ICAR 2016

BOROVETS, BULGARIA

DUAL CAPABILITY TWO TENSIONED ROPE SYSTEMS

- A SYSTEMS ANALYSIS

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Government of Canada
National Search and Rescue Secretariat
Gouvernement du Canada
Secrétariat national Recherche et sauvetage
Canada

We would like to acknowledge the financial support of the Government of Canada for this project through the Search and Rescue New Initiatives Fund (SAR NIF).

British Columbia

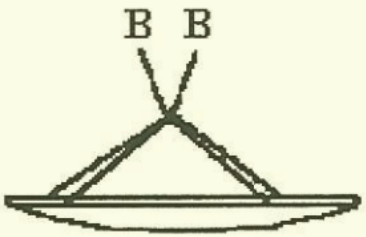
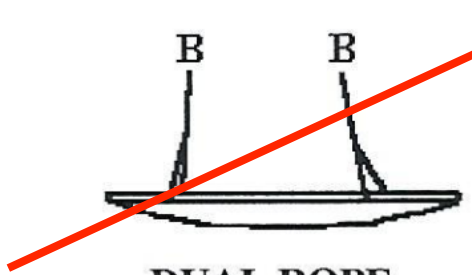
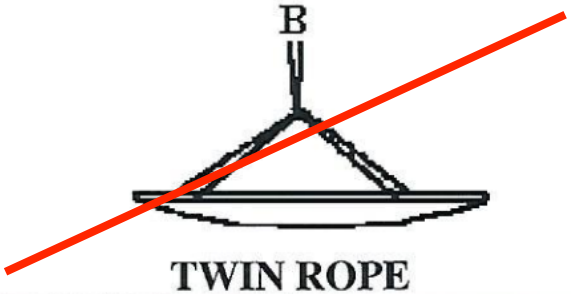
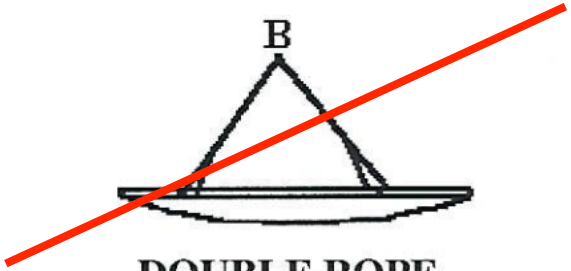
80+ Voluntary SAR Teams
2500 Rescuers

Most mountainous province

Complete review of Terrestrial Rope Rescue Techniques and Practices

Which Two Rope System best manages/mitigates risks?
Evidence based decision making.

Previous research and testing favoured Two Rope Systems

	1 POINT ATTACHMENT (most often with 1 attendant)	2 POINT ATTACHMENT (most often with 2 attendants)
TWO BRAKES ON TOP	 **TWO ROPE**	 **DUAL ROPE**
ONE BRAKE ON TOP	 **TWIN ROPE**	 **DOUBLE ROPE**

…but there are many ways which a Two Rope System can be rigged and operated!

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Canadian Government provided funding to BC for Research and Testing of Rope Rescue Systems

Evidence Based Comparative Analysis of:

Dual Capability Two Tensioned Rope Systems, and Dedicated Mainline, Dedicated Back-up Systems

Results:

Complete Revision of BC SAR Rope Rescue Techniques, Standards, and Training.

Results:

(best risk management/mitigation)

Dual Capability Two Tensioned Rope System

Each rope system must be fully *capable* and *competent* as both a mainline and a back-up line, at the same time.

FOCUS AREAS OF TESTING AND RESEARCH

Key Factors:

1. Environment
2. Method
3. Materials
4. Human

Testing and Research Conducted on:

- Sharp Edges (tensioned/un-tensioned ropes)
- Rock Fall (falling objects onto rope systems)
- Maximum Arrest Force (MAF) comparison
- Stopping Distance comparison
- Force Limiting Requirements and Strength requirements of rope rescue systems
- Manual override of self-braking devices (human factor)

This is what we learned…

Managing Sharp Edges:

Two Tensioned Rope Systems have better safety margins than *Dedicated Mainline with Un-Tensioned Back-up* Systems

Sharp Edge Tests Conducted:

1. Drop over sharp edge
2. Pendulum of Load
3. Sudden sweep of ropes

Pendulum of Load

Two Tensioned Rope System

Pendulum of Load

Dedicated Main, Un-Tensioned Back-Up

Sweep of Ropes

Two Tensioned Rope System

Sweep of Ropes

Dedicated Main, Un-Tensioned Back-Up

Two-tensioned ropes performed better than dedicated main & back-up rope systems.

LESS TENSIONED ROPES ARE LESS LIKELY TO BE DAMAGED/ CUT FROM SHARP EDGES

Rock Fall (falling objects)

Results:
No observable difference in outcome between *Two Tensioned Rope Systems* and *Dedicated Main, Un-tensioned Back-Up* Systems.

Three types of tests:

1. Crushed rock
2. Blunt Strike
3. Sharp Edge Strike

Falling Crushed Rock onto Dedicated Main/Back-up as well as Two Tensioned Rope System

Blunt object striking ropes lying on sharp edge

Sharp object striking ropes lying on flat surface

Edge Transition Failures (highest drops and forces)

TESTING RESCUE BACK-UP SYSTEMS (CAPABLE AND COMPETENT)

Edge Transition Failures (highest drops and forces)

A rope rescue Back-Up must be able to:

Back-up Capability and Competence Test:

1m drop onto 3m rope with 200 kg mass

- Peak force <12 kN
- Stopping Distance <1 m
- >80% residual rope strength
- Must remain functional

1.5m drop onto 3m rope with 200 kg mass

- Must remain functional (strength margin test)

TESTING RESCUE BACK-UP SYSTEMS (CAPABLE AND COMPETENT)

Rescue Back-up Performance Testing

Dual Capability Two Tensioned Rope Systems

Human Factor Problem!

The Self-Braking feature of the devices are being manually overridden… therefore there is a chance that the operator may not do the correct action if one system fails

Human Factor: Assess Rope Tailing Effectiveness

Tests showed that
the maximum rope tailing
force/tension requirement
Should be about 0.1kN

This ensures *all* rescuers can achieve this function. The average gripping ability on two ropes was found to be about 0.5 kN

Test: Self-Braking feature overridden, (mechanical rope tailing at 0.1 kN)

Human Factor: Assess Rope Tailing Effectiveness

Results:

Not all devices pass the Rope tailing test of 0.1 kN

Only devices and techniques that pass were adopted by BC SAR and EMBC.

Maximum Force and Stopping Distance Comparisons Between Tensioned and Un-Tensioned Back-up Ropes

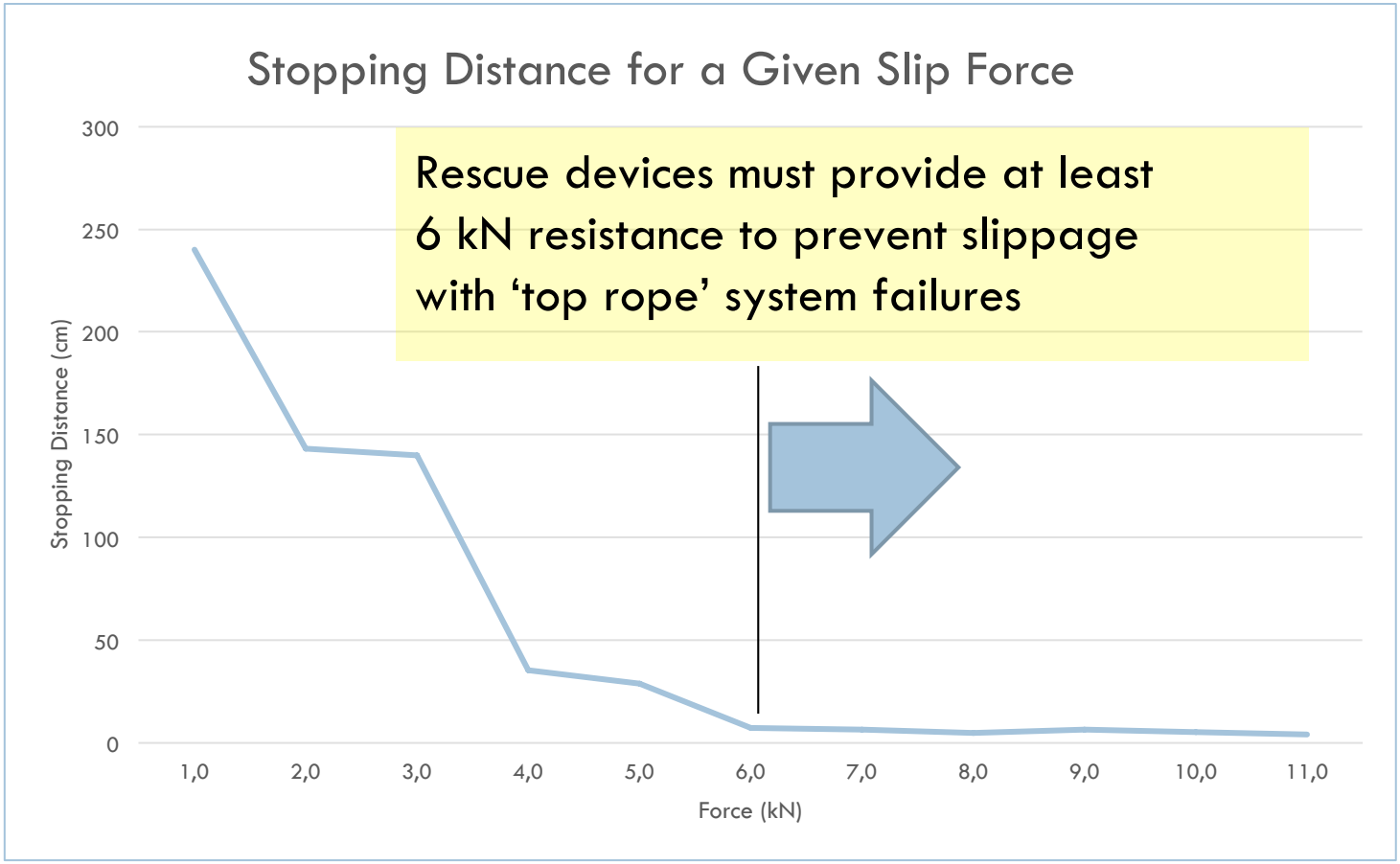
Results:

Two Tensioned Rope Systems provide:

- 35-50% reduction in Maximum arrest force
- 50-90% shorter stopping distance

These are significant reductions in risk!

Determining the Minimum Slip Force Requirements of Rope Rescue Devices



The Important Relationship between *Working Load*, *Force Limiting* Requirements, and *Minimum Equipment Breaking Strength*

Working Load	Force Limiting Requirement	Breaking Strength
1-4 kN	6-12 kN	20+ kN

Objectives/Purpose:

Top Rope failure (<6 kN) result: no slip of device

Free Fall failure (<12 kN) result: device slips between 6-12 kN

Breaking strength of 20 kN provides sufficient strength margin above 12 kN

Dual Capability Two Tensioned Rope Systems

Key Attributes:

- Working Load capability 1-4 kN
- Devices Force Limit 6-12 kN
- Capable and Competent Back-ups (<12kN MAF; <1m stop distance; >80% residual strength; remains functional after FF ½ test)
- Equipment Breaking Strength 20+ kN
- Rope Tailing capability at <0.1 kN
- Truly redundant
- Self-Braking Devices

Benefits:

- Better safety margins for managing sharp edges
- Lower peak forces and shorter stopping distances
- Common equipment between rope systems
- Simpler systems and improved human factor management

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BOROVETS, BULGARIA

THANK YOU

DUAL CAPABILITY
TWO TENSIONED
ROPE SYSTEMS

Parks Canada Parcs Canada