NAVAL
POSTGRADUATE
SCHOOL

I could do great statistics if only my data was not so lousy

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April 2008

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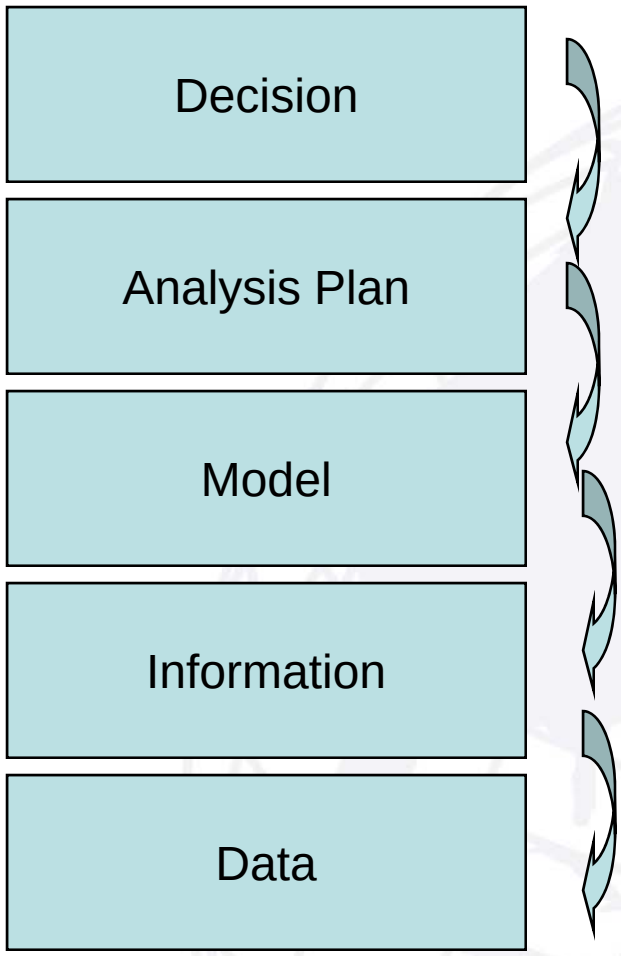
Agenda

- Overview and main point
- OIF/OEF battle data example
- AIM7 examples
- CROWS example
- Common points
- Remedies
- Conclusion

Overview and main point

- Data based decisions need data
- We frequently do not anticipate what data will be needed so we don't collect it
- Capturing valid data retrospectively can be very difficult if not impossible, and very expensive
- Attention to future data needs when designing systems and building in a flexible, expansive capability can pay big dividends
  - Be imaginative
  - Be organized


Decision
Analysis Plan
Model
Information
Data

OEF/OIF battle data example

- Hundreds of data bases and reporting systems
- "The fundamental issue for the display and statistical analysis of the Iraq data was getting a large quantity of high quality data." MAJ Paul Schneider, USMC
- Document-centric reports prevailed until 2005
  - DTG, grid, and text
  - Lack of common definitions
  - Variance in what would be reported
  - Naval and air data grossly under-represented
- Move to XML schema and data bases

Example of simple tagging report

```
- <Node NodeID="2">
    <Classification>Unclassified</Classification>
    <EventID>SIGACT-2</EventID>
    <Date>2003-05-09</Date>
    <Day>Thu</Day>
    <Time>22:39:17.326</Time>
    <TimeZone>Local</TimeZone>
    <Lat>N33 13' 58.1"</Lat>
    <Long>E043 40' 55.1"</Long>
    <City>Al Fallujah</City>
    <Province>Al Anbar</Province
    <CPAArea>CPA South Central
    <MilitaryAOR>CENTCOM</Milit
    <TypeofAttack>SAF</TypeofA
    <EnemyKIA>0</EnemyKIA>
    <EnemyWIA>0</EnemyWIA>
    <EnemyCaptured>0</EnemyCa
    <EnemyID>Unknown</EnemyI
    <EnemyCapturedIntel>None</
    <CoalitionKIA>0</CoalitionKIA>
    <CoalitionWIA>1</CoalitionWIA
    <CoalitionCaptured>0</Coalitio
    <CoalitionID>CentCom</CoalitionID>
    <CoalitionReportingUnit>CENTCOM</CoalitionReportingUnit>
    <UnitActivity>Convoy</UnitActivity>
    <NeutralKIA>0</NeutralKIA>
    <NeutralWIA>0</NeutralWIA>
    <NeutralCaptured>0</NeutralCaptured>
    <NeutralID />
    <NeutralActivity />
    <WordDescription>A Coalition convoy was attacked with an SAF on MSR resulting in one WIA.</WordDescription>
    <Symbol>small-square-red</Symbol>
  </Node>
```

2239D 5 May 2003

At 2239, a Coalition convoy was attacked with small arms fire at MB123456 resulting in one coalition WIA. The QRF was send to the attack site

Schema comments

- Schema can be adjusted as you go, but going back and re-tagging data is a huge chore
  - Previous example; what might we want to add?
  - Unit ID
  - Proximity to key land marks (power station, eg.)
  - Where the convoy was heading
  - Type of vehicle (MRAP or not?)
  - Size of convoy
  - Social network indicators
  - Etc.
- Costs (labor, time, storage) of over-collecting of data must be balanced against potential future need
- MAJ Schneider's final schema was 12 pages long, and looks woefully dated today as the battle patterns have changed.
- Unanswered: what decisions are we trying to support?
- Unanswered: for what analyses, metrics, models do we need to build capability in the future?

Point

- OIF/OEF has suffered from not ‘getting the metrics right’
- Data collection was not originally driven by need to support decision makers, as the strategic situation unfold unexpectedly
- Who owns the data collection systems in theater? Who sets requirements, including interoperability? Who owns the common schema?

AIM7 example

- Sparrow missile fielded beginning in 1940s.
- Only air-to-air current version, AIM7M, entered service in 1982 with a 20 year service life.
  - About 20,000 fielded
  - 18,000 remained in late 1990s; about $2B in inventory
- Several misfires in late 1990s indicated age-related damage in stockpiles
- What was the risk of extending the service life?

(Pictures from Federation of American Scientists web site)

Failure mechanisms

- Physical analysis indicated one key failure mode was due to temperature cycling from being flown from sea level to operating altitudes and back
- There were competing failure modes
  - Standard age effects
  - A second ‘clock’: cycles to altitude
- No data available on cycles to altitude
- Impossible to do precise estimates of risk of extending service life
- Solution: embed chip on missile case to record environmental history for next generation of munitions
  - But what to collect?

CROWS example

- Crew Remotely Operated Weapons System fielded rapidly by USARDEC for OIF.
- The CROWS is a stabilized, gunner-operated system that provides the capability to remotely aim and fire a suite of crew-served weapons.
- It supports the MK19 Grenade Machine Gun, 50 Caliber M2 Machine Gun, M249 Semi Automatic Weapon and M240B Machine Gun.
- CROWS includes two axis-stabilized mounts, a sensor suite and fire control software allowing on-the-move target acquisition and first-burst target engagement.
- The CROWS sensor suite permits target engagements under day and night conditions and includes a daytime video camera, image intensifier, heavy thermal weapon sight and laser rangefinder.

Components

System Components

DISPLAY UNIT

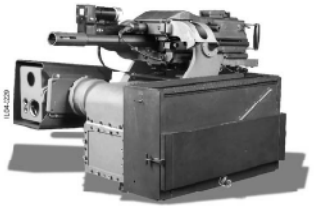
INTERFACE CONTROL UNIT (ICU)

CONTROL GRIP (JOYSTICK)

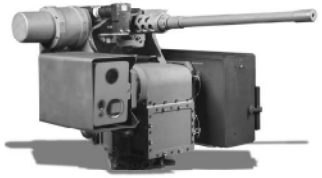
ELECTRONIC MODULE UNIT (EMU)

SWITCH PANEL UNIT (SPU)

M240B

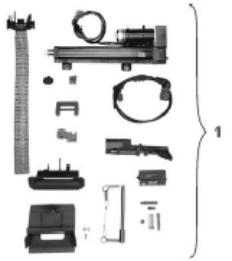


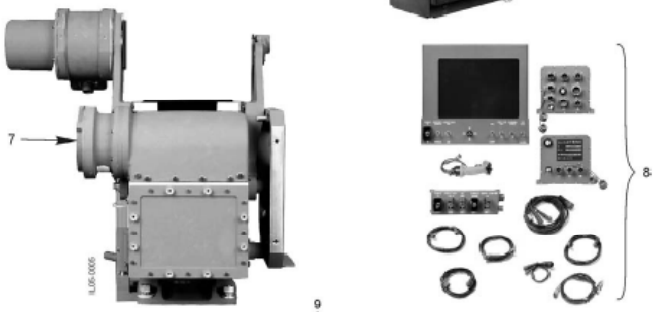
MK-19



M2, .50 cal

M249 SAW



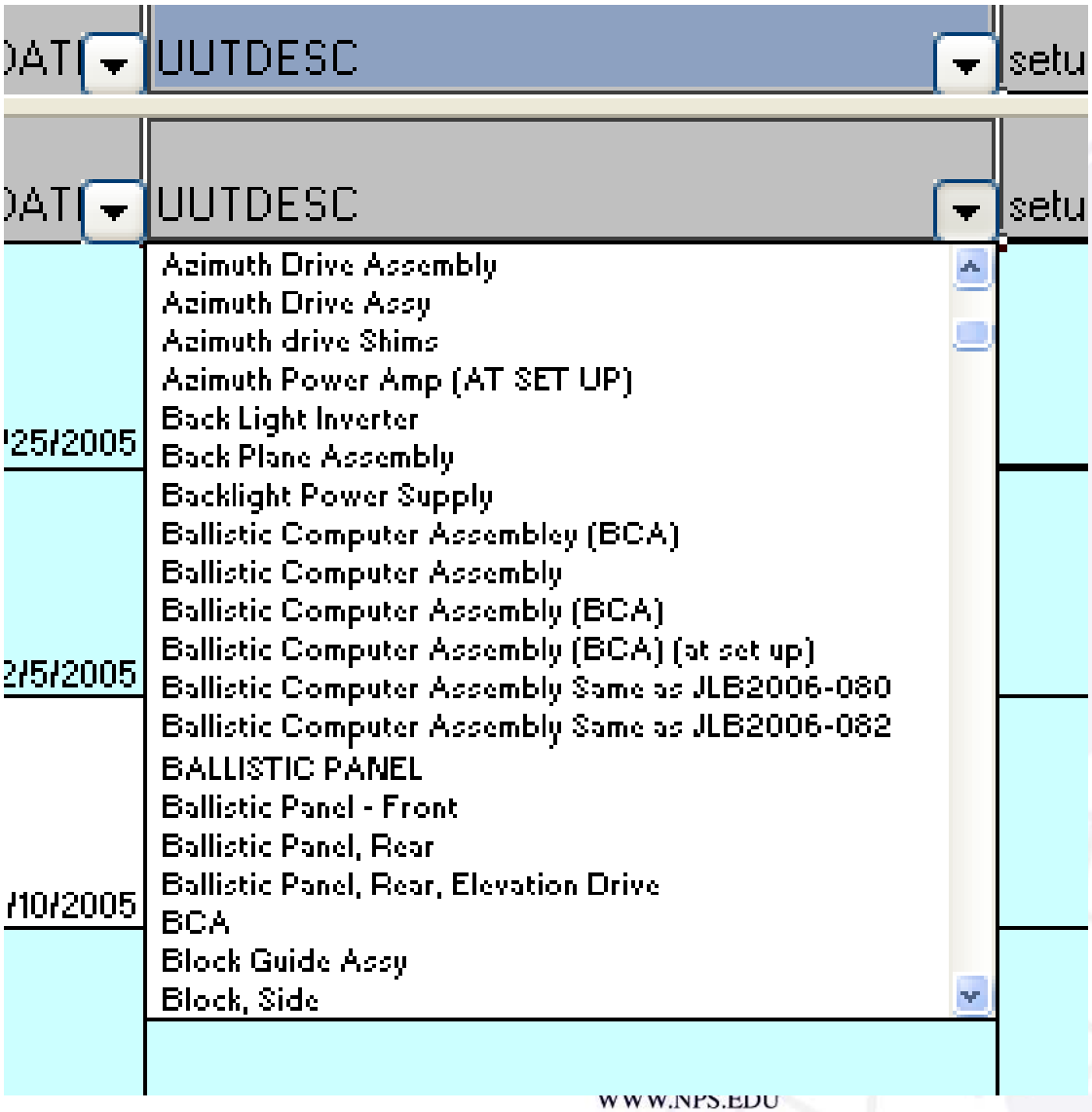


Reliability issues

- Three units tested at APG for ‘production prove-out’ in 2004
  - 28 total failures over 62 missions with 168 hours usage per unit
- IOTE conducted in Jan 2005 at Ft Bragg
  - 20 failures, mostly software
- 240 units fielded to Iraq from April 2005 through 2007
  - About 400 failures recorded in FRACAS database
  - Maintenance done by contractor, who also runs a separate database
  - Document-driven database (all text fields)

Data issues

- Data is incomplete
- Data is not in a format that is simple to use
- Nomenclature and taxonomy not followed
  - E.G. six different names for ballistic computer assembly
- The number of operating hours does not follow the LRUs
  - Component ages at failure not known as only system age is known
- Separate datasets are maintained
- Data is sometimes conflicting between the two datasets
- Student team estimated “A detailed line by line merging of *all* current information would be necessary and would require someone with intimate knowledge of the CROWS, and would take about ½ a man year to complete.”


DAT
UUTDESC
setu
DAT
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Azimuth Drive Assembly
Azimuth Drive Assy
Azimuth drive Shims
Azimuth Power Amp (AT SET UP)
Back Light Inverter
Back Plane Assembly
Backlight Power Supply
Ballistic Computer Assembley (BCA)
Ballistic Computer Assembly
Ballistic Computer Assembly (BCA)
Ballistic Computer Assembly (BCA) (at set up)
Ballistic Computer Assembly Same as JLB2006-080
Ballistic Computer Assembly Same as JLB2006-082
BALLISTIC PANEL
Ballistic Panel - Front
Ballistic Panel, Rear
Ballistic Panel, Rear, Elevation Drive
BCA
Block Guide Assy
Block, Side
25/2005
2/5/2005
/10/2005

Consequences

- Impossible to do meaningful analysis with data on hand
  - Data on overall availability okay, but not possible to drill down to fix with precision
- Difficult to establish if components were meeting requirements.
  - System time of failure for components was known, but not time of installation on system
  - So heavily censored as to be useless

Point

- System fielded without due consideration of data needs for the inevitable analyses and decision points across its life cycle.
- Inevitable analysis and decision point arises and data is unavailable.

Common points

- Modeling, especially statistical modeling, depends on data quality. The assumptions underlying most statistical methods cannot be met in practice.
- While you can't get perfect data, with some foresight you can economically get useful data. Applying that foresight early in the system development can greatly aid managers later in the life cycle.
- These issues are usefully and most appropriately addressed when system suitability requirements are being defined.

Remedies

- Consider the common life cycle decisions that may occur after a system is fielded.
  - Service life extensions
  - Reliability assessments
  - Cost analyses
  - Effectiveness studies
- Plan the data collection support system
  - Include extensibility
  - Drill down to the appropriate level
  - Automate to the extent possible

Teaching implications

- What fraction of our problems have perfect data for students?
- Do we teach our students the messiness of real data collection?
- Do we teach them how to handle messy data?
- Do we integrate statistics instruction with software and CS programs to teach the nuts and bolts of how to automate data collection?

Conclusion

- Current statistics instruction too often treats data as a given.
- 90% of the effort in most studies is getting good data, 5% doing the analysis, and 5% writing it up.
- We need to emphasize sound data strategies in our instruction.
  - And also the limits of classical statistics on flawed observational data