Working paper No. : TYREgtr-03-02
Status Approach and Road Map
(Document presented by RMA)

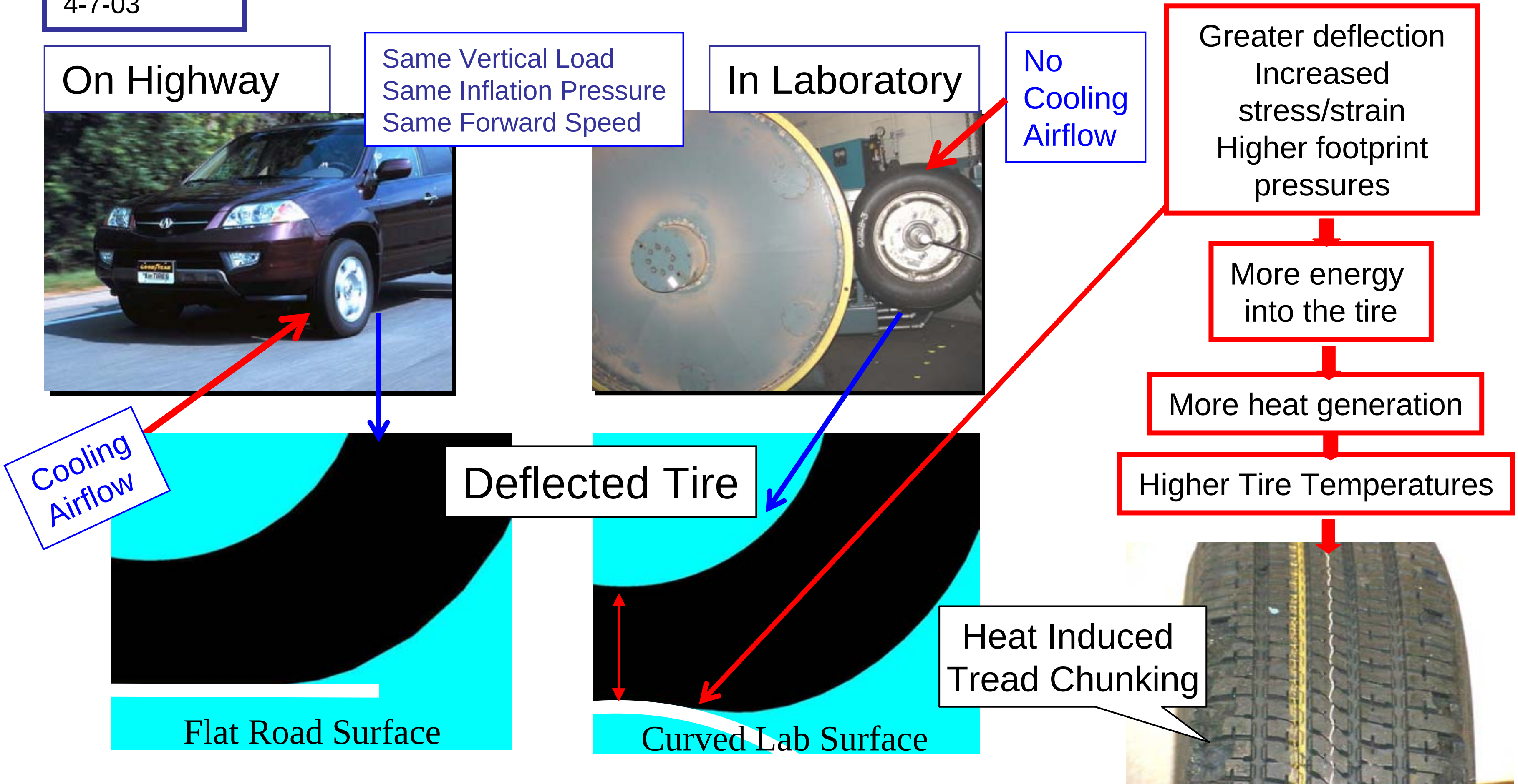
Tyre Endurance/Low Pressure Test

- Test versions implemented by US DOT in 1960s (FMVSS 109) for use on passenger car tyres. Updated in June 2003 (FMVSS 139) to more closely represent real world worst-case conditions on flat highway surface.
- Use of 1.7 metre roadwheel, with significant under inflation and at 120 kmh, may result in significantly different tyre behaviors than observed on highway or flat surface.
  - Smaller Contact Area
  - Higher Deflection
  - Higher Cyclic Stress-strain Amplitudes
  - No Cooling Airflow
  - Significantly higher internal tyre temperatures
  - Parasitic loses and removal conditions such as tread chunking which is not prevalent in the field.
- Need to establish scientifically based severity adjustment for evaluating vehicle tires on a 1.7-m roadwheel to more accurately reflect actual customer usage conditions.

Figure #1

RMA OMB
Presentation
4-7-03

Tire operating temperatures are significantly higher in the laboratory due to a more severe loading surface and no cooling airflow.



- Laboratory Roadwheel produces higher test severity vs. highway
- Higher test severity can produce removal conditions that are not representative of field.

Creating Equivalent Test Severity for Light Vehicle Tyres

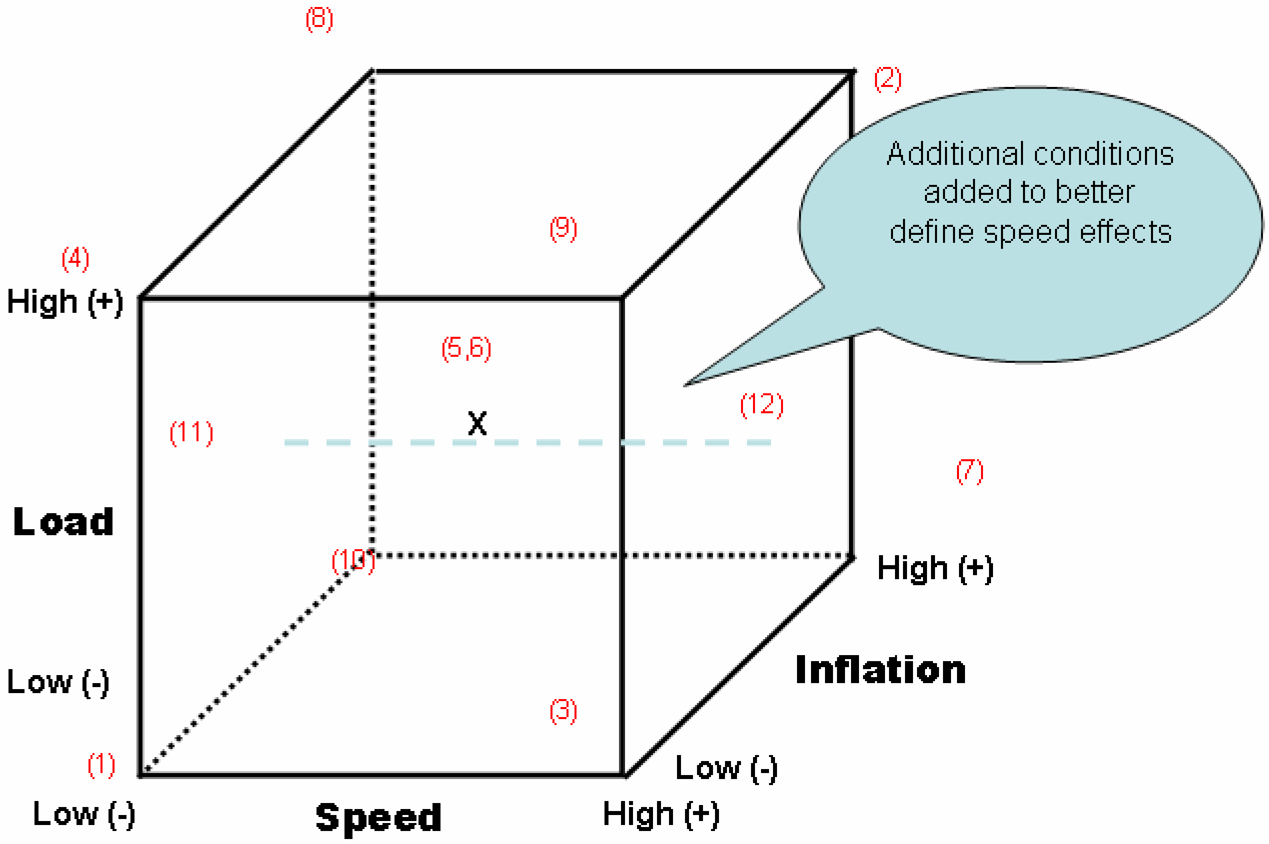
- ASTM to establish a scientifically based severity adjustment for evaluating light vehicle tires on a 1.7 meter roadwheel

- Objective is to develop a standard which provides equivalent test severity on a curved surface vs. flat (real-world) surface.

Data Acquisition Approach

- Design of Experiment (DOE) on both outdoor real-world flat surface and Indoor 1.7 meter roadwheel
- DOE consisted of varying the following three parameters
  - Load: 85 to 115% of T&RA SW Maximum
  - Inflation Pressure: 50 to 100% of T&RA Max.
  - Speed: 80 to 136 kph (50 to 85 mph)
- Surface curvature, ambient and surface temperatures could also have effect

Figure #2

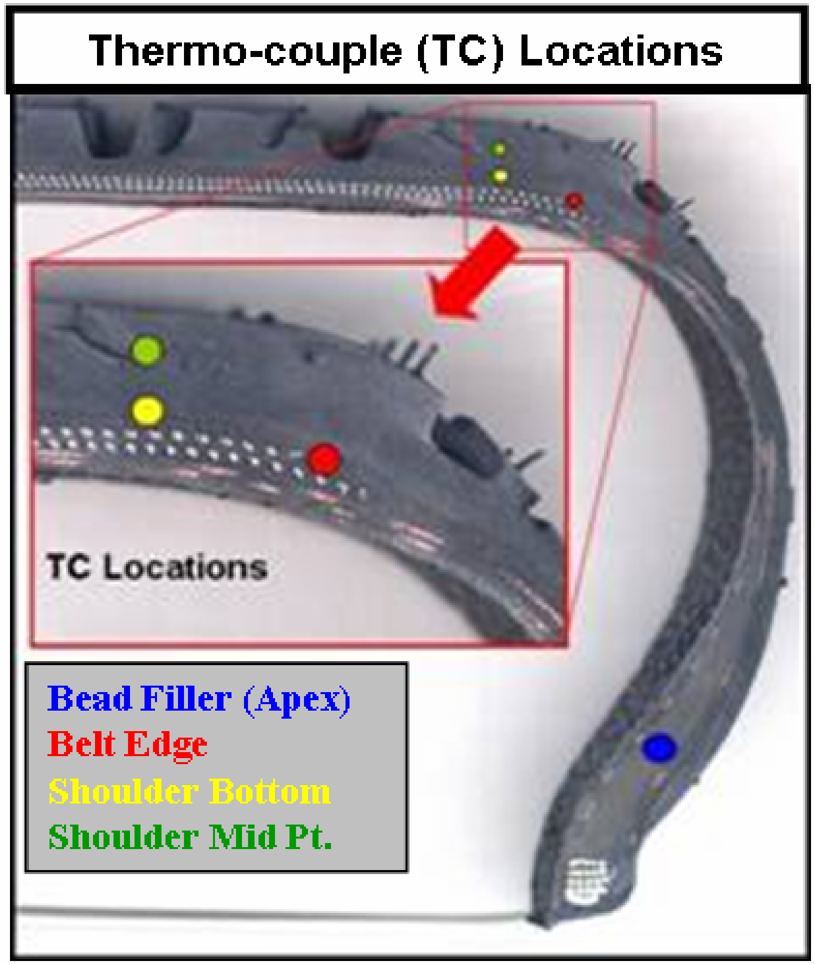

(8)
(2)
Additional conditions added to better define speed effects
(9)
(4)
High (+)
(5,6)
(11)
X
(12)
(7)
Load
(10)
High (+)
Inflation
Low (-)
(3)
(1)
Low (-)
Low (-)
Speed
High (+)

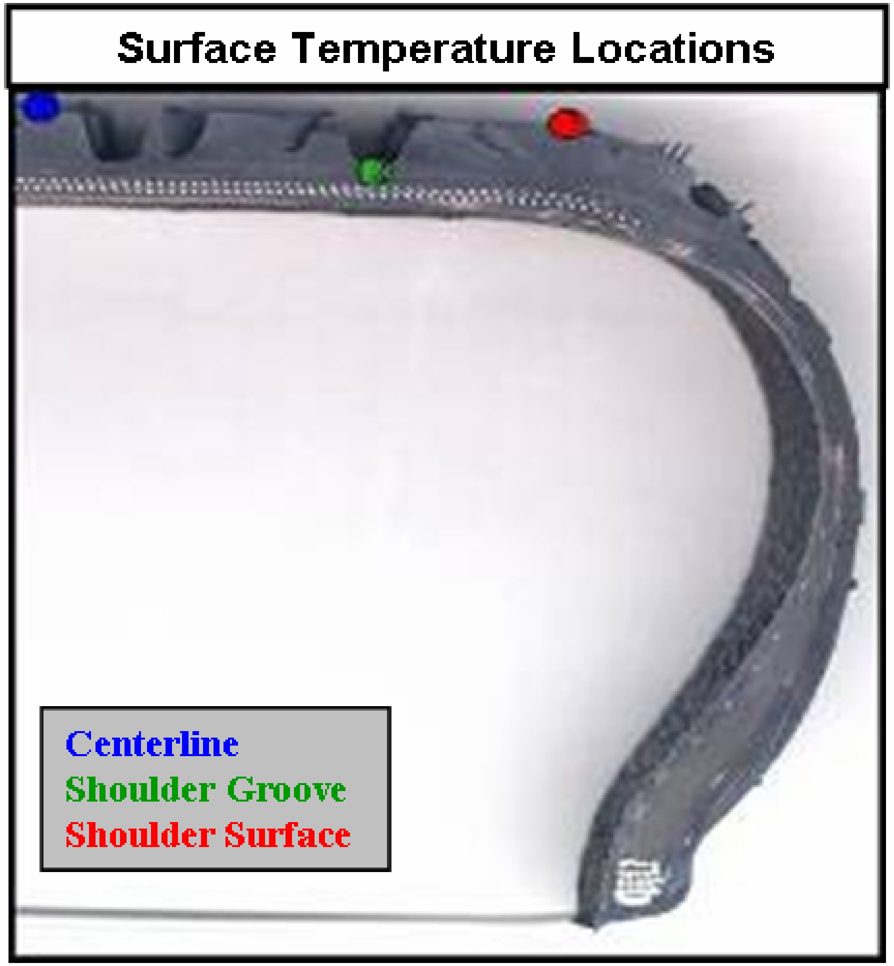
Temperatures Recorded

- Tire internal temperatures were recorded by embedding thermo-couples at the belt edges
  - Center of tread shoulder at top of outermost belt
  - Center of tread shoulder half way between outermost belt and tread surface, and
  - Center of the bead filler at top of rim flange

Temperatures Recorded

Figure #3





Most Influential terms for Belt Edge Temperature Regression Model

1. Curved (1.7 m or 67 in. Roadwheel) or Flat Surface
2. Test Load
3. Tyre Load Capacity
4. Inflation percent
5. Speed
6. Tread Depth
7. Ambient Temperature

Conclusions

A. All recorded tyre temperatures were higher on indoor roadwheel compared to same el of flat outdoor surface

B. Belt edge temperatures were highest of any measured location for all conditions both on indoor roadwheel and flat outdoor highway surface

Conclusions (continued)

C. Equivalent flat highway stress-strain amplitude and therefore test severity can be achieved on the indoor 1.7 meter roadwheel by matching belt edge temperatures.

D. Equivalent flat surface belt edge temperatures can be achieved on the 1.7 meter roadwheel by reducing load or speed or increasing inflation pressure.

Next Steps for ASTM

- To provide best technically valid model possible, range will be expanded to include commercially available passenger and light truck tyre sizes
- Target testing on 1.7m roadwheel and indoor flat surface belt machine (flat-trac) for better ambient temperature control
- Repeat testing of some tyres for validation purposes
- Complete proposal for ASTM standard by end of June 2007

GTR
Tyre Endurance/Low Pressure Test

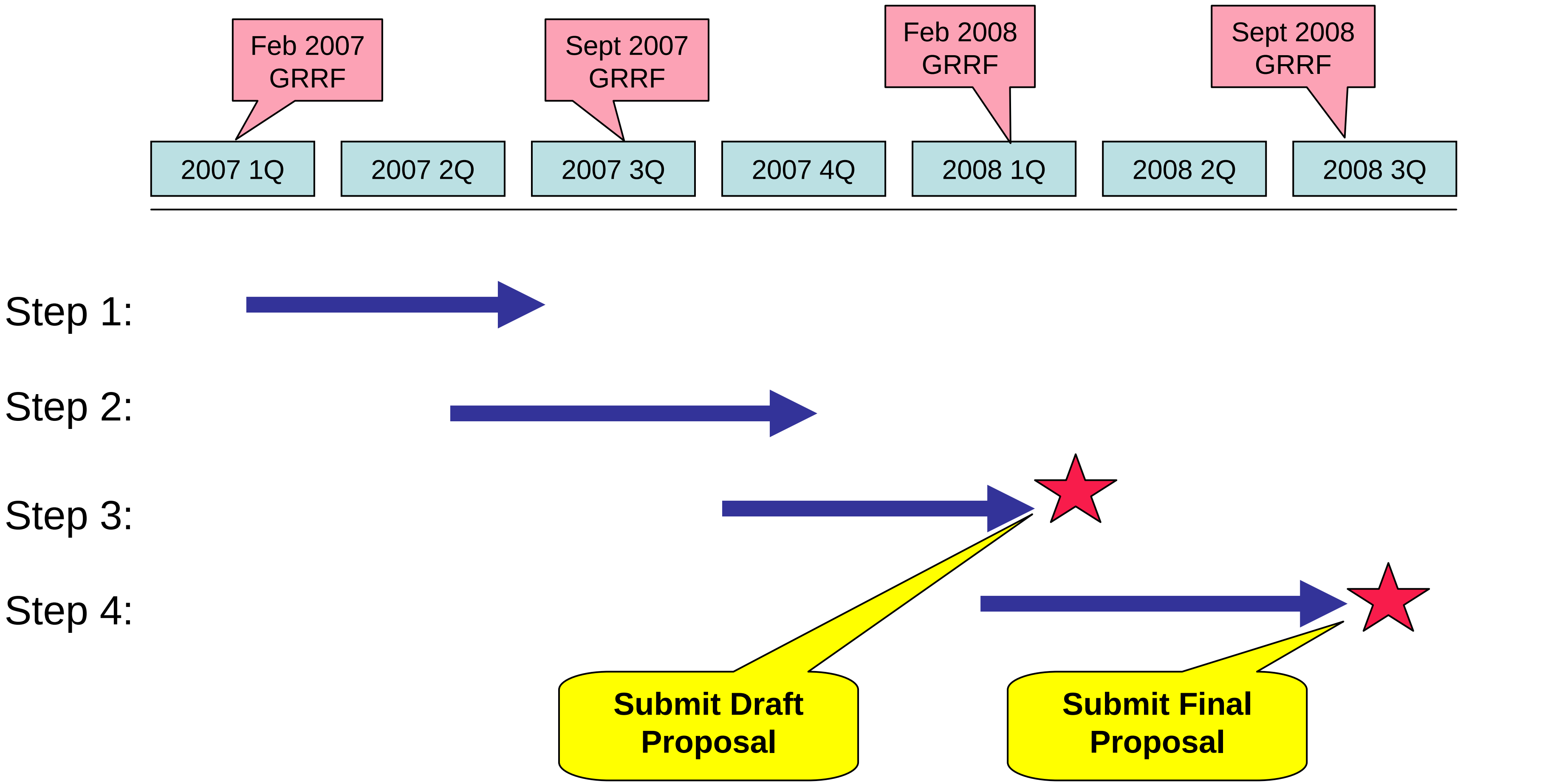
1st Step: Approach:
- Review current test requirements
  - Regulations of 1998 Agreement Contracting Parties
  - Regulations from other countries
- Study value of creating equivalent test severity for vehicle tyres
  - Review all available data, including work by ASTM to develop a technical standard for tires that provides equivalent test severity on a curved surface vs. a flat (real-world) surface.

2nd Step: Study Draft Proposal
- Validate equivalency factors that can be used in roadwheel testing

3rd Step: Finalize Draft Proposal

4th Step: Submit Final Proposal

Road Map for
Tyre Endurance/Low Pressure Test



Plunger Energy (Tyre Strength)

- Test implemented by US DOT in 1960s for bias ply tyres
- US DOT procedure remains model for most world-wide test procedures
- GTS 2000 (from 1997-2000) most parties agreed that this test should not be required for radial ply tyres
  - Should remain requirement for bias ply and bias belted tyres only, and
  - a "bottom-out" condition should be considered a pass
- May be able to discern value of test by comparing regions where test is and is not required
- Difficult to show value-added when all tyres must comply
- Do Contracting Parties have any experience with casing penetrations for radial ply tyres through tread area?

Plunger Energy (Tyre Strength)

1st Step: Approach:

- Review current test requirements
  - Regulations of 1998 Agreement Contracting Parties
  - Regulations from other countries
  - GTS 2000 requirements
- Study value of test for bias and radial
  - Solicit experience from CP regarding casing penetrations for radial ply tyres
  - Consider options for industry proposal based on needs and application of test to modern radial tyres

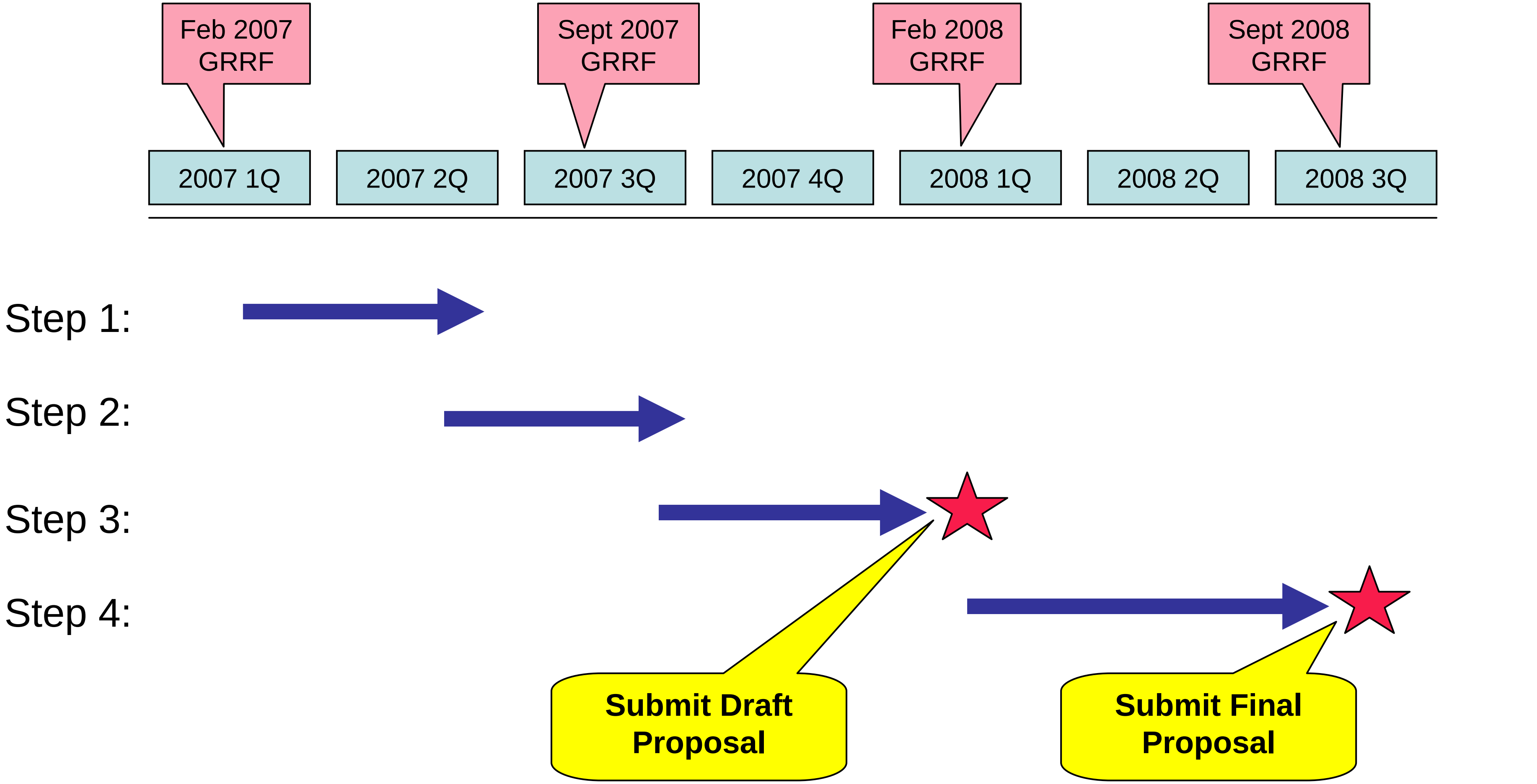
2nd Step: Study Draft Proposal

- Review all available input and construct draft application based on best available information

3rd Step: Finalize Draft Proposal

4th Step: Submit Final Proposal

Road Map for Plunger Energy (Tyre Strength)



Bead Unseating Resistance Test

- Test implemented by US DOT in 1960s for bias ply, high aspect ratio passenger car tyres only
- Scope later modified to include radial ply passenger car tyres, with no change in performance requirements
- US DOT procedure remains model for most world-wide test procedures
  - increasingly inadequate for low aspect ratio tyres (small section height)
- Transfer of forces from tread region to sidewall (normal tyre operations) is radically different between bias ply tyres and radial ply tyres
- As a static laboratory test applying a force through the sidewall to the bead, it can indeed unseat a bead, but is not representative of a real-world occurrence
- We are not aware of any credible industry state-of-the-art lab bead unseat test
- GTS 2000 (from 1997-2000) most parties agreed that this test should not be required for radial ply tyres
  - Could remain requirement for bias ply tyres only
  - May be able to discern value of test by comparing regions where test is and is not required

Bead Unseating Fixture

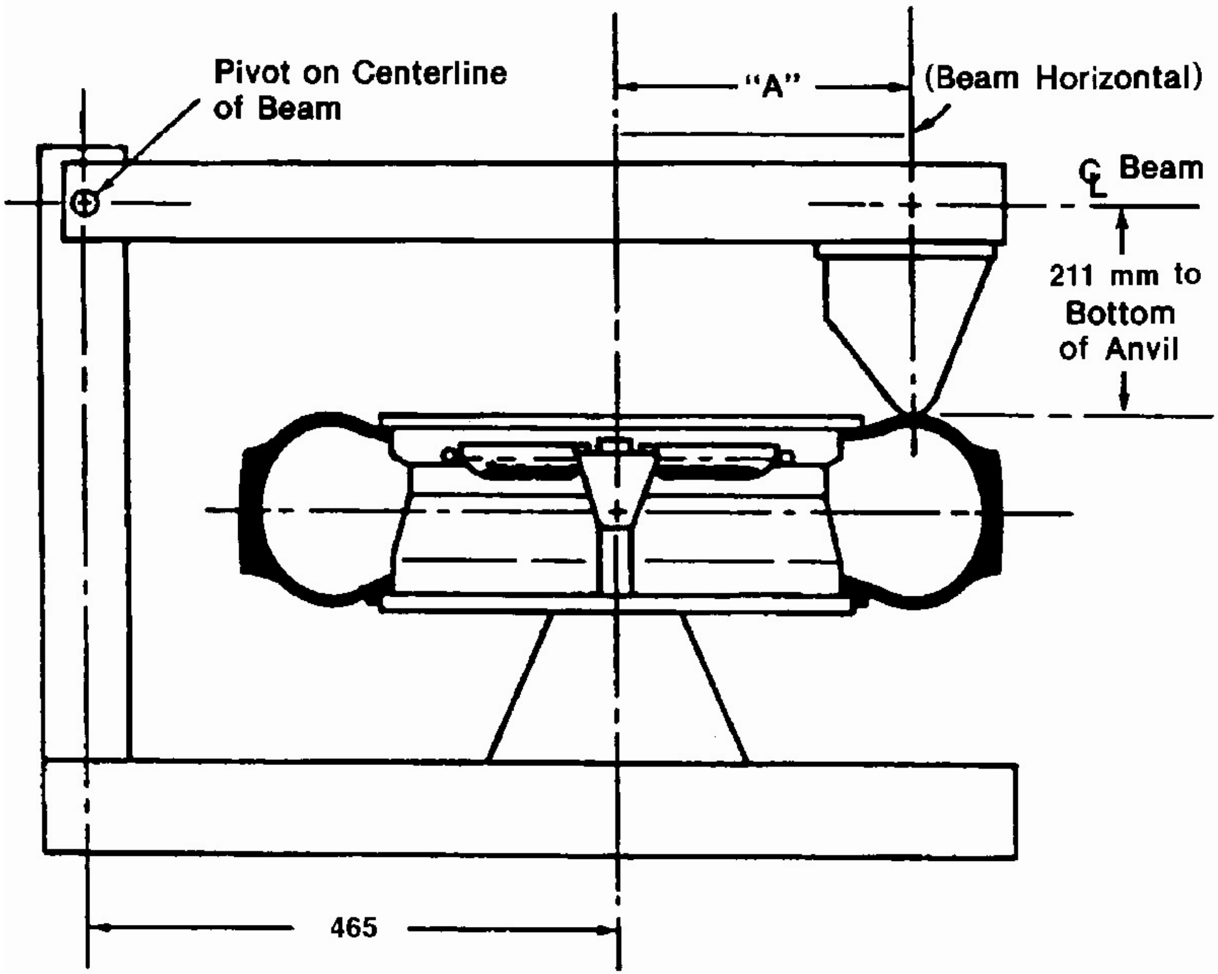


Figure 1.—Bead Unseating Fixture
All Dimensions in Millimeters (mm)

Bead Unseating Resistance Test

1st Step: Approach:

- Review current test requirements
  - Regulations of 1998 Agreement Contracting Parties
  - Regulations from other countries
  - GTS 2000 requirements
- Study value of test for bias and radial
  - Solicit experience from CPs and other stake holders regarding bead unseating for radial ply tyres
  - Consider options for industry proposal based on needs and application of test to modern radial tyres, including low aspect ratio tires

2nd Step: Study Draft Proposal

- Review all available data, including transfer of forces, simulation of actual field conditions and construct draft proposal

3rd Step: Finalize Draft Proposal

4th Step: Submit Final Proposal

Road Map for Bead Unseating Resistance Test