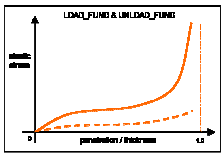
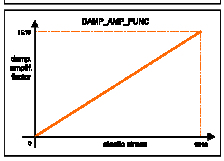
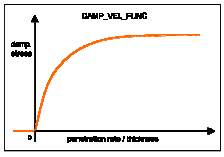
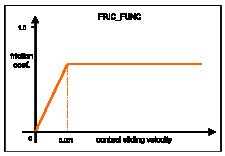
FACET MODELLING CHECKLIST - MADYMO V7.2

	Additional Information
CONTROL_ANALYSIS.TIME • Integration method: EULER • Time step: ≤1.10^{-5} for facet dummy models (FE models like airbags may require smaller time steps) • Avoid sub-cycling between MB & FE models, if needed USE_FE_TIME_STEP=ON, contact interaction between FE models and/or GF can reduce FE time step	

FACET SURFACE DEFINITION
• A facet surface is a fully supported PART under FE_MODEL referring to PROPERTY.MEM|MEM3|MEM4 and MATERIAL.NULL. Facet surface compliance is represented by allowing finite penetrations of nodes contacting the surface (NOT by deformation of the surface).
• Let element thickness represent physical thickness of compliant surface :
  ○ uniform surface thickness ➔ use THICK under PROPERTY.MEM|MEM3|MEM4.
  ○ non-uniform surface thickness ➔ use THICK under ELEMENT.TRIAD3|QUAD4 (this overrules thickness definition under PROPERTY.MEM|MEM3|MEM4)
• Use MATERIAL.NULL with DENSITY_NULL=0.0 (physical mass lumped in supporting rigid bodies):
  ○ surfaces considered rigid in contact ➔ define CONTACT_E and CONTACT_NU (used in penalty- or adaptive-based contacts with FE models like airbags)
  ○ surfaces considered compliant in contact ➔ refer to characteristic with CONTACT_CHAR (used in characteristic-based contact with other facet surfaces or FE models)
• All nodes must be supported in all (translational) DOFs. Facet surfaces can only show deformation when supported to either deformable bodies or multiple rigid bodies.
	Reference manual - appendix I - section 2.1 and 2.2

MESHING GUIDELINES
• Both ELEMENT.TRIAD3 and ELEMENT.QUAD4 can be used to mesh facet surfaces.
• MADYMO facet dummy models have an average element size of 10-15 mm. Recommended element size vehicle components interacting with dummy models ➔ 10-15 mm.
• Existing FE models (in MADYMO or other codes) are good basis for facet surface models:
  ○ smaller elements ➔ no real problems, though CPU costs will increase.
  ○ larger elements ➔ model responses may be less accurate.
• Meshing tips to avoid contact problems with facet surfaces :
  ○ close openings in surface where possible
  ○ avoid (unrealistically) sharp edges in the mesh
  ○ make sure mesh connectivity is correct (remove duplicate nodes)
  ○ make sure all element normals point outwards (towards other contacting structure)
• Predefined facet dummy contact groups are all closed volumes with element normals pointing outwards.
	Reference manual - appendix I - sections 1.2 & 1.3

SURFACE COMPLIANCE DEFINITION (CHARACTERISTIC.CONTACT)
• Use CONTACT_MODEL=STRESS :
  ○ sensitive to contact area and (varying) thickness of the facet surface.
  ○ LOAD_FUNC and UNLOAD_FUNC are defined in engineering stress vs. engineering strain (strain = penetration / element thickness).
• Define element (or part) thickness equal to thickness of physical compliant layer:
  ○ Range of X-axis in LOAD_FUNC and UNLOAD_FUNC ➔ 0.0 to 1.0.
  ○ X = 1.0 equals 100% compaction of compliant layer.
• Damping is defined as a physical representation of rate dependency in surface material compliance. Use DAMP_AMP_FUNC in combination with either a DAMP_COEF or a DAMP_VEL_FUNC. It is advised to always include some damping in the characteristic to damp out noisy vibrations in contact forces.
• Rate dependency can also be modelled using the RATE.* elements under MATERIAL.NULL
• Contact characteristics can best be derived from either material test data or FE material models
• Some facet contact modelling issues to keep in mind :
  ○ additional contact stiffness due to “pocketing” effects is not represented. (pocketing occurs when a stiff and edged structure is pushed in softer surface)
  ○ contact area calculation becomes less accurate as area gets smaller w.r.t. to slave element size.
• Defining CONTACT_CHAR under MATERIAL.NULL (instead of GROUP.FE) allows use of different contact characteristics in one GROUP.FE ➔ larger contact groups and less contact definitions.
	Reference manual - appendix I - sections 2.2 & 2.3
	 
	 
	 

	Additional Information
CONTACT DEFINITION (CONTACT.FE_FE + child elements)	
• CONTACT_METHOD.* options :	Reference manual - appendix I - sections 1.2 & 1.3
○ Use CONTACT_METHOD.NODE_TO_SURFACE|SURFACE_TO_SURFACE for non-compliant facet surfaces contacting FE surfaces (e.g. airbags).	
○ Use CONTACT_METHOD.NODE_TO_SURFACE_CHAR for contacts involving compliant facet surfaces. Use SMOOTH_MASTER_THICK=ON to help reduce high frequency vibrations in contact forces. If contact with edges of master surface is inevitable, RELEDG=ON and FACE_TYPE=FRONT may be used as workaround solutions. Do not use GAP_TYPE.*.	
• CONTACT_FORCE.* options :	Reference manual - appendix I - sections 1.2 & 1.3 section 3.1
○ For contacts between non-compliant facet surfaces and FE surfaces (e.g. airbags) use CONTACT_FORCE.PENALTY|ADAPTIVE.	
○ Use CONTACT_FORCE.CHAR for contacts involving compliant facet surfaces:	
CONTACT_TYPE=MASTER|SLAVE ➔ referring to the (most) compliant surface.	
CONTACT_TYPE=COMBINED ➔ use only if both surface compliances are really relevant.	
- this option can cause significant increase of CPU costs	
- too deep nodal penetrations result in inaccurate solutions.	
○ Use FRIC_FUNC to refer to friction function (friction coefficient as function of relative velocity)	
- Avoid noise due to static friction ➔ always start function at (0,0)	
- Option to model direction- and penetration-dependent friction to model “belt pocketing” effects in dummy-belt contacts.	Application manual - section 2.7
• INITIAL_TYPE.* options :	Reference manual - appendix I - sections 1.2 & 1.3
○ Use INITIAL_TYPE.CHECK to identify undesired initial nodal penetrations (check reprint file).	
○ Use INITIAL_TYPE.MASTER to apply initial contact forces to desired initial nodal penetrations.	
○ Make sure that contact surface normals point towards each other when using INITIAL_TYPE.*	
• MASTER / SLAVE selection - general guidelines (in order of priority):	Theory manual - section 9.3
○ Surface edges in contact ➔ choose this surface as slave	Reference manual - appendix I - sections 1.2 & 1.3
○ Curved surfaces with large nodal penetrations ➔ choose most curved surface as slave	
○ Significant difference in element size ➔ choose finer meshed surface as slave	
• MASTER / SLAVE selection - dummy specific guidelines:	Model Manual - sections 3 of chapters
○ For some facet dummy models, guidelines concerning master and slave surface selection are given in the model manual. These guidelines may overrule the guidelines given above.	
• MASTER / SLAVE selection - guidelines for facet dummy - belt / airbag / seat contacts:	Reference manual - appendix I - sections 3.1 & 3.2
○ FE belts should always be chosen as slave surface	
○ Airbags are generally chosen as slave surface, but sometimes choosing master can help avoiding contact problems with sharp edges (e.g. dummy nose)	
○ Facet seat foam surfaces are generally chosen as master surface	
○ FE seat foam surfaces are generally chosen as slave surface	
CHECK YOUR OUTPUT	
• Request sufficient output to avoid having to run the model again if some data is missing.	
• Reprint file : Check in reprint file (*.rep) for initial penetrations in contacts (if undesired, try removing them, if desired make sure INITIAL_TYPE.MASTER is used). Check for extrapolation warnings in contact characteristics (bottoming out stiff enough?)	
• Kinematics : Study model kinematics (*.kn3) for missing contacts or non-realistic contact behaviour.	
• Contact forces : Check contact forces (*.cntfrc) to see if contacts are handled correctly, eg.:	
○ contact forces back to zero after contact has passed in kinematics?	
○ contact directions in line with expectations from kinematics / reality?	
• Energy : Define energy balance output per system and/or for the complete model. Check for drifts in total energy of the system or complete model (*.energy). Also check for spikes or discontinuities in energy output signals. These phenomena may point to local model instabilities.	
• Time history files Use EXTENDED_SAMPLING in relevant output to avoid aliasing effects.	