

## Projet ANR-19-CE33-0010

# MERCI : Mixed Musical Reality with Creative Instruments

Programme AAPG 2019

PRCE - CE33 Interaction, Robotique

A	IDENTIFICATION .....	1
B	LIVRABLES ET JALONS.....	2
C	RAPPORT D'AVANCEMENT .....	3
	C.1 Objectifs initiaux du projet.....	3
	C.2 Travaux effectués et résultats atteints sur la période concernée ..	4
	C.3 Difficultés rencontrées et solutions.....	8
	C.4 Faits et résultats marquants.....	9
	C.5 Travaux spécifiques aux entreprises (le cas échéant) .....	10w
	C.6 Réunions du consortium (projets collaboratifs) .....	10
	C.7 Commentaires libres .....	11
D	VALORISATION ET IMPACT DU PROJET DEPUIS LE DEBUT .....	11
	D.1 Publications et communications .....	11
	D.2 Autres éléments de valorisation.....	14
	D.3 Pôles de compétitivité (projet labellisés) .....	14
	D.4 Personnels recrutés en CDD (hors stagiaires) .....	14
	D.5 État financier.....	14
E	ANNEXES EVENTUELLES.....	15

## A IDENTIFICATION

Acronyme du projet	MERCI
Titre du projet	Mixed Musical Reality with Creative Instruments
Coordinateur du projet (société/organisme)	IRCAM
Date de début du projet	1 <sup>er</sup> janvier 2020
Date de fin du projet	31 décembre 2022 repoussé à 14 juillet 2023
Labels et correspondants des pôles de compétitivité (pôle, nom et courriel du corresp.)	

Site web du projet, le cas échéant	repmus.ircam.fr/merci/
------------------------------------	------------------------

Rédacteur de ce rapport	
Civilité, prénom, nom	M. Gérard Assayag
Téléphone	0144784858
Courriel	Gerard.assayag@ircam.fr
Date de rédaction	21 février 2022
Période faisant l'objet du rapport d'activité	1er janvier 2020 à 31 décembre 2021

Contributeurs : G. Assayag, F. Beaulier., J. Borg, M. Chemillier, M. Malt, A. Mamou-Mani, J. Nika

## B LIVRABLES ET JALONS

Sont indiqués **en gras** les livrables restant à livrer ou replanifiés pour une date ultérieure, *en italique* les livrables fournis en avance sur le planning original.

Le contenu détaillé des livrables disponibles (en non-gras) peuvent être consultés sur le site du projet : [repmus.ircam.fr/merci/deliverables](http://repmus.ircam.fr/merci/deliverables)

Code	Content	Type	Partners	Comment
<b>M6</b>				
D.CO.1	Consortium agreement	Agreement	I, E, H	
D.CO.2	Communications and collaborative tools	Web site	I	
<b>M12</b>				
D.AK.1	Report Cyber-human improvisation dynamics	Report	E, H	
D.DD.1	Report Embedding spaces and multivariate time series	Report	I	
D.CA.1	Prototype Enhanced Creative Agents I	Proto	I,E	
<b>M18</b>				
D.CO.3	Report to ANR 1	Report	I, E, H	
D.AK.2	Report Rhythmic synchronization humans/machines	Report	I, E	
D.HA.1	Prototype Mixed reality with active vibration	Proto	H	
D.HA.2	Report Embodied interaction on creative instruments	Report	I, H	
D.ED.1	Report on experimentation, user feedback and validation I	Report	I, E, H	
<b>D.ED.2</b>	<b>International workshop and festival I</b>	Workshop	I, E	<b>Delayed</b>
<b>M24</b>				
<b>D.AK.1</b>	<b>Report Cyber-human improvisation dynamics (revised)</b>	Report	E, H	
<i>D.AK.3</i>	<i>Report Scenario/Corpus based improvisation</i>	<i>Report</i>	<i>I, E</i>	<i>ahead of schedule</i>
<b>D.DD.1</b>	<b>Report Embedding spaces and multivariate time series (final)</b>	Report	I	
<b>D.DD.2</b>	<b>Model Predictive and interactive orchestration</b>	Report	I	
<b>D.CA.2</b>	<b>Report Discovering multi-scale time structure</b>	Report	I	

<b>D.CA.3</b>	<b>Prototype Enhanced Creative Agents II</b>	Proto	I, E	
<b>D.HA.3</b>	<b>Prototype Creative Instrument I</b>	Proto	I, E, H	
<b>M30</b>				
<b>D.AK.2</b>	<b>Report Rhythmic synchronization humans/machines (revised)</b>	Report	I, E	
<b>D.DD.3</b>	<b>Model of ML Music recognition and generation</b>	Report	I	
<b>D.CA.4</b>	<b>Report Musical information dynamics</b>	Report	I	
<b>M36</b>				
<b>D.CO.4</b>	<b>Report to ANR 2</b>	Report	I, E, H	
<b>D.AK.3</b>	<b>Report Scenario/Corpus based improvisation (revised)</b>	Report	I, E	
<b>D.HA.4</b>	<b>Prototype Creative Instrument II</b>	Proto	I, E, H	
<b>D.ED.3</b>	<b>Report on experimentation, user feedback and validation II</b>	Report	I, E, H	
<b>D.ED.4</b>	<b>International workshop and festival II</b>	Workshop	I, E	<b>Delayed</b>

## C RAPPORT D'AVANCEMENT

### C.1 OBJECTIFS INITIAUX DU PROJET

*L'improvisation constitue un moteur primordial des interactions humaines dans tous les aspects de la communication et de l'action. Dans sa forme la plus élevée, l'improvisation musicale est un mélange d'actions structurées, planifiées et de décisions et d'écarts locaux imprévisibles, optimisant l'adaptation au contexte, exprimant de façon unique la créativité du sujet et stimulant la coordination et la coopération entre agents. La mise en place d'environnements homme-machine puissants et réalistes pour l'improvisation nécessite d'aller au-delà de l'ingénierie logicielle des agents créatifs avec des capacités d'écoute et de génération de signaux audio. Ce projet propose de renouveler radicalement le paradigme de l'interaction improvisée homme-machine en établissant un continuum allant de la logique musicale co-créative à une forme d' "interréalité physique" (un schéma de réalité mixte où le monde physique est activement modifié) ancrée dans des instruments acoustiques.*

Improvisation can be seen as a major driving force in human interactions, strategic in every aspect of communication and action. In its highest form, improvisation is a mixture of structured, planned, directed action, and of hardly predictable local decisions and deviations optimizing adaption to the context, expressing in a unique way the creative self, and stimulating the coordination and cooperation between agents. An invaluable observation deck for understanding, modeling and promoting co-creativity in a context of distributed intelligence, Improvisation is an indispensable ability that any cyber-human system should indeed cope with in an expert way. Improvisation is instantiated in its most refined form in music, where the strongest constraints govern the elaboration of highly complex multi-dimensional, multi-scale, multi-agent actions in a cooperative and timely fashion so as to achieve creative social and cultural cooperation.

Setting up powerful and realistic human-machine environments for improvisation necessitates to go beyond the mere software engineering of creative agents with audio-signal listening and generating capabilities. We propose to drastically renew the paradigm of human-machine

improvised interaction by bridging the gap between the computing logics of co-creative musical agents and mixed reality setups anchored in the physics of acoustic instruments.

In such setups of “physical interreality” (a mixed reality scheme where the physical world is actively modified by human action), the human subjects will be immersed and engaged in tangible actions where full embodiment in the digital, the physical and the social world will take place thanks to a joint effort gathering experts from a large inter-disciplinary spectrum.

The main objective of this project is to create the scientific and technological conditions for mixed reality musical systems, enabling human-machine improvised interactions, based on the interrelation of creative digital agents and active acoustic control in musical instruments. We call such mixed reality devices Creative Instruments. Functionally integrating creative artificial intelligence and active control of acoustics into the organological heart of the musical instrument, in order to foster plausible physical interreality situations, necessitates the synergy of highly interdisciplinary public and private research, such as brought by the partners. Such progress will be likely to disrupt artistic and social practices, eventually impacting music industry as well as amateur and professional music practices in a powerful way.

## C.2 TRAVAUX EFFECTUES ET RESULTATS ATTEINTS SUR LA PERIODE CONCERNEE

During this first half of the project, the partners have provided intensive research, development and creation work each in their specific domain, and at the intersection of their work packages. **Ircam** has created a new **AI creative agent software** environment, Somax II, and collaborated with **CAMS** in order to create a **new version of the Djazz software** and adapt it to the context of MERCI. Ircam has also continued greatly improving the **Dyci2 software** environment (initiated formerly in the DYCI2 ANR project coordinated by Ircam). CAMS has launched a series of studies in social sciences related to **improvisation in social networks**, experimentation and survey about **“acceptability” of the AI’s in cyber-human collectives**, and new music creations, whose data will be precious for ameliorating the next generation of software environments by taking better account of the human perception and expectations. The company **HyVibe** developed a **guitar with a hexaphonic sensor**, and prototyped an **embedded automatic improvisation system** with a Raspberry PI nanocomputer in close collaboration with Ircam by using the Somax II kernel newly adapted for embedding in a micro-controller. So the basic collaborative scheme of the project — working in both directions from cyber augmentation (enhancing the models and softwares) and from human augmentation (bringing the physical instrument to be ready to accept high level interaction), so that they meet together, with control and assessment from the human sciences side (seeing what it really means in real life for humans to interact with machine) — works very well so far and produces ideas, publications, software and hardware. In the following we detail the work done by work package.

In the work package **WP CA : Cyber Augmentation**, mainly conducted at Ircam, the Somax co-creative software has been totally redesigned and reprogrammed into a new environment, Somax II, with totally new back-end and front-end server, musical transformations, model improvements, and a new embedded and distributed code for future integration into the “creative instrument” based on the Hyvibe Guitar.

Somax is an interactive system which improvises around a musical material, aiming to provide a stylistically coherent improvisation while in real-time listening to and adapting to input from a musician. The system is trained on some musical material selected by the user, from which it constructs a corpus that will serve as a basis for the improvisation. The main idea is that Somax should serve as a co-creative agent in the improvisational process, where the system after some initial tuning is able to listen and adapt to the musician in a self-sufficient manner.

The front-end has gone through a number of changes during the past two years, where the most important one is the "wireless paradigm". With this update, the system has gone from supporting a single co-creative agent to being able to support an entire ensemble of co-creative agents, each of them improvising over their own musical material, where the user may specify how the agents should listen to each other and/or to the musician (or musicians) interacting with the system. This is possible thanks to a fully parallelized implementation of the back-end server, where each of the parallel agents communicates with a single, centralized scheduler to ensure that the musical timing and tempo is maintained by all agents.

A co-creative agent in the Somax system improvises over the musical material on which it has been trained by essentially recombining short segments of the material in an order that is musically coherent with what the musician (or any other agent it listens to) is playing. But this also means that the system – at least originally – could not play anything that does not exist in the original material. The recently introduced concept of transformations changes this fact: by utilizing pitch shifting and time stretching algorithms, each agent is now able to improvise over transposed and/or temporally altered versions of its musical material, thereby greatly increasing the number of possibilities, which in turn results in a higher coherency between the agent and its listening sources.

A number of improvements have been made to the Somax model in order to provide the user/musician with a higher degree of control over the agents and overall increase the quality of the musical improvisation performed by each agent. Among these are a number of parameters to control which segments in the corpus the agent may use at a given time, a number of adaptive algorithms to control various musical domains of the generation (loudness, duration, orchestration, tempo) as well as a number of algorithms to control how each agent selects its output at a given time.

See more details in the deliverable **CA.1** in the project's web site.

In the work package **WP HA : Human Augmentation**, mainly conducted at Hyvibe, important work has been done to consolidate the active vibration model and prepare it for integration in the Creative Instrument that will consist in the Hyvibe active acoustics guitar plus embedded AI coming from **WP CA**. In particular we have decided to implement hexaphonic sensors on the instrument to decode strings individually because polyphonic guitar audio analysis is still an open challenge. After having studied the state of the art of hexaphonic guitar sensors, it appeared that only a few products were available in the market. They were generally dedicated to electric guitars, which are not suitable for HyVibe as the electric guitar body does not vibrate enough. We finally chose the Graph Tech Ghost Acoustic. Its installation was quite challenging in the Lâg HyVibe dreadnought guitar, due to mechanical integration difficulties. Its final design is presented in the deliverable report **HA.1** on the project's web site. We tested the prototype empirically, using a Roland GR 55 synthesizer pedal. The output of the hexaphonic sensor was sent to the input of the pedal, and the output of the pedal was sent to the input of the HyVibe System. This test showed excellent results, in terms of polyphonic guitar real time analysis and synthesis. The two main conclusions were 1) the hexaphonic sensor makes it possible to split efficiently the six guitar strings, and 2) the mechanical feedback in the guitar is treated efficiently using the HyVibe processing, whatever synthesized sounds were used (instrumental sounds with effects). Once the guitar prototype was validated, first experiments were organized between the ANR MERCI partners (see deliverable **HA.2** on the project site). Different music corpuses were tested, from Palestrina to Ligeti and Jazz standards. These works showed promising results. Even if the HyVibe and Somax technologies were developed independently, they interacted very smoothly. However, certain errors in the detection of events appeared so a thorough study on audio segmentation state of the art was launched (see deliverable **HA.2 Annex 1** on the project's site for more details).

Following the promising results of the first experiment, we decided to study the performance of Somax when running on a Raspberry Pi (a small single-board computer), which is a first step before embedding Somax in a HyVibe System. The sensor analysis is still done by a laptop computer. Overall, This experiment was successful. The code transfer (into the Raspberry PI) did not show any major difficulty. The co-improvisation worked well. However, an audible latency occurred, due to the Raspberry PI processing. Several challenges will have to be addressed, e.g.- Optimizing the Somax code for the HyVibe guitar case, in order to reduce the latency, and developing new signal analysis algorithms in the HyVibe System to remove the laptop computer in the prototype's signal loop. (see deliverable **HA.2 Annex 2** on the project's site for more details).

In the work package **WP AK : Anthropology of Human Practices**, mainly conducted at EHESS, work so far has allowed to study cyber-human improvisation dynamics through difficult problem of "acceptability" of machine productions, in an investigation with the guitarist Charles Kely Zana-Rotsy from Madagascar, and in a beginning study on social networks (Tik Tok) where networks of collaborating musicians use the cyber-human tools for participative music. The interest of the work on acceptability comes from the strongly idiomatic context of Charles Kely ZanaRotsy's music deeply rooted in Malagasy traditions. The integration of a computer in this context raises the general question of hybridity in music: which combinations of influences and sources of inspiration work well and which do not? Research on hybridity has tended to take place at a macro level, focusing on the transnational intersections of musical genres, the formation of national identities, or issues related to the commercial aspects of "world music". The case of Malagasy music is interesting because many authors have emphasized the strongly syncretic aspect of this music characterized by a powerful "tradition of crossbreeding" and the "unabashed mastery of borrowings". Our investigation has made it possible to begin collecting interesting data on this openness to borrowing as seen through the music of Charles Kely Zana-Rotsy: Charles' openness to other musical genres / other regions and finally openness to the technologies developed in MERCI. It became clear during the interviews with Charles that he has a clear vision of what his music can absorb as external influences, including technology, and the rest of the investigation will focus on determining the criteria for distinguishing what is effectively "absorbable" and what is not.

We have begun to explore another field of study of improvisational musical practices linked to social networks, and more particularly to TikTok. We have started a web scraping study in order to track musicians improvising on the network and to filter them according to musical criteria. We visualized the relationships between musicians in the form of a graph using the Force Atlas algorithm . We can thus show the dense points, the sparse areas, the connected components, thus setting the ground for a generalized study of human dynamics among social networks improvisers. The ultimate goal is to deliver a synthesis of the communities of musicians on TikTok and their musical practices. This will allow to explore the social network to establish contacts with some of them and to consider collaborations that could involve the improvisation software for example in order to make videos of virtual duets(see deliverable **AK.1**)

Another subject has made a fruitful contribution to the reflection on the acceptability of the productions of improvisation software. It is related to the centenary of the birth of the Belgian harmonica player Toots Thielemans (1922-2016). On this occasion, we realized a musical avatar. The experiment implemented several technological components of the MERCI project. Thanks to state-of-the-art machine learning technology, we were able to extract the harmonica part from a recording of Toots Thielemans with pianist Bill Evans. Then we improvised with the Djazz software, in the new version developed by Mikhail Malt for MERCI (see deliverable **AK.3**), from this hamonica sequence following the piano-bass-drums accompaniment that we had reconstructed. In the context of the Toots Thielemans centenary, we were able to interact with

connoisseurs of his style and the reactions of the commentators unanimously underlined the impressively realistic character of the AI avatar.

The experience with the Toots Thielemans avatar as well as the TikTok experience allowed us to explore this notion of tempo flexibility and rhythmic interaction as the issue of tempo micro-variations came up in the practice of dueting and the survey of reactions to the avatar emphasized the issue of rhythmic interaction in the realism of the result. Full study can be found in deliverable **AK.2**.

See more details in the deliverable **AK.1**, **AK.2** and **AK.3** in the project's web site.

In the work package **DD Deep Discovery**, mainly conducted at Ircam, our goal during the period was twofold : to develop an intelligent listening and predictive module of chord sequences based on deep learning and embeddings of musical representations, and to propose an adapted evaluation of the associated Music Information Retrieval (MIR) tasks that are the real-time extraction of musical chord labels from a live audio stream (multivariate signal) and the prediction of a possible continuation of the extracted symbolic sequence. Therefore, we propose two independent modules that allows to extract chords in real-time and to predict a possible continuation of an input chord sequence. This modules are aimed to be used in co-creative context such as through an integration within the MERCI softwares Dyci2 or SoMax. In the case of chords, there exists some strong inherent hierarchical and functional relationships. However, most of the research in the field of MIR focuses mainly on the performance of chord-based statistical models, without considering music-based evaluation or learning. Indeed, usual evaluations are based on a binary qualification of the classification outputs (right chord predicted versus wrong chord predicted). Therefore, our research (detailed in deliverable **DD.1**) introduces a specifically-tailored chord analyzer that allows to measure the performances of chord-based models in term of functional qualification of the classification outputs (by taking into account the harmonic function of the chords). Then, in order to introduce musical knowledge into the learning process for the automatic chord extraction task, we also present a specific musical distance for comparing predicted and labeled chords. Finally, we conduct investigations into the impact of including high-level metadata in chord sequence prediction learning (such as information on key or downbeat position). We show that a model can obtain better performances in term of accuracy or perplexity, but output biased results. At the same time, a model with a lower accuracy score can output errors with more musical meaning. Therefore, performing a goal-oriented evaluation allows a better understanding of the results and a more adapted design of MIR models.

See the deliverable **DD.1 Embedding spaces and multivariate time** on the project site.

Concerning the work package **WP ED : Experimentation, validation, dissemination** jointly conducted by conducted by all three partners, we have listed in deliverable **ED.1** an impressive list of first class artistic productions, artistic residencies, experiments and collaborations with reknown artists using the tools developed in the MERCI project, and we have gathered feed-back from the musicians and the users. It also includes all kind of project dissemination through presentations, workshops, shows, or industrial events. As a few samples, we can cite :

- Production of shows in the IRCAM Manifeste festival, concerts at Centre Georges Pompidou, Maison de la Radio, Philharmonie de Paris, using MERCI technologies and involving international level artists s.a. orchestre National de Jazz, Steve Lehman, Alexandro Markeas, Ensemble Intercontemporain, Bernard Lubat and all-stars (Joëlle Léandre, Michel Portal, Louis Sclavis, Sylvain Luc etc.) Direct retransmission by France Musique, Radio France and coverage in the national press (Le Monde, Liberation, Le Figaro, Jazz Magazine, Telerama etc.)

- Publication of major artistic and didactic objects s.a. the 192 pages book-CD *Artisticiel*, featuring famous pianist Bernard Lubat dialoguing with the MERCI tools
- Experimentations, concerts, interviews, audiovisual documents, around world musicians Charles Kely Zana-Rotsy (Madagascar), Camel Zekri (France, Algeria), Adrien Chaillou Organ Trio, with public performances at Ars Electronica (Linz), La preuve par 9,
- Hyvibe has tested the smart Guitar with many famous musicians, and shown it at various prestigious venues (America's Got Talent, 10 million viewers, Thomas Dutronc Guitar lessons on youtube, American guitar player and influencer Justin Johnson (1 million views youtube)

See deliverable **ED.1** for more details, as well as the **Events** page and the **Social Networks** page on MERCI's web site [repmus.ircam.fr/merci/](http://repmus.ircam.fr/merci/).

### C.3 DIFFICULTES RENCONTREES ET SOLUTIONS

#### 1 - Transfert du CAMS EHESS à l'Ircam d'une partie de la subvention ANR

Un transfert de 84k du laboratoire CAMS à l'Ircam a eu lieu dans le cadre du projet ANR MERCI. Le CAMS avait prévu 24 mois.hommes de niveau post-doctoral portant sur l'improvisation basée sur les scénarios, la pulsation et les études rythmiques (notamment dans le logiciel Djazz) en relation avec les tâches AK (Anthropology of knowledge), CA (Cyber-Augmentation) et HA (Human augmentation) de MERCI.

En recherchant des profils pouvant convenir, Il a été déterminé par Marc Chemillier (Resp. de MERCI au CAMS) et Gérard Assayag (Ircam, coordinateur) que celui de Dr. Mikhail Malt était incontestablement le meilleur choix. M. Malt est un des rares spécialistes mondiaux d'informatique musicale capable de maîtriser à la fois la composition assistée par ordinateur basée sur le langage informatique Lisp, l'interaction basée sur le langage Max /MSP, et les concepts et technologies liés aux recherches de MERCI relatives à l'interaction improvisée entre humains et agents artificiels créatifs. Titulaire d'une HDR et ayant dirigé plusieurs thèses, M. Malt était en CDI à l'Ircam en tant que « Réalisateur en informatique musicale » et professeur au département Pédagogie et Action Culturelle (PAC) de l'Ircam. Il nous a semblé que la meilleure des solutions était, avec le plein accord de l'Ircam et du CNRS tutelle gestionnaire du CAMS, de rejoindre l'équipe de recherche du projet MERCI à l'Ircam par un transfert inter-départements financé sur des crédits de MERCI, les crédits correspondants étant transférés à cet effet du CAMS / CNRS vers l'Ircam. L'opération a été acceptée et actée par l'ANR et il a été convenu les coûts salariaux soient financés sur la base de 18 h.m sur les 24 h.m disponibles au CAMS, 6 h.m devant être conservés au CAMS pour des travaux relatifs aux réseaux sociaux relevant d'un autre type de profil.

**Cette opération menée l'automne 2021 a permis une très grande efficacité et se mesure déjà en termes de résultats :** le livrable **AK.3 Report Scenario/Corpus based improvisation** prévu à M24 a ainsi été fourni **avec 6 mois d'avance** sur la planning initial.

#### 2. Report du Workshop - Festival Improtech

Le workshop prévu (livrable **ED.2 International workshop and festival I**) prévu à M18 n'a pu se tenir du fait de la situation internationale liée à la pandémie. C'est en effet un événement de nature essentiellement internationale, et nous avons durant notre séjour de professeur invité à Tokyo (G. Assayag, février-mars 2020) pris tous les contacts pour une édition japonaise, avec un co-financement de la Saison de la France au Japon, structure émanant de l'Institut Français. La crise sanitaire a ruiné tout ce travail préparatoire, et la Saison est elle même annulée. Nous réfléchissons



à la prochaine étape, qui pourrait être soit une repliement sur un site français, soit l'attente de la rouverture des échanges interanationaux.

#### C.4 FAITS ET RESULTATS MARQUANTS

En quelques lignes pour chaque fait ou résultat marquant. Cet élément pourrait donner lieu à communication, après accord du coordinateur du projet.

##### Evènements, Concerts, Prix

Tous les événements sont documentés en détail sur le site de MERCI : [repmus.ircam.fr/merci/](http://repmus.ircam.fr/merci/) dans les pages **Events** et **Social Networks**. Nous en listons seulement quelques uns parmi les plus saillants

- **Forbes Magazine**, Jan 18, 2022, **What are the limits of #ArtificialIntelligence** in #music? ERC grantee G. Assayag explores the role of #AI in creativity from teaching AI to improvise and cooperate with musicians live on stage.
- **Air Liquide / Fondation France Japon EHESS Workshop** on AI and Arts, Feb 18, 2022, G. Assayag on The Role of Art in Advanced Technology
- **Concert "Ex Machina"**, **Steve Lehman**, Orchestre National de Jazz and MERCI member Jérôme Nika at the Maison de la Radio, Feb 11, 2022, in Festival Presence. Famous american saxophonist Steve Lehman collaborates with ONJ and MERCI to integrate AI live interaction software from the project. "Ex Machina" will then go on tour, beginning in Amsterdam on February 12, 2022. Live-streamed by France Musique.
- **The Press and the Radio** talks about **Ex-Machina** in Le Monde, Liberation, France-Info, Jazz Magasine , Citizen Jazz
- **Workshop Conservatoire national supérieur de musique et de danse de Lyon**, Sept 29, 2021. G. Assayag and J. Nika present their research work and perform with the students using the MERCI tools.
- **Concert "Music of Choices"**, Alexandros Markea, June 16, 2021 in Centre Pompidou as part of the Ircam Festival Manifeste. A creation commissioned by IRCAM-Centre Pompidou. Famous pianist A. Markeas interacts in real time with MERCI AI live interaction software controlling a second disklavier piano.
- **The Press and the Radio** talks about **Music of Choices** in Le Figaro, Le Monde, Telerama
- **Concert « Improvise cum machina »**, Dec 3, 2021, Grand Soir Numérique at Philharmonie de Paris during Biennale Nemo des Arts Numériques, Solists of the Ensemble intercontemporain interact with the MERCI AI interaction software, streamed on France Musique.
- **CD-Book Artisticiel, Cyber Improvisations** published, May 28, 2021. Famous Multi-instrumentist Bernard Lubat and MERCI members M. Chemillier and G. Assayag have recorded concerts using the teams's AI interaction tools all over the world presented in this opus along with 192 p. of critical writings on how humans interaxct with AI in music.
- **Two artistic residencies** are offered to Saxophonists Rémi Fox and Steve Lehman in 2021-2022. Musicians will have the opportunity to experiment with MERCI creative tools and include them in their creations.
- **HyVibe wins the prix Industrie 2021** de la Société Française d'Acoustique at the SFA meeting hosted by the NAVAL GROUP at the La Cité de la Mer.
- **The Lâg HyVibe Guitars win the Gold Award** from Guitar World Magazine in june 2020. The magazine claimed that « the HyVibe guitar system is one of the most fascinating recent developments for acoustic guitar since the "Golden Era" of the Thirties. »
- **HyVibe in the 100 best startups** of 2021 du magazine Challenges
- **Millions of views on youtube** : Hyvibe has tested the smart Guitar with many famous musicians, and shown it at various prestigious venues (America's Got Talent, 10 million

viewers, Thomas Dutronc Guitar lessons on youtube, American guitar player and influencer Justin Johnson (1 million views youtube)

- **Concert Improvista !** a historical concert at the Philharmonie de Paris, on Feb 1 & 2, 2020, gathered the cream of french Jazz improvisers around Bernard Lubat (Michel Portal, Joëlle Léandre, Louis Sclavis, Sylvain Luc, Jacques Di Donato etc.) with MERCI members G. Assayag @ M. Chemillier operating the project's AI interactive softwares.
- **Concert Gnawa Machine** at Ars electronica festival, September 12-13, 2020. The challenge of Gnawa machine is to integrate the computer into a particular cultural context, that of the Gnawa brotherhood in North Africa, with MERCI member M. chemillier operating on MERCI AI interactive software.
- **Djazz Concerts in the Malgache Tradition**, Nov 12, Dec 17, 2021. Djazz duet Charles Kely Zana-Rotsy (guitare-vocals) and Marc Chemillier (computer-keyboard), Chez Adel, Paris, explore the « acceptability » of MERCI AI interaction tools by humans in an idiomatic musical experience
- **Concert Three Ladies Project** at Ircam Festival Manifeste 2020. This piece by G. Bloch with famous pianist H. Sellin premiered the interaction of MERCI AI creative tools with the musician using audio and video materials from the Montreux Jazz Festival.
- **Centre Pompidou Exhibition** : " Neurones : les intelligences simulées", feb 26 – apr 26 2020, features MERCI with demo videos and demonstrations of the project's AI creative tools.
- **Press and radio** : The project MERCI has been featured in many press or radio publication, see the section Publication / Other publications

## C.5 TRAVAUX SPECIFIQUES AUX ENTREPRISES (LE CAS ECHEANT)

### Entreprise HyVibe

Entreprise	HyVibe
Rédacteur (nom + adresse mél)	Adrien Mamou-Mani adrien@hyvibe.audio
<p>L'entreprise HyVibe a contribué au projet par le développement d'une guitare avec capteur hexaphonique, ainsi que par le prototypage de système embarqué d'improvisation automatique avec un nano-ordinateur Raspberry PI. HyVibe a aussi expérimenté avec son système actuel auprès de nombreux musiciens, permettant ainsi de mieux cibler les futures applications pertinentes du projet. Les développements effectués ont été élaborés et validés en collaboration avec les partenaires du projet IRCAM et EHESS. Les perspectives principales pour l'entreprise HyVibe dans le cadre du projet sont la finalisation du prototype d'instrument créatif et l'expérimentation avec cet instrument auprès de musiciens. Une fois ces étapes validées, HyVibe envisage d'industrialiser les technologies et de les intégrer dans ses systèmes pour guitares.</p>	

## C.6 REUNIONS DU CONSORTIUM (PROJETS COLLABORATIFS)

Date	Lieu	Partenaires présents	Thème de la réunion
23 Janvier 2020	Ircam	Ircam, Hyvibe, EHESS	Lancement du projet
15 sept 2020	Ircam	Ircam, Hyvibe, EHESS	Point d'étape et de planification
17 Juin 2021	Ircam	Ircam, Hyvibe, EHESS	Expérimentation du premier prototype Hyvibe et Point d'étape et de planification

Date	Lieu	Partenaires présents	Thème de la réunion
3 décembre 2021	Hyvibe	Ircam, Hyvibe	Lancement du prototypage de système embarqué d'improvisation

## C.7 COMMENTAIRES LIBRES

## D VALORISATION ET IMPACT DU PROJET DEPUIS LE DEBUT

### D.1 PUBLICATIONS ET COMMUNICATIONS

#### Journal papers

L'hybridité vue à partir du sujet : le cas du musicien franco-malgache Charles Kely Zana-Rotsy

Marc Chemillier, Yuri Prado, Cahiers d'ethnomusicologie, Ateliers d'ethnomusicologie, A paraître  
Tristan Carsault, Jérôme Nika, Philippe Esling, and Gérard Assayag. 2021. "Combining Real-Time Extraction and Prediction of Musical Chord Progressions for Creative Applications" Electronics 10, no. 21: 2634.

Théo Golvet, Louise Goupil, Pierre Saint-Germier, Benjamin Matuszewski, Gérard Assayag, et al.. With, against, or without? Familiarity and copresence increase interactional dissensus and relational plasticity in freely improvising duos. Psychology of Aesthetics, Creativity, and the Arts, American Psychological Association, 2021.

Gérard Assayag. Co-créativité humains-machines. Une réflexion sur les indisciplines symboliques.. Revue Francophone d'Informatique et Musique, Association Francophone d'Informatique Musicale, 2020.

#### Conference Papers

Marc Chemillier, Ke Chen, Mikhail Malt, Shlomo Dubnov, A posthumous improvisation by Toots Thielemans, accepted submission to the conference Toots Thielemans (1922-2016). A Century of Music across Europe and America, Bruxelles, 9 -11 May 2022.

Marc Chemillier et Yuri Prado, L'hybridité vue à partir du sujet : le cas du musicien franco-malgache Charles Kely Zana-Rotsy, Cahiers d'ethnomusicologie, n° 36, 2022 (accepted paper, to appear).

Adrien Mamou-Mani, Florentin Ménage, Serge Puvilland, Giuseppe Pennisi, Mathieu Carré, François Beaulier, Active Vibration Control Applied to Flat Panel Loudspeakers Using the HyVibe Pro, Proceedings of SIA Comfort Conference, Le Mans, France, 2021.

Mikhail Malt, Benny Sluchin, Geometric Notation for Time-Bracket works, application and performance The case of John Cage's Music for, TENOR Conference 2020 (delayed to 2021).

Jérôme Nika, Jean Bresson. Composing Structured Music Generation Processes with Creative Agents. 2nd Joint Conference on AI Music Creativity (AIMC), 2021, Graz, Austria.

Fouilleul M., Bresson J. Giavitto J.-L. A Polytemporal Model for Musical Scheduling. 15th International Symposium on Computer Music Multidisciplinary Research. Les éditions du PRISM, ISBN 979-10-97-498-02-3, 2021.

Marc Chemillier, De la musique aux mathématiques... et réciproquement, actes du colloque Création musicale et intelligence artificielle en musiques du maqam, Université de Sfax, Tunisie, 9-10 mars 2020, pp. 31-44.

Théis Bazin, Gaëtan Hadjeres, Philippe Esling, Mikhail Malt. Spectrogram Inpainting for Interactive Generation of Instrument Sounds. Proceedings of the 2020 Joint Conference on AI Music Creativity, Jul 2020, Stockholm, Norway. (10.30746/978-91-519-5560-5).

Philippe Esling, Ninon Devis. Creativity in the era of artificial intelligence. arXiv:2008.05959. Journées d'Informatique Musicale, Oct 2020, Strasbourg, France.

Mathieu Prang, Philippe Esling. Signal-domain representation of symbolic music for learning embedding spaces. The 2020 Joint Conference on AI Music Creativity, Oct 2020, Stockholm, Sweden.

Georges Bloch, Jérôme Nika, Quentin Barrois. Synthèse concaténative et image : DYCI2 et Omax-vidéo. Journées d'Informatique Musicale 2020 (JIM 2020), Oct 2020, Strasbourg, France.

Tristan Carsault, Andrew Mcleod, Philippe Esling, Jérôme Nika, Eita Nakamura, et al. MULTI-STEP CHORD SEQUENCE PREDICTION BASED ON AGGREGATED MULTI-SCALE ENCODER-DECODER NETWORKS. MLSP 2019, Oct 2019, Pittsburgh, United States.

Yiming Wu, Tristan Carsault, Kazuyoshi Yoshii. Automatic Chord Estimation Based on a Frame-wise Convolutional Recurrent Neural Network with Non-Aligned Annotations. Eusipco, Sep 2019, Coruña, Spain.

Axel Chemla-Romeu-Santos, Stavros Ntalampiras, Philippe Esling, Goffredo Haus, Gérard Assayag. Cross-Modal Variational Inference For Bijective Signal-Symbol Translation. Proceedings of the 22nd International Conference on Digital Audio Effects (DAFx-19), 2019.

### **Directions of work or proceedings**

Bernard Lubat, Gérard Assayag, Marc Chemillier. Artisticiel / Cyber-Improvisations. Association Improvisation Musicale et Technologie. Phonofaune, 2021, Dialogiques d'Uzeste, Bernard Lubat.

### **Book sections**

Marc Chemillier, Organigrammes informatiques : présence humaine et intelligence artificielle dans les arts et la culture, Marion Laval-Jeantet et Yann Toma (éds.), Organigrammes. L'art face aux mondes complexes (to appear 2022).

Marc Chemillier, Variation versus bouclage. L'improvisation est-elle soluble dans l'électro? Franck Jedrzejewski, Carlos Lobo, Antonia Soulez (éds.), Écrire comme composer: le rôle des diagrammes, Éditions Delatour, 2021, pp. 77-90.

Marc Chemillier. Jazz and Artificial Intelligence : From Presence to Traces. In Bernard Lubat, Gérard Assayag, Marc Chemillier. Artisticiel / Cyber-Improvisations. Phonofaune, 2021, Dialogiques d'Uzeste., 2021.

George Lewis. Co-Creation: Early Steps and Future Prospects. In Bernard Lubat, Gérard Assayag, Marc Chemillier. Artisticiel / Cyber-Improvisations. Phonofaune, 2021, Dialogiques d'Uzeste., 2021.

Gérard Assayag. Human-Machine Co-Creativity. in Bernard Lubat, Gérard Assayag, Marc Chemillier. Artisticiel / Cyber-Improvisations. Phonofaune, 2021, Dialogiques d'Uzeste., 2021.

Marc Chemillier, Cats, jazz et machines: jouer avec ou sans clic, Sylvie Chalaye, Pierre Letessier (éds.), Animal, jazz, machine, Passage(s), Esthétique jazz, p. 149-161, 2019.

### **Master's Thesis**

Ilian Ben-Amar, Mapping and clustering of audio descriptors spaces. [Student Research Report] Internship L3 Université Aix Marseille. 2022.

Benjamin Feldman. Improving the latent harmonic space of SOMax with Variational Autoencoders. [Student Research Report] Centrale Supélec et STMS IRCAM. 2021.

### **PhD Thesis**

Mathieu Prang. Representation learning for symbolic music. PhD Thesis, Sorbonne Université, STMS Ircam, 2021.

Tristan Carsault. Introduction of musical knowledge and qualitative analysis in chord extraction and prediction tasks with machine learning. : application to human-machine co-improvisation. Sorbonne Université, 2020.

Axel Chemla-Romeu-Santos. Manifold representations of musical signals and generative spaces. Sound [cs.SD]. Università Degli Studi di Milano; Sorbonne Université, 2020. English.

### **Invited Talks**

Marc Chemillier, De la musique aux mathématiques... et réciproquement, conférencier invité, actes du colloque Création musicale et intelligence artificielle en musiques du maqam, Université de Sfax, Tunisie, 9-10 mars 2020, pp. 31-44.

Assayag, G., Nika, J., Workshop Conservatoire national supérieur de musique et de danse de Lyon, 29 septembre 2021, Co-créativité humains-machines et IA pour la composition, l'interaction et l'improvisation

Assayag, G., "Co-creativity and Symbolic Interaction", Spotlight Presentation, CSMC + MuMe 2020: 2020 Joint Conference on AI Music Creativity, KTH and KMH, Stockholm, Sweden, October 21-24, 2020

Assayag, G., "The REACH project: Raising co-crEativity in Cyber-Human musicianship", conférence invitée au séminaire du JFLI (Japan French Lab. Of Informatics), Tokyo University, 27 février 2020

Assayag, G. Conférence invitée, « Travaux de l'équipe RepMus et du laboratoire STMS », Forum des Sciences Cognitives, Lab Pitches Program, 25 avril 2020.

J. Nika, Conférence "Musique et IA", Collegium Musicae, Sorbonne Université 24 mars 2021.

J. Nika, Table ronde "IA et création" organisé par l'association Class'Code, et le Ministère de l'éducation nationale

### **Other publications, large audience**

Gérard Assayag et Jérôme Nika et Jean-Louis Giavitto, Interview pour "Le Blob - Cité des sciences et de l'industrie". [https://www.youtube.com/watch?v=L\\_\\_rvMhX6FI](https://www.youtube.com/watch?v=L__rvMhX6FI)

Gérard Assayag, Forbes : Research Project Will Study How AI Can Be Used In Creative Collaboration, par Eva Amsen, cité par l'European Research Council

Gérard Assayag & Shlomo Dubnov, Computers in a Jazz Ensemble? Inventing Improvisational AI, UC San Diego News Center Publications, 13 Janvier

Gérard Assayag interviewed in the newspaper Liberation « La musique en bonne intelligence (artificielle) » March 13, 2020

Gérard Assayag, Marc Chemillier, on France Musique, Jazz Culture, release of the Book-CD "Artisticiel – Cyber Improvisations" <https://www.radiofrance.fr/francemusique/jazz-culture-bernard-lubat-gerard-assayag-marc-chemillier-artisticiel-6398171>

Ninon Devis - "Créativité à l'ère de l'intelligence artificielle", The conversation

Jérôme Nika, portrait dans "Le Monde" par Pierre Gervasoni.  
[https://www.lemonde.fr/culture/article/2021/05/27/jerome-nika-marie-science-et-musique-en-bonne-intelligence\\_6081637\\_3246.html](https://www.lemonde.fr/culture/article/2021/05/27/jerome-nika-marie-science-et-musique-en-bonne-intelligence_6081637_3246.html)

Jérôme Nika, Interview dans "Le Figaro" à propos de "Music of Choices" d'Alexandros Markeas,  
<https://www.lefigaro.fr/culture/quand-l-intelligence-artificielle-devient-un-instrument-de-musique-20210616>

Jérôme Nika, Interview dans "Télérama" à propos de "Music of Choices" d'Alexandros Markeas,  
<https://www.telerama.fr/sortir/manifeste-2021-ircam-invente-le-festival-musical-de-demain-6888013.php>

Jérôme Nika, Interview sur la BBC à propos de "Music of Choices" d'Alexandros Markeas,  
[https://www.youtube.com/watch?v=Ec5gJaSKnB4&feature=emb\\_logo&ab\\_channel=TimAllman](https://www.youtube.com/watch?v=Ec5gJaSKnB4&feature=emb_logo&ab_channel=TimAllman)

## D.2 AUTRES ELEMENTS DE VALORISATION

## D.3 POLES DE COMPETITIVITE (PROJET LABELLISES)

## D.4 PERSONNELS RECRUTES EN CDD (HORS STAGIAIRES)

Identification				Avant le recrutement sur le projet			Recrutement sur le projet			
Nom et prénom	Sexe H/F	Adresse email (1)	Date des dernières nouvelles	Dernier diplôme obtenu au moment du recrutement	Lieu d'études (France, UE, hors UE)	Expérience prof. antérieure (ans)	Partenaire ayant embauché la personne	Poste dans le projet (2)	Date de recrutement	Durée missions (mois) (3)
Borg Joakim	H	joakim.borg@ircam.fr	23/2/2022	Master	UE	1.5	HyVibe	ingénieur	01/12/2021	2
Borg Joakim	H	joakim.borg@ircam.fr	23/2/2022	Master	UE	0	Ircam	ingénieur	01/06/2020	18
Carsault Tristan	H	Tristan.carsault@ircam.fr	23/2/2022	PhD	UE	0	Ircam	Postdoc	01/01/2021	12

Note : le recrutement de Mikhail Malt qui a fait l'objet d'un transfert du CAMS – CNRS n'apparaît pas dans les cdd car M. Malt est CDI Ircam, cf détails dans C.3 difficultés rencontrées.

## D.5 ÉTAT FINANCIER

Donner un état indicatif de la consommation des crédits par les partenaires. Indiquer la conformité par rapport aux prévisions et expliquer les écarts significatifs éventuels.

Nom du partenaire	Crédits consommés (en %)	Commentaire éventuel
Ircam	34%	Le pourcentage est donné sur le budget (cout complet) après transfert du CAMS, (cf C.3) il est donc un peu plus réduit que prévu du fait de cet apport récent.
CAMS EHESS	16 %	En accord avec ANR CAMS a transféré 84K€ à Ircam pour recrutement interne de M. Malt (cf C.3) et n'a donc pas dépensé en personnel additionnel.
Hyvibe	20 %	En conformité avec les prévisions, HyVibe va consommer la grande majorité des crédits en deuxième partie de projet.

## Annexes éventuelles