# Accounting for the Value of Earth Science Data

Bruce R. Barkstrom
and
Paula L. Sidell

# Outline

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- The Accountant's View of the Value of Earth Science Data
- The Governmental Context
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- A Refined Balance Sheet
- Next Steps
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  - Developing Strategies for Distributing Risk

# The Paradoxes of Information Preservation

- Digital Data is Intangible – and Very Fragile
  - The equipment to collect the data and hold it for use is very tangible – and even impressive
  - Because of equipment obsolescence, data need to be migrated (new media, new read/write hardware, new software) about every 3 years
- Managers are Impressed by Storage Volume Increases – but the Cost per Volume Decreases at about 45% Per Year
  - Real cost lies in people
- Preserving Information (ability to use data) Depends on Preserving “Academies of Knowledgeable Users”

# Communities Receiving "Societal Benefits"

| GEOS Societal Benefit Area | Kind of Benefit Desired | Long-Term Data Need |
|---|---|---|
| Disasters | Warning – 3 hr latency at most | |
| Health | Warning and Information Service | |
| Energy | Operations Information Service + Site Planning | X |
| Climate | History Reconstruction and Mitigation/Adaptation Planning | X |
| Water | Operations Information Service + Site Planning | X |
| Weather | Information Service | |
| Ecosystems | History Reconstruction and Mitigation/Adaptation Planning | X |
| Agriculture | Operations Information Service + Land Use Planning | X |
| Biodiversity | History Reconstruction and Mitigation/Adaptation Planning | X |
| Architecture | History Reconstruction and Mitigation/Adaptation Planning | X |
| Data Management | Information Technology Infrastructure Development | |

# The Accountant's View of Value

- Accountants View an Organization in terms of the *Flow of Funds*
- *Funds are placed in a Chart of Accounts*
- *Frequent changes in the Chart of Accounts is not allowed in standard rules of accounting*

A Basic Chart of Accounts

| Debit | Credit |
|---|---|
| Assets [*A*] | Fund Balance [*F*] |
| | Liabilities [*L*] |
| Expenses [*E*] | Income [*I*] |

Funding Balance Requires

$$\Delta A + \Delta L = I - E$$

*or*
Sum of Asset Changes
*plus*
Sum of Liability Changes
*equals*
Difference Between Income and Expenses

# The Governmental Context (US Perspective)

- Archive is a *Governmental Institution*
  - *Income from holdings comes from the general fund of the government – not from market value*
  - *Fund Balance increase does not accrue to owners or managers*
- *Value of Archive Contents arises from value of data access to users – not economic value of data itself*
  - *Usefulness of data arises as intangible residue of intellectual capital invested by data creators*
- *"State-of-the-art" budgets need to include statement of what activity will achieve – even if non-economic outcome desired*

# Accounting Approach

- Need to deal with
  - Basis of Accounting: when transactions and events are recognized (*Full Accrual or Cash)*
  - Measurement Focus: what resources are involved
- Depreciation
  - Most assets should be depreciated over their estimated useful lives in a “rational and systematic” manner (*using a common business accounting practice)*
  - *Inexhaustible assets (land, works of art, historical treasures, scientific works) are not depreciable*
  - ***Earth science information is irreplaceable and therefore is not depreciable***

# Information Life Cycle

1. Acquisition of measurement resources
2. Data production, including validation and reprocessing
3. Transfer of processed data from production facilities into archives
4. Archival curation, including transformational migration and reprocessing
5. Providing user access and access transformation

# Information Asset Valuation

| Activity | Expected Interval [yr] | Accounting Basis | Account Type |
|---|---|---|---|
| *Satellite Missions* | | | |
| Instrument Dev. [T] | 5 | M | DC |
| Instrument Char. & Cal Facil. [T] | 5 | F | DC |
| Instrument Char. & Cal. [I] | 0.2 | M | O |
| Instr.-Sat. Integration | 0.5 | M | O |
| Sat.-Vehicle Integration | 0.5 | M | O |
| Initial Sat./Instr. Checkout | 0.2 | M | O |
| Sat./Instr. Ops. | LOM | F | O |
| *In Situ Data Networks* | | | |
| In Situ Data Site Dev. [T] | 2 | M | HS |
| In Situ Data Site Ops. | LOM | F | O |
| *Science Data Production* | | | |
| Science Algorithm Dev. [T] | LOD | F | SD |
| Science Data Validation [I] | LOM | F | O |
| Science Data Production [T] | LOM | F | O |
| Science Data Prod. Facility [T] | LOM | F | HS |
| *Archival Activities* | | | |
| Archive Ingest [I] | LOM | F | O |
| Archive Curation [T] | LOD | F | O |
| Archive Facilities [T] | LOD | F | HS |
| Archive Operations | LOD | F | O |
| *User Access* | | | |

- For Activity
- **T**: Activity produces a **Tangible** asset, such as hardware, software source code, or documentation
- **I**: Activity produces an **Intangible** asset, primarily information that may be used by researchers, decision makers, or other data users
- For Expected Interval
- **LOM**: Life Of Mission, which may be taken as ten years for a single satellite or instrument, and which may increase to more than a century for operational environmental observation capability
- **LOD**: Life Of Data, which NARA defines as 75 years beyond scientific research use. Here, we take this time period to be 200 years – give or take
- For Accounting Basis
- **M**: Modified Accrual accounting basis
- **F**: Full Accrual accounting basis
- For Account Type
- **DC**: Development and Construction
- **O**: Operations
- **HS**: Hardware and Software, including accounts for initial capitalization, depreciation, and refresh/upgrades
- **SD**: Specialized scientific software Development

# Unexpected Insights

- Some expense accounts (e.g. launch vehicles and instruments) have different valuations at different times
  - Before launch: *inventory of work in progress*
  - *After launch: launch vehicle is sunk cost*
  - *After operations cease: instruments and ground systems are sunk cost*
- Source of residual value
  - Data is a *public good*

# Practical Asset Valuation

- Three Standard Methods
  - *Acquisition Cost*
    - *Ultimate Residual Cost attributable to investment in calibration, data production, validation, and reprocessing*
  - *Replacement Cost*
    - *No possible replacement of lost observations*
  - *Net Present Value of Flow of Future Value*
    - *Non-economic nature of data use of a public good makes method moot*
- *Common-Sense Approach*
  - *Use of data must be timely, relevant, and reliable*
  - *Value of data based on cost of expert interpretation as embedded in software and cal-val cost*

# Expense Accounts

- Non-depreciable Asset subject to Asset Impairment
  - *Equivalent to buying insurance to reduce loss of value due to asset impairment*
- *Standard Approach to Insurance Cost*
  1. *Identify threats*
  2. *Estimate probability of loss and probable value of loss if threat materializes*
  3. *Develop affordable strategy to mitigate risk*

# The Challenges of Preservation

- Potential Loss Mechanisms
  - Institutional instability and funding flow changes
  - Operator errors
  - Media, hardware, and software errors
  - Loss of context, including software obsolescence
  - IT security incidents with loss of user trust
  - Evolution of hardware and software
- Stringent Requirements

| **Probability of Loss per Year, *p*** | **10.00%** | **1.00%** | **0.01%** |
|---|---|---|---|
| **Probability of Survival to Year 201** | **$6.4 \times 10^{-10}$** | **0.13** | **0.98** |

# A Refined Balance Sheet

| Debit | Credit |
|---|---|
| *Assets* | *Capitalization* |
| Data | |
| Metadata | *Liabilities* |
| Documentation | IT Security Incidents |
| Human Capital | Loss of Context |
| General Assets | Format and Software Obsolescence |
| Buildings and Related Assets | |
| | |
| *Expenses [offsets to avoid asset impairment]* | *Income* |
| Replication (between agencies and governments) | |
| Operator Training and Monitoring | |
| Automation and Automation Testing | |
| Hardware Evolution | |
| Software Evolution | |
| Power and Air Conditioning | |
| Preservation Planning | |
| Administration | |

# Next Steps

- Formal Valuation Modeling
  - More detailed expression of chart of accounts using Standard General Ledger (USSGL)
- Formal Threat Modeling
  - Adaptation of existing models, such as the archival threat model of the LOCKSS (Lots Of Copies Keeps Stuff Safe) publication archival system
- Evaluation of Future Cost Profiles
  - Publicly accessible cost basis models