Combat 101:
An Introduction to F2D Control Line Combat

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Verizon Labs – Waltham, MA
19 November 2003
Introduction
Who is this guy?
Name: Mark Rudner
Introduction
The Basics of Control Line Flight
Introduction
The Basics of Control Line Flight – An Animated Example
Control Line Combat

A “2D” Game of Cat and Mouse on the Topology of a Sphere

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A 2D Game of Cat and Mouse on the Topology of a Sphere

The Rules/Scoring

1 minute starting period, 4 minute match

100 pts for each cut on opponent’s streamer

+1 pt for each second own model is airborne

-1 pt for each second own model not airborne

-40 pts for unintentionally leaving pilot’s circle
Control Line Combat
Dogfight or Nouveau Ballet?

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The History of F2D
Champions of the World – Past and Present

<table>
<thead>
<tr>
<th>Year</th>
<th>Champion</th>
<th>Country</th>
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<tr>
<td>1978</td>
<td>Mick Tiernan</td>
<td>GBR</td>
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<tr>
<td>1980</td>
<td>Oleg Doroshenko</td>
<td>USSR</td>
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<td>1982</td>
<td>Tom Fluker</td>
<td>USA</td>
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<td>1984</td>
<td>Loet Wakkerman</td>
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<td>1986</td>
<td>Nikolai Necheukin</td>
<td>USSR</td>
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<tr>
<td>1988</td>
<td>Boris Faisov</td>
<td>USSR</td>
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<tr>
<td>1990</td>
<td>Vjacheslav Baliev</td>
<td>USSR</td>
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<tr>
<td>1992</td>
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<td>USSR</td>
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<td>1994</td>
<td>Mervyn Jones</td>
<td>GBR</td>
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<td>1996</td>
<td>Vjacheslav Baliev</td>
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<td>1998</td>
<td>Alexei Zhelezko</td>
<td>UKR</td>
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<tr>
<td>2000</td>
<td>Stansilas Chornyy</td>
<td>UKR</td>
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<tr>
<td>2002</td>
<td>Michael Willcox</td>
<td>USA</td>
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The History of F2D
Understanding the (former) Soviet Domination

Aeromodelling was seen as an integral part of the military-industrial complex.

Government support, school programs, and an organized training program led to the formation of a highly sophisticated infrastructure.

The best of the best became full-time instructors, training the next generation of aeromodellers and aerospace industry-bound young men and women.
The History of F2D
Understanding the (former) Soviet Domination

Ekaterinburg (formerly Sverdlovsk), Russia

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The History of F2D
Understanding the (former) Soviet Domination

Ekaterinburg Championships, February 2001

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The History of F2D
Why “Russian” Engines Are So Good

Years of empirical modeling/testing, plus unlimited time/material resources for development

Special custom metallurgy and space-grade aluminum starting material for pistons, cases, etc.

Extremely meticulous and precise machining, ensuring that every part will fit just right at operating temperature
The History of F2D

Current Engine Specifications

1. **4 mm** maximum venturi diameter
2. **NO** sub-piston induction
3. Contest-supplied fuel mixture
   - **10% Nitromethane**
   - 20% Castor Oil
   - 70% Methanol
4. Mandatory silencer with **8mm** maximum outlet diameter
The Equipment of F2D Models

**Typical Design**

“Baseball Bat” leading edge
Adjustable aluminum beam mounts
Balsa ribs and spruce trailing edge
Hollow bladder compartment
Tough Mylar film covering
Steamer hook/muffler retainer
The Equipment of F2D

RTF Models – Trim Adjustments

RTF – Ready to Fiddle

Readily available RTF models are made with excellent quality and come truly ready-to-fly.

To really achieve optimal performance, it is still necessary to fine tune each model to ensure that every model in your fleet behaves exactly as all the others.
The Equipment of F2D

RTF Models – Trim Adjustments

Trimming your model is as easy as 1-2-3-4

1) Wings – correct for warps by bending/re-shrinking

2) Engine – fore/aft translation for CG adjustment
   – thrust-line adjustment

3) Control Horn – adjust control-throw sensitivity

4) Tip Weight – balance weight of lines
Control Line Combat

The Merits of “Fly-by-Wire”

Direct connection with the model opens many windows not available in other forms of aeromodeling

a) Can feel forces acting on the model

b) Flying is inherently more interactive

c) “Eyes Off” flying possible (more later)

d) Never have to go very far to pick up the pieces if you crash
Control Line Combat

Automatic Feedback Stabilization

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Control Line Combat
Three Reasons Why C/L is Better Than R/C

“You can run, but you can’t hide”

“Keep your eye on the ball!”
- Any Little League or Tennis coach

“If you don’t know where you’re going, how are you going to get there?”
- P. Dimotakis: Caltech Ae101, Spring 2002

“Don’t become the airplane, let the airplane become a part of you”
- Me: Getting all profound and stuff, Nov. 2003
F2D Combat

Match Procedure

Timing
Minute to the Minute
Minute to Launch
Four Minute Match Period

Flying
Both pilots initially must fly level, anticlockwise
When separated by ½ lap, circle marshal gives sign to start combat
F2D Combat

Match Procedure – Team Netherlands “On the Minute”
F2D Combat
The **Mechanics** of a Typical Pit Stop

Each pilot has 2 models, 2 engines, 2 sets of lines in the circle, ready to go

Only one engine may be running at any instant

**In the event of a crash:**
- One mechanic starts spare model
- Other mechanic retrieves downed model and transfers streamer to the spare
F2D Combat

The **Mechanics** of a Typical Pit Stop
F2D Combat
The **Mechanics** of a Typical Pit Stop

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F2D Combat

The **Mechanics** of a Typical Pit Stop – Sorting Things Out

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F2D Combat
Hard Work in the Center Circle

F2D, along with F2C and F1A are probably the most physically demanding aeromodel-sporting events.

All action is confined to the 2 meter radius pilot’s circle.

Getting a cut requires precise alignment; a wing-slap just won’t do.
While control line flight is typically thought of as occurring on a closed 2D surface, in combat there is a very important, compact, third dimension at one’s disposal.

This is one of the most interesting and challenging aspects of control line combat.
F2D Combat
Prepare to Enter the Third Dimension

Just the Facts:

Propeller Diameter: ~ 16 cm
Streamer Width: ~ 3 cm
Pilot Circle Diameter: 4 m
Range of Pilot Arm Lengths: 60 – 70 cm
Range of Pilot Heights: 160 – 195 cm
Range of Pilot Masses: 50 – 100 kg
F2D Combat

Working the Center Circle – Audience Participation (Yay!)
F2D Combat

Working the Center Circle
Control Line Combat is **fun** and **exciting**

High quality equipment is readily available and can be tuned to your liking

The uniquely **control line** aspects of F2D present an interesting set of challenges and benefits, and make the sport every bit as physical as it is mental
F2D Combat

Final Remarks – For More Information

My email: rudner@mit.edu
Great Combat Info Website: www.clcombat.info
Combat in New England: www.homestead.com/necn/
Miniature Aircraft Combat Association (MACA): www.aerovents.com/maca/

2004 Control Line World Championships:
July 6 – 10, 2004: Muncie, Indiana

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