

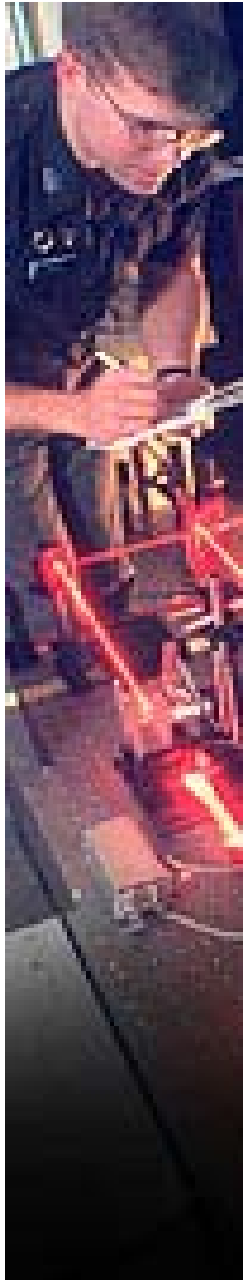
**Academic Scheduling
at
United States Military Academy
West Point, NY**

Fred O'Brien

United States Military Academy

Michael R. Bussieck, Alexander Meeraus

GAMS Development Corporation



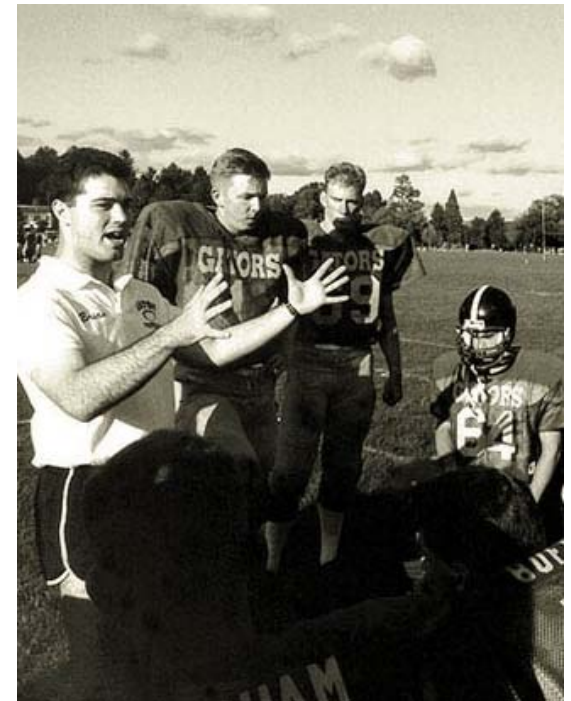
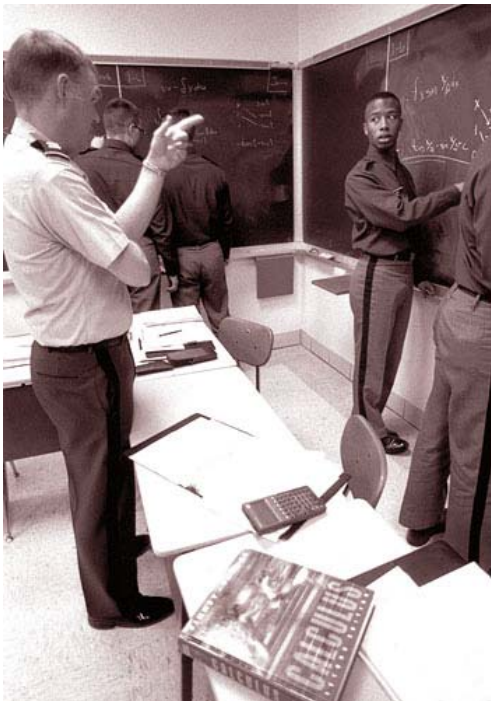
USMA MISSION

To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country; professional growth throughout a career as an officer in the United States Army; and a lifetime of selfless service to the nation.



Program at USMA

“... each student’s daily activities are a carefully regimented balance of academic, military, and physical requirements.”



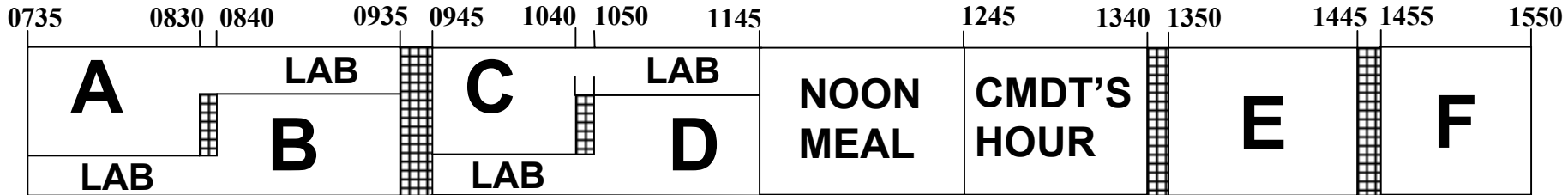


**OFFICE OF THE DEAN
UNITED STATES MILITARY ACADEMY**

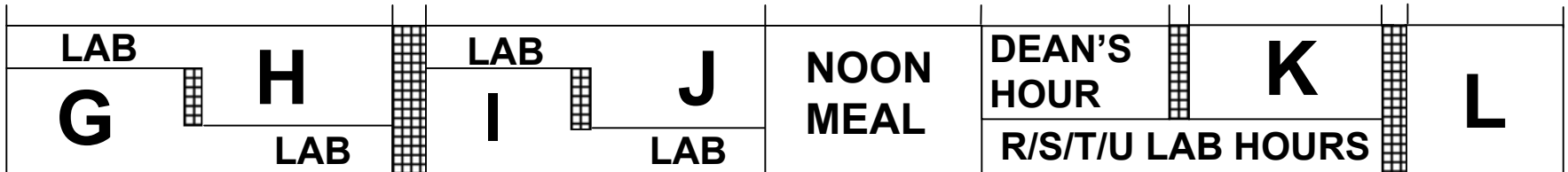
**AUGUST 1999
(EDITION OF AUG 98 IS OBSOLETE)**

ATTENDANCE PERIODS

1-DAY CLASS PERIODS



2-DAY CLASS PERIODS



Academic Program

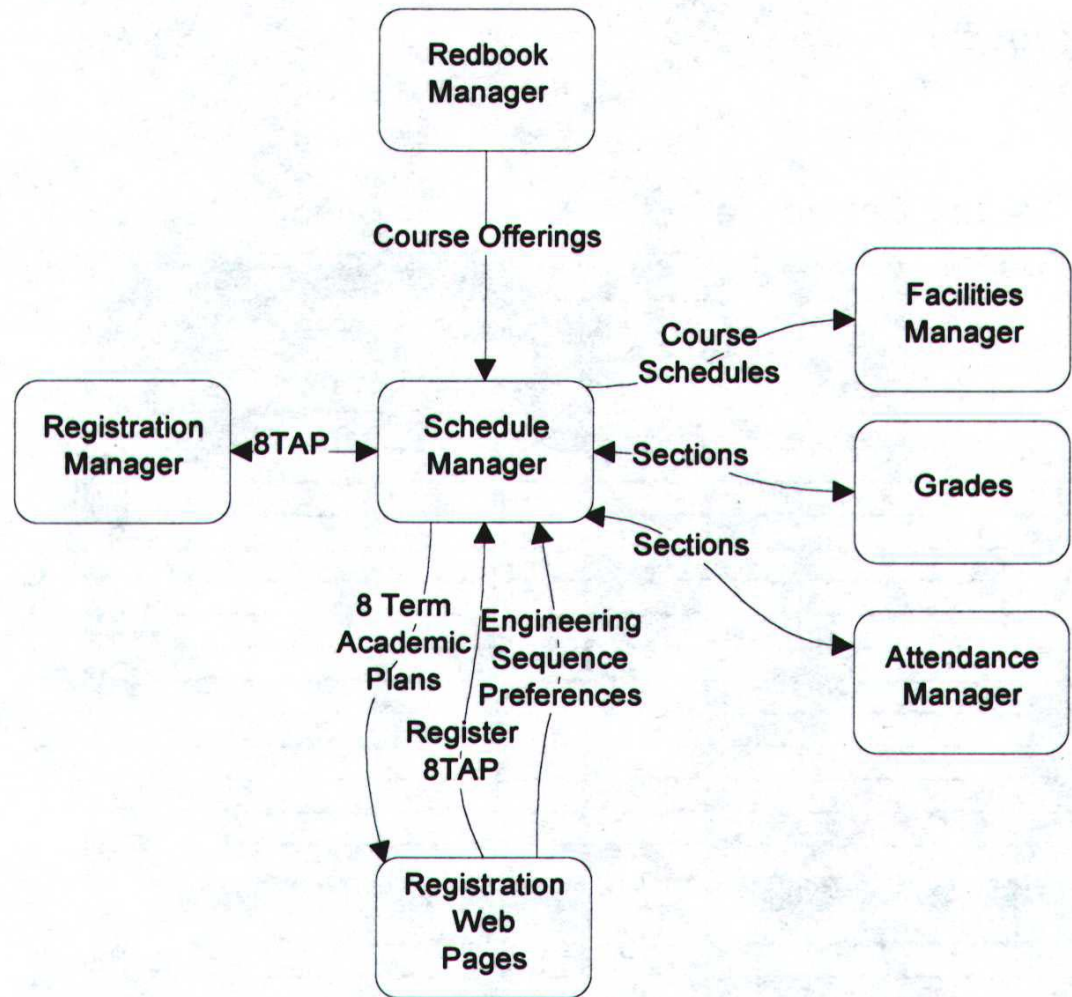
- 8 Term Academic Program (8TAP)
- E.g MATHEMATICS MAJOR: Statistics/Optimization

	4		5	6		7	8
1	PH202		ENG SEQ	ENG SEQ		ENG SEQ	ENG SEQ
2	MA206		ENG SEQ	MA363		MA386	MA476*
3	LX2XX		MA376	MA371		MA381*	MA481*
4	SS20X		MA383	MA387		MA492D	MA491
5	EV203		SS307	EN302		* HI301	HI302
6	MA 391		PL300			LW403	


Enterprise Academy Management System

Management of :

Redbook
Registration
Schedule
Facility
Attendance
Grades



Scheduling at USMA

- Pre Scheduling
 - Term Balancing (Dept Resources)
 - Initialize Hour Offerings
 - **Scheduling**
 - Post Scheduling
 - Sectioning
- 
- Associate Cadet Courses to hours
 - Display Infeasible Schedules

Course:

 Search

Offerings

Sections

Future Terms:

Course Planner:
 Planner

Next Term:

Instruction Periods:
 Inst Periods

Instruction Periods Rollup:
 Inst Periods

View all courses sponsored by department:

Curric Database

Main

MA104 COURSE OFFERINGS

COURSE NBR	SECT	SECT SIZE	CPBLTY	ENRLD	SEATS
MA104	<input type="text" value="52"/>	18	936	933	3

MA104 INSTRUCTION PERIODS

COURSE	HOUR	NBR SECT	SECT SIZE	CPBLTY
MA104	AG	13	18	234
MA104	BH	13	18	234
MA104	CI	13	18	234
MA104	DJ	13	18	234

Tight

MA205 COURSE OFFERINGS

COURSE NBR	SECT	SECT SIZE	CPBLTY	ENRLD	SEATS
MA205	<input type="text" value="5"/>	18	90	70	20

MA205 INSTRUCTION PERIODS

COURSE	HOUR	NBR SECT	SECT SIZE	CPBLTY
MA205	AG	1	18	18

Depts

Scheduling Cadet Courses to Hours

- Given course hours & capacity

MA481,AB,36 MA481,CD,18 MA481,EF,18
PE300,C,180 PE300,J,60 MA371,F,18

- Given cadet's course registration

043671XXX,MA481
043671XXX,PE300

- Objective: Find a *good* assignment of cadet's course requests to course hours

043671XXX,MA481,CD
043671XXX,PE300,J

Scheduling System Objectives

- Produced in a timely fashion
- Complies with *most* constraints/rules...
 - Individual:
 - Cadet can't be at two places at the same time
 - Course hours are balanced over Day-1, Day-2
 - Free hour
 - Cadet gets scheduled for all courses he/she has registered for
- Capacity:
 - Enrollment of course hour cannot exceed capability
 - Course enrollment of freshmen which are also athletes cannot exceed 60% of the total enrollment

DEAN (Scheduler) Application, AYT 2001-2

File Manage Utility PreSchedule Schedule Manual Schedule Sectioning Reports Change Password Window Help

Scheduler AYT 2001-2

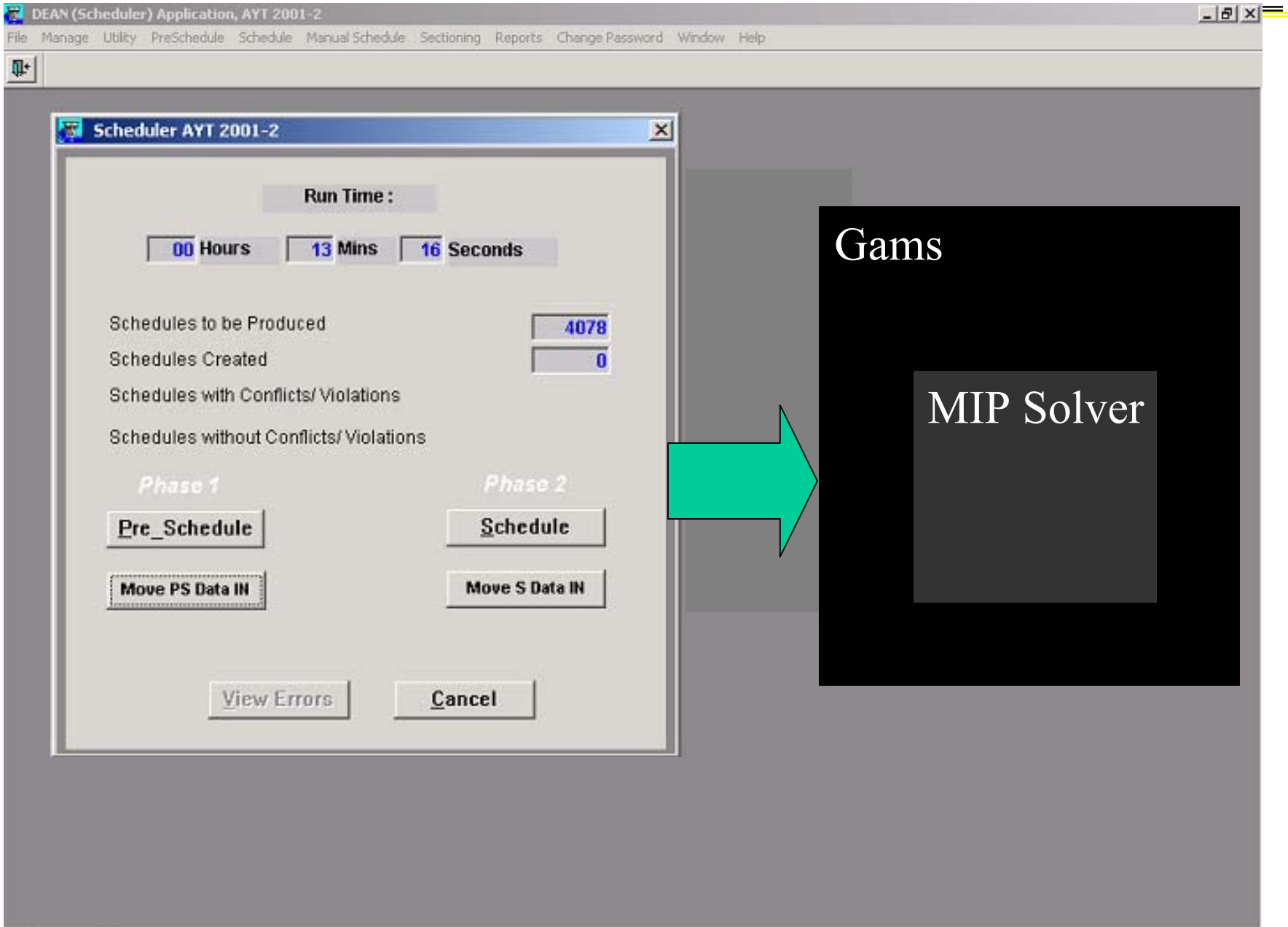
Run Time :
00 Hours 13 Mins 16 Seconds

Schedules to be Produced: 4078
Schedules Created: 0
Schedules with Conflicts/ Violations
Schedules without Conflicts/ Violations

Phase 1: Pre_Schedule, Move PS Data IN
Phase 2: Schedule, Move S Data IN

View Errors, Cancel

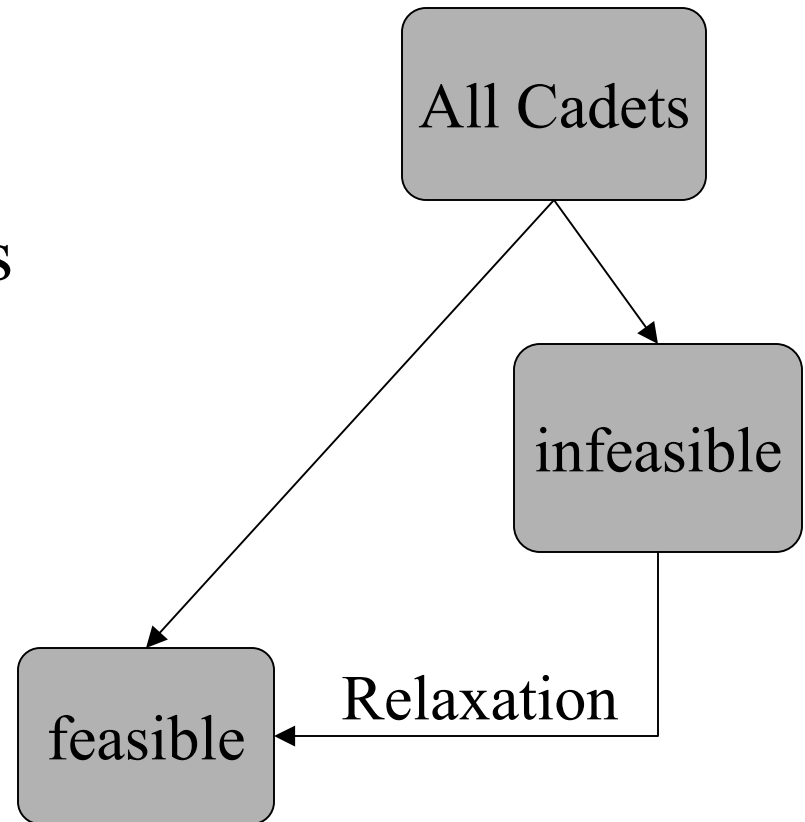
Gams
MIP Solver



Opening a new window...

Prescheduling

- One cadet at a time
 - Check feasibility
 - If infeasible produce several infeasible schedules ranked by severeness of infeasibility
 - Hour Conflict
 - Day – Day Balance
 - Last Hour Free
 - Human Intervenes



Options

- Change Model Data Inputs
 - Modify hours
 - Modify number of sections per hour
 - Modify cadets 8tap
- Waive Constraint
 - Unbalanced days
 - Last hour free
 - Design Group

Conflicting Objectives

- Departments want to teach minimum number of sections and good hours.
- Dean wants to keep course enrollment at 18 cadets per section.
- Registrar wants to ensure cadet's day to day balance is satisfied.
- ODIA want to ensure their star running back gets last hour free for football practice

Dean (Scheduler) Application

Course Combinations Causing Cadet Hour Conflicts EE471

	Course	Total Enrollment	Total Cadets in Conflict	Conflicting Hour	Sched. Hr	Alt Hr
34	PH486	3	1	E	EF	<input checked="" type="checkbox"/>
35	CH486	55	1	B	BU	<input type="checkbox"/>
36	PH384	17	1	J	JT	<input type="checkbox"/>
37	PH204	909	1	K	CR	<input type="checkbox"/>
38	EE471	6	1	B	B	<input checked="" type="checkbox"/>
39	MS498	11	1	H	GH	<input type="checkbox"/>

Course Hours

Conflicts Unique Crse|Conflict Hr: 49 Double Click Activated

Enrolled Cadets with Hour Conflicts

Course	Total Enrollment	Name	SSN	Grad Yr	Reviewed
CS484	8			2001	<input type="checkbox"/>

Tap
Reviewed

Cadets: 1

Dean (Scheduler) Application

Recommended Courses To Change

Course	Orgnal Hours	Alt Hours	# Resolved	% Resolved
EE471	B	U	1 of 1	100%
EE471	B	G	1 of 1	100%
EE471	B	X	1 of 1	100%
EE471	B	Y	1 of 1	100%
EE471	B	Z	1 of 1	100%

Show Alternatives With No Direct Conflicts

Show OFF

Mail Alts

Course To Modify

EE471

Hr Combinations	Nbr of Sections	Sect Max	Enrolled	Hr Max(Col2 * Col3)
B	1	18	6	18
Totals:	1			18

Add

Change

Scheduling

- Individual (relax constraints):
 - Day-Day course balance
 - Free hour
- Capacity:
 - Enrollment of course hour cannot exceed capability
 - Even hour enrollment distribution

Cadet Schedules with Constraint Violations, AYT 2001-1

Header Information

Select Constraint Type: **3 FREE HOUR CONSTRAINT** Free Hour Violations: **43** ➔

Filter by: Design Group Violations: **4** ➔

Unbalanced Schedule Violations: **7** ➔

Cadets With Schedule Violations FREE HOUR CONSTRAINT

Course	Total Enrollment	Name	SSN	Grad Yr	Reviewed
EM362A				2002	<input type="checkbox"/>
PH365				2002	<input type="checkbox"/>
EM362A				2002	<input type="checkbox"/>
EM301A				2002	<input type="checkbox"/>
EN302				2002	<input type="checkbox"/>
EM301A				2002	<input type="checkbox"/>
EM362A				2002	<input type="checkbox"/>
EM362A				2002	<input type="checkbox"/>

Details

Course Hours

Cadets: 43

Name: **BASS, WILLIE C.** FOS1: Civil Engineering Major FOS2:

Eng Seq: CIVIL ENGINEERING TQPA: 2.414 CQPA: 2.699 (3) 1 Day (3) 2 Day

Activity Code(s): CSWV

Hour	Course	Violation	Override
A	PE310		
B	MA364		
C	PL300		
D	PL300		
E	EM362A	FREE HOUR CONSTRAINT	
F	EM362A	FREE HOUR CONSTRAINT	

Z Hour

Hour	Course	Violation	Override
G	SS307		
H	HI301		
I	EM364A		
J	EM364A		
K	,R		
L			

Schedule

OK

Close

Filter by Course

Unacceptable Hour Enrollment Variance (+/-)

Course(s)	Hours	Enrollment	Max Enrollment	Ideal Enrollment	Variance
CH101	GH	226	253	232.750	-6
CH101	AB	240	253	232.750	8
EM362A	GH	14	24	23.330	-9
EM362A	EF	41	36	35.000	6
EN101	F	254	340	307.140	-53
EN101	E	300	323	291.790	9

Course Hours

Number of Courses: 47

Double Click Activated

Schedule

Enrollment For: CH101 Hour: GH

Name	SSN	Grad Yr	Activity
		2004	CSRI
		2004	CSSR
		2004	
		2004	
		2004	CSFT
		2004	CSIT
		2004	CSBA

Cadet Count: 225

Double Click Activated

Cancel

Results

- AY 2000/2 parallel tested
- AY 2001/1 deployed

	Legacy System + human deconflicter	New System
Individual Relaxations	203/304/116	58/25/4
Capacity Overloads	12/54	9/21
Number of Schedulers	3	1
Time to produce Schedule	4 Weeks	1 Day

Conclusion

- Model is only one component of the system
- Human intervention throughout the process
- “*Solved*” difficult *real world* scheduling problem