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## BFFICIENCY AND CAPABILITIES OF MULTI-BODY SIMULATIONS

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#### ABSTRACT

Simulation efficiency and capability go hand in hand. The more capability you have the lower the efficiency will be. Section 1 of this paper discusses efficiency and section 2 deals with capabilities. The lesson we have learned about generic simulation is: Don't rule out any capabilities at the beginning but keep each one on a switch so it can be bypassed when warranted by a specific application.

#### 1. **BFFICIENCY**

Efficiency means different things to different people. For the person running simulations interactively on a terminal quick turn around time is efficiency. For the person making 10,000 Monte-Carlo runs low cost is efficiency. For the person running real time simulations minimum CPU time is efficiency.

Three aspects of a simulation should be considered when dealing with efficiency; hardware, software and modeling.

<u>Hardware</u> A fast processor will reduce CPU time for a given simulation but this doesn't necessarily equate to improved efficiency. For example, the Monte-Carlo simulation may take 10 minutes on a super computer and 2 weeks on a PC but if time is free on the PC then that may be an efficient solution. We will not discuss hardware related issues except for two points. 1.) Fast hardware is of primary importance to the real time simulation because it means higher fidelity models can be incorporated 2.) Vector processors and parallel processors should use custom algorithms that take full advantage of the special machine architecture.

<u>Software</u> A fast algorithm will also reduce CPU time but again this doesn't necessarily equate to improved efficiency. For example, it is generally accepted that an ad-hoc simulation is much faster than a generic simulation. The cost of developing and testing the ad-hoc simulation may exceed the run time saving thereby reducing overall efficiency.

Recent work in the area of symbolic programming has shown that significant savings can be achieved by symbolicaly forming the equation of motion and numerically solving them. Other algorithms have been proposed that promise similar savings. There is one point that software developers should keep in mind. With generic simulations the user must have complete flexibility in retaining or deleting different parts of his model. This is because generic simulations are often used for model development and validation. In that environment an analyst will add or delete certain features to determine the effect on performance and whether or not the feature should be retained in the model.

More on this subject in section 2.

<u>Modeling</u> This is the domain of the simulation user and the area in which many improvements in efficiency can be made. For example, deleting a high order mode in a flexible body model has a compound effect. It reduces the model complexity and at the same time allows a bigger integration step size both of which reduce run time. Often times the reduced fidelity is justified by the savings in run time.

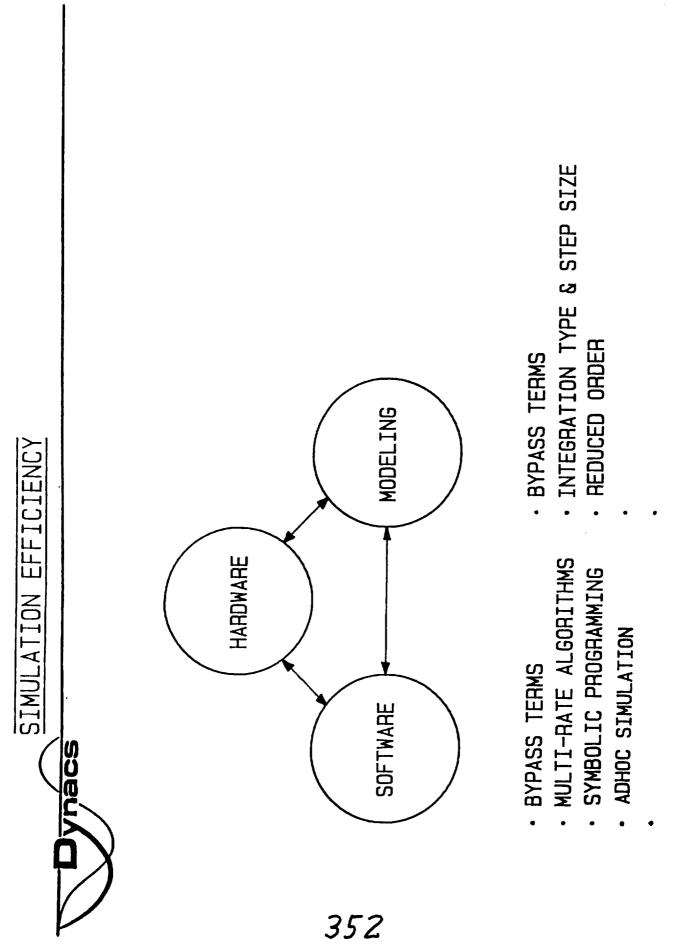
The point to be made is that the analyst is the end authority on the "correct" model for a given application. The more flexibility he has in changing his model the easier it is for him to select the best model for the job.

### 2. CAPABILITIES

Capability in our context is synonymous with flexibility and not with complexity. A simulation may be very detailed and complex but if it can't be changed then it's only useful in a narrow range of applications and has limited capability.

In our experience with TREETOPS and DCAP we have found that it is much easier to generate a model and obtain a response than it is to predict the correct response. In other words, when we don't get the expected response the simulation is usually correct and our expectation is wrong. This is not entirely unexpected because it is very difficult, even for an expert, to solve the equations of anything but the simplest dynamical systems. The solution to this dilemma is flexibility. Start with simple models that have known analytic solutions. Then add complexity one step at a time while gaining confidence in your model and insight into the behavior of your system. For multibody systems with flexible bodies the same arguments apply but the complexity of the model increases more rapidly than for rigid bodies. The person doing software development makes assumptions that simplify the resulting equations of motion. If this is done carelessly then terms are dropped that may prove essential in specific applications. On the other hand, if simplifications are not made then the computation burden becomes too great.

The lesson we learned is that you must retain as many terms as possible in the kinematics but they must have associated switches so you can easily add or delete them from a specific application. This is done for two reasons. 1.) to give you insight into the effect of various model elements on system response and 2.) to allow the selection of the most efficient model for a given application.



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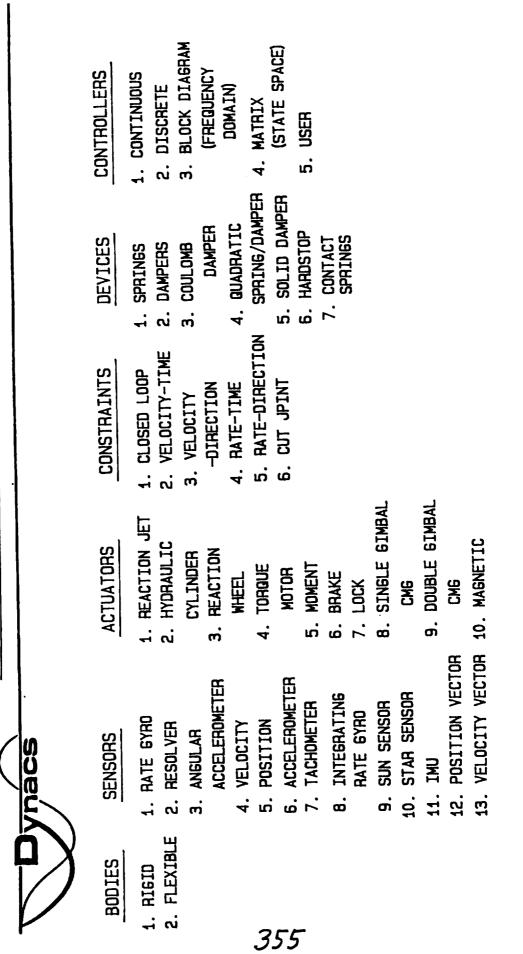
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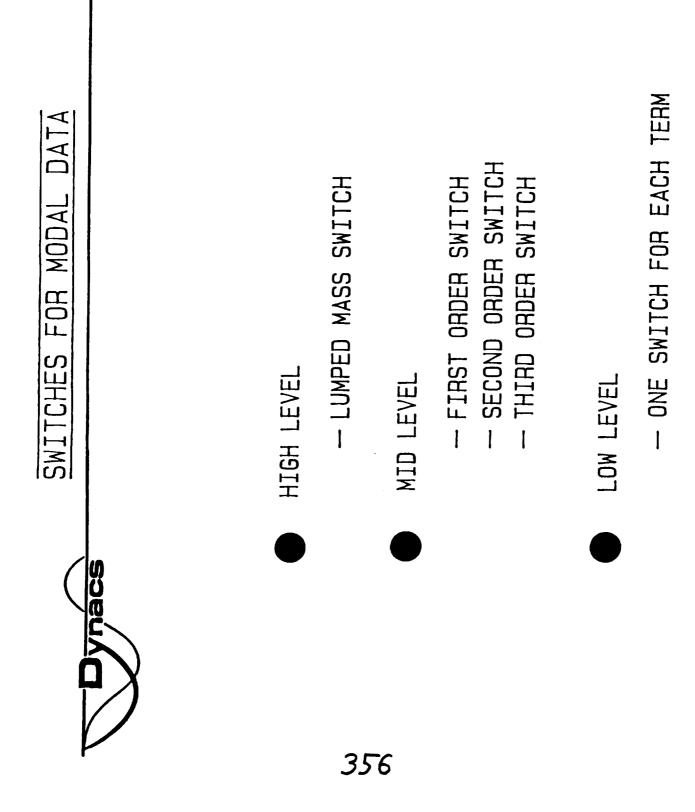
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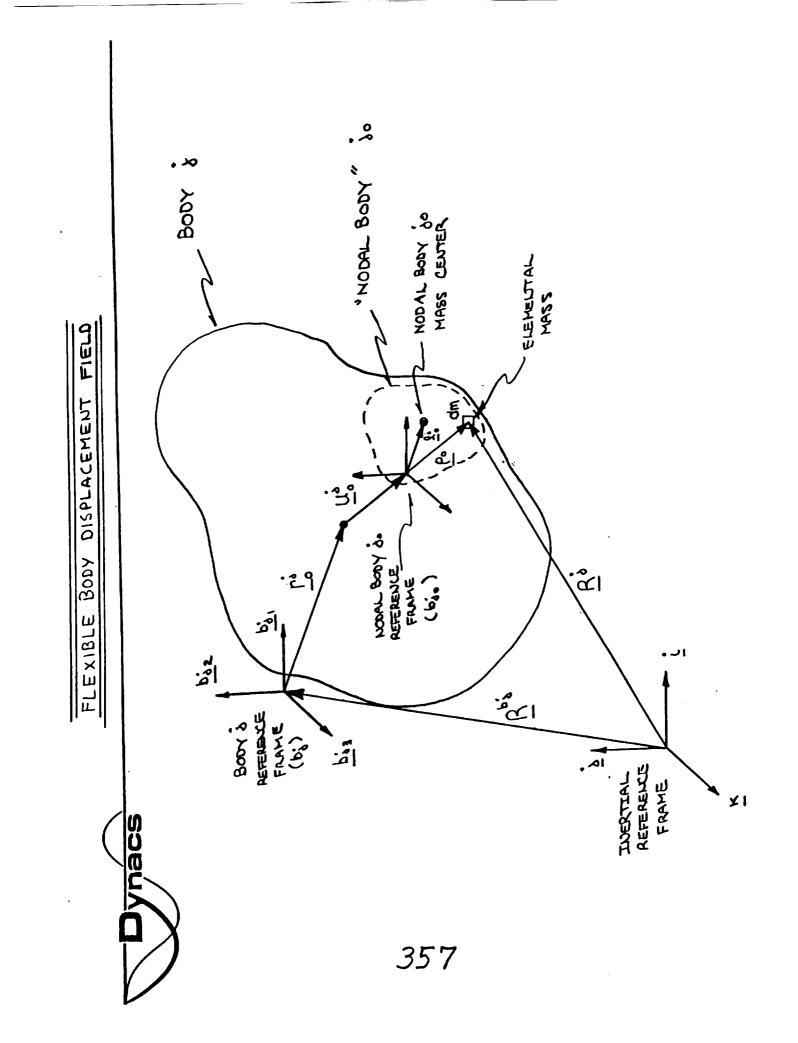
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SIMULATION CAPABILITY-MENUS







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Transiention mus of the g-m hune, fixed in L(g), BODY suborad of g-m BODY g-m BODY i-m Rommon mus (elleq mus) of the g-m hunce i-m Rommon mus (elleq mus) of the g-m hunce cong Locamue BODY is reference was BODY g met are corring underwred Hinke Attach Point on g met are corring underwred Hinke Attach Point on BODY g with are corring underwred Hinke Attach Point on g with are corring and g ( $\lim_{i=1}^{N} = \sum_{i=1}^{N} B_{i}^{2}(m_{i}) \eta_{i}^{2}$ ) for the point g on BODY g ( $\lim_{i=1}^{N} = \sum_{i=1}^{N} B_{i}^{2}(m_{i}) \eta_{i}^{2}$ ) and locating BODY is reference was BODY g ( $\lim_{i=1}^{N} = \sum_{i=1}^{N} B_{i}^{2}(m_{i}) \eta_{i}^{2}$ ) to BODY is are ucornice BODY is reference was BODY g ( $\lim_{i=1}^{N} = \sum_{i=1}^{N} B_{i}^{2}(m_{i}) \eta_{i}^{2}$ ) to BODY is are ucornice BODY is defenence was BODY g ( $\lim_{i=1}^{N} = \sum_{i=1}^{N} B_{i}^{2} (m_{i}) \eta_{i}^{2}$ ) to BODY is are ucor ( if is is g $\int_{i=2}^{N} M_{i}^{2} = D$ ) if of AII BODIES OUTBOARD OF THE g-th BODY INCLUDENG BY g
Translation has of the g-m HINE, FIRED IN L(g), BODY ENDORED OF g-m BODY g-m BODY g-m BODY c-m Rannon has deterred of the g-m HINGE core LOCATING BODY 3 REFERENCE HINGE COR LOCATING BODY 3 REFERENCE HING $g$ REFERENCE of LOCATING BODY 3 REFERENCE HAT BODY $g$ MERT REFERENCE of LOCATING BODY 3 REFERENCE HAT BODY $g$ HINCE ATTACH POUT ON a REFERENCE. COR LOCATING BODY 3 REFERENCE HAT BODY $g$ HINCE ATTACH POUT ON a FRAMMON AT $\Gamma_{ng}$ on BODY $g$ ( $\mu_{ng} = \sum_{i=1}^{n} \mathcal{D}_{i}^{i}(\Gamma_{ng}) \eta_{i}^{2}$ ) core LOCATING BODY 3 REFERENCE HAT BODY $g$ HINCE ATTACH POUT ON a FRAMMON AT $\Gamma_{ng}$ on BODY $g$ (LAND $g$ HINCE ATTACH POUT ON a REFERENCE. Core LOCATING BODY 3 REFERENCE HAT BODY $g$ HINCE ATTACH POUT ON a FRAMMON AT $\Gamma_{ng}$ on BODY $g$ (LAND $g$ HINCE ATTACH POUT ON a generation of the g-TH BODY ENCLUDENCE of Rom POULT PQD on BODY $g$ (LAND $g$ THE g-TH BODY ENCLUDENCE A $G$
Fransurrich Anis OF THE Q-TH HINCE, FIXED IN L(Q), BODY ENDORED OF G-TH BODY TH RETATION ANIS (ELERANIS) OF THE Q-TH HINCE TH RETATION ANIS (ELERANIS) OF THE Q-TH HINCE TR LOCATING BODY & REFERENCE UNT BODY & REFERENCE RE LOCATING BODY & REFERENCE UNT BODY & REFERENCE RECORTING BODY & REFERENCE UNT BODY & REFERENCE RECORTING BODY & REFERENCE UNT BOUT ON BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & HINCE ATTINGH POINT ON RECORTING BODY & REFERENCE UNT BODY & LUCULDING RECORTING BODY & THE G-TH BODY ENCLUDING REVEL. (IF & SIRG MODAD OF THE G-TH BODY ENCLUDING ( 3
AMBLATION MUE OF THE G-TH HINCE, FLYED IN LL(B), BODY ENDORED OF TH ROTATION MXIS (ELLER MIL) OF THE G-TH HINCE TH ROTATION AXIS (ELLER MIL) OF THE G-TH HINCE RECATION AXIS (ELLER MIL) OF THE G-TH POINT ON RECATION AT TYR ON BODY $g$ ( $\int_{10}^{10} g = \sum_{i=1}^{17} 2i_i (f_{10}) f_i^2$ ) RATION AT TYR ON BODY $g$ ( $\int_{10}^{10} g = \sum_{i=1}^{17} 2i_i (f_{10}) f_i^2$ ) RATION AT TYR ON BODY $g$ (LANDAT ON $g$ HINCE ATTOCH POINT ON g. RECATION BODY $\dot{a}$ REFERENCE URT BODY $g$ HINCE ATTOCH POINT ON $\dot{a}$ FROM POINT RQI ON BODY $g$ (LEANDAC TO BODY $\dot{a}$ ) TO BODY $\dot{a}$ CE AII GODIES OUTDOADO OF THE $g$ -TH BODY ENCLUDING $\dot{a}$ of POINT BODY $G$ THE $g$ -TH BODY ENCLUDING $\dot{a}$
Musicinov Avis of the g-m Hinke, Fixed IN L(g), Boby suborad of M ROTATION AXIS (ELERANIS) OF THE G-TH HINCE A ROTATION AXIS (ELERANIS) OF THE G-TH HINCE R LOCATION DAIS (ELERANIS) OF THE G-TH HINCE R LOCATION DAIS (ELERANIS) OF THE G-TH HINCE LOCATING BODY & REFERENCE UNT BODY & REFERENCE LOCATING BODY & REFERENCE UNT BODY & REFERENCE HAMON AT TAG ON BODY $g$ ( $\underbrace{JI}_{16} = \sum_{i=1}^{N/4} \mathcal{O}_i^4(n_g) n_i^g$ ) HAMON AT TAG ON BODY $g$ ( $\underbrace{JI}_{16} = \sum_{i=1}^{N/4} \mathcal{O}_i^4(n_g) n_i^g$ ) HAMON AT TAG ON BODY $g$ (LEALLY FOUNT ON $g$ HINCE ATTINCH POUT ON $\widehat{f}$ HAMON AT TAG ON BODY $g$ (LEALLY TO BODY $\widehat{g}$ HINCE ATTINCH POUT ON $\widehat{f}$ TRAN POULT P(g) ON BODY $g$ (LEALLY TO BODY $\widehat{g}$ ) TO BODY $\widehat{a}$ EVEL. (IF $\widehat{a}:=g$ ) ( $\widehat{a}:THE G-THE G-TH BODY INCLUDING \widehat{f}$
WE GRATION ANIS OF THE G-TH HINCE, FIXED IN L(R), GODY ZHBORRD OF REATION ANIS (ELLER ANIS) OF THE G-TH HINCE ROTATION ANIS (ELLER ANIS) OF THE G-TH HINCE LOCATING BODY & REFERENCE UNT BODY & REFERENCE LOCATING BODY & REFERENCE UNT BODY & REFERENCE REFERENCE. HATTON AT TYR ON BODY $g (J_{11}^{H_{T}} = \sum_{i=1}^{T_{T}} \mathcal{O}_{i}^{i}(f_{11}) f_{1}^{i}$ ) HATTON AT TYR ON BODY $g (J_{11}^{H_{T}} = \sum_{i=1}^{T_{T}} \mathcal{O}_{i}^{i}(f_{12}) f_{1}^{i}$ ) HATTON AT TYR ON BODY $g (LANDY R HINCE TO NOV g HINCE ATTINCH POINT ONFROM PRINT R(R) ON BODY g (LEANDE TO R R R FILL COMPLE (TF \delta = g, f_{12}^{e_{2}} = C)FROM PRINT R(R) ON BODY g (LEANDE TO DOY \delta) TO BODY \deltaFROM PRINT R(R) ON BODY g (LEANDE TO DOY \delta) TO BODY \deltaFROM PRINT R(R) ON BODY g (LEANDE TO DOY \delta) TO BODY \deltaFROM PRINT R(R) ON BODY g (LEANDE TO DOY \delta) TO BODY \deltaFROM PRINT R(R) ON BODY g (LEANDE TO DOY \delta) TO BODY \deltaFROM PRINT R(R) ON BODY g (LEANDE TO THE g-TH BODY ZULLUDINGFROM RECENTED THE g-TH BODY ZULLUDINGFROM RECENTED TO THE g-TH BODY ZULLUDING$
Is control and of the g-m mixe, fixed in L(g), body suborad of is good and of the g-m mixe, fixed in L(g), body suborad of Rotation and (ELER and) of the g-m mixe Locating body is deferrence unt body is reference Locating undergament mixe attract point on body is met Reference. Introl AT Typ on Body is ( $\underline{M}_{11}$ , $\underline{B}_{12}$ , $\underline{D}_{11}^{2}$ , $\underline{D}_{1$
BUTTON ANIS OF THE Q-TH HINCE, FIYED IN LIG), BODY INDORLD OF BUDY BODY BODY AGRATION ANIS (ELLER ANIS) OF THE Q-TH HINCE LOCATING BODY 3 REFERENCE UNT BODY 9 REFERENCE LOCATING BODY 3 REFERENCE UNT BOUT ON 9 REFERENCE LOCATING BODY 3 REFERENCE UNT BOUT ON 9 REFERENCE MIDON AT TAG ON BODY 9 ( $\underline{U}_{10} = \sum_{i=1}^{NM3} \underline{\mathcal{O}}_{i}^{i}(\underline{f}_{10})_{10}^{2}$ ) MIDON AT TAG ON BODY 9 ( $\underline{U}_{10} = \sum_{i=1}^{NM3} \underline{\mathcal{O}}_{i}^{i}(\underline{f}_{10})_{10}^{2}$ ) MIDON AT TAG ON BODY 9 (LABUT ON BODY 9 HINCE ATTACH POUT ON ATOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 3 TOM POULT PQ ON BODY 9 (LEADLICE TO BODY 3) TO BODY 4
Latticed have of the g-m hinke, fixed in Lig), Boby suborred of Boby Gramon axis (ELERANS) of the g-m Hinke Gramon axis (ELERANS) of the g-m Hinke Gramon Boby à Reference was boby g met Corning Undersonned Hinke Attach Point on Boby g met Reference. Thow AT Tyg on Boby g ( $\underline{U}_{10} = \sum_{i=1}^{n-1} \underline{\mathcal{O}}_{1i}^{i} (\underline{n}_{2i})_{ij}^{ij}$ ) Thow AT Tyg on Boby g ( $\underline{U}_{10} = \sum_{i=1}^{n-1} \underline{\mathcal{O}}_{1i}^{i} (\underline{n}_{2i})_{ij}^{ij}$ ) Thow AT Tyg on Boby g (Lensurg to Boby g Minke Attach Point on Reference. Those Points Reference was Boby g Minke Attach Point on Ach Points Reference was Boby g (Lensurg to Boby j) to Boby j fin Bobles Outborad OF THE g-TH BODY ENCLUDING All Bobles Outborad OF THE g-TH BODY ENCLUDING
STRON ANIS OF THE G-TH HIXE, FIXED IN L(g), BODY ENBORDD OF BODY BODY TATATON ANIS (ELLEQ PANS) OF THE G-TH HINCE TATATON ANIS (ELLEQ PANS) OF THE G-TH HINCE TATATON ANIS (ELLEQ PANS) OF THE G-TH HINCE COATING BODY & REFERENCE ATTEL UNDEFORMED HINKE ATTACH POILUT ON & REFERENCE ATTLE, UNDEFORMED HINKE ATTACH POILT ON & REFERENCE ATTLE, UNDEFORMED & REFERENCE WAS BODY & HINKE ATTACH POILT ON ATT POILT P(Q) ON BODY & LEASTER TO BODY & HINKE ATTACH POILT ON ATT & d = Q MODY & LEASTERCE WAS DOT THE Q-TH BODY ENCLUDENCE ATTLE & d = Q MODY & LEASTERCE OF THE Q-TH BODY ENCLUDENCE ATTLE & DIDORED OF THE Q-TH BODY ENCLUDENCE
They must be the g-m Hince, Fixed in L(g), Boby Indoned of Boby The most and Generations of the g-m Hince termon and (Elled Ands) of the g-m Hince cannod Boby 3 Reference and Boby 9 Reference with Undernated Hince Attach Point on Boby 9 Met Filler Undernated Hince Attach Point on Boby 9 Met Frince Undernated Hince Attach Point on Boby 9 Mine Attach Point on Mine Boby 3 Reference wer Boby 9 Mine Attach Point on Attach Boby 9 (Lang = $\sum_{i=1}^{M} 2i(\underline{ing}_i) n_{ij}^{0}$ ) Annua Boby 3 Reference wer Boby 9 Mine Attach Point on Attach Boby 9 (Leasther To Boby 3) To Boby 5 (Ter 3=9, $n_{22}^{0}$ , i = 0) All Bobles Outbordd OF THE 9-TH BODY INCLUDING
NON AXIS OF THE G-TH HINCE, FIRED IN L(g), BODY INBORDD OF ODY ATTON AXIS (ELLEQ ANIS) OF THE G-TH HINCE ATTON AXIS (ELLEQ ANIS) OF THE G-TH POINT ON ATTON AXIS (ELLEQ ANIS) $\left( \underbrace{\bigcup_{i=1}^{N}}_{i=1}^{N} \underbrace{O_i^{(i)}}_{i=1}^{(i)} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{Q_i} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{(i)} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{Q_i} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{Q_i} \Big _{i=1}^{Q_i} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{Q_i} \Big _{i=1}^{Q_i} \Big _{i=1}^{Q_i} \underbrace{O_i^{(i)}}_{i=1}^{Q_i} \Big _{i=1}^{Q_i} $
CU MAIS OF THE G-TH HIVE, FIXED IN L(g), BODY INDORED OF DUT THON ANIS (ELLEQ ANIS) OF THE G-TH HINCE ATHOR BODY & REFERENCE WAT BODY & REFERENCE ATHOR BODY & REFERENCE WAT BOWY & REFERENCE THE UNDERDATED HINCE ATTACH POINT ON BODY & REFERENCE THE UNDERDATED HINCE ATTACH POINT ON BODY & REFERENCE AT TAG ON BODY $g$ (LAN = $\sum_{i=1}^{NH} O_i^2(C_{MB}) n_i^g$ ) A AT TAG ON BODY $g$ (LAN = $\sum_{i=1}^{NH} O_i^2(C_{MB}) n_i^g$ ) THOM BODY & REFERENCE WAT BODY $g$ HIVEE ATTACH POINT ON ING BODY & REFERENCE WAT BODY $g$ HIVEE ATTACH POINT ON (IF $\delta_i = g_j T_{SD}^{SD} = O$ ) I BODIES OUTBOARD OF THE $g$ -TH BODY INCLUDING (IF $\delta_i = g_j T_{SD}^{SD} = O$ )
Now or the g-m hince, fixed in L(g), Goby Eubored of the mode and a fetelette unt go-m hince muc boby 3 reference unt boby 9 reference which bours a fetelette unt boby 9 reference the undependent hince Attrach Point on boby 9 met reference. I AT The on Boby 9 ( $I_{Heg} = \sum_{i=1}^{NA2} \mathcal{O}_i^i (f_{Heg}) \eta_i^g$ ) I AT The on Boby 9 ( $I_{Heg} = \sum_{i=1}^{NA2} \mathcal{O}_i^i (f_{Heg}) \eta_i^g$ ) I AT The on Boby 9 (Lensure to Boby 9 Hince Attrach Point on the Boby 3 Reference was Boby 9 Hince Attrach Point on the Boby 3 reference was Boby 9 Hince Attrach Point on (I S 3= g $\eta_{123}^{i_2} s_{i_1} = 0$ ) I Bobies outbordd OF THE 9-TH BODY INCLUDING (I Bobies Outbordd OF THE 9-TH BODY INCLUDING
W MUS OF THE G-TH HILLE, FIRED IN L(G), BODY INBORDD OF W MUS OF THE G-TH HILLE, FIRED IN L(G), BODY INBORDD OF MON MUS (ELERANIS) OF THE G-TH HILLE MON MUS (ELERANIS) OF THE G-TH HILLE THE BODY 3 REFERENCE WAS BODY 9 REFERENCE THE BODY 3 REFERENCE WAS BODY 9 WILL FITTICH POUT ON MIT Fig ON BODY 9 ( $\underline{U}_{Hg} = \sum_{i=1}^{L_{Hg}} \underline{O}_{i}(\underline{U}_{Hg}) \eta_{i}^{2}$ ) MIT Fig ON BODY 9 (LEASENCE TO BODY 3) TO BODY 3 MULT FIG ON BODY 9 (LEASENCE TO BODY 3) TO BODY 3 (IF 3=9, $\eta_{122}^{-1} = 0$ ) BOLDES OUTBOARD OF THE G-TH BODY INCLUDING BODES OUTBOARD OF THE G-TH BODY INCLUDING
VANS OF THE G-TH HINCE, FIRED IN L(g), BODY INBORDD OF VANS OF THE G-TH HINCE, FIRED IN L(g), BODY INBORDD OF ON AXIS (ELLEQ ANIS) OF THE G-TH HINCE ING BODY 3 REFERENCE UNIT BODY 9 REFERENCE C. UNDEFRANED HINCE ATTACH POINT ON BODY 9 WET ELLE. AT $\Gamma_{10}$ ON BODY 9 ( $\underline{U}_{10}$ = $\sum_{i=1}^{2} \mathcal{O}_{i}(\underline{U}_{10}) \eta_{i}^{2}$ ) AT $\Gamma_{10}$ ON BODY 9 (LEADLICE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON THE BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON G. BODY 3 REFERENCE UNIT BODY 9 HINCE ATTACH POINT ON
Anis OF THE G-TH HUNC, FIXED IN L(g), BODY INDORED OF NAIS (ELLEQANS) OF THE G-TH HINCE DG BODY À REFERENCE UNT BODY & REFERENCE DG BODY À REFERENCE UNT BODY & REFERENCE - UNDEFORMED HINCE ATTACH POINT ON BODY & WET ELLE. AT L'A ON BODY A ( $\underline{U}_{Hg} = \sum_{i=1}^{NA} \mathcal{O}_i^i (\underline{U}_{hg})_{ij}^{\beta}$ ) AT L'A ON BODY A ( $\underline{U}_{Hg} = \sum_{i=1}^{NA} \mathcal{O}_i^i (\underline{U}_{hg})_{ij}^{\beta}$ ) AT L'A ON BODY A (EANLER TO A DONY A HUNCE ATTACH POINT ON A BODY À REFERENCE UNT BODY A HUNCE ATTACH POINT ON THE 'S = Q ( $\underline{U}_{hg} = \frac{1}{2}$ ) TO BODY À BODUES OUTDOARD OF THE Q-TH BODY INCLUDING GODUES OUTDOARD OF THE Q-TH BODY INCLUDING
ANS OF THE G-TH HINCE, FIXED IN L(g), BODY INDORRD OF N ANIS (ELLEQANIS) OF THE G-TH HINCE DG BODY & REFERENCE UNT BODY & REFERENCE DG BODY & REFERENCE UNT BODY & REFERENCE DG BODY & REFERENCE UNT BOUT ON $g$ WET THE THE ON BODY $g$ ( $\underline{U}_{Hg} = \sum_{i=1}^{MA} \mathcal{O}_i^i (\underline{U}_{gg}) \eta_i^g$ ) $\stackrel{\text{P}}{=} \sum_{i=1}^{MA} \mathcal{O}_i^i (\underline{U}_{gg}) \eta_i^g$ ) TO BODY $i$ DOUV & REFERENCE UNT BODY $g$ HINCE ATTACH POINT ON $\stackrel{\text{P}}{=} BODY & REFERENCE UNT BODY g HINCE ATTACH POINT ON\stackrel{\text{P}}{=} DODY & REFERENCE UNT BODY g HINCE ATTACH POINT ON\stackrel{\text{P}}{=} T \stackrel{\text{P}}{=} g, \stackrel{\text{P}}{=} g$
ANS OF THE G-TH HINCE, FIYED IN L(R), BODY ENDORRD OF A ANIS (ELLEGANS) OF THE G-TH HINCE G BODY À REFERENCE URT BODY & REFERENCE UNDEFORMED HINCE ANTACH POINT ON BODY & MET UNDEFORMED HINCE ANTACH POINT ON BODY & MET T Type ON BODY & ( $\underline{MM}_{10} = \sum_{i=1}^{NM} \underline{C}_{i}^{i} (\underline{M}_{10}) \eta_{i}^{i}$ ) BODY À REFERENCE URT BODY & HINCE ATTACH POINT ON BODY À REFERENCE URT BODY & HINCE ATTACH POINT ON GUIT PQI ON BODY & (LEANLICE TO BODY Å) TO BODY Å FF $\dot{a} = g_{i}^{i} g_{2}^{i} = \underline{O}$ ) BODY OF THE G-THE G-TH BODY ZUCLUDING GODIES ONTOORD OF THE G-TH BODY ZUCLUDING
We of the g-TH HUNC, FIXED IN L(g), BODY INDORUD OF ANIS (ELEGANS) OF THE G-TH HINCE ANIS (ELEGANS) OF THE G-TH HINCE BODY 2 REFERENCE URT BODY & REFERENCE UNDEFORMED HINCE ATTACH POINT ON BODY 9 WET T Ly ON BODY 9 ( $\underline{U}_{Ng} = \prod_{i=1}^{NAg} \mathcal{O}_i^2(\underline{U}_{ng})\eta_i^g$ ) T Ly ON BODY 9 ( $\underline{U}_{Ng} = \prod_{i=1}^{NAg} \mathcal{O}_i^2(\underline{U}_{ng})\eta_i^g$ ) BODY 3 REFERENCE URT BODY 9 HINCE ATTACH POINT ON HINT R(g) ON BODY 9 (LEANLIG TO BODY 3) TO BODY 3 T dig 0, BODY 9 (LEANLIG TO BODY 3) TO BODY 3 T dig 0, BODY 9 (LEANLIG TO BODY 3) TO BODY 3 T dig 0, BODY 9 (LEANLIG TO BODY 3) TO BODY 3 T dig 0, BODY 9 (LEANLIG TO BODY 3) TO BODY 3 T dig 0, $\underline{G}_{1,2}^{*} = \underline{O}$ )
WE OF THE G-TH HINCE, FIXED IN L(g), BODY ENDORUD OF ANIS (ELLEGANE) OF THE G-TH HINCE BODY À REFERENCE URT BODY & REFERENCE BODY À REFERENCE URT BODY & REFERENCE DUREFORMED HINCE ATTACH POINT ON BODY & MINE ATTACH POINT ON $T_{12}^{12}$ ON BODY $G (I_{13}^{12} = \sum_{i=1}^{NM} \mathcal{O}_{i}^{1}(T_{13}^{12}) \eta_{i}^{2})$ BODY À REFERENCE URT BODY $g$ HINCE ATTACH POINT ON HINT FQ) ON BODY $g (LANELGTO DOPY Å) TO BODY ÅHINCE ATTACH TO THE g-TH BODY ENCLUDENDHOUT FQ) ON BODY g (LEANELGTO DOPY Å) TO BODY ÅHINCE OUTBOARD OF THE g-TH BODY ENCLUDEND$
IS OF THE G-TH HINCE, FIXED IN L(g), BODY ENDORED OF ANIS (ELLEQANS) OF THE G-TH HINCE BODY 2 REFERENCE URT BODY & REFERENCE BODY 2 REFERENCE URT BODY & REFERENCE DODEFORMED HINCE ATTACH POINT ON $g$ WET E. $\Gamma_{19}$ ON BODY $g$ ( $\underline{U}_{19}_{19} = \sum_{i=1}^{7} \mathcal{O}_{i}(\Gamma_{19}_{19}) \eta_{i}^{g}$ ) $\Gamma_{19} ON BODY g (EASLER DONY g HINCE ATTACH POINT ONDODY 2 REFERENCE URT BODY g HINCE ATTACH POINT ONUT R(g)$ ON BODY $g$ (LEASLER TO BODY 3) TO BODY 3 $\dot{a} = g$ , $\eta_{22}^{G} \dot{a} = \underline{O}$ ) DODES OUTDOARD OF THE $g$ -TH BODY ENCLUDING
S OF THE G-TH HINCE, FIYED IN L(R), BODY SUBORDD OF THE G-TH HINCE ANIS (ELERANS) OF THE G-TH HINCE BODY & REFERENCE URT BODY & REFERENCE BODY & REFERENCE URT BODY & REFERENCE HINCE ATTACH POINT ON BODY & WET CIPY ON BODY & ( $\underline{U}_{Hg} = \sum_{i=1}^{N+1} \mathcal{O}_i^{i}(\underline{U}_{ig}) \eta_i^{g}$ ) ODY & REFERENCE URT BODY & HINCE ATTACH POINT ON TRY ON BODY & (LEANLICE TO BODY & HINCE ATTACH POINT ON 3 R M ON BODY & (LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & (LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & LEANLICE TO BODY & 10 BODY & 3 R M ON BODY & REFERENCE URT BODY & NUCLUDING
I OF THE G-TH HIVE, FIXED IN L(g), GODY INDORED OF XIS (ELERANS) OF THE G-TH HINCE BODY & REFERENCE URT BODY & REFRENCE BODY & REFERENCE URT BODY & REFRENCE BODY & REFERENCE URT BOUT ON BODY & MITT MARCH DOUT ON BODY & MITTER POINT ON The ON BODY & LEADERCE URT BODY & MITTER POINT ON The ON BODY & LEADERCE URT BODY & MITTER POINT ON The ON BODY & LEADERCE URT BODY & MITTER POINT ON The ON BODY & LEADERCE URT BODY & MITTER POINT ON The ON BODY & LEADERCE TO BODY & MITTER POINT ON The ON BODY & LEADERCE TO BODY $\frac{1}{2}$ , THE DOTY in BODY & $\frac{1}{2}$ , $\frac{1}{2}$ , $$
OF THE G-TH HINCE, FIXED IN L(g), GODY INDORED OF VIS (ELLER ANIS) OF THE G-TH HINCE ADDY 3 REFERENCE UNT GODY & REFERENCE ADDY 3 REFERENCE UNT GODY 8 REFERENCE REFORMED HINCE ATTACH POINT ON BODY 9 HINCE ATTACH POINT ON $f_{10}^{10}$ ON BODY 9 ( $\int_{10}^{10} = \sum_{i=1}^{10} \mathcal{O}_{i}^{1}(f_{10}) \eta_{1}^{2}$ ) TO BODY 3 $f_{10}^{10}$ ON BODY 9 (LEADELLE TO BODY 3) TO BODY 3 $i = q_{1}^{10} \eta_{2}^{10} i = O$ ) $i = q_{1}^{10} \eta_{2}^{10} i = O$ )
OF THE G-TH HINCE, FIXED IN L(g), GODY INDORED OF IS (ELLER ANIS) OF THE G-TH HINCE GOV 3 REFERENCE UNT BODY & REFERENCE GOV 3 REFERENCE UNT BODY & REFERENCE FERRINED HINCE ATTACH POILUT ON $g$ WET FERRINED HINCE ATTACH POILUT ON $g$ WET FERRINED HINCE THE POILT ON $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 3 REFERENCE UNET BODY $g$ HINCE ATTACH POILT ON V 4 Ref ON BODY $g$ (LANDET TO BODY $i$ ) TO BODY $i$ i = g $i = 0$ )
OF THE G-TH HINCE, FIXED IN L(g), BODY INDORED OF IS (ELLER ANIS) OF THE G-TH HINCE BDY 3 REFERENCE UNT BODY 9 REFERENCE FRAMED HINCE ATTACH POINT ON 9 REFERENCE FRAMED HINCE ATTACH POINT ON 9 REFERENCE FOR NED HINCE ATTACH POINT ON 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 3 REFERENCE URT BODY 9 MINCE ATTACH POINT ON Y 4 RUE ON BODY 9 (LEANLICTO CON 3) TO BODY 1 EQ 1, 2020 1 DOT 7 ME 9-TH BODY INCLUDING
OF THE G-TH HINCE, FIXED IN L(g), BODY INBORD OF C ELLER ANS) OF THE G-TH HINCE C ELLER ANS) OF THE G-TH HINCE ON 2 REFERENCE URT BODY & REFERENCE FORMED HINCE ATTACH POINT ON $g$ REFERENCE FORMED HINCE ATTACH POINT ON $g$ WERE ATTACH POINT ON $g$ ON BODY $g$ ( $\underline{J}_{11g} = \sum_{i=1}^{n} \mathcal{O}_i^2 (\underline{f}_{11g}) \cdot \underline{f}_i^2$ ) $i = \sum_{i=1}^{n} \mathcal{O}_i^2 (\underline{f}_{11g}) \cdot \underline{f}_i^2$ ) TO BODY $i$ Fq ON BODY $g$ (LEADLE TO BODY $g$ HINCE ATTACH POINT ON Fq ON BODY $g$ (LEADLE TO BODY $j$ ) TO BODY $iFq$ ON BODY $g$ (LEADLE TO BODY $j$ ) TO BODY $iFq$ ON BODY $g$ (LEADLE THE $g$ -TH BODY INCLUDING
F THE G-TH HINCE, FIXED IN L(g), GODY INDORLD OF (ELLER AND) OF THE G-TH HINCE (ELLER AND) OF THE G-TH HINCE W 2 REFERENCE URT BODY & REFERENCE WATE ATTACH POINT ON BODY & WAT WATE ATTACH POINT ON BODY & WATE MARED HINCE MAT POINT ON BODY $g$ HINCE ATTACH POINT ON 3 REFERENCE URT BODY $g$ HINCE ATTACH POINT ON FQ1 ON BODY $g$ (LEADELCE TO BODY 3) TO BODY 3 FQ3 ON BODY 6 THE $g$ -TH BODY TWUTDELLOF
F THE G-TH HIXE, FIXED IN L(g), GODY INBORD OF (ELLER ANIS) OF THE G-TH HINCE (ELLER ANIS) OF THE G-TH HINCE (ELLER ANIS) OF THE G-TH HINCE (ELLER ANIS) OF THE G-TH HINCE MARE ATTACH POILT ON BODY G METRACE MARE ATTACH POILT ON BODY G METRACE ON BODY G ( $\underline{J}_{Hg} = \sum_{i=1}^{n} \mathcal{O}_i (\underline{f}_{hg}) \hat{\eta}_i^g$ ) is REFERENCE URT BODY G HINCE ATTACH POILT ON Reformed OF THE G-TH BODY INTERMED POINT ON Reformed OF THE G-TH BODY INTERMED TO ONTOD AND OF THE G-TH BODY INTERMED
The g-m hince, Fixed in L(g), BODY ENBORD OF (ELEQANIS) OF THE g-m HINCE (ELEQANIS) OF THE g-m HINCE is REFERENCE UNT BODY & REFERENCE MAED HINCE ATTACH POINT ON & REFERENCE MAED HINCE ATTACH POINT ON BODY & MICH ATTACH POINT ON AMED HINCE WET BODY & HINCE ATTACH POINT ON A REFERENCE WET BODY & HINCE ATTACH POINT ON A REFERENCE WET BODY & HINCE ATTACH POINT ON d' '''''''''''''''''''''''''''''''''''
The g-TH HINCE, FIXED IN L(g), BODY ENBORDD OF (ELEQ ANIS) OF THE G-TH HINCE is REFERENCE is REFERENCE MED HINCE ATTACH POINT ON BODY & WET MED HINCE ATTACH POINT ON BODY & WET MED HINCE ATTACH POINT ON BODY & WET MED HINCE ATTACH POINT ON BODY & WINCE ATTACH POINT ON A REFERENCE WET BODY & HINCE ATTACH POINT ON A REFERENCE WET BODY & HINCE ATTACH POINT ON $i \stackrel{1}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{1}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{2}{} \stackrel{1}{} \stackrel{1}{} \stackrel{2}{} $
The g-m hince, Fixed IN L(g), BODY ENDORED OF (ELLEQAINE) OF THE G-TH HINCE is REFERENCE UNT BODY & REFERENCE is REFERENCE UNT BODY & REFERENCE MED HINCE ATTACH POINT ON BODY & WET MED HINCE ATTACH POINT ON BODY & WET MED HINCE MET BODY & HINCE ATTACH POINT ON MEFERENCE UNET BODY & HINCE ATTACH POINT ON MEFERENCE ON BODY & MERENCE ON BODY & MERENCE ON BODY & MERENCE ON BODY ATTACH POINT ON MEFERENCE ON BODY & MERENCE ON BODY ATTACH POINT ON MERENCE ON BODY & MERENCE ON BODY ATTACH POINT ON ATTAC
The g-th Hunce, Fixed IN L(g), BODY ENDORED OF ELEQANIS) OF THE G-TH HINCE is REFERENCE UNT BODY & REFERENCE is REFERENCE UNT BODY & REFERENCE IED HINKE ATTACH POINT ON & REFERENCE III III HINKE ATTACH POINT ON & REFERENCE III III III III III III III III III II
The grave hince, fixed in L(g), Goby suborad of GLEQANS) OF THE G-TH HINCE CLEQANS) OF THE G-TH HINCE REFERENCE URT BODY & REFERENCE INTRE ATTACH POINT ON & REFERENCE B HINCE ATTACH POINT ON & REFERENCE B HINCE ATTACH POINT ON & REFERENCE WAT NO BODY & ( $\prod_{i=1}^{n} \sum_{i=1}^{n} \sum_{i=1$
LEQ ANIS) OF THE G-TH HINCE LEQ ANIS) OF THE G-TH HINCE REFERENCE UNT BODY & REFERENCE REFERENCE UNT BODY & REFERENCE BINKE ATTACH POINT ON BODY & WAT D'HIKE ATTACH POINT ON BODY & WAT D'HIKE ATTACH POINT ON BODY & WAT D'HIKE ATTACH POINT ON BODY & WIKE ATTACH POINT ON MERENCE UNT BODY & HIKE ATTACH POINT ON REFERENCE UNT BODY & HIKE ATTACH POINT ON REFERENCE UNT BODY & HIKE ATTACH POINT ON MERENCE UNT BODY & HIKE ATTACH POINT ON NOTBOARD OF THE G-TH BODY ENCLUDENCG
E g-TH HINCE, FIXED IN L(g), BODY SUBORED OF LERANS) OF THE G-TH HINCE REFERENCE UNT BODY & REFERENCE REFERENCE UNT BODY & REFERENCE D HINCE ATTACH POILUT ON BODY & WET D HINCE ATTACH POILUT ON BODY & WET D HINCE ATTACH POILUT ON BODY & WINCE ATTACH POILUT ON REFERENCE UNT BODY & HINCE ATTACH POILUT ON REFERENCE UNT BODY & HINCE ATTACH POILUT ON MATERIELE D BODY & HINCE ATTACH POILUT ON D BODY & LEANLICE TO BODY $\frac{1}{2}$ , $\frac$
E g-TH HINCE, FIXED IN L(g), BODY ENDORED OF ERAINE) OF THE G-TH HINCE REFERENCE URT BODY & REFERENCE REFERENCE URT BODY & REFERENCE HINCE ATTACH POILUT ON & REFERENCE BODY & ( $\coprod_{ij}$ = $\sum_{i=1}^{NAR} \bigotimes_{i=1}^{R} (f_{ij} \circ) \eta_{i}^{R}$ ) BODY & ( $\coprod_{ij}$ = $\sum_{i=1}^{NAR} \bigotimes_{i=1}^{R} (f_{ij} \circ) \eta_{i}^{R}$ ) REFERENCE URT BODY & HINCE ATTACH POILT ON WEFERENCE URT BODY & HINCE ATTACH POILT ON SON & BODY & (LEARLICE TO BODY $i$ ) TO BODY $i$ ON BODY & (LEARLICE TO BODY $i$ ) TO BODY $i$ STEDRAD OF THE Q-TH BODY ENCLUDENCE
g-m HIVE, FIXED IN L(g), BODY INBORD OF ERANS) OF THE G-TH HINCE REFEDENCE URT BODY & REFERENCE HINKE ATTACH POINT ON & REFERENCE HINKE ATTACH POINT ON & REFERENCE HINKE ATTACH POINT ON & REFERENCE BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) BODY & ( $I_{Hig} = \sum_{i=1}^{NAg} \bigotimes_{i=1}^{i} (f_{Hig}) g_{i}^{2}$ ) HIVE ATTACH DOUV ON & HIVE ATTACH DOUV ON STEPRENCE URT BODY & HIVE ATTACH DOUV ON
g-m HINCE, FIXED IN L(g), GODY INBORD OF ER ANS) OF THE G-TH HINCE REFERENCE URT BODY & REFERENCE HINCE ATTACH POINT ON & REFERENCE HINCE ATTACH POINT ON & REFERENCE HINCE ATTACH POINT ON & REFERENCE FRANCE URT BODY & HINCE ATTACH POINT ON FERRENCE URT BODY & HINCE ATTACH POINT ON
g-m Huxe, Fixed IN L(g), BODY SUBORD OF RANS) OF THE G-TH HINGE REFECENCE UNT BODY REFERENCE HINKE ATTACH POINT ON BODY REFERENCE HINKE ATTACH POINT ON BODY REFERENCE BODY R ( $\underline{U}_{19} = \sum_{i=1}^{NMR} \mathcal{O}_{i}^{1}(\underline{f}_{19}) \eta_{i}^{2}$ ) BODY R ( $\underline{U}_{19} = \sum_{i=1}^{NMR} \mathcal{O}_{i}^{1}(\underline{f}_{19}) \eta_{i}^{2}$ ) FERENCE UNT BODY R HINKE ATTACH POINT ON FERENCE UNT ROUT TO BODY INCLUDING TODADO OF THE G-TH BODY ENCLUDING
g-TH HINCE, FIXED IN L(g), BODY ENDORED OF RANG) OF THE G-TH HINCE RANG) OF THE G-TH HINCE EFEQENCE UNT BODY & REFERENCE HINCE ATTACH POINT ON & REFERENCE HINCE ATTACH POINT ON & REFERENCE BODY & ( $\underbrace{U_{1g}}_{1g} = \sum_{i=1}^{T/3} \bigotimes_{i=1}^{3} ((\widehat{n_g})_{1g})_{1i}^{3}$ ) FERENCE UNT BODY & HINCE ATTACH POINT ON FERENCE UNT BODY & HINCE ATTACH POINT ON DO ADD OF THE G-TH BODY ENCLUDENCG DO ADD OF THE G-TH BODY ENCLUDENCG
g-TH HINCE, FIXED IN L(g), BODY ENBORRD OF RAIS) OF THE G-TH HINCE FANIS) OF THE G-TH HINCE EFECTECE WAY BODY & REFERENCE HINCE ATTACH POINT ON & REFERENCE HINCE ATTACH POINT ON & REFERENCE MODY & ( $I_{14g} = \sum_{i=1}^{NAG} \bigotimes_{i=1}^{i} (f_{12g}) \eta_{i=1}^{g}$ ) BODY & ( $I_{14g} = \sum_{i=1}^{NAG} \bigotimes_{i=1}^{i} (f_{12g}) \eta_{i=1}^{g}$ ) FORENCE WEY BODY & HINCE ATTACH POINT ON FERENCE WEY BODY & HINCE ATTACH POINT ON ERENCE WEY BODY & HINCE ATTACH POINT ON
G-TH HINCE, FIYED IN L(B), BODY INBORD OF ANS) OF THE G-TH HINCE ANS) OF THE G-TH HINCE FREELEE UNS BODY B REFREENCE IFFREUE UNS BODY B REFREENCE HINCE ATTACH POINT ON B REFREENCE DODY B ( $\underline{U}_{Hg} = \sum_{i=1}^{N} \mathcal{O}_i^i (\underline{U}_{g})_{ij}^{ij}$ ) ELEUCE UNST BODY B HINCE ATTACH POINT ON ELEUCE UNST BODY B HINCE ATTACH POINT ON BODY G (LEADLUCE OBDY 3) TO BODY 3 $\dot{v}_i = \underline{O}$ ) ELEUCE UNST G-THE G-TH BODY INCLUDENCE
B'TH HINCE, FIXED IN L(B), BODY INBORD OF ANE) OF THE G-TH HINCE FRIE WAT BODY B REFERENCE FERENCE WAT BODY B REFERENCE INKE ATTACH POINT ON B REFERENCE ODY B ( $\underline{U}_{Hg} = \sum_{i=1}^{NHB} \underline{\mathcal{O}}_{i}^{i}(\underline{U}_{hg})_{i}^{i} \frac{1}{2}$ ) ODY B ( $\underline{U}_{Hg} = \sum_{i=1}^{NHB} \underline{\mathcal{O}}_{i}^{i}(\underline{U}_{hg})_{i}^{i} \frac{1}{2}$ ) CORD B ( $\underline{U}_{Hg} = \sum_{i=1}^{NHB} \underline{\mathcal{O}}_{i}^{i}(\underline{U}_{hg})_{i}^{i} \frac{1}{2}$ ) CORD B (LANT ON B HINCE ATTACH POINT ON ERENCE WAT BODY B HINCE ATTACH POINT ON ERENCE WAT BODY B HINCE ATTACH POINT ON ERENCE WAT BODY B HINCE ATTACH POINT ON COAD OF THE G-TH BODY ENCLUDENCE
TH HINCE, FIXED IN L(g), BODY INBORDD OF MIS) OF THE G-TH HINCE ERECCE WAT BODY & REFERENCE ERECCE WAT BODY & REFERENCE INSE ATTACH POINT ON BODY & WAT UNSE ATTACH POINT ON BODY & WAT INSE ATTACH POINT ON BODY & WAT MENCE WAT BODY & HINCE ATTACH POINT ON MENCE WAT BODY & HINCE ATTACH POINT ON
TH HINCE, FIXED IN L(B), BODY INBORD OF MUE) OF THE G-TH HINCE EVENTE WAY BODY B REFERENCE EVENTE WAY BODY B WET EVENTER POINT ON BODY B WET DY B ( <u>UN</u> = <u>NMA</u> SE ATTACH POINT ON B <u>BODY</u> B, <u>1</u> DY B ( <u>UN</u> = <u>2</u> SE ATTACH POINT ON B <u>BODY</u> B, <u>1</u> DOY B (LANELTO BODY B) TO BODY B = <u>0</u> ) A MUKE ATTACH DOINT ON B BODY G (LANELTO BODY B) TO BODY B = <u>0</u> )
TH HINCE, FIXED IN L(B), BODY INBORD OF MS) OF THE G-TH HINCE MS) OF THE G-TH HINCE RE ATTACH POINT ON B REFERENCE RE ATTACH POINT ON B MK ATTACH POINT ON WH B ( <u>U</u> = <u>L</u> = <u>C</u> = <u></u>
H HINCE, FIXED IN L(B), BODY INBORDD OF 15) OF THE G-TH HINCE REVEE WAY BODY B REFRENCE REVEE WAY BODY B REFRENCE REVEE WAY BOUT ON BODY B WAY Y B ( <u>U</u> M <sub>9</sub> = <u>NM9</u> <u>8</u> <sup>1</sup> ( <u>M9</u> ) <u>1</u> <sup>3</sup> ( <u>1</u> ) Y B ( <u>U</u> M <sub>9</sub> = <u>2</u> <sup>1</sup> <u>2</u> <sup>1</sup> 2 ( <u>1</u> ) EKKE WAY BODY <u>9</u> HINKE ATTACH POINT ON EKKE WAY BODY <u>9</u> HINKE ATTACH POINT ON 100 OF THE <u>9</u> -TH BODY INCLUDING
HIVE, FIXED IN L(B), BOBY ENBORDD OF E) OF THE G-TH HINCE EKCE WAT BOBY & REFERENCE EKCE WAT BOBY & REFERENCE EKCE WAT BOBY & REFERENCE MATACH POINT ON & WAT E ATTACH POINT ON & WAT E ATTACH POINT ON & WAT C & ( IIII) = 2 (IIII) 9 (I)
HIXE, FIXED IN L(B), BODY ENDORED OF ) OF THE G-TH HINCE EVER URT BODY & REFERENCE EVER URT BODY & REFERENCE ATTACH POINT ON & REFERENCE & ATTACH POINT ON & WAT & ( LING = 212 B ( LING =
HINCE, FIXED IN L(B), BODY ZHBORD OF ) OF THE G-TH HINCE ICE WAY BODY & REFERENCE ICE WAY BODY & REFERENCE ATTACH POINT ON BODY & WAT ATTACH POINT ON BODY & WAT ATTACH POINT ON BODY & WAT ATTACH POINT ON BODY & MINE ATTACH POINT ON VE WAY & (LANZLICTO BODY & 10 BODY & OY & (LANZLICTO BODY & 10 BODY & OY & (LANZLICTO BODY & 10 BODY & O OF THE G-TH BODY ZUCLUDING
HINCE, FIXED IN L(g), BODY ENBORD OF 1 OF THE G-TH HINCE TE WAT BODY & REFERENCE ATTACH POINT ON & REFERENCE ATTACH POINT ON & REFERENCE ATTACH POINT ON & WAT ATTACH POINT ON &
HINCE, FIXED IN L(B), BODY ENBORED OF OF THE G-TH HINCE OF THE G-TH HINCE TE WAT BODY & REFERENCE ATTACH POINT ON & REFERENCE ATTACH POINT ON & REFERENCE ATTACH POINT ON & WAT ATTACH POINT ON & WAT
INCE, FIXED IN L(B), BODY INDORED OF OF THE G-TH HINCE DE THE G-TH HINCE IS UNT BODY & REFERENCE IS UNT BODY & REFERENCE MITTACH POINT ON & REFERENCE MITTACH POINT ON & WET MITTACH PO
WE, FXED IN L(B), BODY ENDORDD OF DE THE G-TH HINCE E UNT DODY & REFERENCE E UNT DODY & REFERENCE TITACH POINT ON & REFERENCE TITACH POINT ON & WET TITACH
WE , FIXED IN L(g), GODY INDORLD OF IF THE G-TH HINGE IN RODY & REFERENCE UNT BODY & REFERENCE TRACH POINT ON & REFERENCE TRACH POINT ON & WAT TRACH POINT ON & WAT TRAC
CE, FIXED IN L(B), BODY INDORED OF FINE G-TH HINCE WAT BODY & REFERENCE WAT BODY & REFERENCE TACH POINT ON & MAT TACH POINT ON & MAT ( Ung = 278 & 21 (Mg) n 8 ) ( Ung = 278 & 21 (Mg) n 8 ) WET BODY & HINCE ATTACH POINT ON WET BODY & HINCE ATTACH POINT ON OF THE G-TH BODY INVENTION
LE, FIXED IN L(B), BODY ENBOARD OF THE G-TH HINCE WAT BODY & REFERENCE WAT BODY & REFERENCE MAT BODY & MAT ACH POINT ON BODY & WAT ( UNG = 21 & 21 & 200 y & 200 ) ( UNG = 21 & 21 & 21 & 200 y & 200 ) WAT BODY & HINCE ATTACH POINT ON WAT BODY & HINCE ATTACH POINT ON OF THE G-TH BODY ENCLUDENCG
E, FIXED IN L(g), BODY INBOARD OF THE G-TH HINCE WAT BODY & REFERENCE WAT BODY & REFERENCE ACH POINT ON & WAT ACH POINT ON & WAT ACH POINT ON & WAT ( Ung = 279 & 2007 g WAT WAT BODY & HIVE ATTACH POINT ON WAT BODY & HIVE ATTACH POINT ON WAT BODY & HIVE ATTACH POINT ON WAT BODY & HIVE ATTACH POINT ON THE G-TH BODY INCLUDING
, FIXED IN L(B), BODY INBORDD OF THE G-TH HINCE WAT BODY & REFERENCE WAT BODY & REFERENCE WAT BODY & WAT ( LING = ZI'''''''''''''''''''''''''''''''''''
, FIXED IN L(B), BODY INBORDD OF THE G-TH HINCE ART BODY & REFERENCE ART BODY & REFERENCE CH POINT ON BODY & WET CH POINT ON BODY & WET (LING = 2.74 BODY & WET POINT ON URT BODY & HINCE ATTACH POINT ON URT BODY & HINCE ATTACH POINT ON THE G-TH BODY INCLUDING
, FIXED IN L(B), BOBY ENDOARD OF THE G-TH HINGE ATE G-TH HINGE ATE G-TH HINGE ATE G-TH HINGE ATE BOBY & REFERENCE ATE BOBY & REFERENCE THE POINT ON BOBY & WET (LANGT C BOBY & HINGE ATTACH POINT ON DET BOBY & HINGE ATTACH POINT ON THE G-TH BODY ENCLUDING
FIXED IN L(g), BODY INBOARD OF HE G-TH HINCE AT BODY & REFERENCE AT BODY & REFERENCE H POINT ON & WET HE DODY & REFERENCE HING & SIGNA, MET HING & SIGNA, S
FIXED IN L(B), BODY ENDOARD OF E G-TH HINCE T BODY & REFERENCE T BODY & REFERENCE POINT ON BODY & WRT POINT ON BODY & WRT THE BODY & HINCE RITTACH DOINT ON THE G-TH BODY ENCLUDENCI
THE GOT BODY ENDORED OF TODY REFERENCE POUT ON BODY & WET POUT ON BODY & WET POUT ON BODY & WET THE GTH BODY ZUCLUDING THE GTH BODY IN TULLDING
KED IN LL(B), BODY INBOARD OF G-TH HINCE BODY B REFERENCE BODY B REFERENCE POINT ON BODY B WET POINT ON BODY B WET POINT ON BODY B WET FILE B-TH BODY INTOLLIDING
KED IN L(B), GODY INBOARD OF G-TH HINCE BODY B REFERENCE BODY B REFERENCE BODY B REFERENCE POINT ON BODY B WET POINT ON BODY B WET POINT ON BODY B WET BODY B HINCE ATTACH POINT ON EARLIE TO BODY B) TO BODY B
ED IN LL(R), BODY ZNBOARD OF G-TH HINCE BODY R REFERENCE BODY R REFERENCE POINT ON BODY R WRT POINT ON BODY R WRT POINT ON BODY R WRT BODY R HINCE ATTACH POINT ON EABLIC TO BODY S) TO BODY S EABLIC TO BODY S) TO BODY S EABLIC TO BODY S TULLIDING
ED IN L(B), BODY INDORLD OF G-TH HINCE BODY B. REFERENCE BODY B. REFERENCE BODY B. REFERENCE BODY B. REFERENCE BODY B. MKR MKR MKR MKR MKR MKR MKR MKR
ED IN L(B), BODY ENBORED OF B-TH HINGE BODY B REFERENCE BODY B REFERENCE BODY B REFERENCE BODY B REFERENCE BODY B WKT BODY B WKT MACH POINT ON BODY B HIKE ATTACH POINT ON BODY B THE ATTACH POINT ON BODY B THE ATTACH POINT ON BODY B THE ATTACH POINT ON
D IN L(g), BODY ENBORDD OF J-TH HINCE DDY & REFERENCE DDY & REFERENCE DDY & REFERENCE DDY & REFERENCE DDY & MIXE ATTACH POINT ON DDY & HIXE ATTACH POINT ON DDY & BODY & VILLIDENG
D IN L(B), BOBY ZNBOARD OF -M HINGE M HINGE M HINGE M HINGE M HINGE M M M M M M M M M M M M M M M M M M
IN L(g), BOBY ENDORED OF TH HINGE TH HINGE TH HINGE TH ON g REFERENCE DY g REFERENCE DY g REFERENCE DY g REFERENCE DY g REFERENCE DY g NUKE ATTACH POINT ON E (21 D' D' D' D' D' D' D' D' D' D' D' D' D' D' D' D' PON 3 PTH BODY ENCLUDING
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IN L(B), BOBY ENBOARD OF H HINGE H HI
N L(g), BOBY INBOARD OF HINCE HINCE REFERENCE ON BOBY & WET ON BOBY & WET NHA ON BOBY & WET CELL CELL DEN 3, TO BOBY &
<ul> <li>L(g), BODY INBOARD OF</li> <li>HINCE</li> <li>HINCE</li> <li>REFERENCE</li> <li></li></ul>
L(g), BOBY ENBORRD OF HINGE HINGE REFERENCE ON BOBY & WET ON BOBY & WET DIA MET MATHON DOWN ON HINCE ATTACH DOWN ON HINCE ATTACH DOWN ON TH BODY IN DOBN i
L(g), BOBY ENBOARD OF HINGE REFERENCE B REFERENCE B REFERENCE OB BOBY & WRT ON BOBY & WRT MRS MIKE ATTACH POINT ON HIKE ATTACH POINT ON TO BOBY & THOULDING TO BOBY & TUCLUDING
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<ul> <li>g), BODY ENBORRD OF</li> <li>d), BODY ENBORRD OF</li> <li>d), BODY ENBORRD OF</li> <li>d), BODY BURT</li> <li>d), 10 BODY J</li> <li>d), 10 BODY J</li> <li>d) 10 BODY J</li> </ul>
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- SCALAR REPRESENTATION FOR LUMPED APPROACH (IV.) MODAL MASS (ASSUMED BODY BASIS)

 $\left[\left(m_{i},\tilde{\chi}_{i}, \right) \left| \left(\mathcal{J}^{b_{0}}, \tilde{\chi}^{i}, \mathcal{J}^{i}, -\mathcal{J}^{i}, \tilde{\chi}^{i}, -\tilde{\chi}^{i}, \mathcal{J}^{i}, \mathcal{J}^{i},$  $\sum_{i=1}^{n} (\underline{w}^{i} + \underline{u}^{i}) \cdot \left( \sum_{i=1}^{n} + \sum_{i=1}^{n} \sum_{i=1}^{n} (\underline{v}^{i}_{i} + \sum_{i=1}^{n} \sum_{i=1}^{n} (\underline{v}^{i}_{i} + \sum_{i=1}^{n} \sum_{i=1}^{n} (\underline{v}^{i}_{i} + \underline{v}^{i}_{i}) \cdot (\underline{v}^{i}_{i} + \underline{u}^{i}_{i}) \right)$  $(\Sigma.) \quad \underline{\omega}^{i} \cdot \left(\underline{\mathbb{W}}^{i}_{i} + \underline{\widetilde{\mathbb{M}}}^{i}_{i} \underline{\mathbb{W}}^{i}_{i}, \underline{\eta}^{i}_{i} + \underline{\widetilde{\mathbb{M}}}^{i}_{i} \underline{\widetilde{\mathbb{M}}}^{i}_{i}, \underline{\eta}^{i}_{i}, \underline{\eta}^{i}_{i}$  $\left\{ \sum_{i=1}^{m} \left( \left\{ \beta_{0i}^{i} \right\}^{T} \left\{ \beta_{0i}^{i} \right\}^{T} \left\{ \beta_{0i}^{i} \right\}^{T} \left\{ \beta_{0i}^{i} \right\}^{T} \right\} \right) \left( m_{1}^{i} \dots n_{n}^{n} \right) \left( m_{1}^{i} \left\{ m_{1}^{i} \right\}^{n} \right)$ 362

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	RATE OF CHANGE OF BODY & ANGULAR MOMENTUM (CONSOLIDATED EXPRESSION FOR H'S)	$H^{*} = \begin{bmatrix} i^{*} & \cdots & \vdots & \vdots \\ \vdots & \cdots & \vdots & \vdots \end{bmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots & \vdots \\ \vdots & \cdots & \vdots & \vdots \end{bmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots & \vdots \\ \vdots & \cdots & \vdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \begin{pmatrix} h^{*}_{i} + \prod_{i=1}^{n} Y^{i}_{i} & \vdots \\ \vdots & \cdots & \vdots \end{pmatrix} \end{pmatrix}$	Ĩ	SHERE .
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 $\mathbb{I}^{i}_{A} + \sum_{i=1}^{n} \{ \mathbb{M}^{i}_{i} + \mathbb{M}^{i}_{i} \} \mathbb{I}^{i}_{i} + \sum_{i=1}^{n} \mathbb{I}^{i}_{i} \mathbb{P}^{i}_{i} \mathbb{I}^{i}_{i} \mathbb{I}^{i}$ 

VECTORS AND DYADICS bir bis), Boby & REFERENCE BASIS	DEFINITION	$\mathcal{F}_{m_{3}}\left\{ \sum_{n=1}^{m_{1}} m_{1}^{n} \mathcal{Q}_{1}^{n} = m_{1}^{n} \underbrace{I_{n}}_{n} \times \mathcal{Q}_{1}^{n} = -\sum_{n=1}^{m_{1}} m_{1}^{n} (\mathcal{Q}_{1}^{n} \times \underline{v}_{n}^{n}) \times \mathcal{Q}_{n}^{n} \underbrace{I_{n}}_{n} \right\} $	$\mathbf{b}^{T} \Big\{ \mathcal{J}^{i o} + \tilde{\mathbf{u}}_{o}^{i} \mathcal{J}^{i o} - \mathcal{J}^{i o} \tilde{\mathbf{u}}_{o}^{i} - \tilde{\mathbf{u}}_{o}^{i} \mathcal{J}^{i o} \cdot \tilde{\mathbf{u}}_{o}^{i} \Big\} \mathbf{b}$	$\hat{J}_{i}^{i}$ is Internal Marraux (3×3) OF worden Boory is were worden Boory is REFERENCE FRAME , Dio $P_{i}^{*} \left\{ \prod_{i=1}^{n} \sum_{i=1}^{n} \left\{ \prod_{i=1}^{n} \sum_{i=1}^{n} \sum_{i=$
$\mathbf{F}_{i}^{T} = \begin{pmatrix} \mathbf{b}_{i} & \mathbf{b}_{i} \\ \mathbf{b}_{i} & \mathbf{b}_{i} \\ \mathbf{b}_{i} & \mathbf{b}_{i} \end{pmatrix}$	0.0.F. Association	MODAL	ROTATIONAL / MODAL	ROTATIONAL
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 $\mathbf{D}^{\mathsf{T}}\left\{\sum_{i=1}^{n}\left(\widetilde{\mathcal{D}}_{i}^{\mathsf{i}}\left(\mathsf{m}_{i}^{\mathsf{i}}\widetilde{\mathbf{I}}_{i}^{\mathsf{i}}\left\{\boldsymbol{\varphi}_{i}^{\mathsf{i}}\right\}\right)\left\{\boldsymbol{\varphi}_{i}^{\mathsf{i}}\left\{-\widetilde{\mathcal{D}}_{i}^{\mathsf{i}}\right\}-\widetilde{\mathcal{D}}_{i}^{\mathsf{i}}\widetilde{\mathcal{D}}_{i}^{\mathsf{i}}\left\{\boldsymbol{\varphi}_{i}^{\mathsf{i}}\right\}\right\}\right\}$  $-\breve{\omega}_{i}^{i} m_{i} \widetilde{l}_{i}^{i} \{ \wp_{oi}^{i} \} - m_{i}^{i} (\widetilde{l}_{i}^{i} \{ \wp_{oi}^{i} \}) \{ \wp_{oi}^{i} \}$  $\mathbf{D}^{\mathsf{T}}\left\{\sum_{i=1}^{\mathsf{T}}\left[\left(\left(\mathsf{m}_{i},\widetilde{\mathsf{N}}_{i}\left\{\boldsymbol{p},\boldsymbol{\omega}_{i},\widetilde{\mathsf{Z}}\right\}\right)\left\{\boldsymbol{p},\boldsymbol{\omega}_{i},\widetilde{\mathsf{Z}}\right\}\right)\widetilde{\mathsf{P}}_{i},+,,\widetilde{\mathsf{m}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{\mathsf{P}}_{i},\widetilde{\mathsf{Q}}_{i},\widetilde{$  $\mathbf{b}^{\mathsf{T}}\left\{ \sum_{i=1}^{n} \left\{ m_{i} \sum_{i=1}^{n} r_{i}^{\mathsf{T}} - \left( m_{i} \sum_{i=1}^{n} p_{i}^{\mathsf{T}} \sum_{i=1}^{n} r_{i}^{\mathsf{T}} \right) \right\} \mathbf{b}$ + ( & & Ste - Je & De & ) { & & }  $\mathbf{b}^{T} \{ \sum_{i=1}^{n} \{ m_{i}, \widetilde{\phi}_{i}, [\phi_{i}, 2 - \widetilde{\phi}_{i}, m_{i}, \widetilde{\lambda}_{i}, \{\phi_{i}, 3\} \} \}$  $\mathbf{b}^{\mathsf{T}}\left\{\sum_{n=1}^{\infty}\left\{m_{i}^{\mathsf{n}}\widetilde{\boldsymbol{\varphi}}_{i}^{\mathsf{n}}\left\{\boldsymbol{\varphi}_{i}^{\mathsf{n}}\right\}+\widetilde{\mathbf{r}}^{\mathsf{n}}\left\{m_{i}^{\mathsf{n}}\widetilde{\boldsymbol{\chi}}_{i}\left\{\boldsymbol{\varphi}_{i}^{\mathsf{n}}\right\}\right\}\left\{\boldsymbol{\varphi}_{i}^{\mathsf{n}}\right\}\right\}$  $\mathbb{D}^{\mathsf{T}}\left\{ \widetilde{\mathbb{Z}}^{\mathsf{i}}_{\mathsf{c}}\left(\widetilde{\mathcal{D}}^{\mathsf{i}}_{\mathsf{c}}\left(\mathsf{m}^{\mathsf{i}},\widetilde{\mathfrak{I}}^{\mathsf{i}}_{\mathsf{c}}\left\{\varphi^{\mathsf{i}}_{\mathsf{c}},\widetilde{\mathfrak{c}}^{\mathsf{i}}\right\}\right) \left\{ \varphi^{\mathsf{i}}_{\mathsf{c}},\widetilde{\mathfrak{c}}^{\mathsf{i}}_{\mathsf{c}}\right\} \right\}$ - (mi Ĩi, {øi; i) õi, ]} D NORFHNH110 D.O.F. Association ROTATION ROTATIONAL / MODAL HODAL MODAL MODAL MODAL MODAL ORDER VARIABLE Ĩ  $\mathbf{s}$ 

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	DEFENITION	$\mathbb{D}^{T}\left\{\mathbb{L}^{n}\left[\left(\left(\mathfrak{m},\tilde{\mathfrak{n}},\{\boldsymbol{\beta},\boldsymbol{\alpha},\boldsymbol{\beta}\right),\{\boldsymbol{\beta},\boldsymbol{\alpha},\boldsymbol{\beta},\tilde{\boldsymbol{\beta}},\boldsymbol{\beta},\boldsymbol{\alpha},\boldsymbol{\beta}\right)\right\}\mathbb{D}\right\}$	$\mathbf{b}^{T}\left\{ \breve{\boldsymbol{\beta}}_{i}^{i}, m_{i}^{i} \breve{\boldsymbol{\gamma}}_{i}^{i} + \breve{\boldsymbol{\gamma}}^{i}, \breve{\boldsymbol{\beta}}_{i}^{i} \right\} \mathbf{b}$	$\mathbf{b}^{T}\left\{-\widetilde{\boldsymbol{p}}_{0}^{i}\left(m_{0}^{i}\widetilde{\boldsymbol{l}}_{0}^{i}\left\{\boldsymbol{p}_{0}^{i}\right\}\right)+\widetilde{\boldsymbol{p}}_{0}^{i}\mathcal{J}^{i}\cdot\widetilde{\boldsymbol{p}}_{0}^{i}\left(-\widetilde{\boldsymbol{p}}_{0}^{i},\widetilde{\boldsymbol{p}}_{0}^{i}\right)\right\}$	D { - Bin Jin Bin Bin Bin Bin Bin Bun	$\mathbb{D}^{T}\left\{\sum_{i=1}^{m} \left\{ \begin{array}{c} \widetilde{\mathcal{D}}_{i}^{i}, -m^{i}, \widetilde{\mathcal{U}}_{i}, \left\{ \widetilde{\mathcal{D}}_{i}^{i}, \left\{ \widetilde{\mathcalD}_{i}^{i}, \left\{ \widetilde{\mathcalD}_{i}^{i$	$- b^{T} \{ \sum_{i=1}^{n} \left\{ -\widetilde{\lambda}_{oi}^{i} \left( m_{i} \widetilde{\lambda}_{o}^{i} \left\{ \varphi_{oi}^{i} \right\} \right) \left\{ \varphi_{oi}^{i} \right\} \} \}$	b <sup>7</sup> { J <sup>4</sup> , <i>p</i> <sup>4</sup> , <i>s</i> }	$b^{T}\left\{ \breve{\beta}_{o_{k}}^{i} \breve{\beta}_{o_{k}}^{i} \breve{\beta}_{o_{i}}^{i} \right\} - \breve{\delta}_{o_{k}}^{i} \breve{\beta}_{o_{i}}^{i} \left\{ \breve{\beta}_{o_{i}}^{i} \right\}$	$ \left\{ \mathbf{b}^{T} \left\{ - \mathbf{\beta}^{M}_{m} \mathbf{y}^{M}_{m} \mathbf{\beta}^{M}_{m} \left\{ \mathbf{\beta}^{M}_{m} \right\} \right\} $	
	0.0.F.	MODAL	MODAL	MODAL	MODAL	MODAL	MODAL	MODAL	MODAL	Modal	
	ORDER								- <u>10 - 10 - 10 - 10 - 10 - 10 - 10 - 10</u>	<u></u>	
<u>ynacs</u>	VARIABLE	سرز سرز		ن <sup>ور م</sup> رز الحرا			الار: الار:				
$\mathbf{V}$	,				30	67				<i>.</i> .	

+  $(\mathfrak{m}_{i}, \tilde{k}_{i}, \{ \varphi_{o_{k}}, \tilde{k} \}) \widetilde{\varphi}_{i}^{i} - \widetilde{\beta}_{o_{k}}^{i} \operatorname{T}_{v} \circ \widetilde{\varphi}_{oi}^{i} \} \mathbb{B}$  $\mathbf{b}^{\mathsf{T}}\left\{\sum_{i=1}^{n}\left(\mathbf{z}^{\mathsf{i}_{i}}+\mathsf{m}_{\mathsf{i}}\,\widetilde{r}_{\mathsf{i}}\,\widetilde{r}_{\mathsf{i}}-\widetilde{r}_{\mathsf{i}}\,\mathsf{m}_{\mathsf{i}}\,\widetilde{r}_{\mathsf{i}}-\mathsf{m}_{\mathsf{i}}\,\widetilde{r}_{\mathsf{i}}\,\widetilde{r}_{\mathsf{i}}\right)\right\}\mathbf{b}$  $\mathbf{b} \left\{ \sum_{i=1}^{n} \left( -m_{i} \sum_{i=1}^{n} \widetilde{\beta}_{i} + \widetilde{r}_{i} \left( m_{i} \widetilde{r}_{i} \left\{ \rho_{i}, \widetilde{s} \right\} - m_{i} \widetilde{r}_{i} \widetilde{\rho}_{i}, \widetilde{\rho}_{i} \right\} \right\}$ ROTATIONAL  $\mathbb{D}\left\{\sum_{i=1}^{m} \left[-m_{i} \widetilde{p}_{i}; \widetilde{r}_{i} - \widetilde{p}_{i}; m_{i}; \widetilde{l}_{i} + \left(m_{i} \widetilde{\lambda}_{i}; \{p_{i}'; \widetilde{l}\}\right)\widetilde{r}_{i}\right\}\right\}$ ROTATIONAL  $\mathbb{D}^{\mathsf{T}}\left\{\sum_{o=1}^{\mathsf{m}}\left(-m_{o}^{\mathsf{m}}\widetilde{p}_{o}^{\mathsf{n}},\widetilde{p}_{o}^{\mathsf{n}},+\widetilde{p}_{o}^{\mathsf{n}},(m_{o}^{\mathsf{m}}\widetilde{p}_{o},p_{o}^{\mathsf{n}},\varepsilon)\right\}\right\}$ - Jto Zii] } b + کَرْزُ حَذْنَ کَارُ لَك DEFINITION ROTA TIONAL ROTATIONAL ROTATIONAL ASSOCIATION 0.0.5. ORDER うろいろろ -1 0 ん -1 VARIADLE ر. بر الم لا ال **S** 2 

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VARIABLE	CRUER	D.O.F. Association	DE FINITION
		ROTATIONAL	D { [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] ] ] ]
		ROTATIONAL	$\mathbf{b}^{T}\left\{\sum_{i=1}^{m}\left(\widetilde{\boldsymbol{\beta}}_{i}^{A}, \mathbf{J}^{A}, \widetilde{\boldsymbol{\beta}}_{i}^{A}\right) + \mathbf{J}^{A}, \widetilde{\boldsymbol{\beta}}_{i}^{A}, \widetilde{\boldsymbol{\beta}}, $
		ROTATIONAL	$\mathbf{b}^{T}\left[\sum_{i=1}^{n} \left\{2  \widetilde{\mathcal{B}}_{i}^{t}, \left\{\widetilde{\mathcal{B}}_{i}^{t}, \left[\widetilde{\mathcal{B}}_{i}^{t}, \left[\widetilde{\mathcal{B}}_{i}$
			- 21: 21. 21. 21. J
Ĩ. Ĵ	ろうち	ROTATIONAL	ROTRTIONAL $\sum_{i=1}^{10} \{ \omega_i \times \mathbf{v}_i \cdot \mathbf{v}_i + \mathbf{v}_i \times \mathbf{v}_i \times \mathbf{v}_i \cdot \mathbf{v}_i \}$
			+ $(\vec{r}_{i} + \vec{u}_{i}) \times (\vec{u}_{i} \times (\vec{u}_{i} \times (m_{i}, y_{o} + u_{o}^{*} \times m_{i}, y_{o})))$