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## Mathematicians Solve XFL's Scheduling Problem

By PATRICIA COHEN

**H**ere's the scheduling problem that faced the XFL, the new smack-in-the-mouth, kick-in-the-groin professional football league that has its premiere tonight.

Two divisions with four teams each; each team plays every other team in its own division twice and the teams in the other division once. So far so good. Then the headaches began.

Marquee name games ♦ like the Las Vegas Outlaws against the

New York/New Jersey Hitmen ♦ had to take place on Saturday nights to mesh with NBC's schedule, and the openers had to be in warm- weather locations (no blizzards) and smaller stadiums (so the stands would look packed). Teams were not supposed to have too many away games in a row, but the Chicago Enforcers could not play at Soldier Field in February because the Auto Show needed the parking lots; the Outlaws could not play at home in Week 8 because of the Moto Cross show; and Orlando Rage was probably going to be displaced in Week 4 for a concert.

The organizers could have spent weeks or months matching and rematching teams. But two mathematicians at the University of Vermont ♦ a college that doesn't even have a football team ♦ thought they could do better.

So Jeff Dinitz and Dalibor Froncek, experts in an arcane field of math called combinatorics, offered to be the brains behind the brawns' schedule.

"I just called them out of the blue," Mr. Dinitz, the chairman of the mathematics and statistics department, said. "I was surprised they were pretty receptive."

Indeed, the XFL, which was created by the World Wrestling



Paul O. Boisvert for The New York Times  
Dalibor Froncek, left, and Jeff Dinitz, experts in combinatorics.

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Federation, adopted Mr. Dinitz's and Mr. Froncek's schedule virtually unchanged.

"We were very, very happy," said Rich Rose, a senior consultant to the league who worked with the mathematicians.

Mr. Dinitz has been a fervent football fan ever since graduate school at Ohio State in the late 1970's when the legendary Woody Hayes coached. He invited Mr. Froncek, a visiting professor from the Czech Republic ♦ a nation without the finer art of football ♦ to his house to watch the games. One day last February he mentioned to Mr. Froncek that a new league was forming.

"I said, 'If it's new then they have no schedule,' " Mr. Froncek explained. " 'Don't you think we should offer that we would make a schedule for them?' I was pretty familiar with these kinds of schedules. They're quite similar to what I have done for the Czech guys." Mr. Froncek creates the schedules for the 12- team Czech basketball league and the 14- team Czech hockey league. Mr. Dinitz, meanwhile, discusses the N.F.L.'s cumbersome scheduling procedure in a handbook of combinatorial designs for which he was a co-editor.

So Mr. Dinitz got on his computer and went to the XFL's home page and called the number listed. A public relations person answered and, to Mr. Dinitz's amazement, he was quickly put in touch with Mr. Rose. He began to schmooze football with him.

As it turned out, their timing was perfect. "We knew the basics" of what we wanted, Mr. Rose said, "but we hadn't gotten down to developing a schedule."

Mr. Dinitz said that the XFL had taken a crack at it and was in trouble. "They sent us a sample schedule and it wasn't very good," he said, "so we knew that we could help them."

For hundreds of years mathematicians have fiddled with combination problems. Seventeenth-century mathematicians were obsessed with figuring out gambling odds, like what the chances are of getting a pair of aces in five-card poker. Galileo figured out the odds for dice.

Las Vegas isn't the only place where combinatorics mavens gravitate. It can also be used to devise a college course schedule that accommodates all students' class preferences, postal routes that begin and end in the same place but ensure that no block is walked twice, and pharmaceutical experiments that require trying out different combinations of drugs. In the last few decades the field has become critically important because it is used in computers.

"The main problem is to combine constraints," Mr. Froncek said. "You can do one thing relatively well and the other relatively well, but when you want to put these things together, you can't do that without a deep knowledge of some mathematical methods."

For the XFL schedule, Mr. Rose sent Mr. Dinitz and Mr. Froncek a list of must-haves (like one Eastern time game and one Pacific time game each weekend) and a list of it-would-be-nice-to-haves (like

minimizing the number of times teams had to travel coast to coast).

Mr. Dinitz and Mr. Froncek used graphs to visualize the schedule. "Once you picture something, it's a lot easier to work with," Mr. Dinitz explained. "I represent each of the eight teams by just a dot on my page. There's a dot for New York and a dot for Chicago, and if New York is at Chicago, I'll draw a line between them with an arrow from New York to Chicago."

He and Mr. Froncek kept adding dots and flipping arrows, trying out various combinations. "The cool thing is it's mathematics, but there isn't an equation in it," Mr. Dinitz said.

By the end of March, the two professors sent the XFL three possible schedules that satisfied various soups of requirements and preferences. They asked for \$1,000 and an expense-paid trip to the league's Super Bowl. Excuse me, Mr. Rose scolded over the telephone, the N.F.L. has a Super Bowl; the XFL has a Championship Game.

They received a check for \$1,250, with no mention of championship tickets. But then in July, Mr. Rose called back with the first in a series of new requirements (for example, the San Francisco Demons had to be at home the first week), and wish lists (that Los Angeles be the host to either New York or Chicago). The two mathematicians also made some suggestions of their own, like avoiding three home games in a row, and an intradivisional round robin for the last three weeks.

They asked for \$4,000 more, a lot less than the \$100 an hour that Mr. Dinitz usually charges for consulting. "I didn't know how much to ask," he said, and "I didn't want to scare them away." Still, he and Mr. Froncek began suggesting other types of remuneration at the end of their letters: "We also remember that the XFL is into performance bonuses ♦ does that include us? How about one of those cool-looking footballs? Stock options?" (So far, only the footballs have shown up.)

After the 14th version of the schedule, which they labeled X5 and called perfect, the league was satisfied.

"Jeff and Dalibor were great," Mr. Rose said, adding that there were a couple of last-minute adjustments to X5. "We fully plan on using them in 2002."

Mr. Dinitz is having an XFL party at his house tonight for the math department. And while the XFL has unveiled its schedule to tens of millions of potential fans, he and Mr. Froncek plan to unveil the work behind that schedule to tens of combinatorics fans in the March-April issue of *Congressus Numerantium*, a journal published in Winnipeg.

So what about the N.F.L.? Mr. Dinitz said he believed they could improve its schedule, too, "but we haven't gotten around to calling them yet."

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