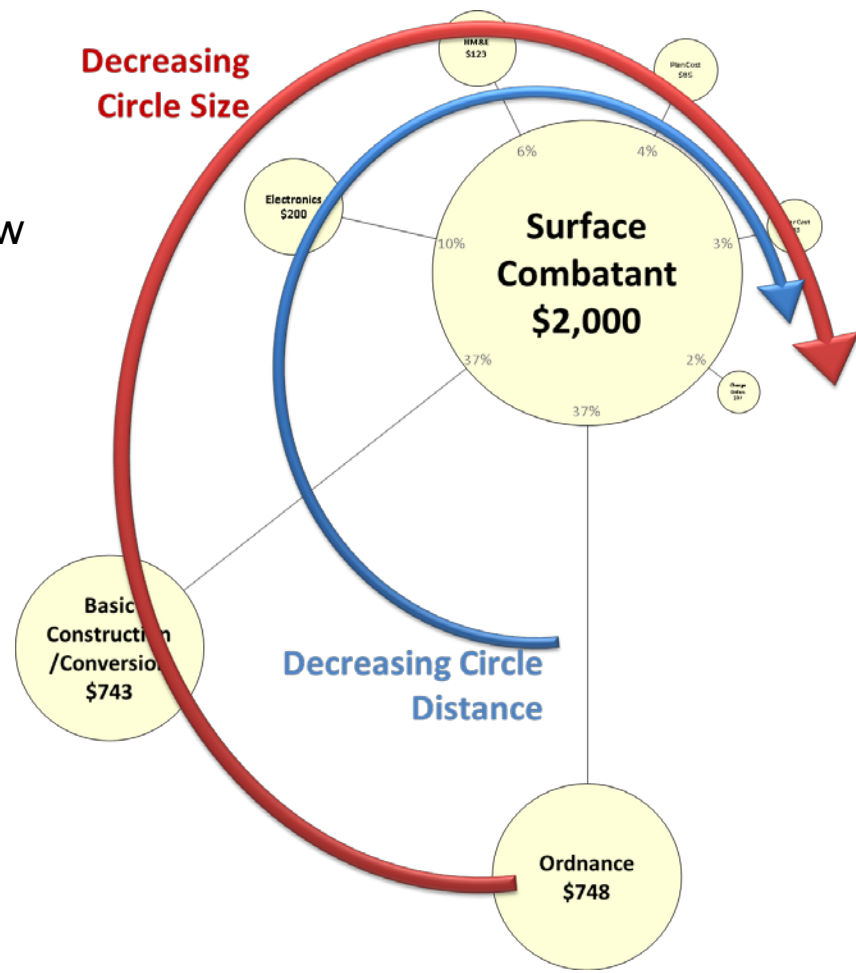
# Circle Sizing

- ▶ All circles are sized by area relative to the Sun
  - Parent–level area =  $\Sigma$ (Child–level areas)
  - Large cost elements are large circles
  - Small cost elements are small circles
- ▶ Large, emphasized circles are by design
- ▶ Small, unreadable circles are also by design



# Circle Location

- ▶ Children–circles orbit the parent in a clockwise manner, at an ever–decreasing distance
  - Largest child of Total Cost begins below Total Cost at 180° degrees
  - Remaining children are ordered largest to smallest and evenly spaced around the parent
  - Distance between parent and children decreases relative to child’s cost





# Constructing a Galaxy Chart (1)

---

- ▶ Start with the Sun, i.e., the top-most WBS element
  - Insert the label: WBS element name and Total Cost
  - Color the circle: light yellow with a black circumference line



Circle Area = 2.0 in<sup>2</sup>

# Constructing a Galaxy Chart (2)

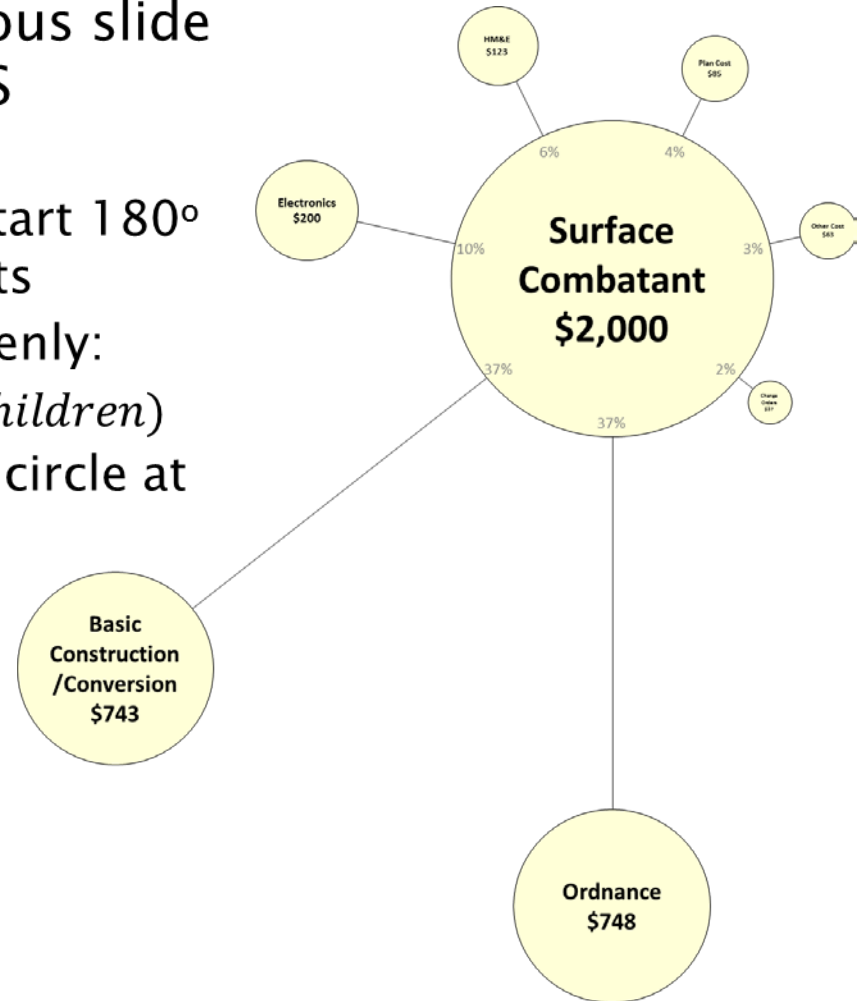
- ▶ Move on to Sun's children
  - Sort the WBS elements from largest to smallest
  - Locate the largest WBS element's circle directly below the Sun

| WBS Number | WBS Element Name              | Cost           | Percent of Total | Area (in <sup>2</sup> ) | Radius (in) |
|------------|-------------------------------|----------------|------------------|-------------------------|-------------|
| 1.7        | Ordnance                      | \$748          | 37.4%            | 0.75                    | 0.49        |
| 1.2        | Basic Construction/Conversion | \$743          | 37.2%            | 0.74                    | 0.48        |
| 1.4        | Electronics                   | \$200          | 10.0%            | 0.20                    | 0.25        |
| 1.5        | HM&E                          | \$123          | 6.1%             | 0.12                    | 0.20        |
| 1.1        | Plan Cost                     | \$85           | 4.3%             | 0.09                    | 0.16        |
| 1.6        | Other Cost                    | \$63           | 3.2%             | 0.06                    | 0.14        |
| 1.3        | Change Orders                 | \$37           | 1.9%             | 0.04                    | 0.11        |
|            | <b>Total Cost</b>             | <b>\$2,000</b> | <b>100%</b>      | <b>2.0</b>              |             |

$$\text{Radius} = \sqrt{\frac{\text{Area of the Child Level Element}}{\pi}}$$

# Constructing a Galaxy Chart (3)

- ▶ Follow the steps on the previous slide for each of the remaining WBS elements until all are drawn
  - The largest circle will always start 180° from where the parent connects
  - Space the remaining circles evenly:  
 $Angle\ Increment = 360^\circ / (\# Children)$
  - Move clockwise, drawing each circle at an ever-decreasing distance



# Galaxy Chart Insights

---

- ▶ Initial Estimate
- ▶ Analysis of Alternatives (AoA)
- ▶ Independent Cost Estimate (ICE) vs. Initial Estimate reconciliation
- ▶ Earned Value Management (EVM)

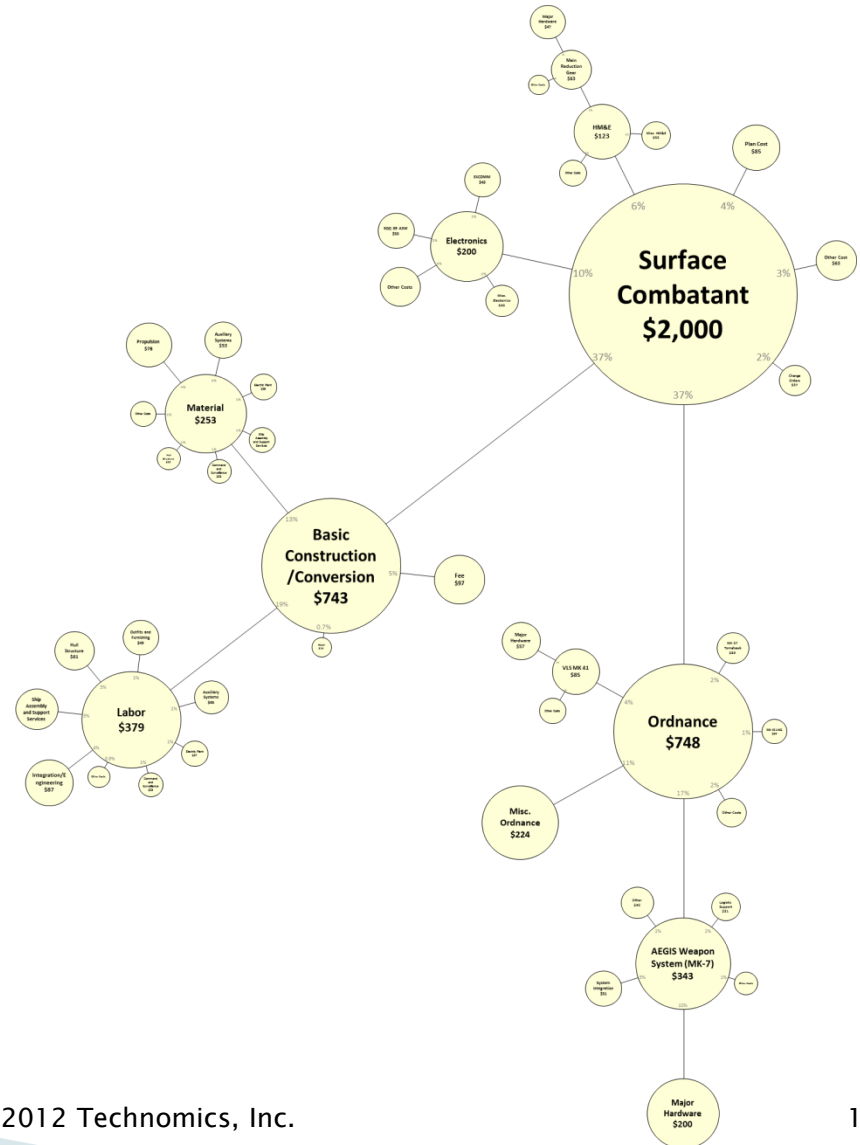


# Initial Estimate Insights

- ▶ Identification of large cost elements



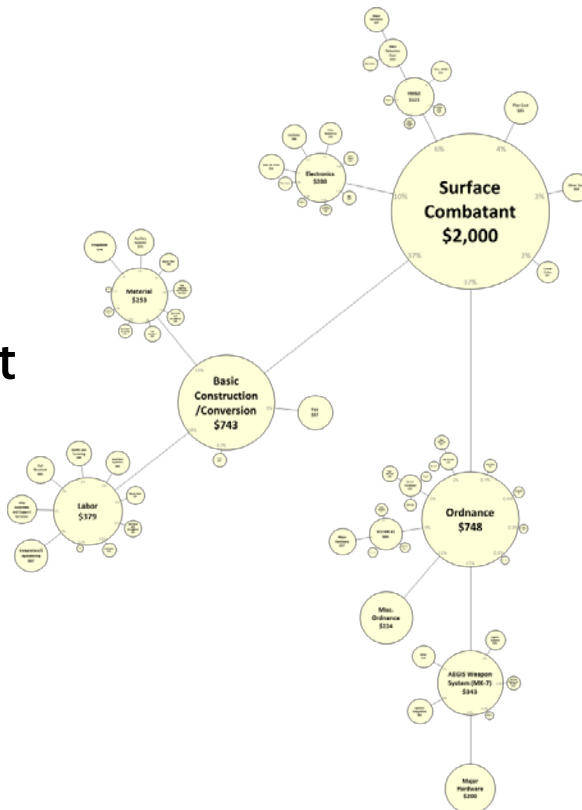
- ▶ Removal of small circles
- ▶ Comparisons between dissimilar elements



# AoA Insights (1)

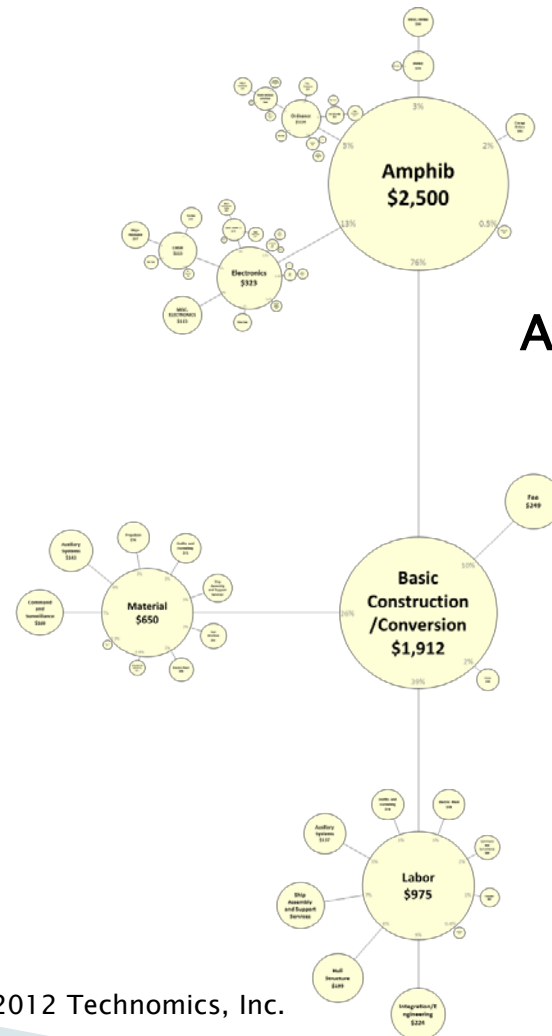
- ▶ Side-by-side comparisons of ship types

**Surface  
Combatant**



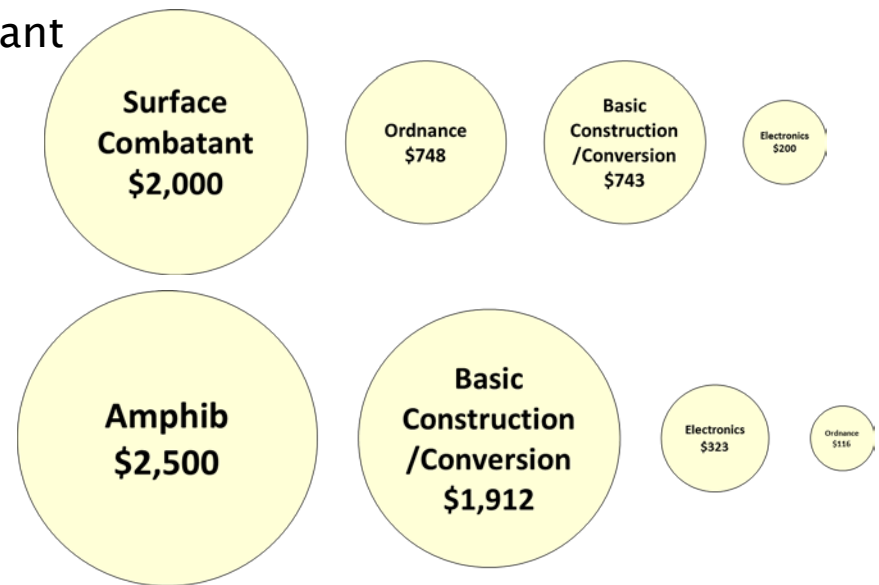
© Technomics, Inc.

**Amphibious  
Ship**



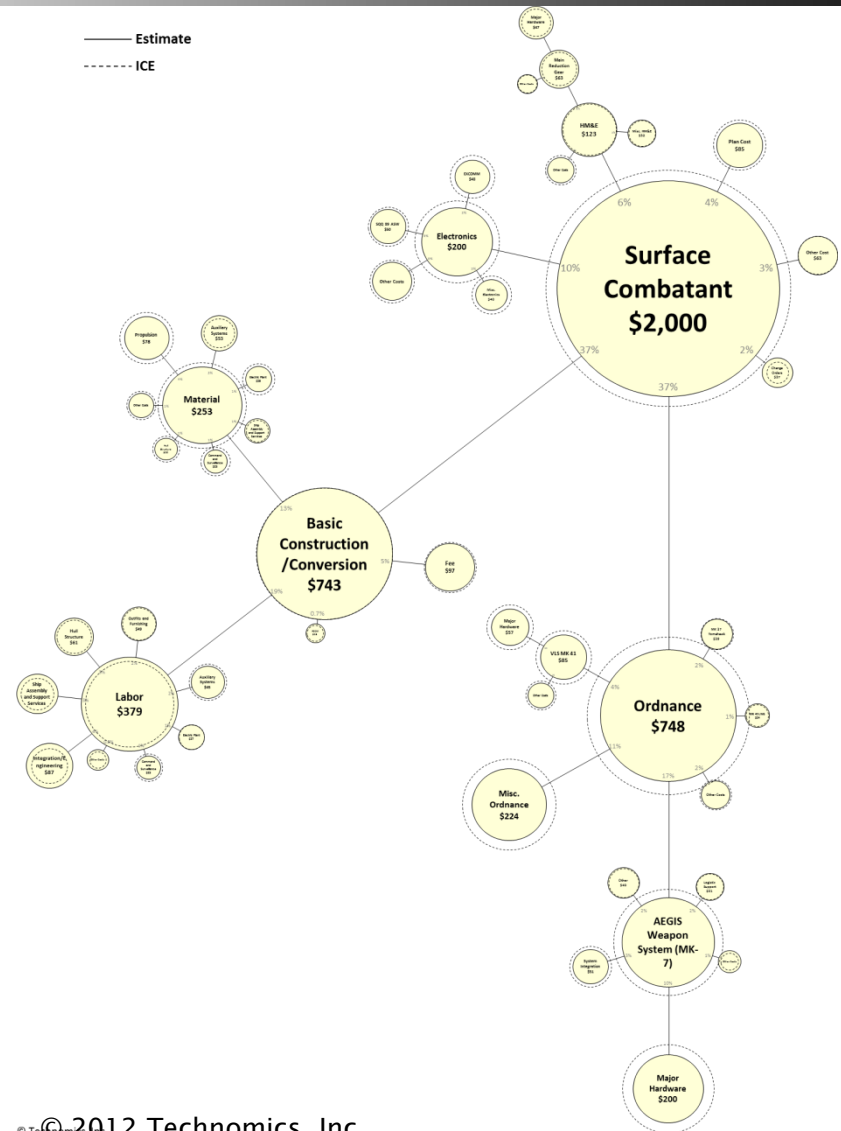
# AoA Insights (2)

- ▶ Circle Order
  - Largest to smallest
- ▶ Circle Sizing
  - Amphib BCC > Combatant BCC
  - Amphib BCC  $\cong$  Total Surface Combatant
- ▶ Linkage to a cost model...dynamic Galaxy charts
  - Changing line segments
  - Changing circle sizes
  - Changing numeric text



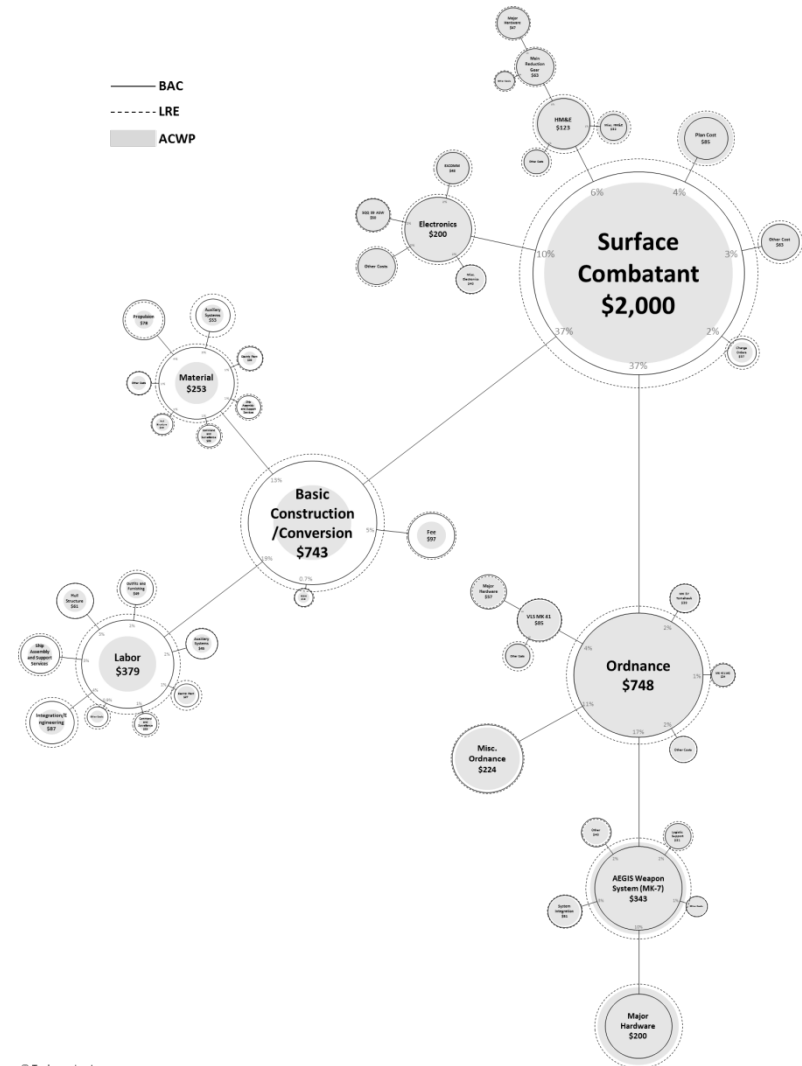
# Reconciliation Insights

- ▶ Superimpose the ICE on the Initial Estimate
  - Dashed line is the ICE
  
- ▶ Identify *significant* differences
  - AEGIS is the most significant contributor to Ordnance cost divergence
  - The two estimates for Basic Construction are virtually identical, but components are not



# Earned Value Management Insights

- ▶ Summarize three important EVM metrics on the same chart:
  - BAC (solid line)
  - LRE (dashed line)
  - ACWP (shaded)
- ▶ Visualize WBS element effort-sequencing
  - Basic Construction is “last”
- ▶ Indicate actual and potential overruns, i.e.,  $LRE > BAC$
- ▶ Show WBS element relationships
- ▶ Add time-dimension with “flipbook” of multiple charts



# Further Research and Enhancements

---

- ▶ Use the circle-to-circle line segments to add another dimension
  - Schedule, duration, start dates, end dates, etc.
- ▶ Apply concept to other WBS's:
  - Non-DoD systems
  - Schedule analysis
  - Weight
  - Any other hierarchal data
- ▶ 3-Dimensional model of the Galaxy Chart
- ▶ A more detailed application for comparative analysis



# Summary

---

## Galaxy Charts

1. Provide an intuitive way to gain an accurate and comprehensive view of costs within a WBS
2. Allow analysts to gain understanding not available in other visualization techniques
3. Help an analyst discern what costs are important, how elements are related, and where analysis time enjoys the greatest potential payback



# References

---

- ▶ *Department of the Navy Fiscal Year (FY) 2012 Budget Estimates, Shipbuilding and Conversion, Navy.* (2011, February). Retrieved March 1, 2012, from Office of the Assistant Secretary of the Navy, Financial Management and Comptroller: [http://www.finance.hq.navy.mil/FMB/12pres/SCN\\_BOOK.pdf](http://www.finance.hq.navy.mil/FMB/12pres/SCN_BOOK.pdf)
- ▶ Cooper, L., & Plowden, L. (2010, April 30). *Business Case Analysis.* Retrieved March 1, 2012, from Slideshare: <http://www.slideshare.net/Timothy212/powerpoint-document-business-case-analysis>
- ▶ NAVSEA. (2005). *Cost Estimating Handbook.* Washington, DC: SEA 017.
- ▶ Society of Cost Estimating and Analysis. (2010). *Cost Estimating Body of Knowledge.*
- ▶ Tufte, E. R. (1990). *Envisioning Information.* Cheshire, Connecticut: Graphics Press LLC.
- ▶ Tufte, E. R. (1997). *Visual Explanations.* Cheshire, Connecticut: Graphics Press LLC.
- ▶ Tufte, E. R. (2001). *The Visual Display of Quantitative information* (2 ed.). Cheshire, Connecticut: Graphics Press LLC.
- ▶ Tufte, E. R. (2006). *Beautiful Evidence.* Cheshire, Connecticut: Graphics Press LLC.

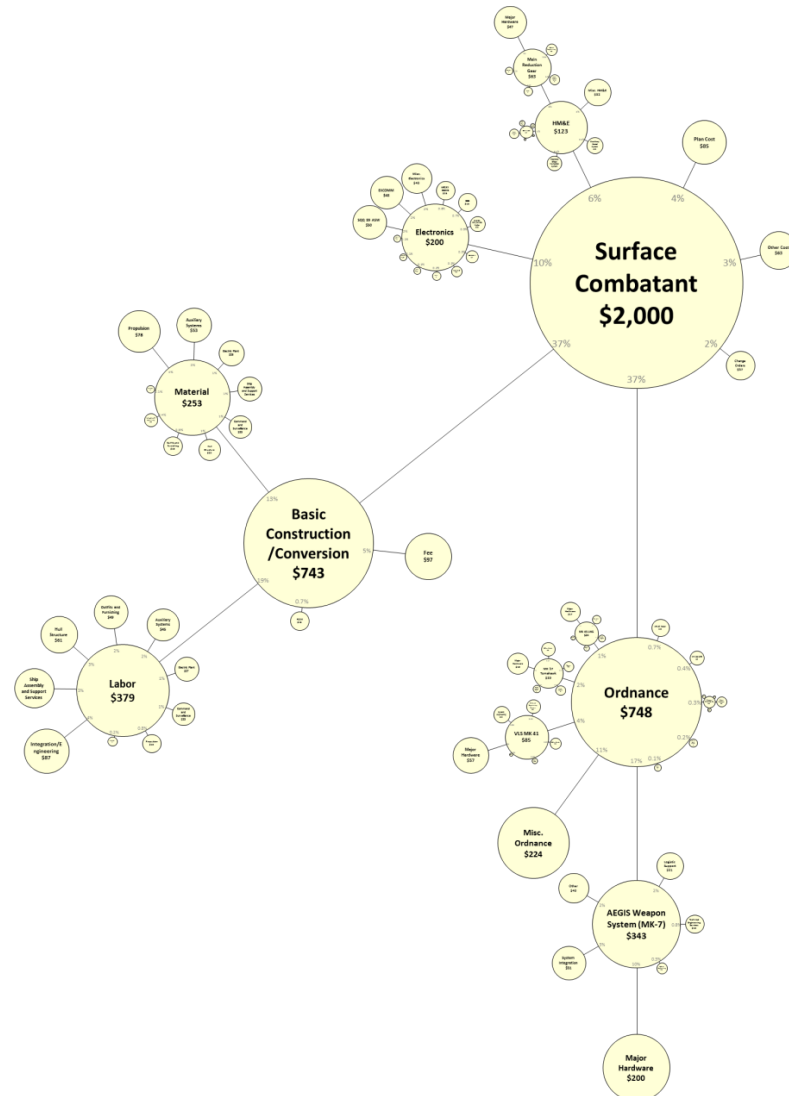


# Questions?

**Bob Nehring**  
rnehring@technomics.net  
571-366-1441

**Kammy Mann**  
kmann@technomics.net  
571-366-1400 ext. 1360

**Bob Jones**  
rjones@technomics.net  
517-366-1412



# Taxonomy

