# The Huffy Project

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| **Code** | **adi-pub-01149** |
| **Title** | The Huffy Project |
| **Subtitle** | Using the computer, Dr. Ariel and his assistants figured out an aceleration curve for Stu's first three pedals out of the gate. |
| **Name** | BMX Action |
| **Author** | The Huffy Project |
| **Published on** | Sunday, June 2, 1985 |
| **Subject** | ACES; Biomechanics; Digitize; Discus; Exercise Machine; Favorite; Force Plate; Horses; Media; Science; Shoes; Sports; Track and Field |
| **URL** | https://arielweb.com/articles/show/adi-pub-01149 |
| **Date** | 2013-01-16 15:40:47 |
| **Label** | Approved |
| **Privacy** | Public |

## Biomechanical Analysis of BMX Starts Using Computer Digitization

This article discusses the use of computer digitization to analyze and improve the starting technique of BMX rider, Stu Thomsen. The process involves filming the rider's starts at high speed, then using a GrafPen Digitizer to mark out the body's major joints on each frame of the film. These points are then connected to form stick figures which are fed into a computer for analysis.

The computer can calculate movement, velocity, center of gravity, strength, acceleration, and other factors. It can also simulate changes to the rider's technique or equipment, such as different crank lengths or body positioning.

The analysis revealed several areas for potential improvement, including increasing the pedal area or using a stiffer shoe to reduce energy loss, using toe clips to allow the rider to pull up with one leg while pushing down with the other, and adjusting the handlebars to make it easier for the rider to stay down on the bike.

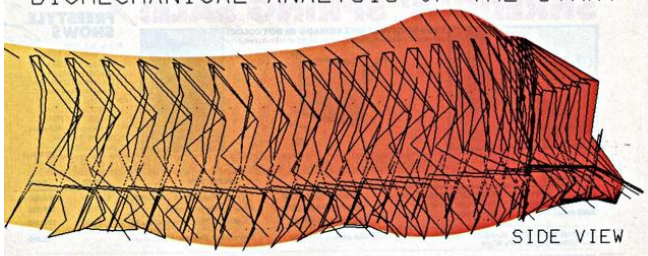
The research also suggested that a wider rear tire could improve traction and speed. The team at Huffy, the bike manufacturer, plans to use this data to make improvements to their bikes and to the rider's technique.



Below find a reprint of the 5 relevant pages of the article "The Huffy Project" in "BMX Action":


# The Huffy Project

## BIOMECHANICAL ANALYSIS OF THE START




*Here it is, one of Stuart's starts, digitized for posterity. Viewing the finished analysis on the computer screen is like watching an erector set in motion, with the motion trailing behind the rider like a flowing wave.*

### USING COMPUTERS TO BUILD FASTER BMX'ERS

Not too long ago, things were just like any other normal day around the headquarters of the Most Factory Magazine. R.L. and Wilton were out in the warehouse making a bunch of noise practicing and brainstorming up some insane new freestyle moves, and Don-Boy and Andy were across the hall in the FREESTYLIN' magazine editorial office, cracking up over one of A.J.'s bizarre cartoon doodles. Meanwhile, Gibey had his feet up on his desk in a creative trance (a nice way to say he's catching 20 winks) while trying to think of an intro for a test story.

Suddenly, Steve's phone started ringing, completely startling him and causing him to tip over backwards in his chair. Picking himself up off the floor, he answered it.

"Hi and howdy, BMX ACTION."

"Hi Steve, this is Bob Hadley." (He's Huffy's Team Manager.)

"Whazzup?"

"Not much. Say, how would you like to come over and check out a complete computer digitization analysis of Stu Thomsen's starting technique at the Coto Research Center?"

"Huh? What? Run that one by me again."

"Computer digitization. What they do is film several of Stu's starts with a high-speed movie camera — like at 400 frames per second, and we pick the best one and have it digitized for closer examination."

"Okay, I've got you so far — I think. But what's this digi-what-cha-ma-call-it?"

"That's the next step. They have a special motion picture camera that projects each individual frame of the film up on a special computer grid screen. Then, using a t-rick deal called a Graf-Pen Digitizer, they mark out the body's major joints on the screen for EACH and EVERY frame of the film, and then they connect the joints together with lines to form stick figures."

"All this stuff then gets fed into a huge computer and when everything's done, these stick figures run like a movie on the computer screen, except you can stop it at any point for closer examination. You can also view these stick figures from any angle, and the computer can use them to figure out movement, velocity, center of gravity, strength, acceleration, amount of time and distances travelled between specific points, and a whole bunch of other info you can't get from video taping or by watching the starts yourself."

"They can even do 'what if?' games. For example, if we wanted to see what effect 200mm cranks would have on Stu's starts, the crank length could be extended accordingly on the computer screen. Or say we wanted to see what would happen if he used a different knee or head positioning. We could see that, too."

"Another trick thing is the force plate mounted into the floor of the research center's lab. Stu will run across it during his starts, and it'll measure the down-force, forward and rearward movement, and side movement. Huffy has used this in the past to find what kind of forces are put on a stem when a rider lands off a jump. That's how we found out about this place. It's totally rad. Come on down and check it out."

So we did. And it is. It's so high-tech your brain falls out.




*The Mighty One, Stu Thomsen blastin' into the ozone over Colossus.*

### INFILTRATING THE COTO RESEARCH CENTER

Nestled into the hills overlooking El Toro, California, the Coto Research Center isn't just your everyday high-tech training and research center. Their research has resulted in major advancements in athletes' techniques that have led to world records in track and field, dramatic improvements in athletic shoes, and even a shoe design for horses that improves their running. In short, these dudes and dudettes are INCREDIBLY heavy-duty.

Dr. Gideon Ariel is the head honcho, and he's got a list of credentials so long it would take practically the whole story just to list 'em. EXTREMELY notable things about him include that he's a former Olympic discus thrower, and that the computer programming he did to develop the digitization program took over 10,000 hours to complete. UGH!

When we arrived there we asked ol' Hadley to give us the lowdown on what Huffy was hoping to find. "BMX starting techniques have gotten to where everyone is doing basically the same thing. We're looking for an edge."

"We may be able to improve the physical structure of the bike or the positioning of Stu's body. Since the racing season runs all year long, we don't

really have time to keep trying new things because if we make a mistake, it'll affect Stu's performance too much."

"We've done a little playing with video, and we've already made some headway in improving Stuart's starts. He used to have a dramatic pull to the right as he powered out of the gate, and we've 90 percent cured that by setting his crank a little lower on certain gates, and also by just making him aware of it."

"Mostly, this is an experiment. It's a chance we'll take to gain some improvement."

### GETTING THE INFO ON FILM

Filming took the better part of half a day. ABA National No. 1 Mike King came up from San Diego to watch, too.

Stuart was filmed at the center with two cameras at different angles. After three or four starts, the film was in the can, and on its way to being developed. When it returns it'll be digitized, and then we'll come back to view the results.

### ANALYSIS FROM DR. ARIEL

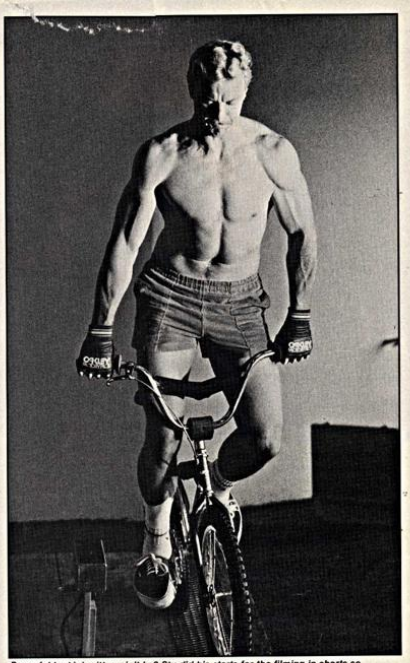
A little over two weeks later we returned to scope the completed program, and listen to the staff's recommendations of things that Stu could improve. One thing that was totally neat was that they were not limited by tradition, or ideas of what's normal in BMX. They came up with some gnarly ideas — some of which were not red-hot for real-life application, and some that could be applied, but they were all interesting nonetheless. Take it away, Dr. Ariel.

"From our analysis, we see that there's loss of energy between the foot and the pedal. You can look on the film and see that the shoe folds over the pedal. If the pedal area could be increased by 30 or 40 percent, or if you could make a shoe that doesn't flex as easily, with a stiff insert inside, maybe it wouldn't be as comfortable, but it would be much more efficient. You would not be able to bend the shoe and the rider would have more power going into the pedalling."

"Also, we suggest the use of toe-clips, but we understand that the rider has to put his foot on the ground sometimes. If you *could* put together something that would be easy to get in and out of, then he would be able to pull up with one leg at the same time his other foot was pushing down. That would relieve some of the force he has to produce with his arms in order to stay down onto the bike. When he pushes down with the legs, the body wants to go up. Part of the reason Stu's so good is that he's got VERY strong arms."

"Also, if the bends of the handlebars were pulled back a little more, it would be much easier for his arms to hold his body down onto the bike."

"The front wheel doesn't do too much in the start, because almost everything



*Powerful lookin' critter, ain't he? Stu did his starts for the filming in shorts so that it would be easier for the Coto Research Center crew to mark his body joints on the grid.*

is on the back tire. I'm willing to bet that if you gave him a wider rear tire, you would improve his speed with the same start because of the extra traction."

"You might think about some harness between his waist and the frame that would allow him to push as hard as he can with his legs so that it relieves some of the pressure on his arms. It would increase his speed, no question about it."

### RATE OF ACCELERATION

Using the computer, Dr. Ariel and his assistants figured out an acceleration curve for Stu's first three pedals out of the gate. As expected, there was a dramatic jump in the percentage of acceleration from when Stu was standing still on the gate to the end of his first pedal stroke, but then they noticed a big drop in acceleration between his first and second pedal. In

real time we're talkin' milliseconds, but when you consider every OUNCE of power counts as you blast out of the gate, it meant this was a big gap nonetheless.

So what's the cure? Well, Mike King has been testing an elliptical-shaped Shimano Bio-Pace chainwheel on his bike (they're used most commonly on 10-speeds and mountain bikes), that's more efficient than a normal round chainwheel because it slightly decreases the amount of dead space between power strokes. Bob plans on having Stu try one of these chainwheels as soon as he can get one in a 42 tooth size. (The one that Mike is using has 44 teeth.)

## THE FORCE PLATE ANALYSIS

We mentioned earlier that Stu would be sprinting across a force plate during the filming of his starts, and this yielded a very interesting tidbit of info. It showed that as he was blazing across the force plate under full power, the back tire was breaking loose! No way was he getting full traction. Bob mentioned that this is VERY common for Stu. "One of Stu's biggest problems is he has to restrict his power. It's very rare that he can go as fast as he can possibly pedal because the back tire just can't get enough traction."

"At a lot of races we've been to he's had to set his crank a couple clicks lower for his starts than he'd like, to cut down on the amount of power on the first pedal because he spins the back tire."

"Now that we have this information we can go to our tire manufacturer and encourage them to make a wider track tire with a 1.75 diameter."

## OTHER THINGS HUFFY'S GOING TO TRY

We asked Bob what other plans Huffy had for the new data . . . without giving away too many factory secrets, of course.

"One problem we've had is the lower part of the handlebar was getting in the way of Stu's knees. We noticed his left knee almost turning the handlebar for him as he'd come forward on his first pedal. I couldn't tell if he was holding back 'cause he knew the bar was there, or if he was getting the max out of the first pedal and his knee was just kissing the bar. I figured that if he had a half inch more room to spare at the bottom, it would just give him a little more room to open up and power into it. He just started using a Flying W ESP stem and it's opened that area up."

## TECHNIQUE CHANGES

What has Stuart changed in his style since scanning through the Research Center data? "I pre-load a little mo when I'm on the gate — putting mo pressure on the gate before it drops that I'm not relying on the first snap much. I'm also concentrating on kee ing my weight forward more during r first two pedals." That's to help c down on the drop in acceleration b tween the first two pedals. Part of t reason for the drop in acceleration that you throw your weight forwa during the initial snap, and you lo time moving your body back away fro the bars for the second pedal.

Anything else, Stu? "Yup, Bob and examined the curve of the power strok and now when I'm on the gate I set r pedal a little lower to get into the ma mum part of the power stroke earlie Most of the time Stu sets his first ped just a hair above horizontal.

## FINISHING UP

Bob and Stu are expecting a ne wider tire from Cheng Shin any da now, so the complete results as to th success of the Huffy Project are st coming in.

One thing's for sure, though — Bo and Stu (along with some HEFT bucks from Huffy) have ushered in new aspect of high-tech experiment tion into the sport, and you can b that this won't be the last time th computers will be used to build fast BMX'ers. ■

# HARO'S CORNER

***BMX futurism – and a little peek at intergalactic speed jumping style through the eyes of our semi-crazed staff artiste, Bob Haro.***