Disposizione n. 1/2019
Prot. N. 146918/07/2019

Oggetto: Acquisto di un simulatore di guida professionale compatto per ricerca e didattica nel settore automotive per un importo massimo di euro 110.000,00 + IVA. Richiedente: Prof. Marco Gadola. Autorizzazione di procedura negoziata a seguito di avviso per manifestazione di interesse.

IL RESPONSABILE AMMINISTRATIVO DELLA MACROAREA DI INGEGNERIA

VISTA la richiesta di acquisto con cui il Prof. Marco Gadola chiede che sia acquistato un simulatore di guida professionale compatto per ricerca e didattica nel settore automotive dalla ditta VI-grade Systems GmbH con sede legale a Marburg (Germania) e sede operativa a Udine per un costo di euro 110.000,00 + IVA;

VISTA la nota Prot. n. 1439 del 13.06.2019 in cui il prof. Gadola esprime la motivazione per la quale è necessario rivolgersi alla ditta VI-grade Systems GmbH con sede a legale a Marburg (Germania) e sede operativa a Udine per l’acquisto del simulatore richiesto:

“A partire dal 2011 il sottoscritto ha accumulato pluriennale esperienza sull’utilizzo dei simulatori di guida professionali per applicazioni ingegneristiche e, vista la peculiare complessità di questi sistemi, ne ha tratto le seguenti linee guida per l’acquisto.

1) È indispensabile che il simulatore sia un sistema unitario composto da hardware e software integrati, in modo che la loro compatibilità sia sotto la responsabilità diretta del fornitore.

2) È altrettanto indispensabile che l’acquisto venga effettuato direttamente dal produttore del sistema, ovvero che il fornitore coincida con il produttore, unica entità ad avere la piena padronanza del sistema. Solo in questo modo si ha certezza di poter risolvere qualsiasi problema di affidabilità, come anche di poter affrontare eventuali nuove esigenze che dovessero emergere durante l’utilizzo.

3) È indispensabile che il fornitore disponga di una struttura di assistenza capillare e qualora necessario possa anche intervenire in loco.

4) Il sistema deve essere di larga diffusione presso i player del settore, in modo da agevolare l’interazione diretta grazie allo scambio di esperienze, all’utilizzo della stessa tecnologia di modellazione e degli stessi formati software. Altrimenti ci si autoesclude dal mercato.

5) Normalmente i software per applicazioni di ingegneria richiedono training specifico ed un lungo apprendistato per una conoscenza adeguata, ed i tool di simulazione per la dinamica del veicolo non fanno eccezione. Ne consegue che va valorizzata l’eventuale esperienza pregressa.

Il sottoscritto ha poi svolto un approfondita analisi di mercato, da cui sono emersi gli aspetti seguenti.
1) A parte la tipologia di simulatori dedicati al training dei pilotti professionisti (Dallara, Allinsports), non adatti al caso in esame, sono attualmente solo tre i produttori di simulatori professionali per attività di ricerca e sviluppo ad esseri affermati nel mercato europeo con prodotti commerciali: Cruden (Olanda), Ansible Motion (UK) e VI-grade (Italia-Germania).

2) A valle di un'accurata indagine di mercato, due anni fa VI-grade è già stata selezionata da UniBS come fornitore del pacchetto educational (15 licenze) del software di simulazione per la dinamica del veicolo VI-CarRealTime, adottato per le esercitazioni del Laboratorio di meccanica e testing del veicolo. Lo staff del gruppo di ricerca ha quindi acquisito un'estesa esperienza su questo tool, su cui si basano i modelli virtuali per il simulatore.

3) Il software VI-CarRealTime si è affermato come leader di mercato, con numerose installazioni da parte di case automobilistiche, fornitori e società di ingegneria. Ciò ha infatti permesso ad UniBS di sottoscrivere importanti contratti di ricerca (TEXA Spa) e svolgere tesi di laurea con Lamborghini Automobili. Dopo la laurea i tesi, avendo potuto inserire nel curriculum l'esperienza acquisita con CarRealTime, sono stati immediatamente assunti da Ferrari e Scuderia Toro Rosso.

4) Oltre che leader di mercato dei software per le simulazioni di dinamica del veicolo, VI-grade si è rapidamente affermata anche come leader nel settore dei simulatori di guida. Grazie a brevetti specifici è l'unico produttore di simulatori dinamici a 9 gradi di libertà invece di 6. Inoltre VI-grade ha al proprio attivo oltre 20 installazioni di simulatori dinamici preso costruttori automobilistici e fornitori OEM tra cui Ferrari, Volvo, Porsche, BMW, Mercedes-AMG, FCA e Honda, oltre che in Cina, Giappone e USA, e circa 30 installazioni di simulatori statici, ad es. presso Lamborghini, Michelin, Subaru e Citroen.


6) Le attività legate ai contratti di ricerca TEXA e al brevetto "Tactile gearshift" hanno già consentito di acquisire un'esperienza non trascurabile sul simulatore di guida compatto grazie ad alcune sessioni di test svolte presso la sede di Udine, applicando anche le tecniche di co-simulazione in modo intensivo.

7) Ansible Motion non offre un pacchetto integrato costituito da simulatore e software di simulazione; quest'ultimo va acquisito separatamente da terze parti, e la piena compatibilità non è quindi garantita.

8) I prodotti Cruden si configurano prevalentemente come simulatori dedicati ad applicazioni motorsport. In Italia sono presenti solo due installazioni presso team di auto da competizione, mentre l'unico costruttore automobilistico che figura ufficialmente tra i clienti è Jaguar-Land Rover.

9) Cruden ed Ansible Motion non hanno sedi operative in Italia.

**Costo e fondi per l'acquisizione**

L'offerta di VI-grade personalizzata per il DIMI (in allegato) prevede un costo pari a 
110,000€ + IV/A 22% = 134,200€

Sono stati identificati i fondi di Dipartimento elencati di seguito, con il relativo ammontare:
Fondo CT3_19_Goriziane_Gadola_Chindamo 24,800€
Fondo CT3_18_Gadola_Texa (18131) 35,084€
Fondo CT3 Foglia Evolut 47,000€
Fondo CT3 La Vecchia La Forgia 27,316€

**Conclusioni**

In sostanza, acquisire il simulatore di VI-grade consentirà di:

1) mettersi sullo stesso piano di interlocutori importanti come i principali costruttori automobilistici europei, grazie all'utilizzo dei medesimi strumenti software e hardware che costituiscono lo stato dell'arte del mercato; ciò può portare a potenziali collaborazioni ed interazioni costruttive, ed è garanzia di maggiori opportunità anche per i neo laureati, come abbiamo già potuto verificare;

2) sfruttare la preziosa esperienza già acquisita sia con il software che con l'hardware, consentendo sinergie tra le attività didattiche e quelle commerciali e garantendo un'auspicabile forma di continuità con gli studi e le collaborazioni svolte di recente;

3) acquisire un sistema integrato composto da software e hardware direttamente dal produttore;

4) avvalersi dell'assistenza diretta dello staff di VI-grade, già in gran parte conosciuto personalmente grazie alle attività precedenti. VI-grade dispone infatti di personale dedicato all'assistenza clienti nella sede operativa di Udine ma anche nelle sedi distaccate di Perugia e Torino. Questo è un vantaggio fondamentale quando si tratta di utilizzare uno strumento tecnologicamente complesso a livello professionale.

Visto quanto sopra appare evidente che per molteplici motivi non esistono alternative a VI-grade. I vantaggi significativi e concreti offerti da questo fornitore renderebbero l'eventuale acquisto dai concorrenti fortemente penalizzante. Chiedo quindi di poter procedere con la valutazione dell'offerta allegata, ed eventualmente con l'ordine correlato. L'offerta, estremamente dettagliata e corredata delle specifiche tecniche e di installazione, è frutto di un lungo lavoro di messa a punto e negoziazione, reso possibile proprio dal fatto che VI-grade è partner di ricerca e didattica di UniBS ormai consolidato.

VISTA l'offerta nr.P046b/2019 del 17.05.2019 pervenuta dalla ditta VI-grade Systems GmbH con sede legale a Marburg (Germania);

CONSIDERATE le applicazioni per ricerca e sviluppo e le applicazioni per didattica indicate nella nota prot. 1439 del 13.06.2019

VISTA la dichiarazione di unicità commerciale del 19.06.2019 rilasciata dalla ditta;

RILEVATO che attualmente non sono presenti Convenzioni quadro stipulate dal Ministero dell'Economia e delle Finanze per il tramite di Consip S.p.a. o dalla Centrale di committenza della Regione Lombardia per l'affidamento di forniture analoghe;

VISTO art. 36, del D.Lgs. del 18 aprile 2016 n. 50 concernente gli affidamenti sotto soglia;

VISTO l’art. 63, comma 2, lettera b, punto 2) del Decreto legislativo 18 aprile 2016, n. 50 (Codice dei contratti pubblici) per il quale “le amministrazioni giudicatrici possono aggiudicare appalti pubblici
mediante procedura negoziata senza previa pubblicazione di un bando di gara, dando conto con adeguata motivazione, della sussistenza dei relativi presupposti.
La procedura negoziata senza previa pubblicazione può essere utilizzata …b) quando i lavori, le forniture o i servizi possano essere forniti unicamente da un determinato operatore economico per una delle seguenti ragioni: …1) la concorrenza è assente per motivi tecnici…… le eccezioni di cui al punto 2) ….si applicano solo quando non esistono altri operatori economici o soluzioni alternative ragionevoli…”;

VISTO l’art. 36 comma 7) del d.lgs n.50/2016 che affida all’ANAC la definizione delle attività di dettaglio per supportare le stazioni appaltanti nelle attività relative ai contratti di importo inferiore alla soglia di rilevanza europea e migliorare la qualità delle procedure, delle indagini di mercato nonché la formazione e gestione degli elenchi degli operatori ecologici;
VISTO il Regolamento di Ateneo per le acquisizioni di opere e lavori, servizi e forniture di importo inferiore alle soglie di rilevanza comunitaria ai sensi del Decreto Legislativo 18 aprile 2016, n. 50 emanato con Decreto Rettorale n. 242 del 01/06/2017;
RAVVISATA l’opportunità di procedere all’individuazione degli operatori economici da invitare mediante pubblicazione sul sito internet del Dipartimento di Ingegneria Meccanica e Industriale di un avviso per manifestazione di interesse;
ACCERTATA l’ammissibilità della spesa la disponibilità economica sul budget 2019 del DIMI ed in particolare i fondi
Fondo CT3_19_Goriziane_Gadola_Chindamo  24,800€
Fondo CT3_18_Gadola_Texa (18131)  35,084€
Fondo CT3 Paglia Evolut  47,000€
Fondo CT3 La Vecchia La Forgia  27,316€

CONSIDERATA la legittimità della procedura seguita;

DISPONE

1. di autorizzare la pubblicazione di un avviso esplorativo per manifestazione di interesse al fine di acquistare, nel rispetto della normativa vigente, eventuali altre offerte da operatori economici in possesso di requisiti professionali adeguati;

2. di autorizzare, all’esito dell’avviso esplorativo pubblico, l’attivazione della procedura negoziata con invito a tutti gli operatori economici richiedenti per l’affidamento della fornitura di cui all’oggetto;

3. di autorizzare l’acquisto di un simulatore di guida professionale compatto per ricerca e didattica nel settore automotive con le caratteristiche tecniche richieste dal Prof. Marco Gadola nella nota Prot. n. 1439 del 13/06/2019;
4. di approvare la spesa complessiva massima di 110.000,00 euro + IVA, che graverà nella seguente maniera
   Fondo CT3_19_Goriziane_Gadola_Chindamo  24,800€
   Fondo CT3_18_Gadola_Texas (18131)        35,084€
   Fondo CT3 Faglia Evolut                   47,000€
   Fondo CT3 La Vecchia La Forgia            27,316€

5. di nominare Responsabile Unico del Procedimento la dott.ssa Chiara Motta, Responsabile dei Servizi Amministrativi del Dipartimento di Ingegneria Meccanica ed Industriale, autorizzandola a compiere tutti i successivi atti di competenza.

Il Responsabile amministrativo dei Servizi Dipartimentali della Macroarea di Ingegneria

(Dott. Vittorio Canino)
Cortese Att.ne

Prof. Rodolfo Faglia, direttore di dipartimento DIMI

e
Dott. Vincenzo Canino, responsabile amministrativo DIMI

Oggetto: proposta per acquisto di simulatore di guida professionale compatto

a cura di M. Gadola

Introduzione
La presente per proporre l’acquisto di un simulatore di guida di tipo professionale compatto dell’azienda VI-grade (sede legale a Marburg, Germania, e sede operativa a Udine). I simulatori di guida sono potenti strumenti di ricerca e sviluppo per l’ingegneria dei veicoli, e si prestano efficacemente anche ad una didattica innovativa e coinvolgente.

Contenuti del documento

a) Il simulatore di guida: di che si tratta?
b) Applicazioni per ricerca e sviluppo
c) Applicazioni per la didattica
d) Simulatore dinamico e simulatore compatto
e) Selezione del fornitore
f) Conclusioni
g) Link utili

a) Il simulatore di guida: di che si tratta?

I simulatori di guida costituiscono lo stato dell’arte degli strumenti per lo studio della dinamica dei veicoli, consentendo un’interazione immersiva tra reale e virtuale. Essi sono composti da una postazione di guida “fisica” costituita da un sedile, un volante con feedback di coppia, un cockpit realistico ed uno schermo...
su cui viene proiettato l’ambiente entro cui il modello numerico di veicolo si muove. È possibile infatti guidare fisicamente un veicolo virtuale in scenari di guida digitalizzati, ad esempio la ricostruzione di un ambiente stradale urbano o di un’autostrada, oppure un autodromo per collaudi o competizioni. Questa tecnologia, derivata dai simulatori di volo e dalla virtual reality, viene chiamata “driver-in-the-loop” perché l’umano fa parte del ciclo di simulazione: a differenza delle simulazioni offline tradizionali la percezione soggettiva è direttamente coinvolta nella valutazione delle qualità dinamiche del veicolo e dell’interfaccia uomo-macchina.

b) Applicazioni per ricerca e sviluppo

Le applicazioni dei simulatori sono molteplici ed oramai irrinunciabili per lo sviluppo della mobilità innovativa, attualmente in rapidissima evoluzione. Ad esempio le case automobilistiche utilizzano i simulatori per il testing virtuale dei sistemi ADAS – Advanced Driver Assistance Systems. La tabella riporta i principali ambiti di applicazione:

<table>
<thead>
<tr>
<th>FATTORE UMANO ED INFRASTRUTTURA</th>
<th>SVILUPPO DEL VEICOLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenari di guida in Virtual Reality:</td>
<td>Veicolo in Virtual Reality: opportunità di test illimitate, vantaggi per R&amp;D e Time-to-market</td>
</tr>
<tr>
<td>ambiente urbano, gestione traffico, viabilità</td>
<td></td>
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<tr>
<td>Driving behaviour modeling</td>
<td>Software- &amp; Hardware-in-the-loop,</td>
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<td></td>
<td>Real-time applications</td>
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<tr>
<td>Interazione utente-traffico-infrastruttura</td>
<td>Sviluppo Full Electric &amp; Hybrid Electric Vehicle</td>
</tr>
<tr>
<td>HMI: Human-Machine Interface</td>
<td>ADAS &amp; guida autonoma</td>
</tr>
<tr>
<td>Smart infrastructure, V2X</td>
<td>Functional safety, ISO26262</td>
</tr>
<tr>
<td>Driver training per veicoli speciali</td>
<td>Vehicle Dynamics, controlli attivi per active safety, Co-simulazione Matlab-Simulink</td>
</tr>
<tr>
<td>Ausili di guida per disabilità: R&amp;S e driver training</td>
<td>Powertrain/chassis integration, alleggerimento</td>
</tr>
<tr>
<td>Fisiologia dell’interazione con il veicolo</td>
<td>Driver training (performance oriented, motorsport)</td>
</tr>
</tbody>
</table>

Dal punto di vista universitario, e del DIMI in particolare, il simulatore rappresenta un ambiente collaborativo integrato di sviluppo veicolo ed infrastruttura e come tale si presta a collaborazioni e ricerche interdisciplinari, sia con aziende del settore Automotive che si occupano di nuove tecnologie della mobilità, sia con entità impegnate nello sviluppo e nella gestione di infrastrutture avanzate. Le possibilità di co-simulazione integrata con l’ambiente Matlab-Simulink costituiscono poi la base per lo sviluppo di sistemi e strategie di controllo attivo.

c) Applicazioni per la didattica

La didattica basata su simulatore è la nuova frontiera della didattica per l’ingegneria dei veicoli: grazie all’opportunità di guidare direttamente i propri modelli e sperimentarne il comportamento, essa offre agli studenti potenzialità enormi di formazione tecnica, anche grazie alle dinamiche motivazionali e di
La figura del "system engineer" è e sarà sempre più ricercata dalle aziende che sviluppano i mezzi di trasporto del futuro. Essi saranno equipaggiati con powertrain innovativi (ibridi ed elettrici) e con sistemi di assistenza alla guida (ADAS) anche basati sull’interazione tra veicoli (V2V) e tra veicolo ed infrastruttura (V2X), fino all’avvento della guida totalmente autonoma. Per gli allievi del curriculum Autoveicoli, ma anche per gli allievi di Automazione industriale, Controlli automatici ed Energia, il simulatore costituisce una potenziale apertura verso applicazioni ove le competenze di meccatronica sono indispensabili.

Durante una o più sessioni su un simulatore professionale gli studenti potranno guidare i modelli virtuali di veicolo da loro stessi creati (anche con trazione elettrica), per poi equipaggiarli con sistemi attivi di base e sperimentarne di persona gli effetti benefici sul comportamento dinamico. In modo analogo ad altri corsi simili attivati in recente in Europa e negli USA, gli studenti potranno acquisire un ineguagliabile livello di consapevolezza sulle potenzialità offerte dalla progettazione dei sistemi ADAS con gli strumenti di sviluppo più moderni.

Va infine detto che UniBS sarà la prima università italiana –ed una tra le prime in Europa– a dotarsi di un simulatore di guida professionale, utilizzabile anche per la didattica.

d) Simulatore dinamico e simulatore compatto

Nei simulatori dinamici la postazione di guida è installata su una piattaforma dinamica a 6 o 9 gradi di libertà. Essi sono indispensabili per le attività che richiedono la percezione del moto, come ad es. il training per piloti professionisti. Il costo va da 500 k€ ad oltre 3 M€; anche l’installazione in sé è gravosa a causa degli ingombri e del fabbisogno energetico.

Nel caso dei simulatori compatti la postazione di guida è invece statica: il feedback principale è quindi visivo e sonoro, mentre un feedback aggiuntivo può essere ottenuto con shakers che riproducono le vibrazioni legate alle asperità del fondo stradale e a particolari fenomeni dinamici, con cinture di sicurezza e sedile dotati di tensionatori e cuscinetti pneumatici etc. Questo tipo di simulatore è particolarmente adatto alla prototipazione virtuale perché può essere letteralmente installato in ufficio; non richiede infatti infrastrutture o servizi particolari, occupa spazio limitato ed ha costi di un ordine di grandezza inferiore (100-200 k€). Le possibilità di sviluppo in co-simulazione sono però equivalenti ai simulatori dinamici.
La nostra scelta cade ovviamente su un simulatore compatto, non solo per il costo ma anche per semplicità di gestione e di accessibilità: si pensa infatti ad una collocazione nell’attuale laboratorio VDL (Vehicle Design Lab), lo spazio dedicato agli studenti della LM curriculum Autoveicoli, che andrà suddiviso opportunamente. Questa collocazione garantirà eccellente fruibilità sia da parte dello staff del gruppo di ricerca Automotive Engineering & Design, sia da parte degli studenti per lezioni, esercitazioni ed attività di tesi.

e) Selezion del fornitore

A partire dal 2011 il sottoscritto ha accumulato pluriennale esperienza sull’utilizzo dei simulatori di guida professionali per applicazioni ingegneristiche e, vista la peculiare complessità di questi sistemi, ne ha tratto le seguenti linee guida per l’acquisto.

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3) Il software VI-CarRealTime si è affermato come leader di mercato, con numerose installazioni da parte di case automobilistiche, fornitori e società di ingegneria. Ciò ha infatti permesso ad UniBS di sottoscrivere importanti contratti di ricerca (TEXA Spa) e svolgere tesi di laurea con Lamborghini Automobili. Dopo la laurea dei tesi, avendo potuto inserire nel curriculum l’esperienza acquisita con CarRealTime, sono stati immediatamente assunti da Ferrari e Scuderia Toro Rosso.
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9) **Conclusioni**

In sostanza, acquisire il simulatore di VI-grade consentirà di:

1) mettersi sullo stesso piano di interlocutori importanti come i principali costruttori automobilistici europei, grazie all’utilizzo dei medesimi strumenti software e hardware che costituiscono lo stato dell’arte del mercato; ciò può portare a potenziali collaborazioni ed interazioni costruttive, ed è garanzia di maggiori opportunità anche per i neolaureati, come abbiamo già potuto verificare;
2) sfruttare la preziosa esperienza già acquisita sia con il software che con l’hardware, consentendo sinergie tra le attività didattiche e quelle commerciali e garantendo un’ausicabile forma di continuità con gli studi e le collaborazioni svolte di recente;
3) acquisire un sistema integrato composto da software e hardware direttamente dal produttore;
4) avvalersi dell’assistenza diretta dello staff di VI-grade, già in gran parte conosciuto personalmente grazie alle attività pregresse. VI-grade dispone infatti di personale dedicato all’assistenza clienti nella sede operativa di Udine ma anche nelle sedi distaccate di Perugia e Torino. Questo è un vantaggio fondamentale quando si tratta di utilizzare uno strumento tecnologicamente complesso a livello professionale.

Visto quanto sopra appare evidente che per molteplici motivi non esistono alternative a VI-grade. I vantaggi significativi e concreti offerti da questo fornitore renderebbero l’eventuale acquisto dai concorrenti fortemente penalizzante. Chiedo quindi di poter procedere con la valutazione dell’offerta allegata, ed eventualmente con l’ordine correlato. L’offerta, estremamente dettagliata e corredata delle specifiche tecniche e di installazione, è frutto di un lungo lavoro di messa a punto e negoziazione, reso possibile proprio dal fatto che VI-grade è partner di ricerca e didattica di UniBS oramai consolidato.

h) Link utili

Sito VI-grade: https://www.vi-grade.com/
Sito Cruden: https://www.cruden.com/
Sito Ansible Motion: https://www.ansiblemotion.com/
VI-grade compact simulator @ Subaru Corp, Japan
Driving Simulator @ Danisi Engineering, Torino (youtube)
ADAS Development using VI-grade Driving Simulators (youtube)

Ringraziando per l’attenzione
Cordialmente

Prof. Marco Gadola
Responsabile gruppo di ricerca Automotive Engineering & Design
Quotation

COMPACT Driving Simulator

Proposal Nr. P046b/2019
Issue Date 17.05.2019
Proposal Expires 15.06.2019

To:
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Revision History

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<th>Rev.</th>
<th>Description</th>
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<tr>
<td>Rev01</td>
<td>First version</td>
<td>09-03-2019</td>
</tr>
<tr>
<td>Rev02</td>
<td>Basic Configuration with Win PC for solver</td>
<td>17-05-2019</td>
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Appendix A – VI-grade – Terms and Conditions for the sale and supply of Goods and Services ("Conditions")... 39
Dear Marco,

Thanks for your interest in our company and in our products.

Reference to your request, here following is our Technical and Economical proposal for a turnkey project to manufacture, integrate, install and commission a VI-grade COMPACT STATIC Driving Simulator at your premises.

VI-grade has multi-years' experience in implementing engineering driving simulators, both static (no motion) and dynamic simulators with motion platform.
For more info, please visit www.vi-grade.com.

VI-grade in the last years has implemented driving simulators at several leading automotive OEMs, Engineering services companies and universities and it has put together a reliable group of partners. This allows VI-grade to provide system integration services and on-site support to its driving simulator customers.

Should you have any questions, please do not hesitate to contact me.

Yours sincerely,

[Signature]

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Web: www.driverinmotion.com
Introduction

Voice of the customer

"The motivation for driving simulator wasn’t that difficult considering top management is pushing very hard for increased usage of virtual tools. The financial motivation was basically to tie the number of prototype weeks we could remove by using the simulator. The simulator promises to tie together the subjective expertise with the CAE team objective analysis expertise in a way previously not possible, cross-pollinating both teams and unifying the whole department. This is simply priceless and my hope is that it will boost knowledge-building and experimentation tremendously."

"I can sense even tiny changes in the setup, like whether the car is under or over-steering."

"The simulator comes very close to reproducing real conditions, and gives the engineers vital insights into vehicle set ups."

"The DiM® is a latest generation simulator used by Ferrari to develop its road cars and adopts leading-edge technologies in its simulations. These provide answers at the design stage that are extremely useful to focusing and accelerating the development of the cars and also to guaranteeing unprecedented performance."

"We also see considerable benefit from conducting active-safety tests that are too dangerous to perform live. For instance, we can now simulate a collision or a puncture at high speed to see how the driver will respond; developing systems to help him or her stop the car safely."

"The use of simulation means that settings can be rapidly tested combining the experiential judgment of a real driver and computer-aided objective data analysis. The beauty of the new simulator is that it provides us with the opportunity to physically experience the calculation models and evaluate them using human test drivers, rather than staring at graphs and numbers in a meeting room."

The Next Step in vehicle development has arrived

Faster to market, reduced costs, increased reliability, avoid warranty costs, and the greater influence of advanced controls are some of the current challenges automotive OEM’s have to face when developing new cars. OEM’s must continue to evolve to the next paradigm of vehicle development and part of that includes driving simulators.

Automotive OEM’s use driving simulators to test more variants than ever, to integrate active subsystems, to reduce expensive proving ground tests, and to get feedback from test drivers earlier in the design process. Vi-grade specializes in bridging the gap between test and simulation, and our Driving Simulator is that solution.

Integration is the key ingredient of the recipe

It is no longer possible for different departments to only develop their own components and to fulfill their own targets; nowadays developing a successful car is a difficult recipe. Different departments struggle to guarantee that all different subsystems and control systems are working together in harmony. Vi-grade Driving Simulators allow OEM’s to integrate all kinds of control systems like hardware-in-the-loop (HIL) and software-in-the-loop (SIL) at the same time. Engineers and professional drivers are now able to meet far earlier in the design process and balance targets long before the full vehicle prototype when only components and subsystems are commonly available in hardware. The driving simulator becomes the integration platform to assure cross-functional targets are met.

Quotation Number: P0646b/2019, Università di Brescia

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Drive all your favorite roads from your office

Each automotive company has its own preferred test tracks to set up and calibrate their prototypes. But very often those tracks are not close to the R&D centers, much less close to each other. Substantial time and money is spent to test prototypes and environmental conditions can compromise the investment in physical testing.

With VI-grade Driving Simulators, you can test vehicles on all your test tracks with laboratory-like consistency. Without leaving your office, you can easily simulate different conditions that you will find on the real track.

It’s what’s inside that counts

At the heart of every driving simulator is a vehicle model. Changing vehicle parameters and testing hundreds of different set ups as if you were on the proving ground is what a driving simulator is all about. With the VI-grade VI-CarRealTime vehicle model, changes are a matter of few clicks. Springs, dampers, tires, bump stops, suspension curves, controller parameters can be changed with just a few keystrokes and the test driver can back up on the track to try new configurations on the same part of the track, in seconds.

Our vehicle model is reliable, robust, and fast to solve. Get the most out of driving sessions with VI-CarRealTime. However, should you need to use another real-time vehicle model for legacy reasons or to be compliant with company standards, our technical staff will be available to support you in order to integrate your vehicle model within the simulator environment.

The driver at the center stage

In the end, as it is in a real car, the ultimate success of any driving simulator depends on the satisfaction of the driver, regardless if he/she is a pro driver or an every-day driver. The way the driver interacts with the simulator and the emotions he/she feels can easily be monitored in a controlled environment like the one VI-grade can implement at your premises. Systems like eye trackers and biotelemetry allow engineers to understand driver’s behavior while driving and to identify high distractive elements during the driving sessions.

Making Active Safety even safer

Advanced driver assistance systems (aka ADAS) are becoming popular and an important part of new vehicles. To develop and test these systems, engineers need to replicate and simulate different traffic conditions and unexpected events that might happen while driving. To support this, VI-grade has developed interfaces with the most popular traffic simulation software’s giving you the power to use the simulator and our vehicle models to drive ADAS development earlier and faster.

Creating city, rural, and highway scenarios, defining sensors, and developing control strategies can now be done within the driving simulator. VI-grade Driving Simulators make active safety devices development safer and simpler.
Industry applications covered by VI-grade Driving Simulators

Disciplines
- Real-time vehicle dynamics handling and ride
- Comfort & NVH
- Software-in-the-loop ("SIL")
- Hardware-in-the-loop ("HIL")
- Driver model
- Driver model for autonomous vehicles
- Advanced Driver Assistance Systems
- Design-of-Experiment and Optimization
- Human Machine Interface ("HMI")
- Driving Simulation (with and without motion platform)
- Fuel Economy

Applications
- Vehicle Development
- Vehicle Dynamics (Drivability, Agility, Stability)
- Primary & Secondary Ride
- NVH
- Control System development and testing
- Traffic Simulation and ADAS development
- HMI
- Autonomous vehicles
- Driver Training
- Human Psychometrics studies (biotelemetry, driver's reaction to stress)
- Motorsport activities

Services
- Virtual Vehicle modeling
- Graphic Scenarios modelling
- Cockpit implementation & integration
- Visual and audio systems
- Sound recording and post processing
- Driver's reactions monitoring
- Real-time computing optimization
- Installation
- Training
- System Integration
- Turnkey solutions

Quotation Number: P048b/2019, Università di Brescia
Proof of Application

DiM® Reference Projects

Figure 1: Vi-grade Dynamic Simulator DiM® at Volvo Car Corp, in Gothenburg (Sweden)

Figure 2: Vi-grade Dynamic Simulator DiM® at Ferrari S.p.A., in Maranello (Italy)
Courtesy of Quadrante Magazine (January 2015 issue)

Figure 3: Vi-grade Dynamic Simulator with DiM® platform at Porsche in Weissach (Germany)
Figura 4: VI-grade Dynamic Simulator with DiMB platform at Danisi Engineering in Torino (Italy)

Figura 5: VI-grade Dynamic Simulator with DiMB platform at BMW in Munich (Germany)

Figura 6: VI-grade Dynamic Simulator with DiMB platform at NIO in Shanghai (China)
Figura 7: Vi-grade Dynamic Simulator with DIMB platform at FCA LATAM in Belo Horizonte (Brazil)

Figura 8: Vi-grade Dynamic Simulator with DIMB platform at Vi-SimCenter

Figura 9: Vi-grade Dynamic Simulator with DIMB platform at Saginomiya in Saitama (Japan)
Figure 10: Honda will become the world’s first vehicle manufacturer to adopt new state-of-the-art driving simulator technology, based on a revolutionary architecture called DLM250 (Driver-in-Motion). 

Figure 11: DLM250 @ Mercedes-AMG

Figure 12: DLM250 @ IDIADA

Figure 13: DLM250 @ Multimatic, USA
Figura 14: COMPACT STATIC Simulator @ Michelin (France)

Figura 15: COMPACT STATIC Simulator @ Subaru (Japan)

Figura 16: COMPACT STATIC Simulator @ De Performance (France)
All VI-grade Simulators Worldwide

In addition to DiM projects shown above, it is worthwhile to mention that VI-grade implemented and currently maintains more than 40 simulators:

- 10 DiM150 simulators
- 2 DiM250 simulators
- 4 DiM250 additional simulators (to be installed in first half of 2019)
- 12 STATIC simulators
- 17 COMPACT simulators
- 4 dynamic simulators based on other hardware

These simulators are located in Europe, North America, South America and Asia Pacific.

![Figure 17: COMPACT Simulator](image1)
![Figure 18: STATIC Simulator](image2)
![Figure 19: DiM Simulator](image3)

**VI-grade Driving Simulator Technology**

VI-grade provides both static and dynamic turnkey solutions for driving simulators.

VI-grade's software technology for driving simulation, called **VI-DriveSim**, is capable of working, in the same exact configuration, both on a static and on moving platform simulator. This proposal is about the supply of a COMPACT STATIC simulator.

![VI-grade Software and Hardware Technology for Driving Simulators](image4)
Hardware

Each driving simulator is different from another one, but in principle, it can be said that all COMPACT STATIC driving simulators provided by VI-grade include following hardware components:

- 100" Flat Screen / Fixed Cylindrical Screen (typically R-2500 G-120 H-2400)
- Projector and Support
- Aluminum structure
- Seat
- Pedals
- Steering Wheel Torque Feedback Unit
- Real-time iHawk Linux computer for real-time computing
- IG PC
- PC and screens for broadcasting images and for analyzing telemetry data coming from the vehicle
- Steering wheel motor and controller (including power box)
- Audio System
Steering Wheel Torque Feedback Unit

VI-grade cockpit are always provided with Steering System Torque Feedback unit. The system is composed of following components:

- Phase Electric Motor (various models of the ULTRACT III series are supported) see below for more details.
- Phase AxN motor drive programmed by VI-grade.
- Serial (RS-232) connection from a Windows PC to AxN drive.
- Depending on the industrial fieldbus used one of the following solutions is needed:
  - For CANbus connection with the drive:
    - ESD PCI 405 CANbus board with 2/4 separate channels
    - CANbus connection from AxN drive to ESD board
  - For EtherCAT connection with the drive:
    - A free network card connection on the VI-DriveSim machine
    - EtherCAT connection from AxN drive to network board

We typically use a Phase U03512/1500 "low cogging" motor type with these characteristics:

- Nominal 13 Nm torque
- Peak torque 30 Nm
- Latency: 4 msec
- Encoder resolution: 16-5 deg

The picture below is a schematic representation of connections (for CANbus solution) between VI-DriveSim PC and the steering wheel system.
Additional devices

VI-Biotelemetry

VI-grade develops VI-BioTelemetry (consisting of hardware and software parts) which is able to measure the stress level of a driver during an action on a driving simulator or on a real car. The VI-BioTelemetry package includes the following functionalities:

- Measure of Heart Rate Variability ("HRV")
- Measure of Skin Potential Response ("SPR")
- Eye Tracking
- Calculation of stress indexes
- Interface with WINTAX VI-grade log data software
- Interface with VI-grade Real-Time Database
- Correlation with stressors for DS acceptance (special maneuvers on the DS with and without traffic)
- Correlation with stressors for traffic navigation (maneuvers on real and/or virtual traffic environment, under self or robot driving)

Heart Rate Variability

To measure heart rate the equipment showed in the following picture is used:

![Heart Rate Variability Equipment](image)

A sport-type shirt or a high conductivity soft tissue with 5 electrodes is worn by the driver and 3 ECG signals are measured. From the best of the 3 ECG signals the $RR(t)$ (time domain variation of the heart rate) and HRV (Fast Fourier Transform of the $RR(t)$) diagrams are derived automatically by specialized algorithms.

Skin Potential Response

The Skin Potential Response (SPR) is a measure of the activity of the nervous cells which control the activity of the sweat glands under the skin. In correspondence of some characteristics points on the hand, under the armpit, on the side of the head or in the cave of the foot. To measure the SPR the equipment showed in the following picture is used:

![Skin Potential Response Equipment](image)
SPR complements the HRV measurement with a faster response (1.5-2s delay from the stressor source trigger time) of the variation stress level of the driver. A typical SPR curve during a test with the presence of stressors (pylon avoidance during driving) in the scene is illustrated in the following picture:
VI-BioTelemetry has a special pattern recognition algorithm to identify the starting point, the duration and the intensity of the SPR discharge peak (in the range of few millivolts, similar to the ECG signal). A special algorithm has been implemented to de-correlate possible artefacts (such as hand pressure on the steering wheel, muscle contraction due to steering turning, etc) from the clean signal coming from the central nervous system.

A special electronic board has been developed to connect to the conductive elements that enable the measure of both HRV and SPR, both via BLE and WIFI to the host PC. The board (VI-BioBox) and its HW characteristics are illustrated in the following picture:
Eye Tracking System

Smart Eye Pro is SMART EYE’s flexible and robust eye tracking solution for various environments.

It consists of a true multi-camera system running on a single PC and on a single algorithm. The system is scalable from 2 up to 8 cameras allowing 360 degrees head and eye tracking. Free and wide placement of cameras both horizontally and vertically enables the possibility to handle even the most complex of applications.

Operating under Infra-Red (IR), Smart Eye Pro is completely insensitive to ambient light, making it suitable for projects in all levels of darkness and sunlight.

VI-grade has installed Eye Tracking Systems on several simulators and it has the same system on its dynamic simulator in Italy.

The Eye tracking system quoted in this proposal consists of following components:

1) SmartEye Pro 3-camera system 60Hz 1.3 MP
   - Software license, SmartEye Pro 6.1 60 Hz
   - 1 PC desktop (incl. keyboard, screen and mouse)
   - 3 cameras 1.3 MP, including lenses and filters
   - 2 Flashes 60 Hz
   - 1 Exponent-7
   - 3 sets of cables
   - 1 Calibration Chessboard
   - 1 Mounting kit got 3 cameras
   - 1 Smart Support, one year

2) Mapps Basic analysis software

3) 2-days On-site commissioning and training

TECHNICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Sampling Rate</th>
<th>60 Hz (with up to 8 cameras) / 120 Hz (with up to 4 cameras)</th>
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</thead>
<tbody>
<tr>
<td>Field of View</td>
<td>90° - 360° (depending on number of cameras)</td>
</tr>
<tr>
<td>Head Box (freedom of head movement)</td>
<td>For a typical 2 camera screen measurement setup (8mm lenses): 40 x 40 x 50 (typ.), Adjustable with lenses and positioning of cameras</td>
</tr>
<tr>
<td>Tracking Accuracy</td>
<td>Head: Rotation 0.5 degrees (typ.)</td>
</tr>
<tr>
<td></td>
<td>Gaze: 0.5 degrees (typ.)</td>
</tr>
<tr>
<td>Output</td>
<td>TCP / UDP / CAN (optional)</td>
</tr>
<tr>
<td>Delivered data</td>
<td>Head tracking (6D0F°), eye position, eye gaze, pupil diameter, Saccades, fixations, blinks, eyelid opening and many more.</td>
</tr>
<tr>
<td>Recovery Time (Blink / Tracking Lost)</td>
<td>Immediate</td>
</tr>
<tr>
<td>Optimal Camera - Eye Distance</td>
<td>50-300 cm adjustable with lenses and positioning of cameras</td>
</tr>
<tr>
<td>Eyewear Compatibility</td>
<td>Glasses, contact lenses and sunglasses of non IR type</td>
</tr>
<tr>
<td>Calibration Mode</td>
<td>Any number of calibration points</td>
</tr>
<tr>
<td>Eye Tracking Principle</td>
<td>Pupil and Iris / Corneal Reflection and Head Mode</td>
</tr>
</tbody>
</table>

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Additional HMI

During the project, it will be possible to both replace existing dashboard with a virtual one (realized with a minimonitor) and to add HMI devices to the cockpit.

On these HMI devices it will be possible to visualize any kind of parameters coming from the simulation (from vehicle model, from external environment, from traffic, from driver ...). Additional HMI devices can have any kind of graphical layout decided by customers.

Image below shows an example of additional HMI added to a VI-grade cockpit.
ADAS & AD Systems

Driving simulators are more and more used for ADAS and AD development. This is due to the fact that simulator allows engineers to perform tests in a much safer environment, in a more repeatable and controlled way and in quicker time compared to using real prototypes on real roads. Having this in mind, VI-grade has interfaced GPUs from Nvidia and cameras to its driving simulators. This allows engineers to have on the simulator the same working environment they have on a prototype and to perform feasibility studies as well as validation of ADAS systems. Pictures below show what has been done recently in order to connect Nvidia Drive PX-2 and cameras with VI-grade Driving Simulator.

ADAS Systems in the loop: Nvidia Drive PX-2 and cameras
Additional Cues – Active Belt System

VI-grade has developed an active belt system (3 or 6 points belts) which allows for both shoulder and belly segment symmetric pulling, depending on vehicle longitudinal de/acceleration. The active belts could work in sync with the active seat (see below) and is adaptable to any kind of seat (passenger car and racing car).

The active belts could be installed on any static and dynamic simulator. On DIM® and other Driving simulators provided by VI-grade the functionality is controlled by the VI-MotionCueing logic which takes into account vestibular as well as somato-sensory physiological models to minimize the difference between in-car and on-sim driver dynamic perception. On other motion platforms, the control logic can be interfaced with existing motion cueing algorithm.

The system is composed of:

3. Hardware

- Belts
- Pneumatic muscle for belt pulling
- Data and power cables
- Action cables and connecting bars
- On board controller box, filter, switches
- Power Box (could be integrated in steering system box)

2. Software

- VI-DriveSim compatible control logic to control:
  - action cut-off frequency
  - steady intensity (preload)
  - acceleration action multiplier [Kg/g], subtracts from preload
  - braking action multiplier [Kg/g], adds to preload
  - acceleration unload value

The controller is connected and driven with the VI-grade ETHERCAT standard protocol to the CCUR real-time PC. Both hardware and software are customizable depending on cockpit installation/customer requests.
Additional Cues – Active Seat System

Vi-grade has developed an active seat at works in sync with the active belts (if available) and it is adaptable to any kind of seat (both passenger and racing seat).

The active seat could be installed on any static and dynamic simulator. On DiM® the functionality is controlled by the VI-MotionCueing logic which takes into account vestibular as well as somato-sensorial physiological models to minimize the difference between in-car and on-sim driver dynamic perception.

The action on the driver is done using pneumatic bags that are inflated or deflated based on information about the accelerations of the vehicle (longitudinal, lateral and vertical). Inflation of bags is taken care by an external compressor (on DiM Driving simulator it is possible to use the same compressor used for air bearings).

During the driving simulator functioning, vehicle accelerations are developed and processed on the PC where the vehicle model runs in real-time. The pneumatic bag is inflated (or deflated) proportionally to the value assigned by the VI-MotionCueing signal.

Active Seat and Active Belts assembly
1-2-3-4-5-6: Pneumatic bags
7: Six Points Active Belts
8: Pulley system for Active Belts
9: Valves Box
The system is composed of:

3. **Hardware**
   - Any custom seat (provided by the end user)
   - Proportional valves (9 in the pictures)
   - Data and power cables (24V max 300mA)
   - 8 Pneumatic bags
   - Pipes to connect compressor, valves and pneumatic bags
   - Pneumatic box (see image below)

2. **Software**
   - VI-DriveSim compatible control logic to control:
     - action cut-off frequency
     - steady intensity (preload)
     - max/min pressure inside the pneumatic bags

3. **System requirements**
   - Air compressor, Air filter and Air dryer (DiM compressed air can be used also for this device)

The pneumatic bags are positioned inside the foam of the seat and then covered with the original seat cover; in this way the look & feel of the original seat are not modified. When the pneumatic bags are inflated, the pressure is transmitted to the driver body, giving the sensation of transient (max 4Hz) and steady acceleration. The system latency is around 100ms.

The controller is connected and driven with the VI-grade ETHERCAT standard protocol to the CCUR real-time PC by means of an A/D conversion box. Both hardware and software are customizable depending on cockpit installation/customer requests.
Computers

This is the list of computers typically used on a COMPACT STATIC Simulator:

- Real-time iHawk Linux by Concurrent Computer
- Windows PCs for graphics (one computer per each projector)
- Windows PC for broadcasting

All computers are then stored into a computer rack.

Minimum specifications for all Windows PCs are:

- GPU Nvidia GTX 1080Ti (or higher)
- Intel i7
- 24 GB RAM @ 2000 MHz

In order to ensure the hard real-time computation on the driving simulator, VIGRADE utilizes real-time Linux machines from Concurrent Computer. This machine will host the vehicle model, the motion cueing algorithm and all interfaces with the cockpit.

Here is a short description of main hardware and software components that will be included in the real-time computer (specifications might change without notice):

- iHawk rackmount system
  - one 3.2 GHz Gold 6134 8-Core CPU
  - 48 GB memory 2400 MHz
  - Dual Gigabit Ethernet ports
  - 7 PCIe slots 1 unused
  - on-board RAID configured as RAID 1
  - two 2.0 TB 2.5" SSD SATA drives
  - 4U SATA rack chassis (20.5 in. D.)
  - 660W power supply, rails
  - DVDD+RW (+R DL) / DVD-RAM drive
  - Quadro P4000, 2 GB mem. Graphics
  - Quad Port Gigabit Ethernet PCIe card
  - 64-bit RedHawk Linux real-time OS
  - Real-Time Clock & Interrupt Module
- 4-ch CAN Interface PCIe card with breakout cable
- RedHawk Driver for CAN-403 PCIe Card
- SWB CAN I/O Module License
- SWB/C3 Development License For 8 Cores
- SWB/C3 Ml Toolkit License
- RedHawk Frequency-Based Scheduler 64-bit
- SWB Network I/O Module License
- System Integration & test for preceding items
Software

General Operation

VI-grade Driving Simulators are equipped with VI-DriveSim software. VI-DriveSim is the software that supervises all Driving Simulator operations and makes it possible for all software (both VI-grade proprietary and 3rd party software) to work together.

As an example, VI-DriveSim allows following operations:

- Loading Vehicle model
- Loading Driving Scenarios
- Start and Stop the simulation
- Modifying Motion cueing settings
- Performing playback simulations (from recorded RES files)
- Save and Reload (= stop the simulation at any time and re-start the simulation at a specific point in time).
- Managing active belts and seat (if available)
- Managing VI-BioTelemetry parameters (if available)

Vehicle Dynamics

VI-grade develops a real-time vehicle modelling environment called VI-CarRealTime. VI-CarRealTime is part of the VI-DriveSim product suite and it is always installed on all VI-grade simulators. Regardless of the VDM that end-user wishes to use on the Driving Simulator, VI-grade performs all site acceptance tests (SAT) using the complete VI-DriveSim product suite, including vehicle model from VI-CarRealTime.

VI-CarRealTime provides a real-time vehicle simulation environment where the same simplified vehicle model can be used by vehicle dynamics and controls engineers to optimize vehicle and control system performance.

VI-CarRealTime is the only real-time solution available in the market that can automatically and seamlessly export a real-time vehicle model directly from ADAMS Car and/or K&C results. VI-CarRealTime also enables to share component property files such as tires, springs, dampers, and bumpstops with ADAMS Car.

VI-CarRealTime provides validated models that can be used by vehicle dynamics and control engineers to optimize their design based on accurate vehicle performance. VI-CarRealTime can be integrated with Matlab Simulink as well as FMI/FMU compatible software for controls systems specific development and to include additional subsystems, such as detailed driveline or hybrid/electric systems, into the vehicle model.

VI-CarRealTime helps to reduce the time spent by the different engineering teams to obtain and prepare very often the same data. It also improves the consistency of the engineering approach while providing state of the art technology. The investment pays off because it can be leveraged by many different teams, including Hardware-in-The-Loop and driving simulator departments.

Vehicle models generated by VI-CarRealTime can be used both on Windows and Linux platforms (in this case only the VI-CarRealTime solver runs on Linux, while the GUI will run on Windows).

As mentioned above, VI-CarRealTime is interfaced with Adams Car making it very easy to use same vehicle models for both off-line, detailed simulations and driving simulator session. The picture below describes the entire process from Adams Car to Driving Simulators. VI-CarRealTime vehicle models can be created in one of the following ways:

- From Adams Car
- From K&C measurements
- Starting from predefined models available in the VI-CarRealTime shared database (available models are city car, C-segment compact car, sedan, SUV, GT car)
- Populating VI-CarRealTime vehicle database directly from GUI

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Here below is the list of tire models that run on VI-grade Driving Simulator and that have been already implemented:

- F1 tire
- CD T1re
- MF Tyre
- SWIFT Tyre
- MegaRide

**VI-GraphSim**

VI-grade develops a software named VI-GraphSim that addresses points from 1 to 3. VI-GraphSim is therefore a graphic environment and model visualization tool for real-time vehicle simulation. VI-GraphSim can be used for all Vehicle Dynamics, Ride & Comfort and NVH studies.

VI-GraphSim in conjunction with wide cylindrical screens provides drivers with an immersive environment for a unique driving simulation experience with very low latency and high quality image rendering. Through the usage of different cameras it is possible to satisfy, at the same time, driver's and track engineer's needs. Replay functions allow users to easily review driving simulator sessions.

VI-grade provides, together with VI-GraphSim license, a large number of racing tracks and proving ground as well as common scenarios such as city, countryside, highway and many others.
SCANeR

When it comes to traffic simulations where several surrounding objects can move and interact with the driver, VI-grade relies on 3rd party software.

VI-grade suggests using SCANeR by AV Simulation (formerly OKTAL).

For this project, VI-grade is proposing, as option, the usage of SCANeR by OKTAL for traffic and ADAS applications. SCANeR features an official interface with VI-CarRealTime vehicle model which makes it easy to use the two software modules together on driving simulators.

SCANeR™ Studio is a worldwide-recognized solution for Human-in-the-loop engineering studies.

SCANeR™ Studio is a dedicated engineering solution developed by automotive engineers for the automotive engineers. Car manufacturers and their suppliers use SCANeR™ Studio for advanced ergonomics studies, ADAS development and driver behavior studies.

SCANeR studio allows:

- Driving simulation performance with an extremely low transport delay between driver action and simulation restitution
- High end graphics
- Artificial intelligence for traffic and pedestrians
- Driver monitoring (trackers, video, etc.)
- Intuitive scenario production with a 3D GUI and access to all the simulation data.
- Post processing: all the data are synchronized (including videos) and can be analyzed with a user friendly environment
- Powerful development tools for the engineers:
  - Simulink with ready to use libraries
  - LabView toolboxes
  - C++ with many samples.
  - Flash interface

SCANeR is open software: any part of SCANeR can be replaced by the user, all the variables are available for the users, and they are recorded. The API is included and there is no license restriction for the API based SCANeR module.

This offer includes the adequate configuration of SCANeR™ Studio allowing, among other features:

- VI-CarRealTime for Vehicle dynamics
- Road network creation (RoadXML format)
- Traffic simulation
- Data logging

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SCANeR Visual provides high quality image rendering, in real-time with all the state of the art quality levels (HDR, BRDF, dynamic reflections, ambient occlusion...).

SCANeR has been already implemented by VI-grade on 4 DiM simulators and several STATIC Simulators.

**Other interfaces**

In case customer wishes to use a different traffic simulation software, VI-grade has also experience with following softwares:

- PreScan by TASS
- VIRES by VTD
- Slab by Wurzburg Institute

**Included default scenarios**

<table>
<thead>
<tr>
<th>Track</th>
<th>Description</th>
<th>Picture</th>
</tr>
</thead>
</table>
| 3-lanes Infinite Straight | • Created from CAD data  
• Good for familiarization with driving simulator  
• Good for steering wheel feeling  
• Possibility to have other cars in the scenario | ![Picture](https://via.placeholder.com/150) |
| #1          |                                                                             |         |
| Highway (AutoBahn 66) | • Created from CAD data  
• Good for familiarization with driving simulator  
• Good for steering wheel feeling  
• Good for high speed behavior  
• Good for LKA development and validation | ![Picture](https://via.placeholder.com/150) |
| #2          |                                                                             |         |
| Proving Ground | • Large Flat Proving ground for typical vehicle dynamics maneuvers  
• Typical markings for most common maneuvers (e.g. ISO Lane Change, Slalom, Constant Radius cornering...)  
• Cones can be positioned according to configuration file  
• μ split area for ABS testing  
• Collisions with cones | ![Picture](https://via.placeholder.com/150) |
| #3          |                                                                             |         |
| Calabogie Track | • Created from Laser scan data  
• Good handling track with both slow velocity corners and high velocity corners  
• Good for dynamic set up of the car | ![Picture](https://via.placeholder.com/150) |
| #4          |                                                                             |         |
Here below is a detailed picture of the VI-grade Proving Ground that can be used for vehicle dynamics maneuvers like ISO Lane Change, Slalom, Constant Radius Cornering and others. Cone positions are completely parameterized and user can change their positions into a configuration file. Collisions are also implemented and user gets a visual and sound warning when a cone is hit.

All scenarios are composed by:
- Road data files (to be used in conjunction with VDM)
- Graphic scenario

All scenarios provided by VI-grade support 3D road profiles and it is possible to modify road characteristics such as friction coefficient.

To create new scenarios, user has to model them using 3D StudioMax and then import those files into VI-GraphSim environment. If requested, VI-grade can provide a specific training on how to do these operations in 3D StudioMax. Import to VI-GraphSim must be done by VI-grade.

VI-grade supports following road formats:
- OpenCRG
- OpenDrive
- RDF
- RGR (with FTire)
- User

Under RDF definition, are included also all VI-grade roads such as analytic, measured and meshed. We can also convert into meshed road graphic files in wavefront format.

With USER road data file, we can support external road data files such as Terrain Server.

Together with VI-GraphSim, VI-grade will also provide a 3D graphical representation of a C-segment vehicle model (including interior details such as dashboard and instrumentation and audio files).
SCANeR European Database

This European environment includes:

- European traffic signs
- Right hand driving
  - A) a village
  - B,C,D) a 18km highway
  - E) a 18km mountain road with 800m of elevation
  - F) a snowy village
  - G) a city
  - H) the test surface areas (parking, hangars)

More than 100km of road to drive
Under request, we can also provide the following databases:

- North American database
- City database
- N104 database
Data log, post processing and telemetry

The ultimate goal of a driving session on a driving simulator is to make important decisions about the car you are developing and/or improving.

Decisions can be made based on subjective evaluation of the driver, but it is also extremely important to analyze carefully all vehicle data, that can provide powerful supporting information for strategic engineering decisions.

In collaboration with Magneti Marelli Motorsport, VI-grade implemented Wintax VI-grade, a professional tool that allows capturing the data stream from the driving simulator to the real-time computer where the data can be visualized in real-time. Or the data can be exported into all most widely used formats (e.g. ASCII, csv…) for synchronized comparison with data coming from off-line simulations or from the test track.

All data coming from the real-time vehicle model or from the environment as well as BioTelemetry data can be visualized in Wintax VI-grade and exported.

Wintax VI-grade has been specifically designed for VI-grade Driving Simulators and leverages the experience by Magneti Marelli Motorsport in collecting and handling large data sets of vehicle data.

To summarize, the picture below shows the entire Ecosystem that VI-grade put together around the VI-DriveSim technology. Basically VI-DriveSim is a complete software bundle that allows users to use all VI grade technology for Driving Simulators but, at the same time, it is an open architecture that allows to interface with 3rd party softwares and protocols.

VI-grade Driving Simulator Software and Hardware Ecosystem
Services

VI-grade is able to provide the following services activities in order to help customers to implement a professional driving simulator:

- Project Management
- Virtual Vehicle modeling
- Graphic scenarios modeling (starting from laser scan data, GPS data or other kind of data)
- Cockpit set up and integration
- Projection and audio systems (incl. sound recording)
- Real-time computing optimization
- Installation and Training
- Turn-key solution

Please see cost table to check which services are included in the current proposal.

Project Management

A Project Manager who is responsible for the complete scope of the project will manage the project.

The Project Manager understands not only organizational items, but also timing and cost items. The project Manager will maintain contact with the customer at set intervals. Contact will be through telephone, e-mails and on-site visits.

Project Manager will take care of following activities (among others):

- Link between end user and VI-grade and suppliers
- Make time planning for the entire project and make sure the time plan is respected
- Execute and maintain project checklist
- Inspect installation site and make sure everything is done according to specifications provided by VI-grade
- Make sure all components are ordered in a timely manner
- Make sure end user provides all needed infrastructures and equipment for unloading and installing all components (PC, projectors, cylindrical screen, …)
- Organize periodical conference calls with end user and VI-grade to track project progress and status
- Make sure all safety requirements are met
- Make sure all applicable standards are met
- Collect customer's questions and feedback
- Keep contacts with local representatives of suppliers (e.g. BARCO…)
- Join onsite visits
- Supervision of installation
- Supervision of Site Acceptance Tests (SAT)
System Integration Services

VI-grade is able to provide a turnkey solution and doing so means that we are also able to integrate all different software and hardware components into a fully functional driving simulator.

Here is a list of services VI-grade is able to provide based on customer's request:

Vehicle model creation and validation
Upon request, VI-grade can support end user in modelling and validating real-time vehicle models to be used online on the simulator. Vehicle models will be done in VI-CarRealTime (starting from Adams Car or CarSim or K&C measurements) environment and they will be optimized for usage on the simulator.

Test Track and Graphic scenario modelling
VI-grade, together with partners, is able to laser scan any kind of road as well as test track. From laser scan point cloud then VI-grade has skills to generate road data file and graphic environment for VI-GraphSim and traffic environments such as SCANeR, PreScan and VTD.

Projectors setting, calibration, and image blending
VI-grade and its partners are able to provide additional services to optimize projector performances and to minimize latency for optimal driver experience.

Real-time computers installation and set up
Real-time computer is the core of the real-time computation on the simulator since the vehicle model and the real-time database will be installed there. VI-grade will deliver real-time computer as part of the complete delivery. Furthermore VI-grade can provide optimization of real-time computer performance upon request.

Training
VI-grade will instruct the end user how to operate, maintain and troubleshoot the simulator. Training is delivered right after the installation of the driving simulator. VI-grade assumes that training attendees will have enough technical background and skills in mechanical engineering and vehicle dynamics. Training must be attended by those persons who will be in charge for the daily operation of the driving simulator.

Final sign-off and commissioning
Once Driving Simulator is installed, site acceptance tests ("SAT") will be performed by VI-grade personnel based on VI-grade SAT procedures. Once SAT will be completed, end user is expected to sign delivery documents. Note that VI-grade will perform SAT with the complete VI-DriveSim software package (incl. VI-CarRealTime, VI-GraphSim, VI-MotionCueing, VI-SteeringTorque, SimworkBench).

CE Marking
The CE marking (an acronym for the French "Conformite Europeenne") certifies that a product has met EU health, safety, and environmental requirements, which ensure consumer safety. Manufacturers in the European Union (EU) and abroad must meet CE marking requirements where applicable in order to market their products in Europe.

Together with a partner company, VI-grade provides CE marking certification for the complete assembled machine. If different safety marking will be locally required (outside Europe), then additional discussion is required among parties. Costs incurred for this additional certification will be quoted separately.

Support (local and remote)
After installation, it is key to support users to speed up the learning process of using a driving simulator within the development process. VI-grade provides both local support and remote support. It is worth to note that VI-grade has an identical COMPACT STATIC driving simulator in its premises in Italy and this makes it very easy to exchange models with users and help them in optimizing everything for the usage on the simulator.
**Economic Offer**

**Option 1 – Purchase of a COMPACT Static Simulator**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Qty</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td>Compact Simulator Cylindrical Screen - Diameter: 4 m - angle 70°</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F-50 projector – WUXGA</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compact Simulator Projector Support</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PC-to-Projector Cables</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows PC for Image Generation</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows PC for Broadcast and Sound</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Windows PC for Vehicle Solver</strong></td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Concurrent-Hawk Hard Real-Time Computer</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Computer Rack</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Broadcast Monitor</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 5+1 Audio System</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Steering Wheel Torque Feedback Unit</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Set of Shakers for High Frequency</td>
<td>[1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Various Material</td>
<td>[1]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software</th>
<th>[Qty]</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI-DriveSim STATIC 1 Channel (Annual License) - including</td>
<td></td>
</tr>
<tr>
<td>- VI-CarRealTime,</td>
<td>[1]</td>
</tr>
<tr>
<td>- VI-GraphSim,</td>
<td></td>
</tr>
<tr>
<td>- VI-MotionCueing,</td>
<td></td>
</tr>
<tr>
<td>- WinTas VI-grade,</td>
<td></td>
</tr>
<tr>
<td>- Steering Wheel Feedback</td>
<td></td>
</tr>
<tr>
<td>- Concurrent SimworkBench</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Services</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compact Simulator System Integration</td>
</tr>
<tr>
<td></td>
<td>Compact Simulator Project Management</td>
</tr>
<tr>
<td></td>
<td>Seatling Buck Manufacturing and Integration</td>
</tr>
<tr>
<td></td>
<td>Shipment of all Equipment</td>
</tr>
<tr>
<td></td>
<td>Documentation (in English)</td>
</tr>
<tr>
<td></td>
<td>Site Acceptance Test</td>
</tr>
<tr>
<td></td>
<td>Simulator Training</td>
</tr>
<tr>
<td></td>
<td>Travel Expenses</td>
</tr>
<tr>
<td></td>
<td>CE Marking of Completed Machine</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Special University Price</th>
<th>132,000 €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Condition additional discount</td>
<td>22,000 €</td>
</tr>
<tr>
<td><strong>FINAL COST</strong></td>
<td>110,000 €</td>
</tr>
</tbody>
</table>

**NOTE:**

- In exchange of the special additional discount VI-grade requests the following:
  - Press release of the University adoption of the VI-grade driving simulator technology
  - Availability for supporting in the next 2 years the start-up and training phase into 2 installation in Italy / South Europe (total days <= 8 days). This activity will only occur once the University personnel is officially certified as training operator by VI-grade
  - VI-grade will also provide 1-year demo license free-of-charge for the following tracks:
    - Urban Scenario (Trieste)
    - Hockenheim Short
    - Bahrain

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Purchase Order

Purchase order shall be submitted to VI-grade Systems GmbH in writing or through an electronic ordering system.

Purchase order shall be issued to:

VI-grade GmbH
Zum Rosenmorgen 1a
D – 35043 Marburg
VAT No. DE815574407
Email: alessio.lombardi@vi-grade.com

Invoicing Schedule

The following payment schedule will be applied:
- 40% at order acceptance
- 40% before shipment
- 20% after final acceptance

Payment Terms

30 days from invoice date.

Incoterms

DDP Brescia

Cancellation Policy

If the Contract is terminated, end user remains liable for all obligations that occurred prior to the termination date. Furthermore, VI-grade must be reimbursed by Customer for products already taken into production or for products already ordered (at the date of cancellation of the contract) to partners and suppliers of VI-grade by immediate payment of the price for the respective products. In any case VI-grade shall be reimbursed by Customer for any costs resulting from such termination including loss of profits.

Best Regards,

Alessio Lombardi
South Europe Sales Manager
Mobile: +39 348 30 55 785
email: alessio.lombardi@vi-grade.com
Web: www.vi-grade.com
Web: www.driverinmotion.com
Appendix A - VI-grade – Terms and Conditions for the sale and supply of Goods and Services ("Conditions")

INTERPRETATION

For the purposes of these Terms and Conditions of Sale and Supply ("Conditions"):

"Buyer" the person, firm or company which places an order for purchase of Products and/or Services as identified in any such order or Quotation as the case may be.

"Conditions" these terms and conditions of sale and supply as from time to time varied by Supplier.

"Contract" the agreement between Supplier and Buyer arising as a result of Buyer’s submission of an order for Supplier’s Products and Supplier’s written acceptance and/or, in the case of Services, an agreement between such parties for the provision of Services by Supplier, as initiated by a Quotation. Such Contract shall be deemed to incorporate and be governed by these Conditions.

"Products" goods as agreed to be supplied by Supplier to Buyer under any Contract including, Software if any.

"Quotation" a document provided by Supplier describing Product and/or Services offered to Buyer, subject to these Conditions.

"Services" any services which Supplier has agreed to provide using reasonable care and skill under any Quotation or Contract, as applicable.

"Supplier" VI-grade Systems GmbH or any of its Affiliates as named in any Quotation. In this context, an "Affiliate" means any other entity directly or indirectly controlled by Spectris Plc.

2. BASIS OF SALE - THESE CONDITIONS SHALL TAKE PRECEDENCE OVER ANY TERMS AND CONDITIONS WHICH APPEAR IN BUYER’S ORDER OR IN ANY DOCUMENTS INCORPORATED BY REFERENCE IN BUYER’S ORDER.

No term or condition of Buyer’s order additional to or different from these Conditions shall become part of any Contract unless explicitly agreed to in writing by Supplier. Retention by Buyer of any Products delivered by Supplier, receipt by Buyer of any Services performed by Supplier or payment by Buyer of any invoice rendered hereunder, shall be conclusively deemed acceptance of these Conditions. Supplier’s failure to object to any provision contained in any communication from Buyer shall not be construed as a waiver of these Conditions nor as an acceptance of any such provision.

3. QUOTATIONS

Prices, specifications and delivery date referenced in Supplier’s Quotations are for information only and shall not be binding on Supplier until all technical requirements have been agreed and Supplier has accepted Buyer’s order. Quotations terminate if Buyer does not place an order with Supplier within any express period indicated by Supplier or after 60 days, whichever comes first.

4. ORDERS

By submitting an order to Supplier, Buyer agrees to be subject to these Conditions in their entirety. No order, whether or not submitted in response to a quotation by Supplier, shall be binding upon Supplier until accepted in writing by Supplier.

5. PRICES AND TAXES

The prices for Products and Services will be as set out in the Quotation or as otherwise agreed between the parties in writing. As and when applicable to the Products sold and/or Services supplied under any Contract, prices do not include taxes, transport charges, insurance and export and/or import charges or duties, including without limitation sales, value added tax, use or excise taxes, which taxes and other charges may, in Supplier’s discretion, be added by Supplier to the price or billed separately and which taxes and other charges shall be paid by Buyer unless Buyer provides Supplier with any necessary tax exemption certificate. Buyer shall pay for taxes, transport charges, insurance, export/import charges and duties unless agreed otherwise in writing.

6. SHIPMENT AND DELIVERY

6.1 Unless otherwise agreed by both parties in writing, Supplier shall arrange for delivery of Products Free Carrier (FCA Incoterms 2010) to Supplier’s manufacturing facility (or an international) airport close to Supplier’s manufacturing facility as agreed between the parties. Any dates quoted or agreed for delivery of Products or provision of Services are approximate only and Supplier shall not be liable for any delay however caused and time is not of the essence.

6.2 Supplier reserves the right to make delivery of Products and provision of Services by instalments and to issue a separate invoice in respect of each instalment. When delivery is to be by instalments or Supplier exercises its right to deliver by instalments or if there is delay in the delivery of any one or more instalments for whatever reason Buyer shall not be entitled to treat the Contract as a whole as repudiated.

7. RISK AND PASSING OF TITLE

Title to, and risk of loss and damage to the Products shall pass to Buyer on delivery in accordance with Section 6 unless agreed otherwise by the parties in writing. Any claims for loss, damage or misdelivery shall be filed with the carrier and notified to Supplier within 5 days of the date of delivery. If installation is a requirement of the Contract and such installation is delayed by more than 28 days from the agreed delivery date for reasons not attributable to Supplier, then, to the extent allowed by applicable law, the Products shall be deemed accepted and Supplier shall be entitled to invoice the remaining balance of the Contract in full. Invoking the remaining balance does not relieve Supplier from its installation obligations in accordance with the applicable term in the Contract.
8. SERVICES
8.1 Supplier shall provide Services in accordance with these Conditions and the terms of the relevant Contract.
8.2 Buyer shall, upon Supplier's reasonable request and otherwise as required, provide Supplier with all necessary information and materials to enable Supplier to provide Services in accordance with the terms of any relevant contract. Buyer will be responsible for the completeness and accuracy of all such information and materials provided, and will ensure that it is and remains entitled to provide the same to Supplier for use in connection with provision of the Services.

9. TERMS OF PAYMENT
9.1 Each shipment of Products shall be a separate transaction and Buyer will be invoiced on delivery. Notwithstanding the foregoing, if the Products are to be installed by Supplier or a third party acting on its behalf, Buyer may (at Supplier's discretion) be invoiced in accordance with the following payment scheme:
   - 60% of the price upon Buyer's receipt of Supplier's order confirmation;
   - 30% of the price upon delivery of the Products in accordance with Section 6;
   - 10% of the price after acceptance of the Products in accordance with Section 11.
9.2 In the event of a delay in the delivery or acceptance that is not attributable to Supplier, the payment scheme shall not be affected and Buyer shall pay the Installments based upon the initially agreed upon delivery or acceptance date.
9.3 Supplier shall be entitled to invoice Buyer, in respect of Services, yearly or monthly in advance. Terms of payment shall be net thirty (30) days from date of invoice for Products and Services unless agreed otherwise.
9.4 All amounts due under a Contract shall be paid in full by Buyer without deduction, withholding, set-off or counterclaim for any reason whatsoever, whether arising in contract, tort (including negligence), breach of statutory duty or otherwise, save as may be required by law.
9.5 Supplier may, in its sole discretion, determine at any time that Buyer's financial condition requires full or partial payment in advance or the provision of security for payment by Buyer in a form satisfactory to Supplier.
9.6 If Buyer fails to make any payment when due then, without prejudice to any other rights and remedies available to Supplier, Supplier shall (at its option) be entitled: (i) to treat the Contract as repudiated by Buyer; to suspend or cancel further delivery of Products and/or the provision of Services or any part thereof under that Contract or any other Contract between them and claim damages and/or receive reasonable cancellation fees; (ii) to affirm the Contract and claim damages from Buyer; and (iii) to recover, in addition to the payment, interest on the unpaid amount (both before and after judgement) at the rate of 8% per annum above the Royal Bank of Scotland’s prevailing base lending rate from time to time, until payment in full is made. Such interest shall be calculated daily.

10. PRODUCTS
10.1 Supplier may modify specifications provided the modifications do not adversely affect the performance of the Products. In addition, Supplier may furnish suitable substitutes for materials used.
10.2 All descriptions, illustrations and any other information relating to the Products contained in Supplier's catalogues, brochures, price lists, advertising material and any sales or other particulars or literature are made by way of general description, are approximate only and for the general guidance and information of Buyer. They shall not constitute warranties or representations by Supplier nor shall they form part of any Contract.

11. INSTALLATION AND MAINTENANCE OF THE PRODUCTS
11.1 In the event of installation of the Products or the provision of maintenance, the following conditions shall apply and Supplier's price and provision of installation or maintenance are subject to the fulfilment of the following conditions at the expense and responsibility of Buyer:
   i. safe and secure climate controlled on-site storage so that Products and Supplier's tools (as applicable) are protected against theft and any damage or deterioration; any item lost or damaged during the storage period shall be repaired or replaced at Buyer's sole expense;
   ii. the timely and efficient execution and completion of the preparatory works in accordance with all applicable safety, electrical and building codes as well as with Supplier's requirements;
   iii. the availability of Buyer's site to Supplier without obstacles in due time to enable Supplier to start installation or maintenance at the scheduled date;
   iv. the availability of the manpower and equipment necessary to place the Products in their final location or to provide the scheduled maintenance;
   v. the acquisition of all permits, licenses, rights of way, etc. of the pertinent authorities required for or in connection with installation or maintenance to be performed; and
   vi. the availability of all visas or any other permits necessary for Supplier's personnel and for the import and export of tools, equipment, and materials necessary for installation or maintenance to be performed.
11.2 In case any or all of the above conditions are not, not property or not timely complied with, or Supplier has to interrupt its installation or maintenance works, subsequent testing for reasons not attributable to Supplier, the period of completion shall be extended accordingly and any and all additional costs resulting therefrom shall be for Buyer's account.
11.3 Supplier neither assumes liability nor offers any warranty for the fitness or adequacy of the premises or the utilities available at the premises in which the Products are to be installed, used or stored.

12 ACCEPTANCE OF INSTALLATION
12.1 In case of installation of the Products, Supplier shall notify Buyer when the Products installed will be ready for testing and acceptance, inviting Buyer to attend Supplier's standard tests or such tests as may have been agreed upon in the Contract to demonstrate compliance with the agreed specifications and/or to inspect the installation work.

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12.2 If Buyer fails to attend the testing on the date notified, Supplier will commence with the tests according to Supplier's standard test procedures and these tests shall be considered performed in the presence of Buyer and acceptance shall in such case take place on the basis of the results stated in the test certificate signed by Supplier.

12.3 If Buyer rejects the Products installed it should submit to Supplier the reasons for such rejection in detail and in writing within 10 days after completion of the acceptance tests concerned. If, within Supplier's reasonable time of examination, the rejection is justified, Supplier shall as a sole remedy correct the shortcomings as soon as possible and the relevant parts of the acceptance test shall be repeated within a reasonable period of time in conformity which the procedures outlined above.

12.4 Upon acceptance of the Products, Buyer will sign the acceptance certificate. If within 10 days after completion of the acceptance test Supplier shall not have received the acceptance certificate signed by Buyer or a report with a justified rejection, the Products installed shall then be considered as having been accepted by Buyer.

12.5 Minor defects or deviations not affecting the operational use of the Products installed shall be stated in the acceptance certificate, but shall not obstruct or suspend acceptance. Supplier undertakes to remedy such defects as soon as reasonably possible.

13. WARRANTIES

13.1 Supplier warrants that all Products shall be free from defects in material and workmanship under normal use for a period of (twelve) 12 months from delivery. In the event of installation this warranty period shall be for (twelve) 12 months from installation or eighteen (18) months from dispatch, whichever comes first, save that Supplier does not warrant operation of the Software (defined in Section 15) will be uninterrupted or error free or that all program errors will be corrected. This warranty does not include any consumables such as filaments, lamps, fuses or other parts, which fail as a result of normal usage. Buyer shall be responsible for determining that the Product is suitable for Buyer's use and that such use complies with any applicable law. Provided that Buyer notifies Supplier in writing of any claimed defect in the Product immediately upon discovery and any such Product is returned at Buyer's risk to Supplier, Transportation charges prepaid, within the warranty period in accordance with Section 13.1 and upon examination Supplier determines to its satisfaction, after a reasonable period to inspect such Products, that such Product is defective in material or workmanship, Supplier shall, at its option, repair or replace the Products, shipment to Buyer prepaid.

13.2 Supplier shall have a reasonable time to make such repairs or to replace such Product. Any repair or replacement of Products shall not extend the period of warranty. The warranty is limited to a period in accordance with Section 13.1, without regard to whether any claimed defects were discoverable or latent on delivery.

13.3 Supplier shall not be liable for any breach of the warranty or payment of damages in respect of Products supplied if: (i) Buyer makes further use of such Products after giving the notice required in Section 13.1; (ii) the defect or failure arises from Buyer's own fault; (iii) the defect arises from any design, description or specification supplied by Buyer or from other materials or other property supplied by Buyer or from any parts or items that have not been completely manufactured by Supplier (it being understood that items sourced from third parties will be subject to the relevant manufacturer's warranty, as and when applicable); (iv) the defect arises other than out of manufacture, including without limitation improper installation, misuse by Buyer or a third party, neglect or accident; (v) the defect arises out of the use of the Products in conjunction with products or materials not reasonably contemplated by Supplier; (vi) the failure or defect results from Buyer's unauthorized addition to or modification of, or failure to comply with Supplier's written instructions relating to, the Products or Services; and (vii) the failure or defect arises out of any breach by Buyer of its obligations to provide information to Supplier under these Conditions or Contract.

13.4 If Buyer fails to pay within any portion of any payment due from Buyer to Supplier under a Contract or otherwise, all warranties and remedies granted under this Section may, at Supplier's option, be terminated.

13.5 The foregoing warranties are exclusive and exclude all other warranties, terms and conditions, express or implied by statute or otherwise, to the extent permitted by law, including without limitation warranties of quality or fitness for a particular purpose. Supplier's sole and exclusive liability, and Buyer's sole and exclusive remedy for breach of the warranties in this Section 13 shall be as set forth in Section 13.1.

14. LIABILITY

14.1 Nothing in these Conditions or Contract shall exclude or limit Supplier's liability for fraud or death or personal injury caused by its negligence or any other liability to the extent that the same may not be excluded or limited as a matter of law.

14.2 Subject to Section 14.1, in relation to Products, Supplier's maximum aggregate liability under or arising out of any Contract, whether arising in contract, tort (including negligence) or otherwise, shall in no event exceed 100 % of the total amount payable by Buyer in respect of Products under that Contract.

14.3 Subject to Section 14.1 in relation to Services, Supplier’s maximum aggregate liability under or in connection with the supply, non-supply or purported supply of Services under any Contract, whether arising in contract, tort (including negligence) or otherwise, shall in no event exceed 100% of the total amount payable by Buyer in respect of Services under that Contract and in respect of Services continuing beyond one year, shall in no event exceed in any year 100% of the total amount payable by Buyer in respect of Services in that year.

14.4 Subject to Section 14.1, Supplier shall be under no liability to Buyer for any loss of profit, loss of income, loss of use, loss of business, loss of revenue, loss of goodwill, or for any indirect or consequential loss or damage of any kind, in each case, howsoever arising, whether such loss or damage was foreseeable or in the contemplation of the parties and whether arising in tort (including negligence), contract or otherwise.

14.5 Any claim arising out of or in connection with a Contract must be commenced against Supplier within one year from the date upon which Buyer became aware of or should have become aware of Supplier's infringement of Buyer's rights, unless otherwise specified under applicable law.
15. SOFTWARE
Supplier or its suppliers (as the case may be) shall at all times have and retain title and full ownership of all software, firmware, programming routines, and documentation relating to such software supplied by Supplier for use with the Products, and of all copies made by Buyer or the end user of the Products (collectively “Software”). A non-exclusive, non-transferable and non-sublicensable licence to use such Software will be granted to the end user solely for use with the Products.

16. INTELLECTUAL PROPERTY RIGHTS
16.1 Notwithstanding delivery of and the passing of title in any Products and subject to section 15 and 16.3, nothing in these Conditions or any Contract shall have the effect of granting or transferring to, or vesting in, Buyer any intellectual property rights or in or to any Products or Services.

16.2 Buyer acknowledges and agrees that all property, copyright and other intellectual property rights in any work or tangible deliverable item arising from or created, produced or developed by Supplier under or in the course of provision of any Services, wherever in the world enforceable, including without limitations all right title and interest in and to the Services and all documents, data, drawings, specifications, articles, sketches, drawings, reports, inventions, improvements, modifications, discoveries, tools, scripts and other items relating thereto shall immediately upon creation or performance vest in and shall be and remain the sole and exclusive property of Supplier and Buyer shall acquire no right, title or interest in or to the same except as expressly stated in these Conditions.

16.3 The Supplier grants to the Buyer a non-exclusive, non-transferable and non-sublicensable licence to use such of the Works as are necessary, and to the extent necessary, for the end user to obtain and utilise the intended benefit of the Services.

16.4 If any claim is made against Buyer that the Products or Services infringe the patent, copyright or other intellectual property rights of any third party, Supplier shall indemnify Buyer against all losses, damages, costs and expenses awarded against, or incurred by, Buyer in connection with the claim or paid, or agreed to be paid, by Buyer in settlement of the claim provided that: (i) Supplier is given full control of any proceedings or negotiations in connection with any such claim; (ii) Buyer shall not make any admission of liability and shall give Supplier all reasonable assistance for the purposes of any such proceedings or negotiations; (iii) except pursuant to a final award, Buyer shall not pay or accept any such claim, or compromise any such proceedings without the consent of Supplier; (iv) Buyer shall do nothing which would or might vitiate any insurance policy or cover which Buyer may have in relation to such infringement and shall use its best endeavours to recover any sums due thereunder and this indemnity shall not apply to the extent that Buyer recovers any sums under any such policy or cover; (v) Supplier shall be entitled to the benefit of, and Buyer shall accordingly account to Supplier for, all damages and costs (if any) awarded in favour of Buyer which are payable by, or agreed with the consent of Buyer (which consent shall not be unreasonably withheld) to be paid by, any other party in respect of any such claim; and (vi) without prejudice to any duty of Buyer, Supplier shall be entitled to require Buyer to take such steps as Supplier may reasonably require to mitigate or reduce any such loss, damages, costs or expenses for which Supplier is liable to indemnify Buyer under this section 16.4, which steps may include (at Supplier’s option) terminating use of the Product or Service, accepting from Supplier non-infringing, modified or replacement Products or Services.

16.5 Supplier shall have no obligation or liability under Section 16.4 insofar as the infringement arises from: (i) any additions or modifications made to the Products and/or Services in question, otherwise than by Supplier or with its prior written consent; (ii) any information provided by Buyer to Supplier including without limitation any specification; (iii) performance by Supplier of any work required to any Products, or performance of any Services, in compliance with Buyer’s requirements or specifications; (iv) a combination of the Product with or an addition to equipment not manufactured or developed by Supplier, or (v) the use of Products beyond that scope established by Supplier or approved in writing by Supplier.

16.6 Without prejudice to Section 14.1, this Section 16 states the entire liability of Supplier and the exclusive remedy of Buyer with respect to any alleged infringement of intellectual property rights belonging to a third party arising out of or in connection with the performance of any Contract. This Section 16 shall be subject to the limits of liability in Sections 14.2.

17. FORCE MAJEURE
Notwithstanding anything to the contrary in these Conditions, Supplier shall not be liable to Buyer for any loss or damage which may be suffered by Buyer as a direct or indirect result of the supply of Products or Services being prevented, delayed or rendered uneconomic by reason of circumstances or events beyond Supplier’s reasonable control. If due to such circumstances or events Supplier has insufficient stocks to meet all its commitments Supplier may apportion available stocks between its customers at its sole discretion.

18. CONFIDENTIAL INFORMATION
Each party undertakes to keep confidential, not use for its own purposes outside the agreed scope and not without the prior written consent of the other party disclose to any third party, any information of a confidential nature belonging or relating to the other party which may become known to it unless such information is or becomes public knowledge (other than by breach of this Section) or is required to be disclosed by order of a competent authority.

19. CANCELLATION, RESCHEDULING AND TERMINATION
19.1 Orders for Products accepted by Supplier may be cancelled or rescheduled by Buyer only with the written consent of Supplier (which consent Supplier may withhold for any reason) and Buyer shall indemnify Supplier against the cost of all labour and materials used in connection with the order so cancelled or varied and against all loss, damage cost, charges and expenses suffered or incurred by Supplier as a result of that cancellation or variation. Contracts for Services shall commence on the commencement date identified in the relevant Contract and, subject to earlier termination in accordance with Section 19.2, shall continue in force for the initial term as prescribed in such Contract and thereafter for any renewal period (if any) set out in the Contract and thereafter without limit of period unless or until terminated by either party in accordance with 19.2.

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19.2 Either party may terminate a Contract for Services immediately at any time by written notice to the other party. If the other party commits a material breach of the Contract for Services which is incapable of remedy or which fails to be remedied, notwithstanding the foregoing, either party may terminate a Contract for Services by giving ninety (90) days written notice to the other party.

19.3 Upon termination or expiry of any Contract, for Services, each party shall except to the extent permitted or required to exercise or perform its ongoing rights, or obligations hereunder, return to the other party all property of the other party then in its possession, custody or control and shall not retain any copies of the same.

19.4 Termination of any Contract in accordance with these Conditions shall not affect the accrued rights or liabilities of the parties at the date of termination.

20. INSOLVENCY OF BUYER

If: (i) Buyer becomes insolvent, has a receiver, administrative receiver, administrator or manager appointed of the whole or any part of its assets or business, makes any composition or arrangement with its creditors, takes or suffers any similar action in consequence of debt or an order or resolution is made for its dissolution or liquidation (other than for the purpose of solvent amalgamation or reconstruction) or carries on or understructures any analogous act or proceedings under an applicable foreign law; or (ii) Buyer ceases, or threatens to cease to carry on business; then, without prejudice to any other right or remedy available to Supplier, Supplier may treat any Contract as repudiated and/or withhold any further supply of Products and/or Services without any liability to Buyer and, if any Products and/or Services have been supplied but not paid for, the price or prices shall become immediately due and payable notwithstanding any previous agreement or arrangement to the contrary.

21. EXPORT CONTROL

21.1 Buyer understands that where Supplier’s obligations under the Contract to supply any Products or Services are subject to governmental export control laws and regulations, the performance of this Contract and Buyer’s use or export of any Products delivered by Supplier shall be conditional upon the grant of all necessary permits or licences. Buyer shall provide all information and documentation, including where necessary end user certification, not in Supplier’s possession and required by the relevant application procedure to enable Supplier to make the necessary applications for permits or licences required for deliveries to Buyer. Supplier shall be relieved from its obligations to Buyer to supply any Products or Services to the extent that applications for permits or licences for the same are refused by a relevant governmental authority. To the fullest extent permitted by law, Buyer shall have no right to claim compensation for damages, loss of business or otherwise arising from such a refusal or Contract termination.

21.2 Buyer shall not, directly or indirectly, sell, provide access to, export, re-export, transfer, divert, loan, lease, consign, transport (including stop in port), transport, or otherwise dispose of any Supplier’s Product, material, Software (including source code) or technology to, via, or for: (i) any entity known to be headquartered in, or owned or controlled by a national of, any country or region subject to comprehensive sanctions at any time; (ii) any other individual or entity identified on a denied or restricted party list; or (iii) any activity or end-use restricted by applicable laws without first obtaining all required government authorisations.

21.3 Supplier shall have the right, at its option, to suspend performance under or terminate any Contract if: (i) applicable comprehensive sanctions are imposed; (ii) the Buyer is designated as or determined to be a denied or restricted party under applicable law; or (iii) where the Supplier’s obligations under these Conditions or any Contract to supply any Products or Services are subject to governmental export control laws and regulations, the performance of any Contract and Buyer’s use or export of any item delivered by Supplier shall be conditional upon the grant of all necessary permits or licences.

22. GENERAL

22.1 These Conditions and any Contract shall be governed by the laws of England and Wales. The parties agree that the United Nations Convention on Contracts for the International Sale of Goods is specifically excluded from application to these Conditions. The parties shall agree to settle any claims or disputes arising out of or in connection with these Conditions or any Contract by amicable negotiations. If no settlement can be reached through negotiations within sixty (60) days after either party has served written notice to the other requesting such negotiations, then the dispute shall be submitted to the exclusive jurisdiction of English courts, but Supplier shall be entitled to bring a claim against Buyer in court of competent jurisdiction.

22.2 Failure by Supplier to exercise or enforce any rights hereunder shall not be deemed to be a waiver of any such right.

22.3 If any Conditions are found to be invalid, this shall not affect the rest of the Contract, which shall remain in full force and effect.

22.4 Buyer may not assign, transfer, novate or otherwise dispose of all or any of its rights or obligations, in whole or in part, without the written consent of Supplier.

22.5 These Conditions constitute the entire agreement and supersede any prior agreement, understanding, representations or arrangements between the parties with respect to its subject matter.

22.6 Variation to any Contract must be in writing and signed by the parties.

22.7 All notices given under these Conditions shall be sent to the address of the other party set forth in the Quotation or in Contract. Notice shall be regarded as properly given if sent in writing and shall be deemed to have been served on the next working day from delivery if sent by email or fax, and on the day of receipt if sent by express courier or by registered mail.
Quotation

COMPACT Driving Simulator

Proposal Nr. P046b/2019
Issue Date 17.05.2019
Proposal Expires 15.06.2019

To:
Università di Brescia
D1MI - Dipartimento di Ingegneria Meccanica e Industriale
Via Branze 38, I-25123 Brescia, Italy

ATT:
Prof. Ing. Marco Gadola
Automotive Engineering & Design Group
+39.030.3715663
marco.gadola@unibs.it

Revision History

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## Summary

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Marburg, May 17th, 2019

Dear Marco,

Thanks for your interest in our company and in our products.

Reference to your request, here following is our Technical and Economical proposal for a turnkey project to manufacture, integrate, install and commission a VI-grade COMPACT STATIC Driving Simulator at your premises.

VI-grade has multi-years’ experience in implementing engineering driving simulators, both static (no motion) and dynamic simulators with motion platform.

For more info, please visit www.vi-grade.com.

VI-grade in the last years has implemented driving simulators at several leading automotive OEMs, Engineering services companies and universities and it has put together a reliable group of partners. This allows VI-grade to provide system integration services and on-site support to its driving simulator customers.

Should you have any questions, please do not hesitate to contact me.

Yours sincerely,

[Signature]

Alessio Lombardi
South Europe Sales Manager
Mobile: +39 348 30 55 785

email: alessio.lombardi@vi-grade.com
Web: www.vi-grade.com
Web: www.driverinmotion.com

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Introduction

Voice of the customer
"The motivation for driving simulator wasn’t that difficult considering top management is pushing very hard for increased usage of virtual tools. The financial motivation was basically to tie the number of prototype weeks we could remove by using the simulator. The simulator promises to tie together the subjective expertise with the CAE team objective analysis expertise in a way previously not possible, cross pollinating both teams and unifying the whole department. This is simply priceless and my hope is that it will boost knowledge-building and experimentation tremendously."

"I can sense even tiny changes in the setup, like whether the car is under or over-steering."

"The simulator comes very close to reproducing real conditions, and gives the engineers vital insights into vehicle set ups"

"The DiM® is a latest generation simulator used by Ferrari to develop its road cars and adopt leading-edge technologies in its simulations. These provide answers at the design stage that are extremely useful to focusing and accelerating the development of the cars and also to guaranteeing unprecedented performance."

"We also see considerable benefit from conducting active-safety tests that are too dangerous to perform live. For instance, we can now simulate a collision or a puncture at high speed to see how the driver will respond; developing systems to help him or her stop the car safely."

"The use of simulation means that settings can be rapidly tested combining the experiential judgment of a real driver and computer-aided objective data analysis. The beauty of the new simulator is that it provides us with the opportunity to physically experience the calculation models and evaluate them using human test drivers, rather than staring at graphs and numbers in a meeting room."

The Next Step in vehicle development has arrived
Faster-to-market, reduced costs, increased reliability, avoid warranty costs, and the greater influence of advanced controls are some of the current challenges automotive OEM’s have to face when developing new cars. OEM’s must continue to evolve to the next paradigm of vehicle development and part of that includes driving simulators.

Automotive OEM’s use driving simulators to test more variants than ever, to integrate active subsystems, to reduce expensive proving ground tests, and to get feedback from test drivers earlier in the design process. VI-grade specializes in bridging the gap between test and simulation, and our Driving Simulator is that solution.

Integration is the key ingredient of the recipe
It is no longer possible for different departments to only develop their own components and to fulfill their own targets; nowadays developing a successful car is a difficult recipe. Different departments struggle to guarantee that all different subsystems and control systems are working together in harmony. VI-grade Driving Simulators allow OEM’s to integrate all kinds of control systems like hardware-in-the-loop (HIL) and software-in-the-loop (SIL) at the same time. Engineers and professional drivers are now able to meet far earlier in the design process and balance targets long before the full vehicle prototype when only components and subsystems are commonly available in hardware. The driving simulator becomes the integration platform to assure cross-functional targets are met.

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Drive all your favorite roads from your office
Each automotive company has its own preferred test tracks to set up and calibrate their prototypes. But very often these tracks are not close to the R&D centers, much less close to each other. Substantial time and money is spent to test prototypes and environmental conditions can compromise the investment in physical testing.
With VI-grade Driving Simulators, you can test vehicles on all your test tracks with laboratory like consistency. Without leaving your office, you can easily simulate different conditions that you will find on the real track.

It’s what’s inside that counts
At the heart of every driving simulator is a vehicle model. Changing vehicle parameters and testing hundreds of different set ups as if you were on the proving ground is what a driving simulator is all about. With the VI-grade VI-CarRealTime vehicle model, changes are a matter of few clicks. Springs, dampers, tires, bump stops, suspension curves, controller parameters can be changed with just a few keystrokes and the test driver can back up on the track to try new configurations on the same part of the track, in seconds.
Our vehicle model is reliable, robust and fast to solve. Get the most out of driving sessions with VI-CarRealTime. However, should you need to use another real-time vehicle model for legacy reasons or to be compliant with company standards, our technical staff will be available to support you in order to integrate your vehicle model within the simulator environment.

The driver at the center stage
In the end, as it is in a real car, the ultimate success of any driving simulator depends on the satisfaction of the driver, regardless if he/she is a pro driver or an every-day driver. The way the driver interacts with the simulator and the emotions he/she feels can easily be monitored in a controlled environment like the one VI-grade can implement at your premises. Systems like eye trackers and biotelemetry allow engineers to understand driver’s behavior while driving and to identify high distractive elements during the driving sessions.

Making Active Safety even safer
Advanced driver assistance systems (aka ADAS) are becoming popular and an important part of new vehicles. To develop and test these systems, engineers need to replicate and simulate different traffic conditions and unexpected events that might happen while driving. To support this, VI-grade has developed interfaces with the most popular traffic simulation software’s giving you the power to use the simulator and our vehicle models to drive ADAS development earlier and faster. Creating city, rural, and highway scenarios, defining sensors, and developing control strategies can now be done within the driving simulator. VI-grade Driving Simulators make active safety devices development safer and simpler.
Industry applications covered by VI-grade Driving Simulators

Disciplines
- Real-time vehicle dynamics handling and ride
- Comfort & NVH
- Software-in-the-loop ("SIL")
- Hardware-in-the-loop ("HIL")
- Driver model
- Driver model for autonomous vehicles
- Advanced Driver Assistance Systems
- Design-of-Experiment and Optimization
- Human Machine Interface ("HMI")
- Driving Simulation (with and without motion platform)
- Fuel Economy

Applications
- Vehicle Development
- Vehicle Dynamics (Drivability, Agility, Stability)
- Primary & Secondary Ride
- NVH
- Control System development and testing
- Traffic Simulation and ADAS development
- HMI
- Autonomous vehicles
- Driver Training
- Human Psychometrics studies (biotelemetry, driver’s reaction to stress)
- Motorsport activities

Services
- Virtual Vehicle modeling
- Graphic Scenarios modelling
- Cockpit implementation & integration
- Visual and audio systems
- Sound recording and post processing
- Driver’s reactions monitoring
- Rtmi tinnen computing optimization
- Installation
- Training
- System Integration
- Turnkey solutions
Proof of Application
DiM® Reference Projects

Figure 1: Vi-grade Dynamic Simulator DiM® at Volvo Car Corp. in Gothenburg (Sweden)

Figure 2: Vi-grade Dynamic Simulator DiM® at Ferrari S.p.A. in Maranello (Italy)
Courtesy of Quattroruote Magazine (January 2013 issue)

Figure 3: Vi-grade Dynamic Simulator with DiM® platform at Porsche in Weissach (Germany)
Figure 7: VI-grade Dynamic Simulator with DiMB platform at FCA LATAM in Belo Horizonte (Brazil)

Figure 8: VI-grade Dynamic Simulator with DiMB platform at VI-SimCenter

Figure 9: VI-grade Dynamic Simulator with DiMB platform at Saginomiya in Salama (Japan)
Figura 10: Honda will become the world’s first vehicle manufacturer to adopt new state-of-the-art driving simulator technology, based on a revolutionary architecture called DIM250 (Driver-in-Motion).

http://www.honda.co.uk/news/news/2012/12/12/Honda-DIM250.html

Figura 11: DIM250 @ Mercedes-AMG

Figura 12: DIM250 @ IDIADA

Figura 13: DIM250 @ Multimatic, USA
All VI-grade Simulators Worldwide

In addition to DiM projects shown above, it is worthwhile to mention that VI-grade implemented and currently maintains more than 40 simulators:

- 10 DiM150 simulators
- 2 DiM250 simulators
- 4 DiM250 additional simulators (to be installed in first half of 2019)
- 12 STATIC simulators
- 17 COMPACT simulators
- 4 dynamic simulators based on other hardware

These simulators are located in Europe, North America, South America and Asia Pacific.

VI-grade Driving Simulator Technology

VI-grade provides both static and dynamic turnkey solutions for driving simulators.

VI-grade's software technology for driving simulation, called **VI-DriveSim**, is capable of working, in the same exact configuration, both on a static and on a moving platform simulator. This proposal is about the supply of a COMPACT STATIC simulator.
Hardware

Each driving simulator is different from another one, but in principle, it can be said that all COMPACT STATIC driving simulators provided by VI-grade include following hardware components:

- 100° Flat Screen / Fixed Cylindrical Screen (typically R-2500 G-120 H-2400)
- Projector and Support
- Aluminum structure
- Seat
- Pedals
- Steering Wheel Torque Feedback Unit
- Real-time iHawk Linux computer for real-time computing
- IG PC
- PC and screens for broadcasting images and for analyzing telemetry data coming from the vehicle
- Steering wheel motor and controller (including power box)
- Audio System
Steering Wheel Torque Feedback Unit

VI-grade cockpits are always provided with Steering System Torque Feedback unit. The system is composed of following components:

- Phase Electric Motor (various models of the ULTRACT III series are supported) see below for more details.
- Phase AxN motor drive programmed by VI-grade.
- Serial (RS-232) connection from a Windows PC to AxN drive.
- Depending on the industrial fieldbus used one of the following solutions is needed:
  - For CANbus connection with the drive:
    - ESD PCI 405 CANbus board with 2/4 separate channels
    - CANbus connection from AxN drive to ESD board
  - For EtherCAT connection with the drive:
    - A free network card connection on the VI-DriveSim machine
    - EtherCAT connection from AxN drive to network board

We typically use a Phase U03512/1500 "low cogging" motor type with these characteristics:

- Nominal 13 Nm torque
- Peak torque 30 Nm
- Latency: 4 maec
- Encoder resolution: 1E-5 vdeg

The picture below is a schematic representation of connections (for CANbus solution) between VI-DriveSim PC and the steering wheel system.
Additional devices

VI-Biotelemetry

VI-grade develops VI-BioTelemetry (consisting of hardware and software parts) which is able to measure the stress level of a driver during an action on a driving simulator or on a real car. The VI-BioTelemetry package includes the following functionalities:

- Measure of Heart Rate Variability ("HRV")
- Measure of Skin Potential Response ("SPR")
- Eye Tracking
- Calculation of stress indexes
- Interface with the WINTAX VI-grade log data software
- Interface with VI-grade Real-Time Database
- Correlation with stressors for DS acceptance (special maneuvers on the DS with and without traffic)
- Correlation with stressors for traffic navigation (maneuvers on real and/or virtual traffic environment, under self or robot driving)

Heart Rate Variability

To measure heart rate the equipment showed in the following picture is used:

A sport-type shirt or a high conductivity soft tissue with 5 electrodes is worn by the driver and 3 ECG signals are measured. From the best of the 3 ECG signals the RR(t) (time domain variation of the heart rate) and HRV (Fast Fourier Transform of the RR(t)) diagrams are derived automatically by specialized algorithms.

Skin Potential Response

The Skin Potential Response (SPR) is a measure of the activity of the nervous cells which control the activity of the sweat glands under the skin, in correspondence of some characteristics points on the hand, under the armpit, on the side of the head or in the cave of the foot. To measure the SPR the equipment showed in the following picture is used:
SPR complements the HRV measurement with a faster response (1.5-2s delay from the stressor source trigger time) of the variation stress level of the driver. A typical SPR curve during a test with the presence of stressors (pylon avoidance during driving) in the scene is illustrated in the following picture.
VI-BioTelemetry has a special pattern recognition algorithm to identify the starting point, the duration and the intensity of the SPR discharge peak (in the range of few millivolts, similar to the ECG signal). A special algorithm has been implemented to de-correlate possible artefacts (such as hand pressure on the steering wheel, muscle contraction due to steering turning, etc) from the clean signal coming from the central nervous system.

A special electronic board has been developed to connect to the conductive elements that enable the measure of both HRV and SPR, both via BLE and WIFI to the host PC. The board (VI-BioBox) and its HW characteristics are illustrated in the following picture:

Electronic board to collect all data from VI-BioTelemetry
Eye Tracking System

Smart Eye Pro is SMART EYE’s flexible and robust eye tracking solution for various environments.

It consists of a true multi-camera system running on a single PC and on a single algorithm. The system is scalable from 2 up to 8 cameras allowing 360 degrees head and eye tracking. Free and wide placement of cameras both horizontally and vertically enables the possibility to handle even the most complex of applications.

Operating under Infra-Red (IR), Smart Eye Pro is completely insensitive to ambient light, making it suitable for projects in all levels of darkness and sunlight.

VI-grade has installed Eye Tracking Systems on several simulators and it has the same system on its dynamic simulator in Italy.

The Eye tracking system quoted in this proposal consists of following components:

1) **SmartEye Pro 3-camera system 60Hz 1.3 MP**
   - Software license, SmartEye Pro 6.1 60 Hz
   - 1 PC desktop (incl. keyboard, screen and mouse)
   - 3 cameras 1.3 MP, including lenses and filters
   - 2 Flashes 60 Hz
   - 1 Exponentor-7
   - 3 sets of cables
   - 1 Calibration Chessboard
   - 1 Mounting kit got 3 cameras
   - 1 Smart Support, one year

2) **Mapps Basic analysis software**

3) **2-days On-site commissioning and training**

**TECHNICAL SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Sampling Rate</th>
<th>60 Hz (with up to 8 cameras) 120 Hz (with up to 4 cameras)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of View</td>
<td>90°-360° (depending on number of cameras)</td>
</tr>
<tr>
<td>Head Box (freedom of head movement)</td>
<td>For a typical 2 camera screen measurement set up (5mm lenses): 40 x 40 x 50 (typ); Adjustable with lenses and positioning of cameras</td>
</tr>
</tbody>
</table>
| Tracking Accuracy | Head: Rotation 0.5 degrees (typ.)  
                      Gaze: 0.5 degrees (typ.) |
| Output | TCP / UDP / CAN (optional) |
| Delivered data | Head tracking (BOOF), eye position, eye gaze, pupil diameter, Saccades, fixations, blinks, eyelid opening and many more. |
| Recovery Time (Blink / Tracking Lost) | Immediate |
| Optimal Camera – Eye Distance | 30-300 cm adjustable with lenses and positioning of cameras |
| Eyewear Compatibility | Glasses, contact lenses and sunglasses of non IR type |
| Calibration Mode | Any number of calibration points |
| Eye Tracking Principle | Pupil and iris / Corneal Reflection and Head Mode |

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Additional HMI

During the project, it will be possible to both replace existing dashboard with a virtual one (realized with a minimonitor) and to add HMI devices to the cockpit.

On these HMI devices it will be possible to visualize any kind of parameters coming from the simulation (from vehicle model, from external environment, from traffic, from driver ...). Additional HMI devices can have any kind of graphical layout decided by customers.

Image below shows an example of additional HMI added to a VI-grade cockpit.

Programmable Dashboard on VI-grade cockpit

Additional HMI devices on VI-grade cockpit
ADAS & AD Systems

Driving simulators are more and more used for ADAS and AD development. This is due to the fact that simulator allows engineers to perform tests in a much safer environment, in a more repeatable and controlled way and in quicker time compared to using real prototypes on real roads. Having this in mind, VI-grade has interfaced GPUs from Nvidia and cameras to its driving simulators. This allows engineers to have on the simulator the same working environment they have on a prototype and to perform feasibility studies as well as validation of ADAS systems. Pictures below show what has been done recently in order to connect Nvidia Drive PX-2 and cameras with VI-grade Driving Simulator.
Additional Cues – Active Belt System

VI-grade has developed an active belt system (3 or 6 points belts) which allows for both shoulder and belly segment symmetric pulling, depending on vehicle longitudinal de/acceleration. The active belts could work in sync with the active seat (see below) and is adaptable to any kind of seat (passenger car and racing car). The active belts could be installed on any static and dynamic simulator. On DIM® and other Driving simulators provided by VI-grade the functionality is controlled by the VI-MotionCueing logic which takes into account vestibular as well as somato-sensory physiological models to minimize the difference between in-car and on-sim driver dynamic perception. On other motion platforms, the control logic can be interfaced with existing motion cueing algorithm.

The system is composed of:

3. Hardware
   - Belts
   - Pneumatic muscle for belt pulling
   - Data and power cables
   - Action cables and connecting bars
   - On board controller box, filter, switches
   - Power Box (could be integrated in steering system box)

2. Software
   - VI-DriveSim compatible control logic to control:
     - action cut-off frequency
     - steady intensity (preload)
     - acceleration action multiplier [Kg/g], subtracts from preload
     - braking action multiplier [Kg/g], adds to preload
     - acceleration unload value

The controller is connected and driven with the VI-grade ETHERCAT standard protocol to the CCUR real-time PC. Both hardware and software are customizable depending on cockpit installation/customer requests.
Additional Cues – Active Seat System

Vi-grade has developed an active seat at works in sync with the active belts (if available) and it is adaptable to any kind of seat (both passenger and racing seat).

The active seat could be installed on any static and dynamic simulator. On DiM® the functionality is controlled by the VI-MotionCueing logic which takes into account vestibular as well as somato-sensorial physiological models to minimize the difference between in-car and on-sim driver dynamic perception.

The action on the driver is done using pneumatic bags that are inflated or deflated based on information about the accelerations of the vehicle (longitudinal, lateral and vertical). Inflation of bags is taken care by an external compressor (on DiM Driving simulator it is possible to use the same compressor used for air bearings).

During the driving simulator functioning, vehicle accelerations are developed and processed on the PC where the vehicle model runs in real-time. The pneumatic bag is inflated (or deflated) proportionally to the value assigned by the VI-MotionCueing signal.
The system is composed of:

3. Hardware
- Any custom seat (provided by the end user)
- Proportional valves (9 in the pictures)
- Data and power cables (24V max 300mA)
- 8 Pneumatic bags
- Pipes to connect compressor, valves and pneumatic bags
- Pneumatic box (see image below)

2. Software
- VI-DriveSim compatible control logic to control:
  - action cut-off frequency
  - steady intensity (preload)
  - max/min pressure inside the pneumatic bags

3. System requirements
- Air compressor, Air filter and Air dryer (DiM compressed air can be used also for this device)

The pneumatic bags are positioned inside the foam of the seat and then covered with the original seat cover; in this way the look & feel of the original seat are not modified. When the pneumatic bags are inflated, the pressure is transmitted to the driver body, giving the sensation of transient (max 4Hz) and steady acceleration. The system latency is around 100ms. The controller is connected and driven with the VI-grade ETHERCAT standard protocol to the CCUR real-time PC by means of an AVD conversion box. Both hardware and software are customizable depending on cockpit installation/customer requests.
Computers

This is the list of computers typically used on a COMPACT STATIC Simulator:

- Real-time iHawk Linux by Concurrent Computer
- Windows PCs for graphics (one computer per each projector)
- Windows PC for broadcasting

All computers are then stored into a computer rack.

Minimum specifications for all Windows PCs are:

- GPU Nvidia GTX 1080Ti (or higher)
- Intel i7
- 24 Gb RAM @ 2666 Mhz

In order to ensure the hard real-time computation on the driving simulator, VI-grade utilizes real-time Linux machines from Concurrent Computer. This machine will host the vehicle model, the motion cueing algorithm and all interfaces with the cockpit.

Here following is a short description of main hardware and software components that will be included in the real-time computer (specifications might change without notice):

- iHawk rackmount system
  - one 3.2 GHz Gold 8134 8-Cores CPU
  - 48 GB memory 2400 MHz
  - Dual Gigabit Ethernet ports
  - 7 PCIe slots - 4 unused
  - on-board RAID configured as RAID 1
  - two 2.0 TB 2.5" SSD SATA drives
  - 4U Sata rack chassis (20.5 in. D), 668W power supply, rails
  - DVD+RW (+R DL) / DVD-RAM drive
  - Quadro P4000, 2 GB mem. Graphics
  - Quad Port Gigabit Ethernet PCIe card
  - 64-bit RedHawk Linux real-time OS
  - Real-Time Clock & Interrupt Module
  - 4-ch CAN Interface PCIe card w/breakout cable
  - RedHawk Driver for CAN-402 PCIe Card
  - SWB CAN I/O Module License
  - SimWB Development License For 8 Cores
  - SimWB ML Toolkit License
  - RedHawk Frequency-Based Scheduler 64-bit
  - SWB Network I/O Module License
  - System Integration & test for preceding items
Software

General Operation

VI-grade Driving Simulators are equipped with VI-DriveSim software. VI-DriveSim is the software that supervises all Driving Simulator operations and makes it possible for all software (both VI-grade proprietary and 3rd party software) to work together.

As an example, VI-DriveSim allows following operations:
- Loading Vehicle model
- Loading Driving Scenarios
- Start and Stop the simulation
- Modifying Motion cueing settings
- Performing playback simulations (from recorded RES files)
- Save and Reload (= stop the simulation at any time and re-start the simulation at a specific point in time).
- Managing active belts and seat (if available)
- Managing VI-BioTelemetry parameters (if available)

Vehicle Dynamics

VI-grade develops a real-time vehicle modelling environment called VI-CarRealTime. VI-CarRealTime is part of the VI-DriveSim product suite and it is always installed on all VI-grade simulators. Regardless of the VDM that end-user wishes to use on the Driving Simulator, VI-grade performs all site acceptance tests (SAT) using the complete VI-DriveSim product suite, including vehicle model from VI-CarRealTime.

VI-CarRealTime provides a real-time vehicle simulation environment where the same simplified vehicle model can be used by vehicle dynamics and controls engineers to optimize vehicle and control system performance. VI-CarRealTime is the only real-time solution available in the market that can automatically and seamlessly export a real-time vehicle model directly from ADAMS Car and/or K&C results. VI-CarRealTime also enables to share component property files such as tires, springs, dampers, and bumpstops with ADAMS Car.

VI-CarRealTime provides validated models that can be used by vehicle dynamics and control engineers to optimize their design based on accurate vehicle performance. VI-CarRealTime can be integrated with Matlab Simulink as well as FMI/FMU compatible software for controls systems specific development and to include additional subsystems, such as detailed driveline or hybrid/electric systems, into the vehicle model. VI-CarRealTime helps to reduce the time spent by the different engineering teams to obtain and prepare very often the same data. It also improves the consistency of the engineering approach while providing state of the art technology. The investment pays off because it can be leveraged by many different teams, including Hardware-In-The-Loop and driving simulator departments.

Vehicle models generated by VI-CarRealTime can be used both on Windows and Linux platforms (in this case only the VI-CarRealTime solver runs on Linux, while the GUI will run on Windows).

As mentioned above, VI-CarRealTime is interfaced with Adams Car making it very easy to use same vehicle models for both off-line, detailed simulations and driving simulator session. The picture below describes the entire process from Adams Car to Driving Simulators. VI-CarRealTime vehicle models can be created in one of the following ways:
- From Adams Car
- From K&C measurements
- Starting from predefined models available in the VI-CarRealTime shared database (available models are city car, C-segment compact car, sedan, SUV, GT car)
- Populating VI-CarRealTime vehicle database directly from GUI

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Here below is the list of tire models that run on VI-grade Driving Simulator and that have been already implemented:

- F tire
- CD Tire
- MF-Tyre
- SWIFT Tyre
- MegaRide

**VI-GraphSim**

VI-grade develops a software named VI-GraphSim that addresses points from 1 to 3. VI-GraphSim is therefore a graphic environment and model visualization tool for real-time vehicle simulation. VI-GraphSim can be used for all Vehicle Dynamics, Ride & Comfort and NVH studies.

VI-GraphSim in conjunction with wide cylindrical screens provides drivers with an immersive environment for a unique driving simulation experience with very low latency and high quality image rendering. Through the usage of different cameras it is possible to satisfy, at the same time, driver’s and track engineer’s needs. Replay functions allow users to easily review driving simulator sessions.

VI-grade provides, together with VI-GraphSim license, a large number of racing tracks and proving ground as well as common scenarios such as city, countryside, highway and many others.
SCANeR

When it comes to Traffic simulations where several surrounding objects can move and interact with the driver, VI-grade relies on 3rd party software.

VI-grade suggests using SCANeR by AV Simulation (formerly OKTAL).

For this project, VI-grade is proposing, as option, the usage of SCANeR by OKTAL for traffic and ADAS applications. SCANeR features an official interface with VI-CarRealTime vehicle model which makes it easy to use the two software modules together on driving simulators.

SCANeR™ Studio is a worldwide-recognized solution for Human-in-the-loop engineering studies.

SCANeR™ Studio is a dedicated engineering solution developed by automotive engineers for the automotive engineers. Car manufacturers and their suppliers use SCANeR™ Studio for advanced ergonomics studies, ADAS development and driver behavior studies.

SCANeR studio allows:

- Driving simulation performance with an extremely low transport delay between driver action and simulation restitution
- High end graphics
- Artificial intelligence for traffic and pedestrians
- Driver monitoring (trackers, video, etc.)
- Intuitive scenario production with a 3D GUI and access to all the simulation data.
- Post processing: all the data are synchronized (including videos) and can be analyzed with a user friendly environment
- Powerful development tools for the engineers:
  - Simulink with ready to use libraries
  - LabView toolboxes
  - C++ with many samples.
  - Flash interface

SCANeR is open software: any part of SCANeR can be replaced by the user, all the variables are available for the users, and they are recorded. The API is included and there is no license restriction for the API based SCANeR module.

This offer includes the adequate configuration of SCANeR™ Studio allowing, among other features:

- VI-CarRealTime for Vehicle dynamics
- Road network creation (RoadXML format)
- Traffic simulation
- Data logging

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