Medium Girder Bridge and Medical Cost Avoidance Model

A MANPRINT Case Study

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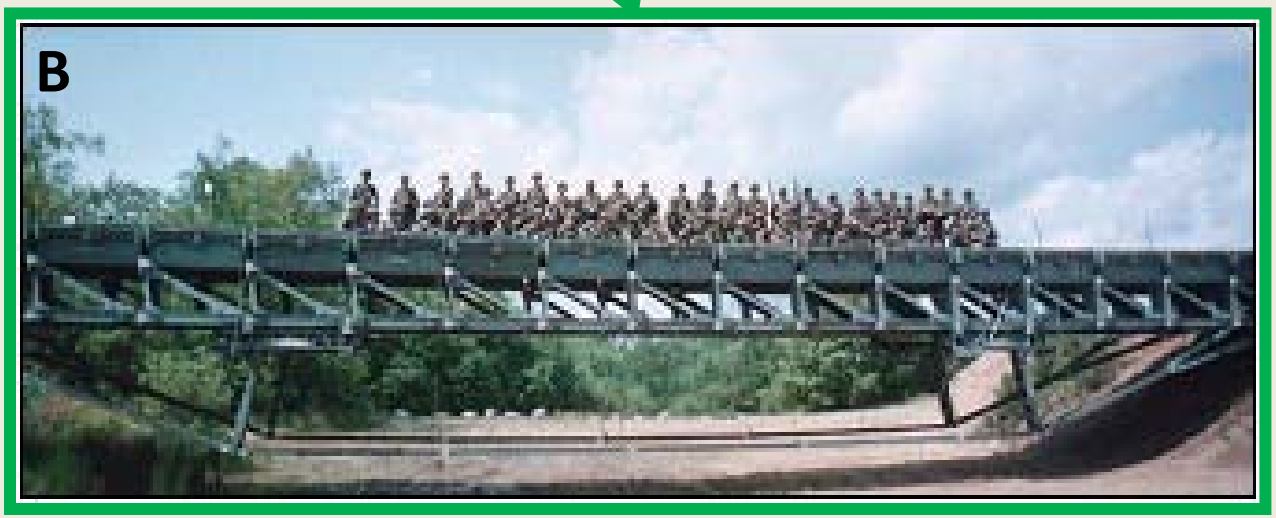
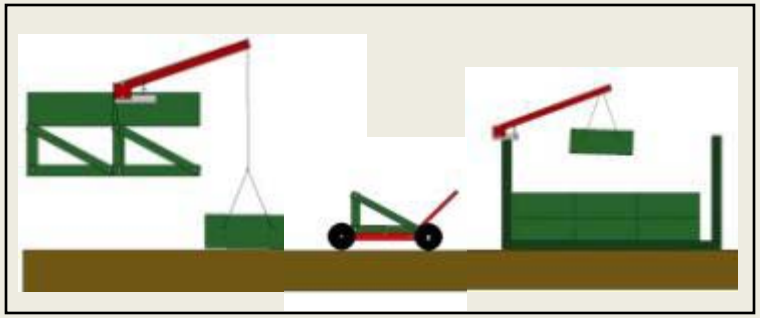
Bridge Building:
Getting from A to B

MOS 21C



Currently:
Bend and Lift

MANPRINT Ergonomic Solutions



1. Use redesigned hand tools for manual handling

2. Unload from pallet with hoists
3. Move to bridge using push carts
4. Lift into position with hoists

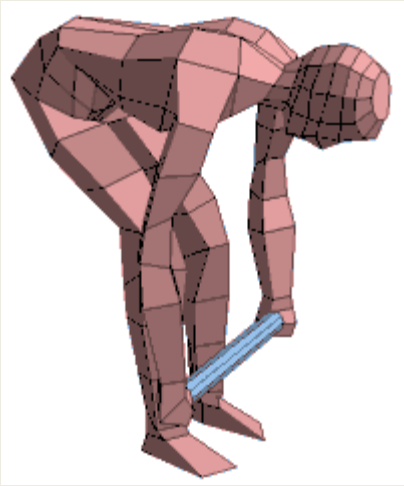
Carry Tools Redesign

Elevated lift start height by 14 inches

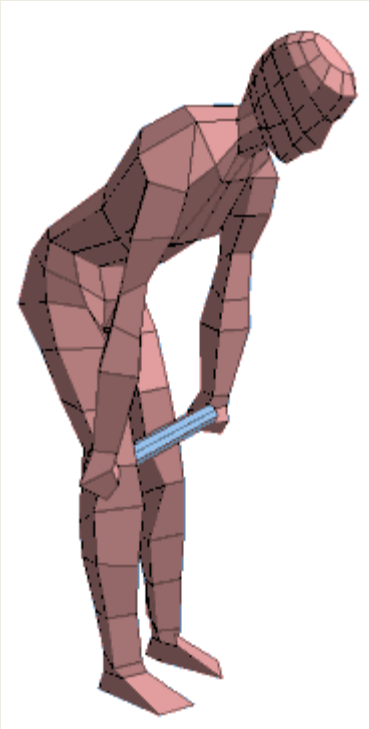
Elevated lift start height by 6 inches for two-hand lift

Carry Tools Redesign

Carry Bar Redesign (Top Panel Lift)

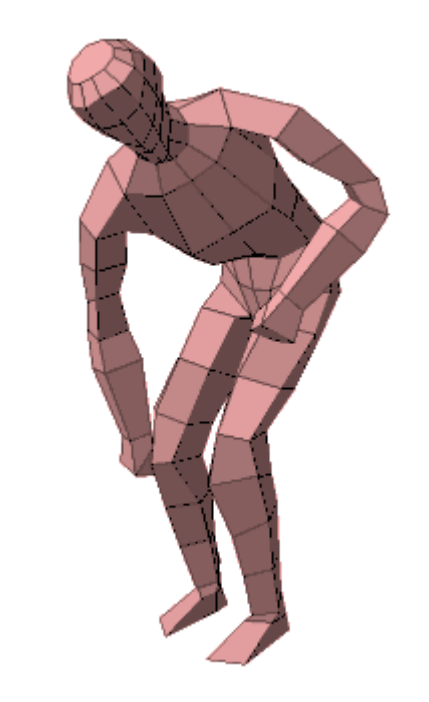


Current



Redesign

Carry Handle Redesign (Long Ramp Lift)



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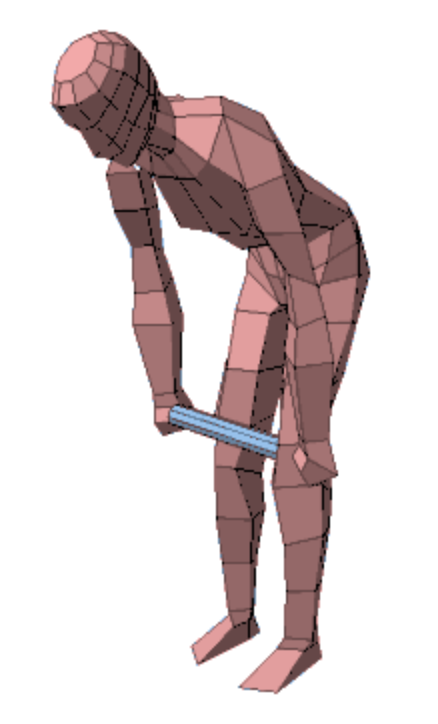


Redesign

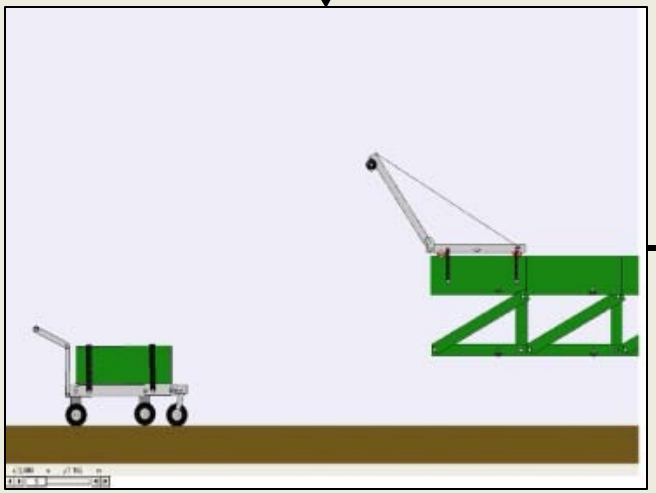
Improved Postures from Redesign

Improved Postures

Push Cart

Manual Carry

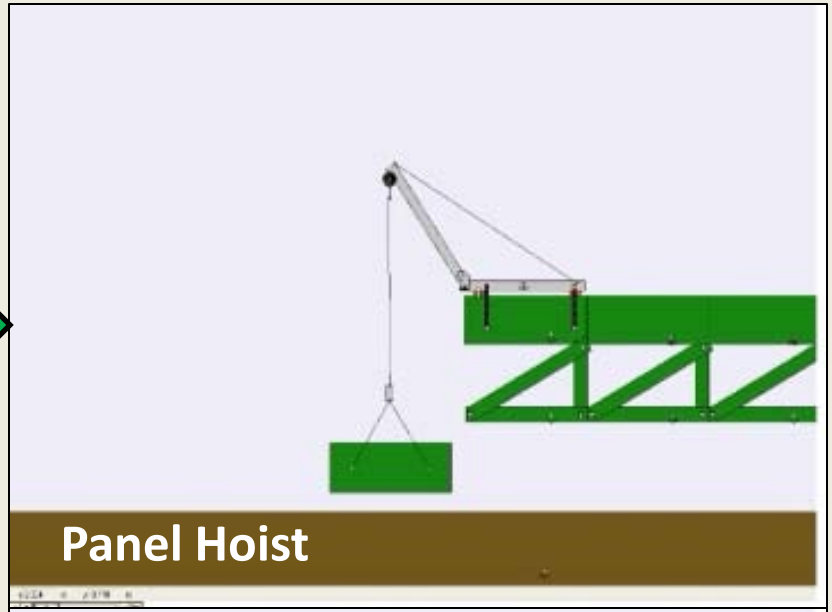
20-25 lb Push vs. 400 lb Carry



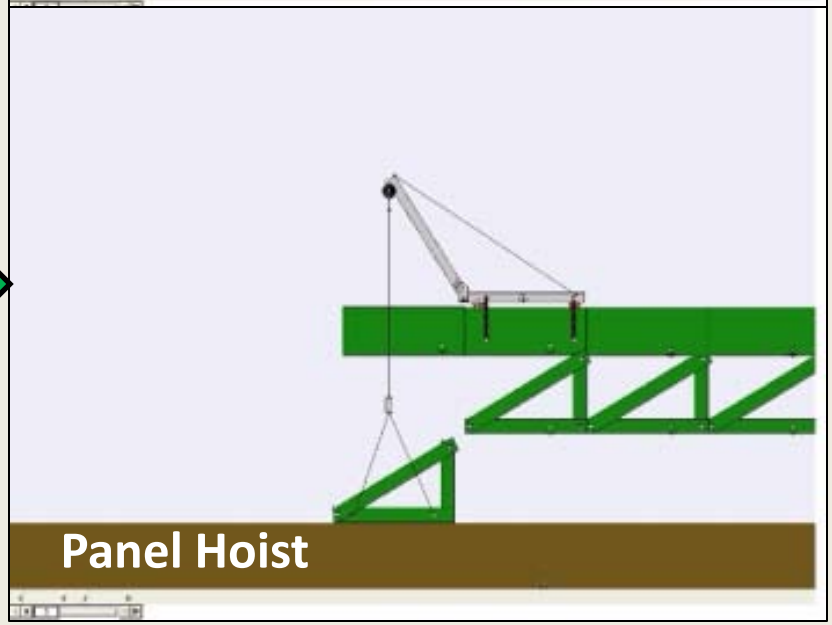
One Soldier does the work of Four

Panel Hoist

4:21:09PM
NOV 1 2003
Manual Lift


Panel Hoist

4:39:38PM
NOV 1 2003
Manual Lift


Panel Hoist

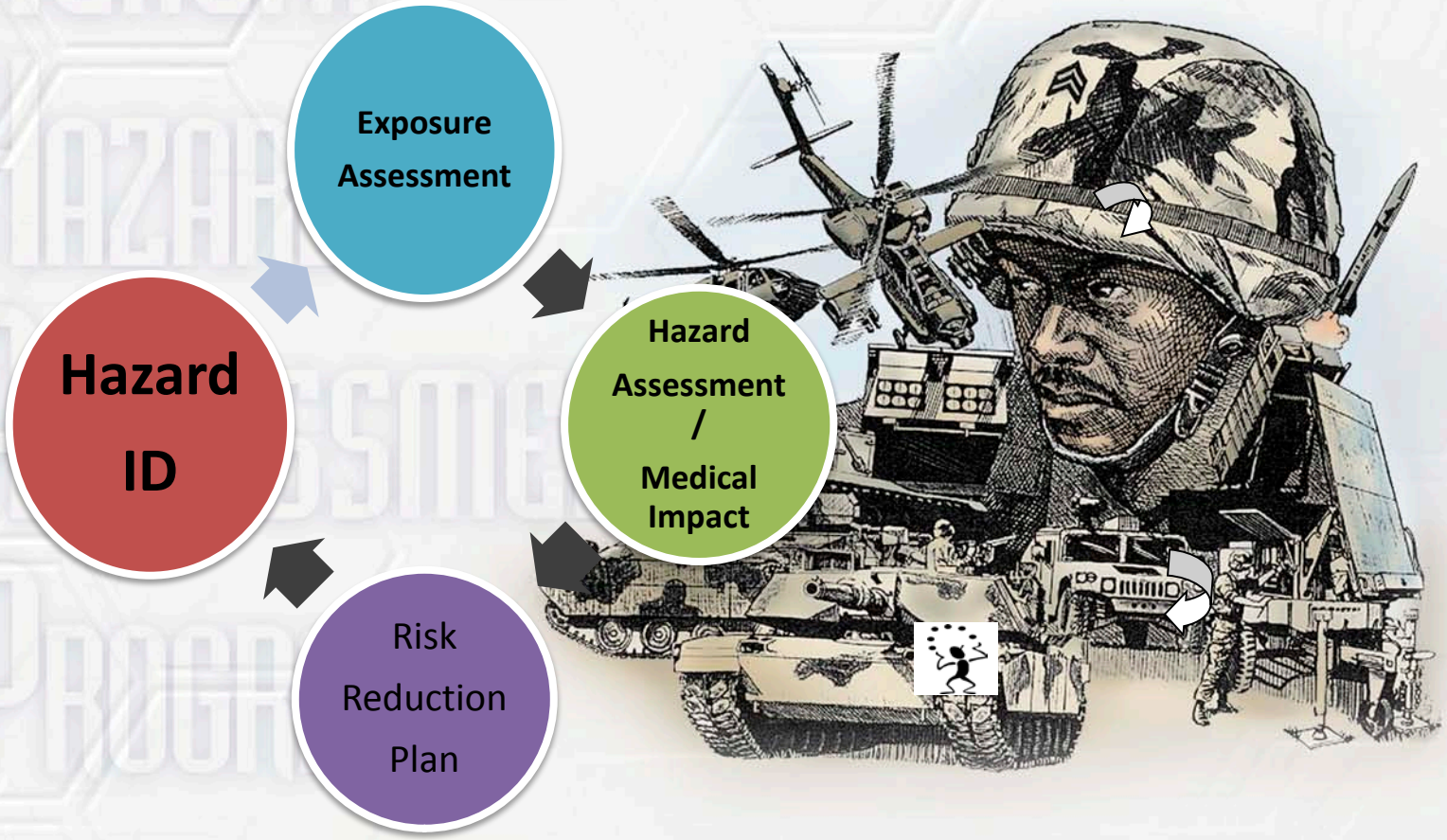
Panel Hoist

Integrated into Build Process
Eliminates both Low and Overhead Exertions

So What?

Army Health Hazard Assessment Program:

Medical Cost Avoidance Model (MCAM)



Dr. AJ Kluchinsky, Manager, Health Hazard Assessment Program
United States Army Center for Health Promotion and Preventive Medicine

Health Hazard Categories Addressed by the HHA Program

ACOUSTIC ENERGY

- Impulse Noise
- Blast Overpressure
- Steady-state Noise

BIOLOGICAL SUBSTANCES

- Field Sanitation & Hygiene
- Poisonous Plants & Animals

CHEMICAL SUBSTANCES

RADIATION ENERGY

- Radio Frequency/Ultrasound
- Laser/Optical Radiation
- Ionizing Radiation

SHOCK

- Rapid Acceleration/Deceleration

TRAUMA

- Sharp/Blunt Impact
- Musculoskeletal Trauma

VIBRATION

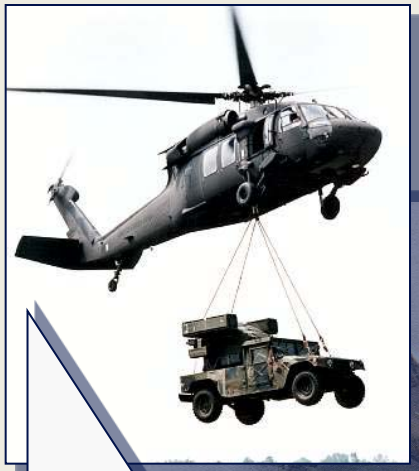
- Whole-body (multiple shock)
- Segmental

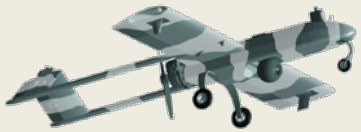
TEMPERATURE EXTREMES

- Heat/Cold

OXYGEN DEFICIENCY

- High Altitude/Confined Spaces
- Ventilation

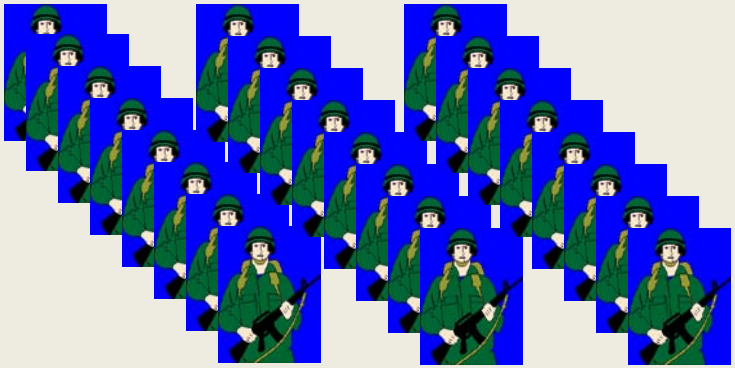




Exposure Assessment

Medium Girder Bridge

117 Bridge Systems



24 Soldiers/system

N = 2808 Exposures

Medium Girder Bridge

Health Hazard

Hazard ID

Chemical Substances

Biological Substances

Acoustic Energy

- Steady-state noise
- Impulse noise
- Blast overpressure

Radiation Energy

- Ionizing
- Laser
- Radiofrequency

Trauma

- **Musculoskeletal**
- Blunt
- Sharp

Oxygen Deficiency

Temperature Extremes

- Cold
- Heat

Hazard Assessment

Hazard: Musculoskeletal

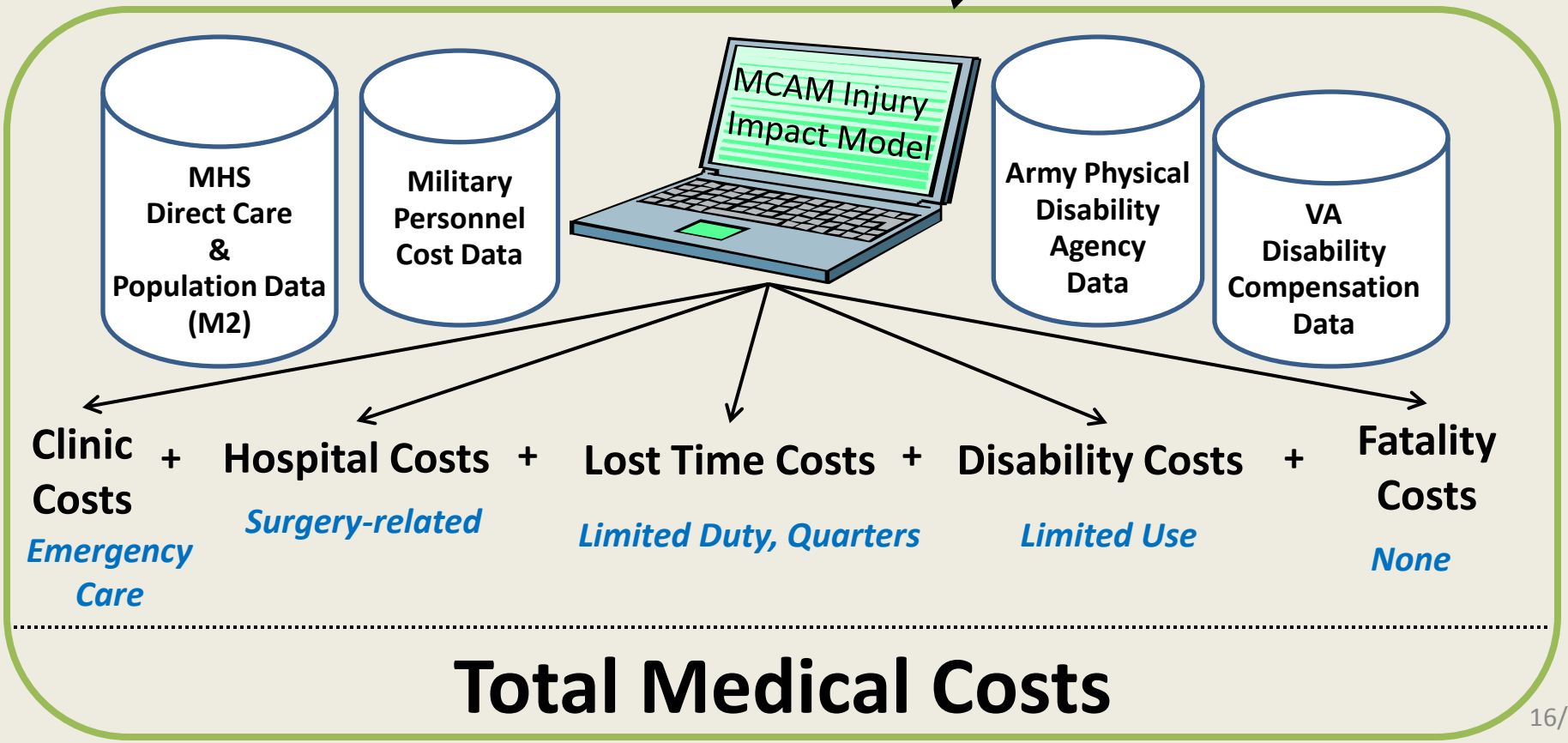
Risk: Hazard Severity & Probability

Hi ⟷ Lo

Hazard Severity	Hazard Probability A	B	C	D	E
I	1	1	1	2	3
II	1	1	2	3	4
III	2	3	3	4	5
IV	3	4	5	5	5

Hi ↕ Lo

AR 40-10 Risk Assessment Codes RAC



Baseline Costs per Soldier: Musculoskeletal Trauma

Risk Assessment Code (RAC) Matrix

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$3,184	$1,769	$708	$35	$4
II (0.1)	$318	$177	$71	$4	$0
III (0.01)	$32	$18	$7	$0	$0
IV (0.001)	$3	$2	$1	$0	$0

High ↕ Low

Current System Unabated Hazards

System Redesign Mitigated Hazards

Total Costs : Musculoskeletal Trauma (2808 Exposures)

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$8,904000	$4,967000	$1,987,000	$99000	$10000
II (0.1)	$894000	$497	$199,000	$10	$1000
III (0.01)	$89,000	$50000	$20000	$1000	$100
IV (0.001)	$9000	$5000	$2000	$100	$10

High ↕ Low

Current System Unabated Hazards

System Redesign Mitigated Hazards

Risk Levels and Medical Costs
Medium Girder Bridge

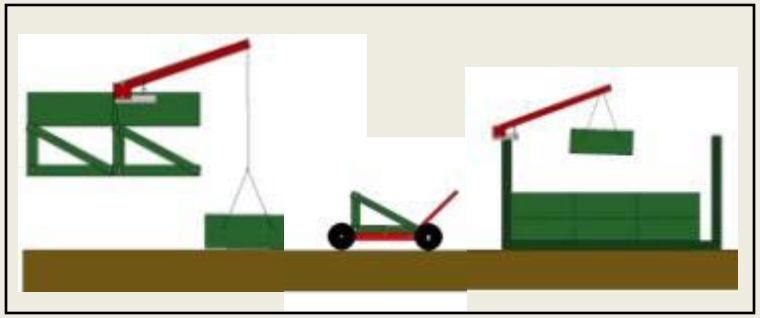
Health Hazard - Musculoskeletal Trauma		
Risk Assessment	**Medical Cost per Soldier One Exposure ($)**	**Medical Cost/ All Soldiers (N=2808) ($)**
2 (II,C) Worst Case	**71**	**199,000**
5 (IV,C) Mitigated	**1**	**2000**
Medical Cost Avoidance		**197,000**

Activity-Based Costs For The Unabated Health Hazards Of The Bridge

Hazard Type	Outpatient	In-Patient	Lost time	Fatality	Disability	Total
WORST CASE						
Musculoskeletal 24 Soldiers/	$1,511	$4,285	$133,338	$0	$57,552	**$196,686**
117 Units						
ACTIVITY BASED						
Top Panel, n=5	$315	$893	$27,779	$0	$11,990	$40,976
Bottom Panel, n=5	$0	$0	$0	$0	$0	$0
Deck, n=2	$1	$4	$112	$0	$48	$166
Long Ramp, n=7	$0	$0	$0	$0	$0	$0
Junction Panel, n=5	$286	$811	$25,253	$0	$10,900	$37,251
						$78,393

Medium Girder Bridge

Risk Reduction Plan



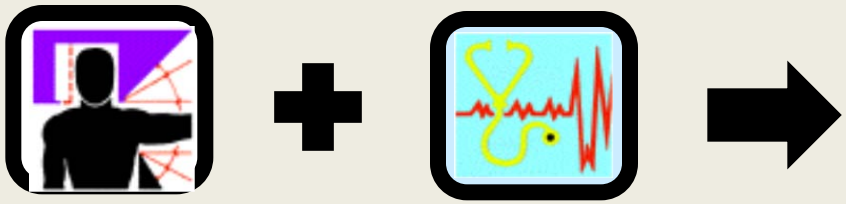
1. Use <u>redesigned hand tools</u> for manual handling

2. Unload from pallet with <u>hoists</u>
3. Move to bridge using <u>push carts</u>
4. Lift into position with <u>hoists</u>

Payoff for the Army

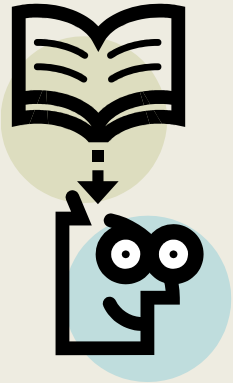
PM-Bridging---U.S. Army Engineer School

- Cost of Design Changes vs. Hazard Risk & Medical Tail
- Reduced Overall Manpower
- Reduced Soldier Stress and Increased Well-Being
- Design and Specifications of Ergonomic Solutions
- MCAM Model and Output Tables



U.S.ARMY

ARMY STRONG.SM



Backup and Reference

MGB Project Team

- ARL-HRED
  - Andrew Bodenhamer
  - Dr. Alan Davison
  - Bradley Davis
- Missouri University of Science & Technology (formerly University of Missouri – Rolla)
- Maneuver Support Center Safety Office
- 1st Engineer Brigade

Engineering Data

Medium Girder Bridge (MGB) Components

Component	Quantity Per Bridge	Weight	Hand Forces (per hand)	Lift Start Height
Top Panel	32	385 lb	50 lb	9 in
Bottom Panel	24	440 lb	78 lb (front) 35 lb (rear)	7 in
Deck	66	165 lb	83 lb (one-hand lift)	14 in
Long Ramp	14	400 lb	68 lb (one-hand lift)	16 in
Junction Panel	4	475 lb	63 lb	14 in

Sources of Information

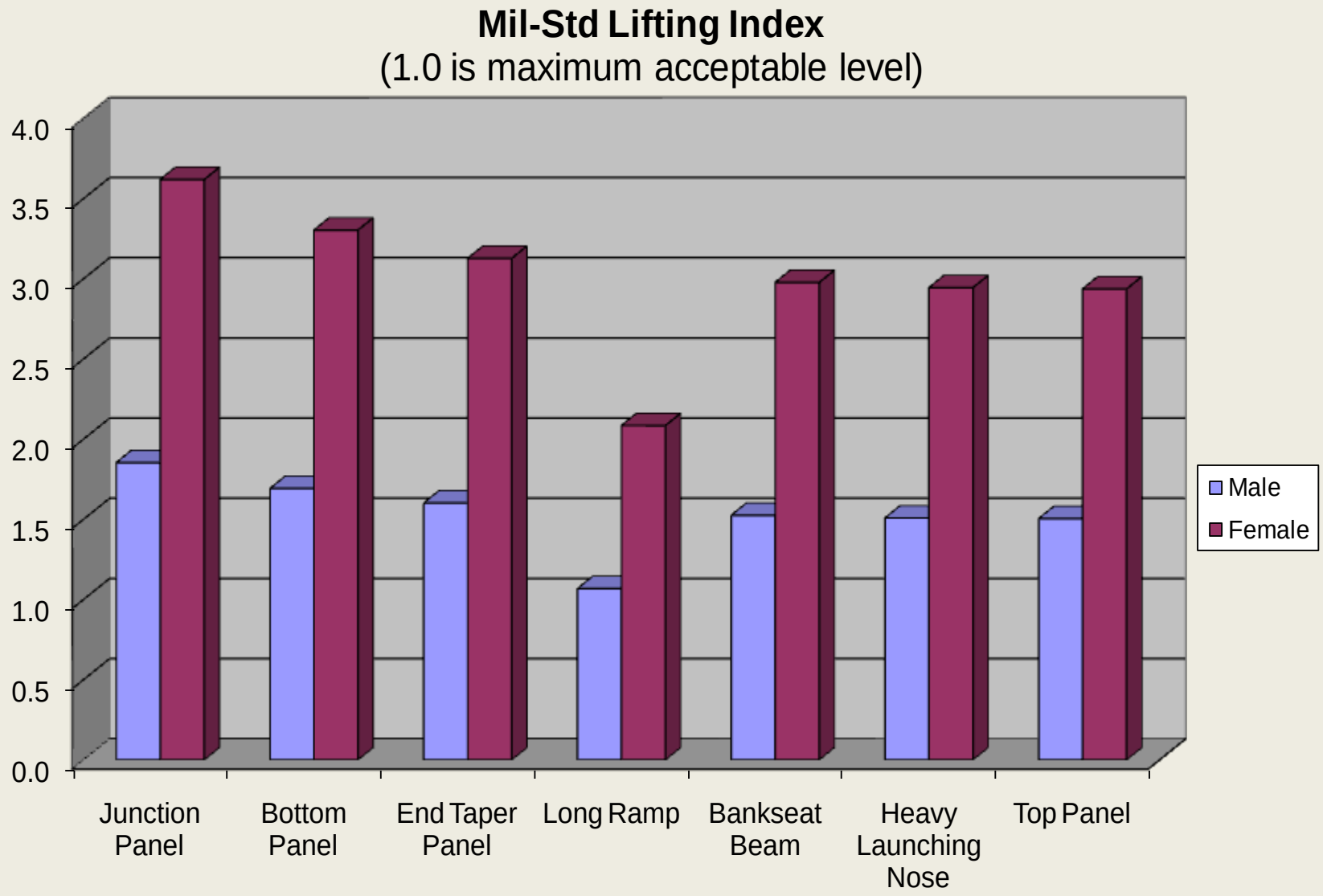
Observation and Ergonomic Assessment

- Videotape construction exercises to obtain task time sequence data and lifting postures
- Five most frequently lifted and ergonomically stressful components analyzed using:
  - Revised NIOSH Lifting Equation (NLE)
  - University of Michigan 3D Static Strength Prediction Program (3D SSPP)

Ergonomic Intervention

- Redesign carrying tools
  - Reduce lower back stress
  - Improve population strength requirements
- Re-analyze tools using NLE and 3D SSPP

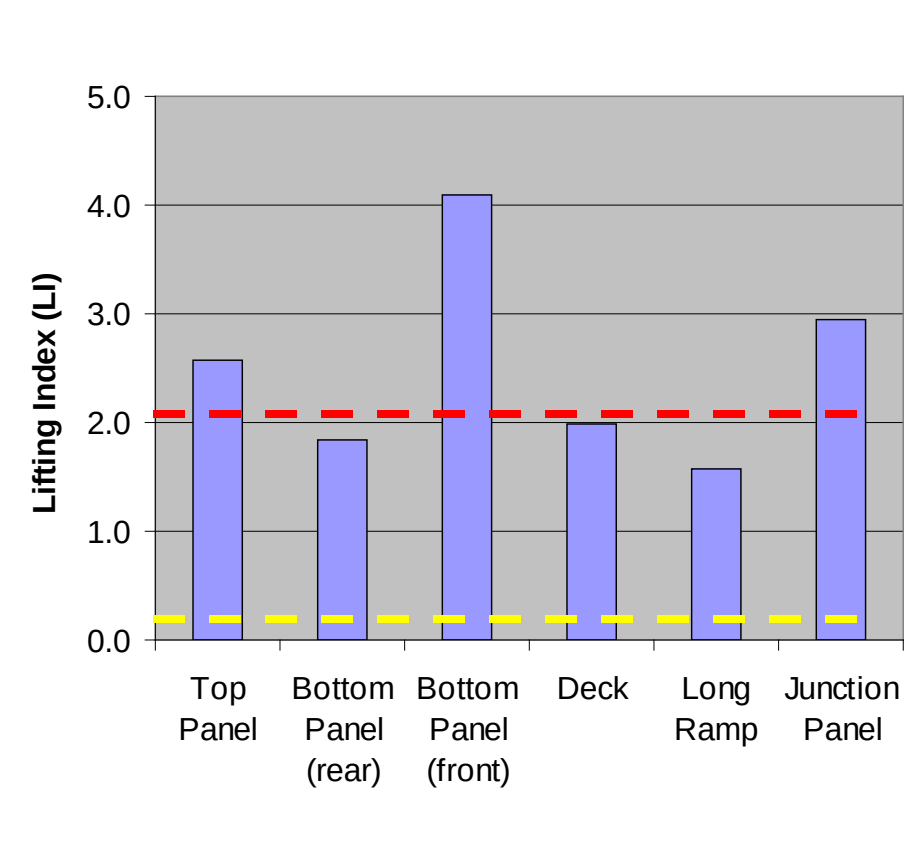
Military Standards



Findings – NLE

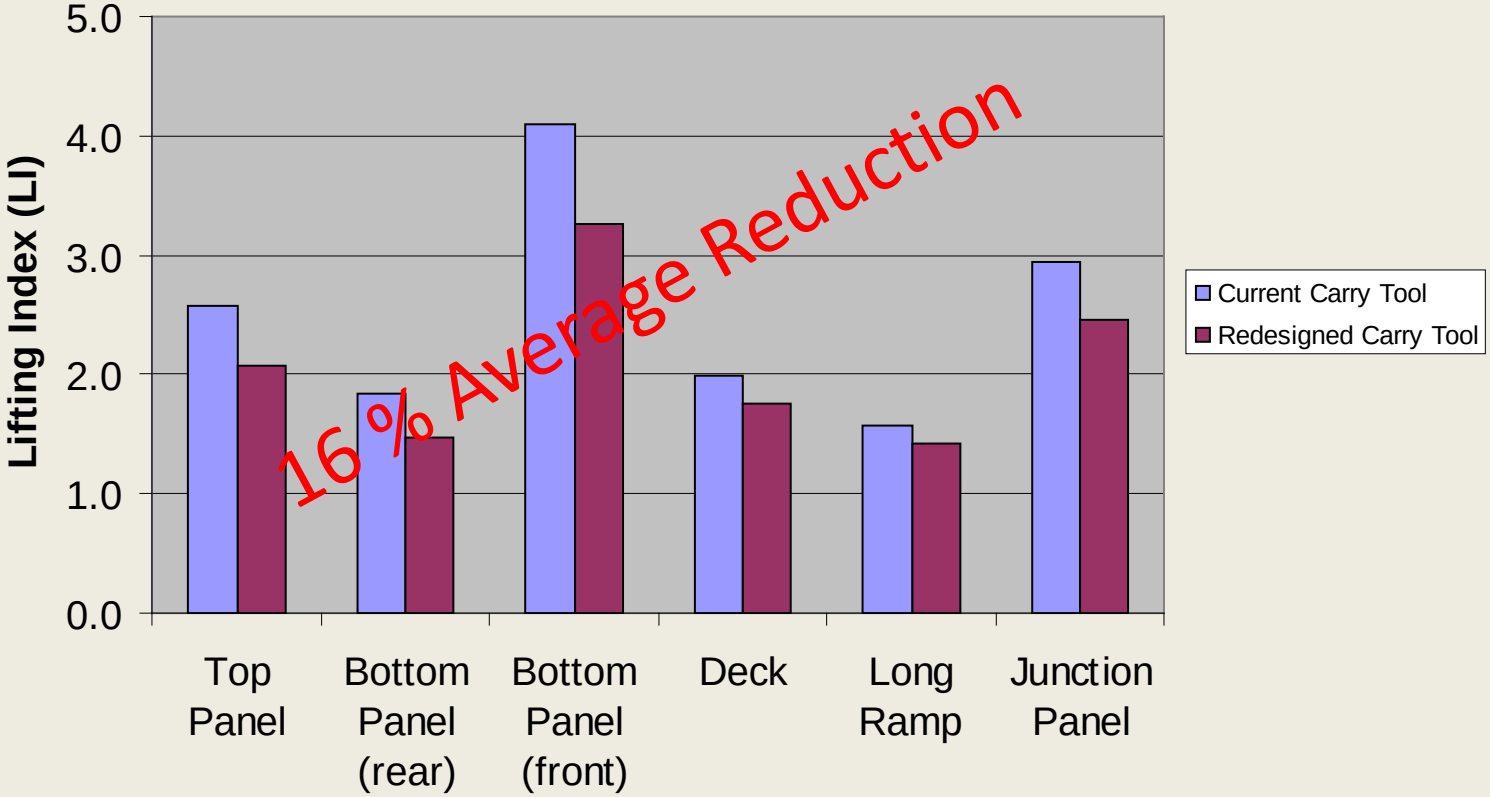
NIOSH Lifting Equation

- Single person lift from observed starting height to comfortable carry height (30 inches)
- Lifting index of 1.0 represents the maximum amount of weight a person should lift in order to avoid injury over time.
- Lifting index greater than 3.0 represents a significant threat of injury



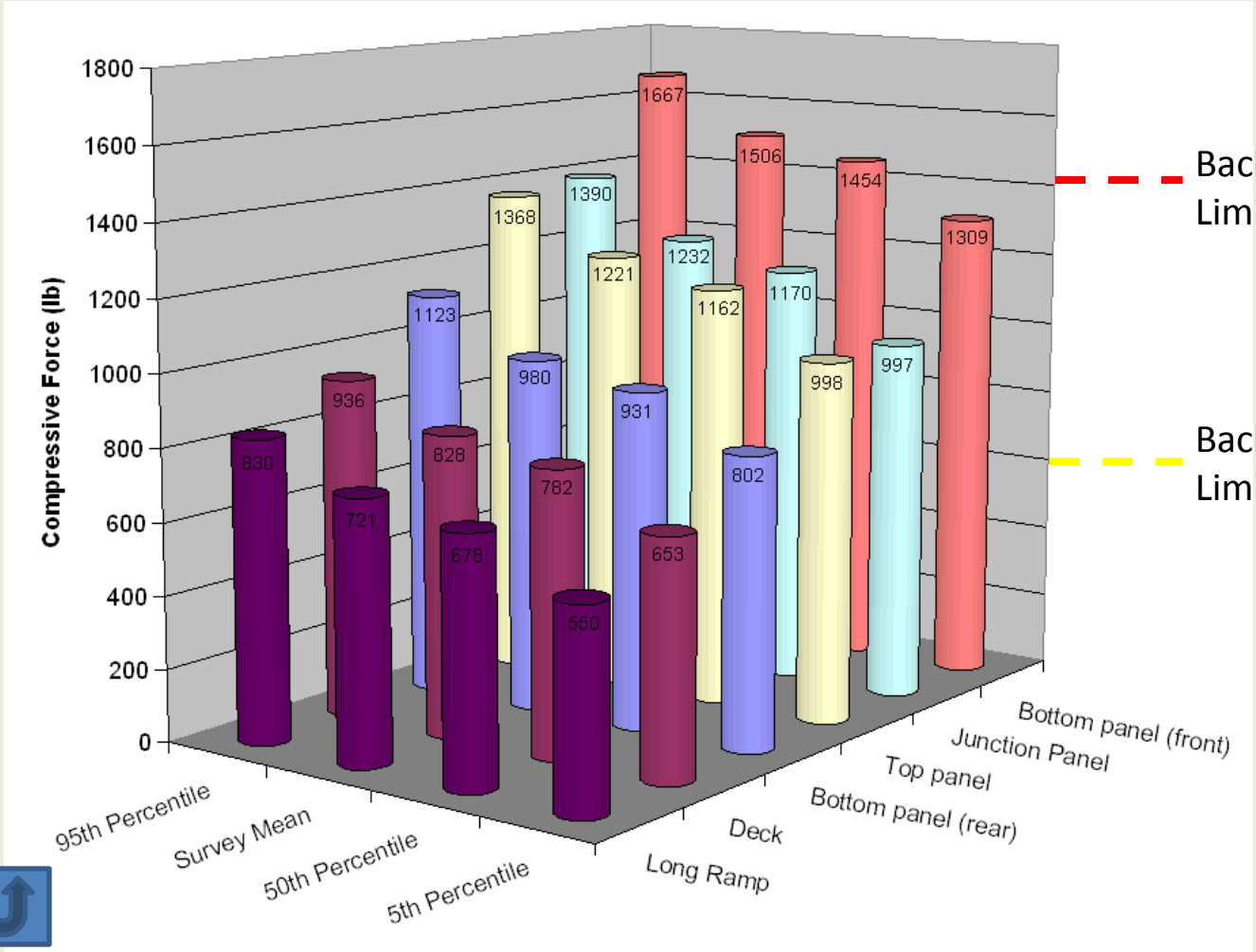
Findings – Ergonomic Intervention

NIOSH Lifting Equation Comparison



Findings – 3D SSPP

L5/S1 Disc Compression (Current Tools)

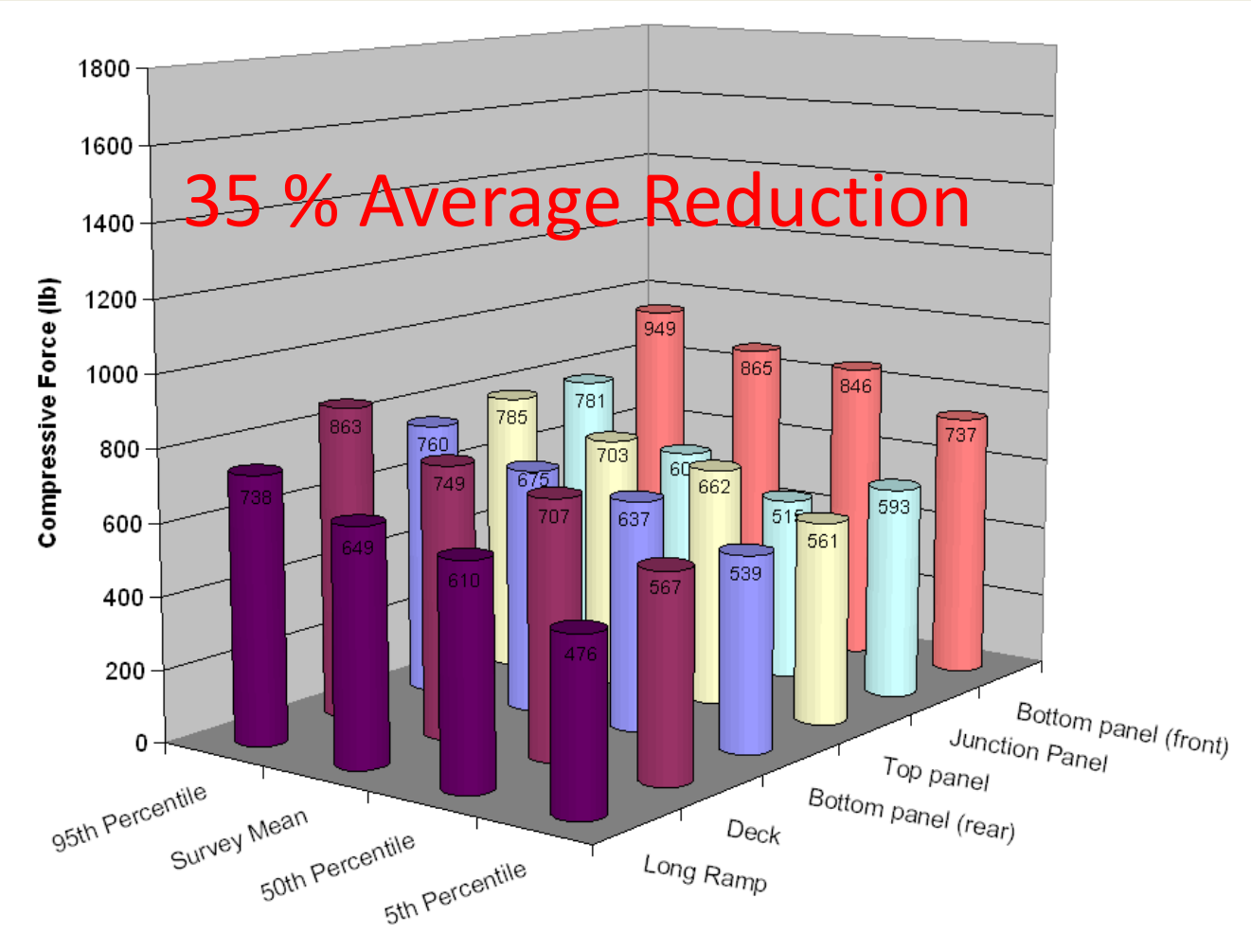


Back Compression Upper Limit: 1430 lbs

Back Compression Design Limit: 770 lbs

Findings – Ergonomic Intervention

L5/S1 Disc Compression (Redesigned Tools)



CHPPM Project Team

- Dr. A. J. Kluchinsky CHPPM
- Mr. Don Goddard CHPPM
- Mr. Clark Spencer Logistics Management Institute

Microsoft Access - [Report: rptCostCalc_CurrentRecord]

File Window Help

HHA Office Cost Avoidance Breakdown Report

21-May-00

Project No: 0273

No Systems: 1500 **No People:** 3 **System Risk:** MEDIUM

No action taken

Recommendation applied

HAZARD: Steady state noise

	CURRENT	RESIDUAL	AVOIDED
Risk Code:	2C, 2	4E, 5	
No. persons exposed:	900	5	896
No. persons injured/ill:	9	0	9
No. persons lost time:	5	0	5
No. persons hospitalized:	1	0	1
No. persons disabled	1	0	1
No. persons require rehab	0	0	0
No. clinic vists:	93	0	93
No. lost days:	57	0	57
No. hospital days:	4	0	4
No. deaths:	0	0	0
Cost of clinic visits:	$11,364	$0	$11,364
Cost of lost time:	$4,340	$0	$4,340
Cost of hospitalization:	$7,045	$0	$7,044
Cost of disability:	$14,630	$1	$14,629
Cost of rehabilitation:	$91	$0	$91
Cost of deaths:	$0	$0	$0
Total Hazard Cost 1 Yr:	$37,470	$2	**$37,468**
Total Hazard Cost 20 Yrs:	$749,401	$35	**$749,366**

1- and 20-year cost avoidance

EXAMPLE MCAM SCREEN SHOT

Page: 1

Ready

Start | Sent Ite... | Microsof... | Docume... | aaavMF... | HEALT... | Microsof... | Microsof... | Micros... | 5:28 PM

Risk Assessment Codes
AR 40-10

Hazard Severity Categories		
Numerical Designation	**Classification**	**Possible Hazard Outcomes**
I	**Catastrophic**	**May cause death or total loss of a bodily system**
II	**Critical**	**May cause severe bodily injury, severe occupational illness, or major damage to a bodily system**
III	**Marginal**	**May cause minor bodily injury, minor occupational illness, or minor damage to a bodily system**
IV	**Negligible**	**Would cause less than minor bodily injury, minor occupational illness, or minor damage to a bodily system**

Risk Assessment Codes
AR 40-10

Hazard Probability Categories			
Descriptive Word	**Level**	**Specific Individual Item**	**Fleet or Inventory**
Frequent	**A**	**Likely to occur frequently**	**Continuously experience**
Probable	**B**	**Will occur several times in the life of an item**	**Will occur frequently**
Occasional	**C**	**Likely to occur some time in the life of an item**	**Will occur several times**
Remote	**D**	**Unlikely but possible to occur in the life of an item**	**Unlikely but can reasonably be expected to occur**
Improbable	**E**	**So unlikely, it can be assumed occurrence may not be experienced**	**Unlikely to occur, but possible**

Medical Cost Avoidance Model (MCAM)

Model Assumptions

- Clinic visit time = 2 hours.
- Limited (temporary restricted) duty duration = 15 days.
- Quarters duration = 3 days.
- Convalescent leave duration = 30 days.
- Limited duty = reduced productivity of 30%.
- Inflation factor = $(1.0204)^{\text{No. Yrs.}}$
- Fatality costs = $674,375.

Model Limitations

- Purchased care (Non-MHS) data is not included.
- Estimates based on worst-case crew position.
- Uses Army-based incidence rates, rather than military occupational specialty (MOS) incidence rates.
- Does not estimate materiel-related pollution prevention costs.
- Does not estimate abatement costs.
- Does not estimate costs to acquire and train replacements.
- Does not estimate family quality of life costs.

MCAM Parameters

OVERALL COST $C_T = C_c + C_h + C_l + C_d + C_f$

Cost Element	Type	Description	Source
C_T	Variable	Overall costs related to unabated health hazards	Calculated by model
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model
C_h	Variable	Cost of hospitalization (includes associated pharmaceutical and laboratory costs)	Calculated by model
C_l	Variable	Cost of days of lost time	Calculated by model
C_d	Variable	Cost of disability	Calculated by model
C_f	Variable	Cost of fatalities	Calculated by model

CLINIC COSTS $C_c = P_e \times N_s \times N_{ps} \times S_k \times I_c \times C_a \times N_v$

Cost Element	Type	Description	Source
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Clinic visit incidence for injury/illness	Model application (Calculated from M2 clinical data)
C_a	Constant (for each hazard)	Average clinic visit cost (includes associated pharmaceutical and laboratory costs)	Model application (Calculated from M2 clinical data)
N_v	Constant (for each hazard)	Number of clinic visits per injury/illness (includes follow-up visits within 30 day initial visit)	Model application (Calculated from M2 clinical data)

International Classification of Diseases (ICD-9) Categories Used in the Model

ICD-9 Category	ICD-9 Descriptor
001-139	Infectious and Parasitic Diseases
140-239	Neoplasms
240-279	Endocrine, Nutritional, and Metabolic Diseases, and Immunity Disorders
280-289	Diseases of the Blood and Blood-Forming Organs
290-319	Mental Disorders
320-389	Diseases of the Nervous System and Sense Organs
390-459	Diseases of the Circulatory System
460-519	Diseases of the Respiratory System
520-579	Diseases of the Digestive System
580-629	Diseases of the Genitourinary System
630-677	Complications of Pregnancy, Childbirth, and the Puerperium
680-709	Diseases of the Skin and Subcutaneous Tissue
710-739	Diseases of the Musculoskeletal System and Connective Tissue
740-759	Congenital Anomalies
760-779	Certain Conditions Originating in the Perinatal Period
780-799	Symptoms, Signs, and Ill-Defined Conditions
800-999	Injury and Poisoning
V01-V83	Supplementary Classification of Factors Influencing Health Status and Contact with Health Services

M2 Beneficiary Population Data Elements[a] Used in the Model

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
	Pseudo Sponsor ID	
	FMP	
	Race	
	Sponsor Pay Grade	
	Sponsor Service	
	Tmt Parent DMIS ID	
	Tmt Parent DMIS Name	
	Service Date	
	Clinical Service, Admitting	
	Clinical Service, Dispositioning	
	Clinical Service, Second	
	Clinical Service, Third	
	Length Of Stay	Procedure 1
	Age	Procedure 2
	Gender	Procedure 3
	Marital Status	Procedure 4
	Patient Category	Pseudo Sponsor ID
	Procedure 1	Race

Notes:
[a] Data Sources for Beneficiary Population data included Defense Enrollment Eligibility Reporting System (DEERS), Standard Inpatient Data Record (SIDR), and Standard Ambulatory Data Record (SADR)

M2 Beneficiary Population Data Elements Used in the Model

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
AGE	Pseudo Sponsor ID	Pseudo Sponsor ID
BENCAT	Bed Days Civilian Hospital, Total	Encounters, Total
DODOCC	Bed Days in ICU, Total	Full Cost, Total
FM	Bed Days, Total	Price, Total
FY	Convalescent Leave Days, Total	Variable Cost, Total
GENDER	Cooperative Care Days, Total	Age
MARSTAT	Dispositions, Total	APG, Med
PSUEDOID	Full Cost, Total	APG, Med Desc
FMP	Medical Hold Days, Total	APG, E&M
CTCHDMIS	Price, Total	APG, E&M Desc
CTCHNAME	Quarter Days, Total	APG Proc 1
RACEETH	RWP, Total	APG Proc 2
GRADE	Sick Days this MTF, Total	APG Proc 3
SERVICE	Supplemental Care Days, Total	APG Proc 4
RACE	Variable Cost, Total	Beneficiary Category
	Admission Date	Catchment Area ID
	Beneficiary Category	Catchment Area Name
	Catchment Area ID	Diagnosis 1
	Catchment Area Name	Diagnosis 2
	Diagnosis 1	Diagnosis 3
	Diagnosis 2	Diagnosis 4
	Diagnosis 3	Disposition Code
	Diagnosis 4	E&M Code
	Diagnosis 5	FY
	Diagnosis 6	FM
	Diagnosis 7	FMP
	Diagnosis 8	Gender
	Disposition Status Code	Inpatient Indicator
	FY	Marital Status
	Diagnostic Related Group (DRG)	MEPRS (3) Code
	FM	Patient Category
	Procedure 3	Sponsor Pay Grade
	Procedure 4	Sponsor Service
	Procedure 5	Tmt Parent DMIS ID
	Procedure 6	Tmt Parent DMIS Name
	Procedure 7	Tmt Service Clinic
	Procedure 8	

Table 6-1-7

Army Population by Rank and AMCOS Lite Personnel Cost[a]

Military Pay Grade	Population	AMCOS Lite Personnel Cost	Total Personnel Cost for Grade
O-10	10	$229,450	$2,294,500
O-9	40	$207,210	$8,288,400
O-8	103	$192,086	$19,784,858
O-7	147	$234,309	$34,443,423
O-6	3,805	$195,119	$742,427,795
O-5	9,124	$197,795	$1,804,681,580
O-4	14,035	$160,565	$2,253,529,775
O-3	24,264	$118,844	$2,883,630,816
O-2	9,553	$98,082	$936,977,346
O-1	6,704	$81,330	$545,236,320
WO-5	419	$140,503	$58,870,757
WO-4	1,598	$125,569	$200,659,262
WO-3	3,553	$110,467	$392,489,251
WO-2	4,624	$94,659	$437,703,216
WO-1	2,070	$79,841	$165,270,870
E-9	3,439	$143,011	$491,814,829
E-8	11,232	$117,761	$1,322,691,552
E-7	37,573	$106,787	$4,012,307,951
E-6	56,197	$92,299	$5,186,926,903
E-5	74,076	$78,084	$5,784,150,384
E-4	118,874	$62,944	$7,482,405,056
E-3	61,607	$55,054	$3,391,711,778
E-2	31,705	$52,975	$1,679,572,375
E-1	16,521	$50,255	$830,262,855
CADETS	4,101	$18,221	$74,724,321
Total Officer	84,150		$10,561,012,490
Total Enlisted	411,224		$30,181,843,683

Notes:
[a] AMCOS Lite data included major cost categories of Military Personnel-Account (MPA); Operations & Maintenance, Army (OMA); and Other. More specific breakouts within these categories were listed in AMCOS and included under the MPA Category: military compensation, officer acquisition costs, other benefits, permanent change of station costs, retired pay accrual, separation costs, special pays, and training; under the OMA Category: medical support costs, morale, welfare and recreation costs, and officer acquisition costs; and under the Other Category: training.

Army Physical Disability Agency (APDA) Data

- Obtained from APDA in 2001.
- Contained decisions of 1980-1999.
- Used to determine disability-related percentages for:
  - Degree of Disability
  - Disposition Category
    - Fit for Duty
    - Separation
    - Permanent Disability Retirement
    - Temporary Disability Retirement

Veterans Administration Schedule for Rating Disabilities (VASRD) Codes used in the Model

VASRD Code	VASRD Descriptor
50	Bones and Joints Disease
60	Eye and Visual Acuity
61 & 62	Ear, Smell, and Taste
63	Systemic Disease
65	Nose and Throat
66	Trachea and Bronchi
67	TB, Lungs, and Pleura
68	Non-TB Diseases
70	Heart Diseases
71	Arteries and Veins
72 & 73	Digestive System
75	Genitourinary System
76	Gynecological
77	Hemic and Lymphatic
78	Skin
79	Endocrine System
80 - 87	Organic Disease Central Nervous System
89	Epilepsies
90 & 92	Psychotic Disorders
91 & 93	Organic Brain Disorders
94 & 95	Psychoneurological Disorders
99	Dental and Oral

Veterans Affairs Compensation Rate Table

Percentage[a]	Rate[b]
10%	$106
20%	$205
30%	$316
40%	$454
50%	$646
60%	$817
70%	$1,029
80%	$1,195
90%	$1,344
100%	$2,239

Notes:
[a] Degree of disability
[b] Monthly rate of compensation