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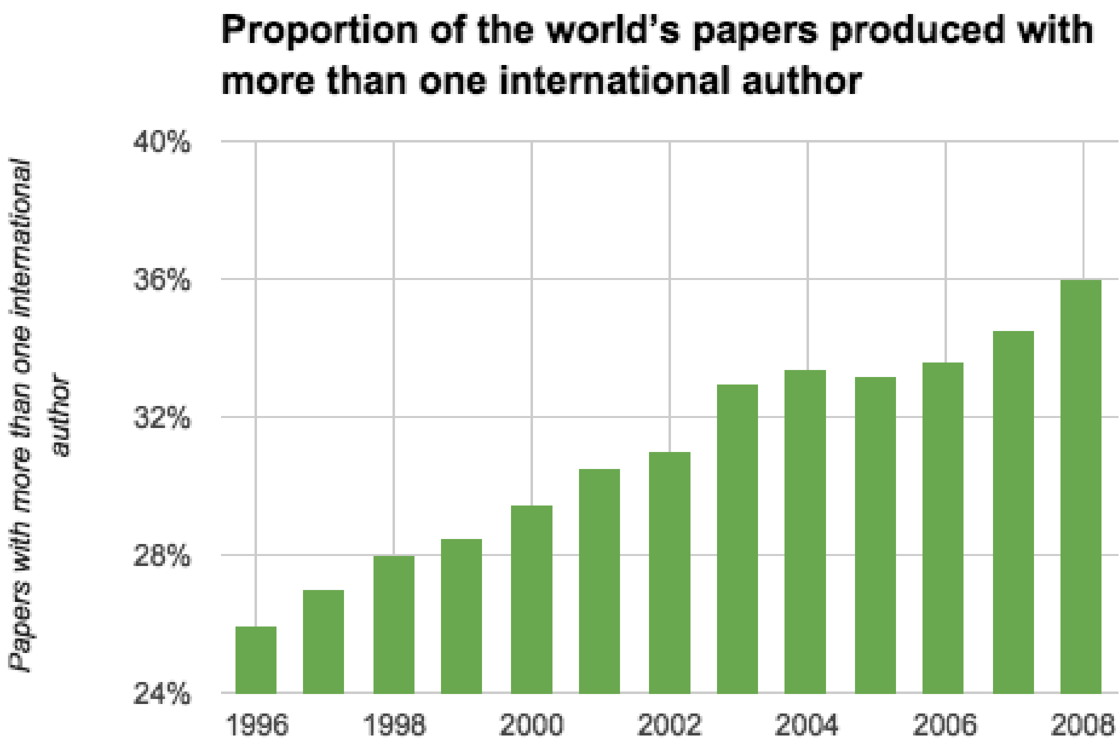

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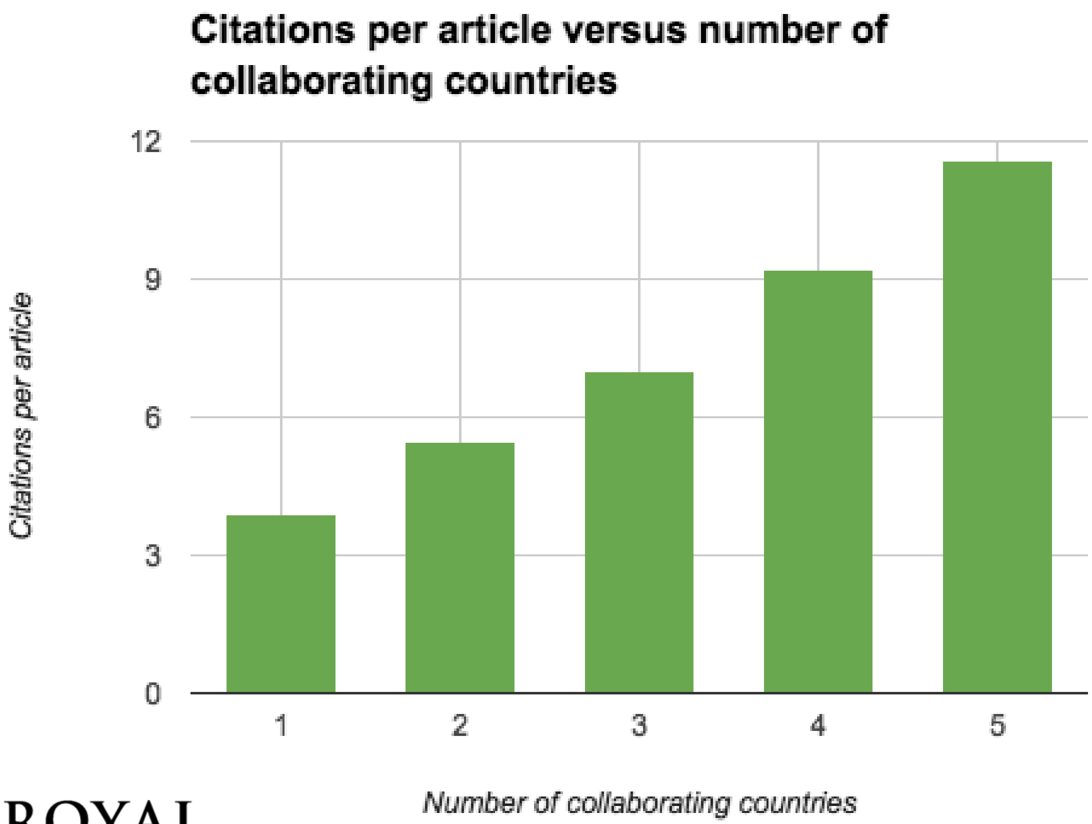

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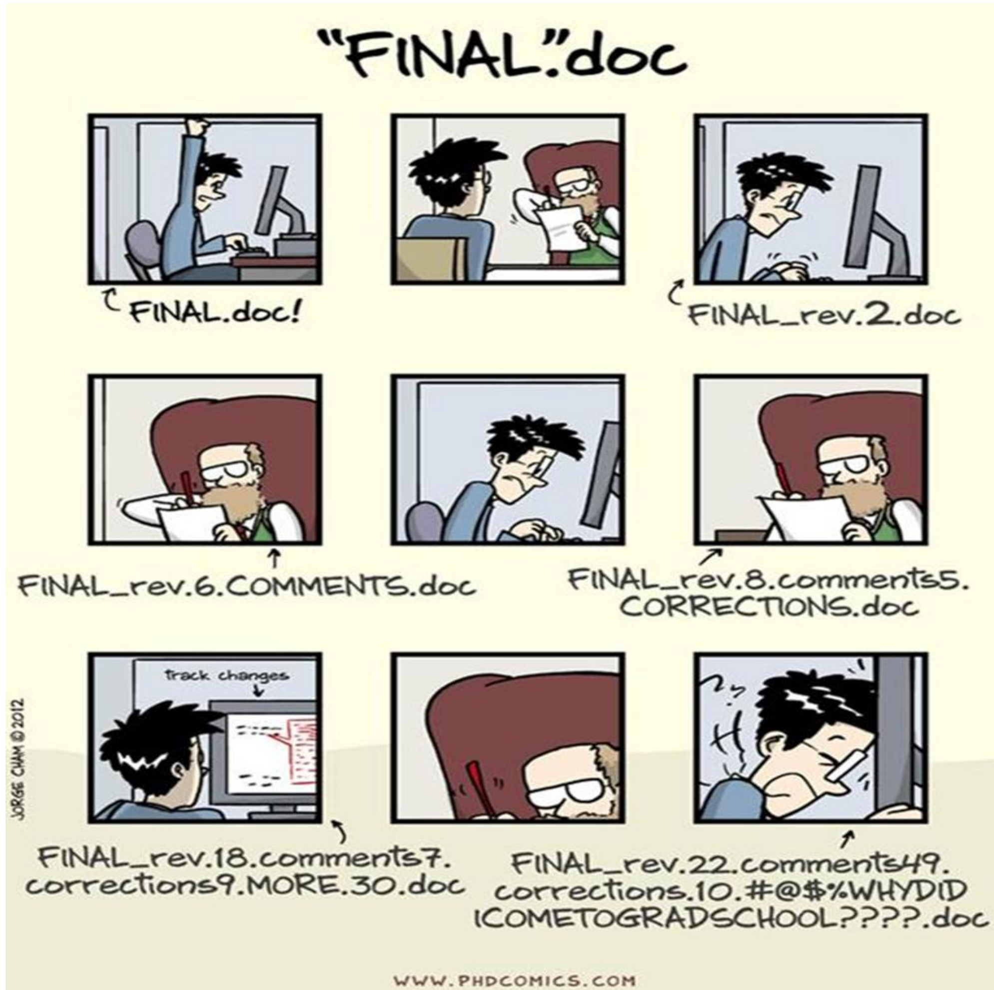

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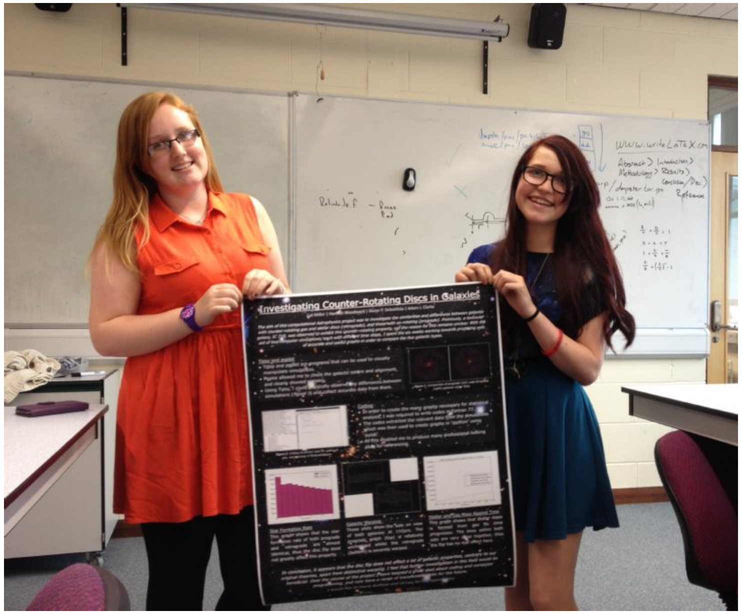

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Modeling of Trap Induced Dispersion of Large Signal Dynamic Characteristics of GaN HEMTs
O. Jardel1, S. Laurent2, T. Reveyrand2, R. Quere2, P. Nakkala2, A. Martin2
S. Piotrowicz1, M. Campovecchio2, S.L. Delage1
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olivier.jardel@3-5lab.fr
Abstract
We propose here a non-linear GaN HEMT model for CAD including a trapping effects description consistent with both small-signal and large-signal operating modes. It takes into account the dynamics of the traps and then allows to accurately model the modulated large signal characteristics that are encountered in telecommunication and radar signals. This model is elaborated through low-frequency S-parameter measurements complementary to more classical pulsed-IV characterizations. A 8x75μm AlInN/GaN HEMT model was designed and particularly validated in large-signal pulsed RF operation. It is also shown that thermal and trapping effects have opposite effects on the output conductance, thus opening the way for separate characterizations of the two effects.
Modeling of Trap Induced Dispersion of Large Signal Dynamic Characteristics of GaN HEMTs
O. Jardel*, S. Laurent†, T. Reveyrand†, R. Quéré†, P. Nakkala†, A. Martin†
S. Piotrowicz*, M. Campovecchio†, S.L. Delage*
*III-V Lab, route de Nozay, 91461 Marcoussis Cedex, France
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Index Terms—Trappings effects, thermal effects, low frequency S-parameters, CAD non-linear model, RF pulsed operation.
I. Introduction
Gallium Nitride (GaN) High Electron Mobility Transistors (HEMT) on SiC are now recognized as good candidates for the development of a number of RF applications and notably Power Amplifiers (PA) for telecommunications and radars, due to their high breakdown voltage, their high cut-off frequency as well as their high temperature capabilities. However they are still subject to parasitics effects such as thermal effects and especially trapping effects. Those trapping effects have been extensively studied using a number of techniques such as pulsed measurements, load-pull measurements as well as frequency dispersion measurements. At the same time, models have been proposed that take those effects into account [1], [2], [3], and while the effects of traps are well taken into account in CW conditions, their impacts on dynamic large signal characteristics remain difficult to understand. They manifest themselves under modulated signals such as RF pulses or telecommunications signals. Memory effects are the main consequence of those trapping effects. In this paper we propose to
account the dynamics of the traps. Finally we conclude and draw some perspectives.
II. Impact of traps on large signal characteristics
One convenient way to identify the impact of trapping effects is to monitor the average drain current of the transistor versus an increasing RF input power. It has already been reported in [1] and [3] that this drain current under class-AB conditions decreases as the input power increases, contradicting the expected characteristics. Clearly this behavior cannot be explained by thermal behavior as far as the channel temperature sinks when the power increases and would leads, at least for moderate powers, to an average drain current enlargement.
Trap free characteristic
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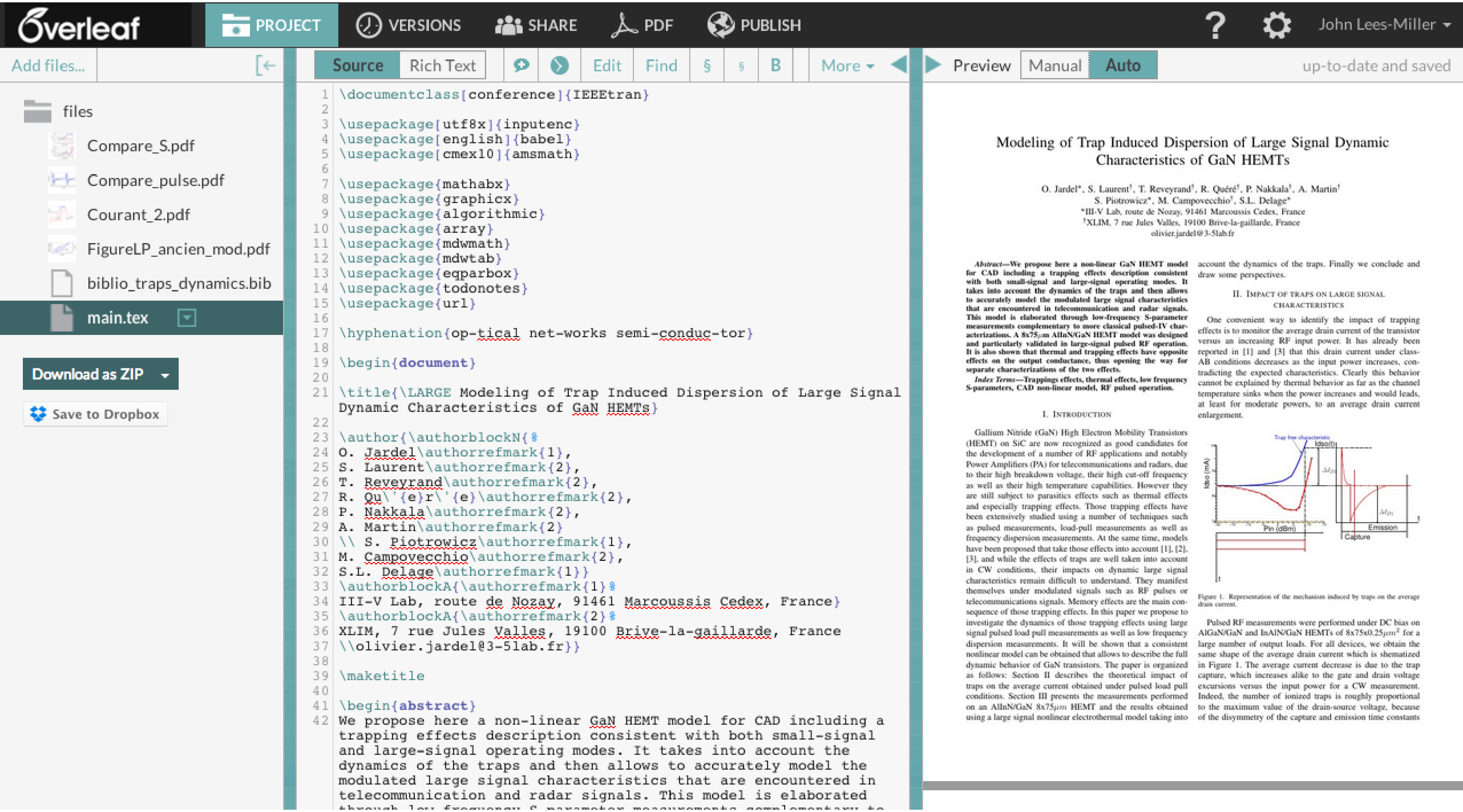
Idso (mA)
Pin (dBm)
Emission
Capture
Fig. 1. Representation of the mechanism induced by traps on the average drain current.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O. Jardel\authorrefmark{1},
S. Laurent\authorrefmark{2},
T. Reveyrand\authorrefmark{2},
R. Qu\'{e}r\'{e}\authorrefmark{2},
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XLIM, 7 rue Jules Valles, 19100 Brive-la-gaillarde, France
\\olivier.jardel@3-5lab.fr}}
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\begin{abstract}
We propose here a non-linear GaN HEMT model for CAD including a trapping effects description consistent with both small-signal and large-signal operating modes. It takes into account the dynamics of the traps and then allows to accurately model the modulated large signal characteristics that are encountered in telecommunication and radar signals. This model is elaborated
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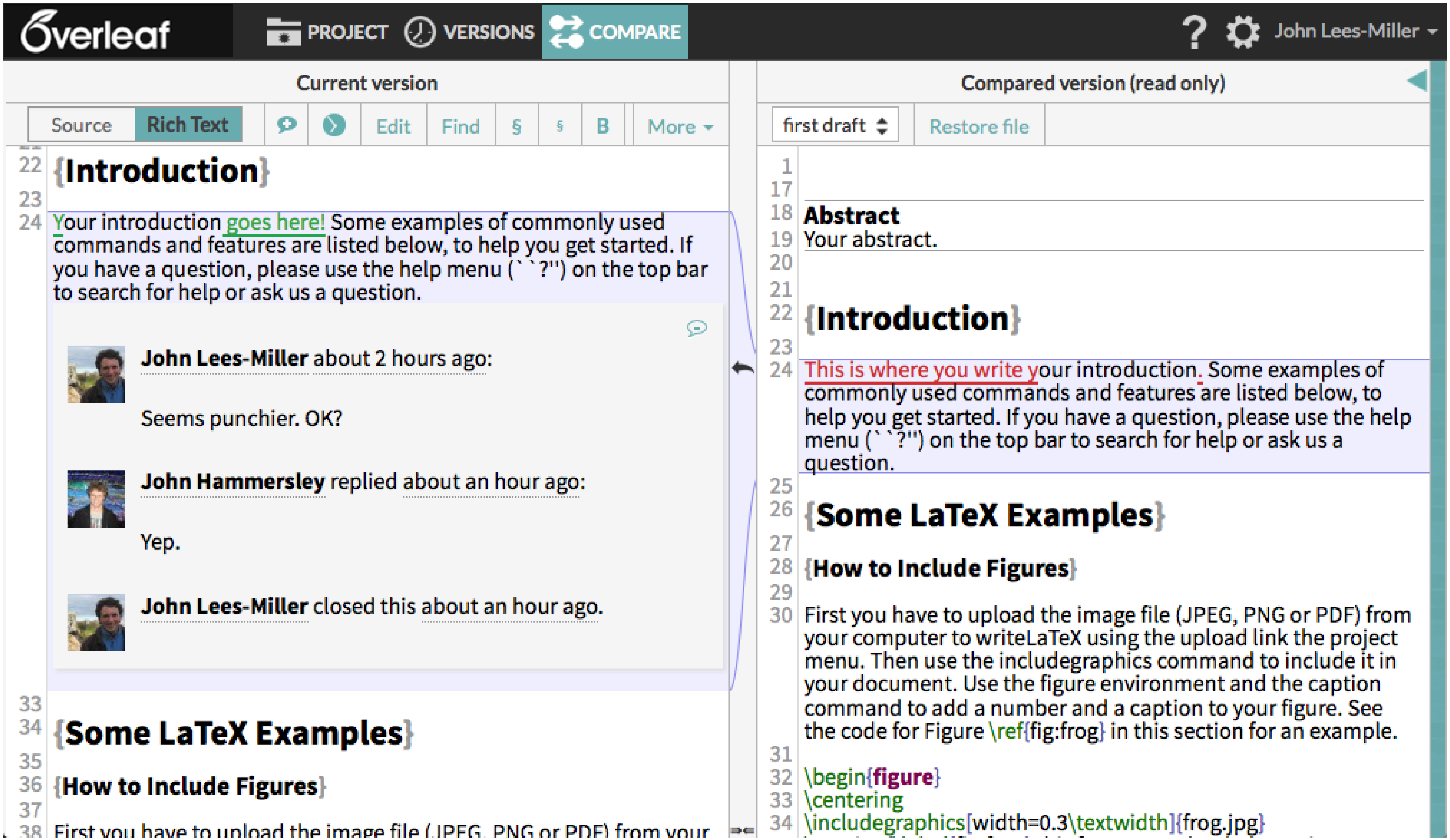

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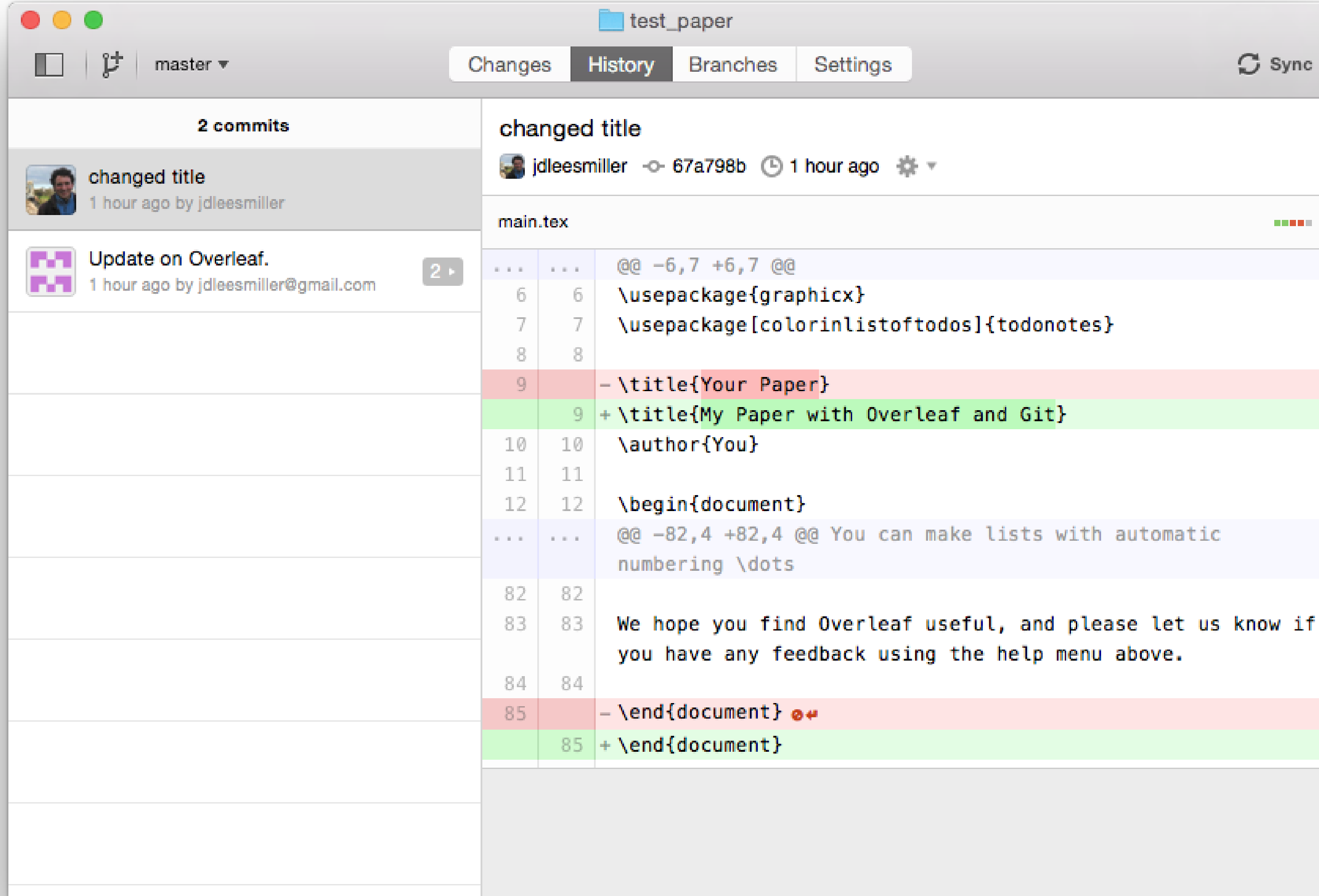
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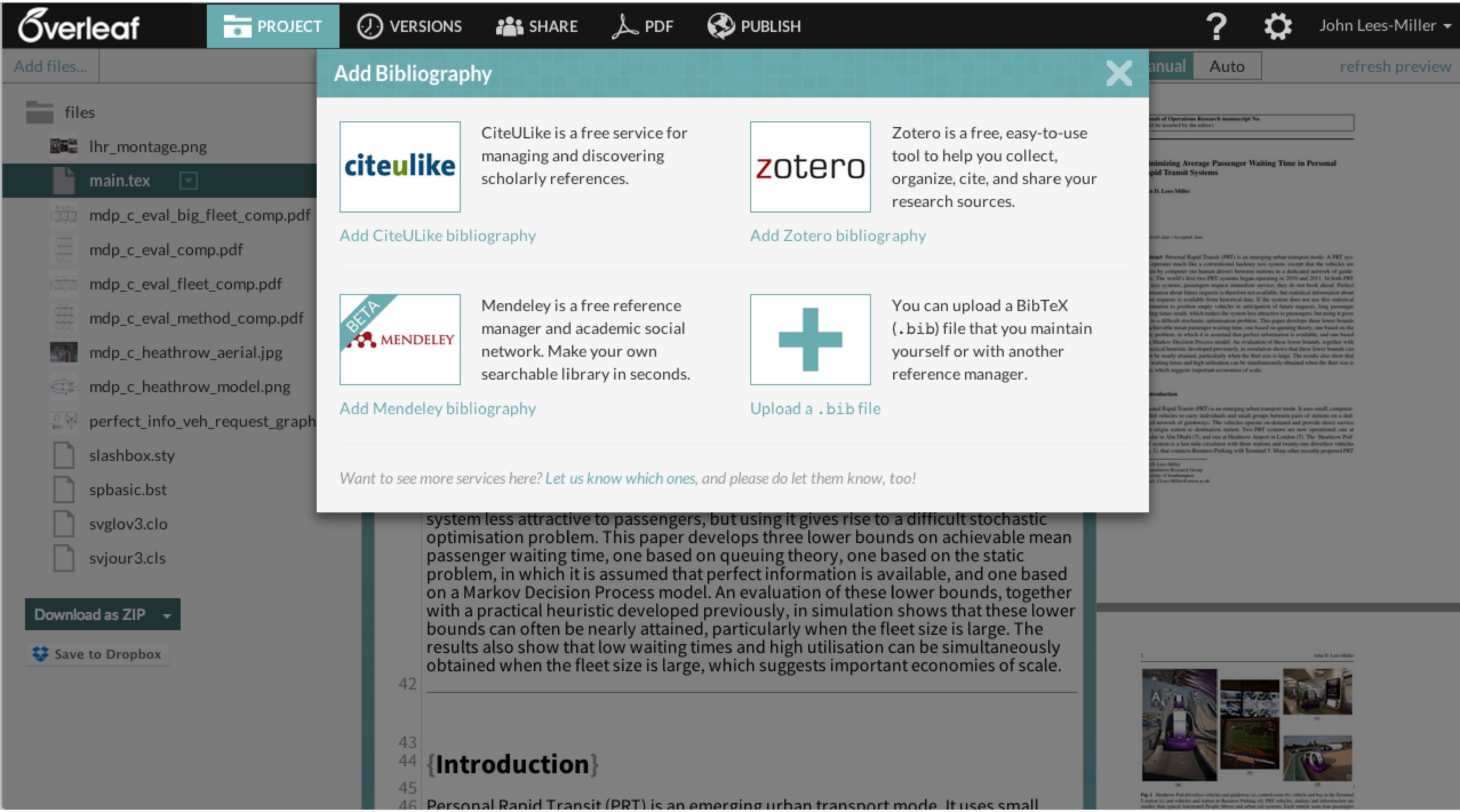

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system less attractive to passengers, but using it gives rise to a difficult stochastic optimisation problem. This paper develops three lower bounds on achievable mean passenger waiting time, one based on queuing theory, one based on the static problem, in which it is assumed that perfect information is available, and one based on a Markov Decision Process model. An evaluation of these lower bounds, together with a practical heuristic developed previously, in simulation shows that these lower bounds can often be nearly attained, particularly when the fleet size is large. The results also show that low waiting times and high utilisation can be simultaneously obtained when the fleet size is large, which suggests important economies of scale.
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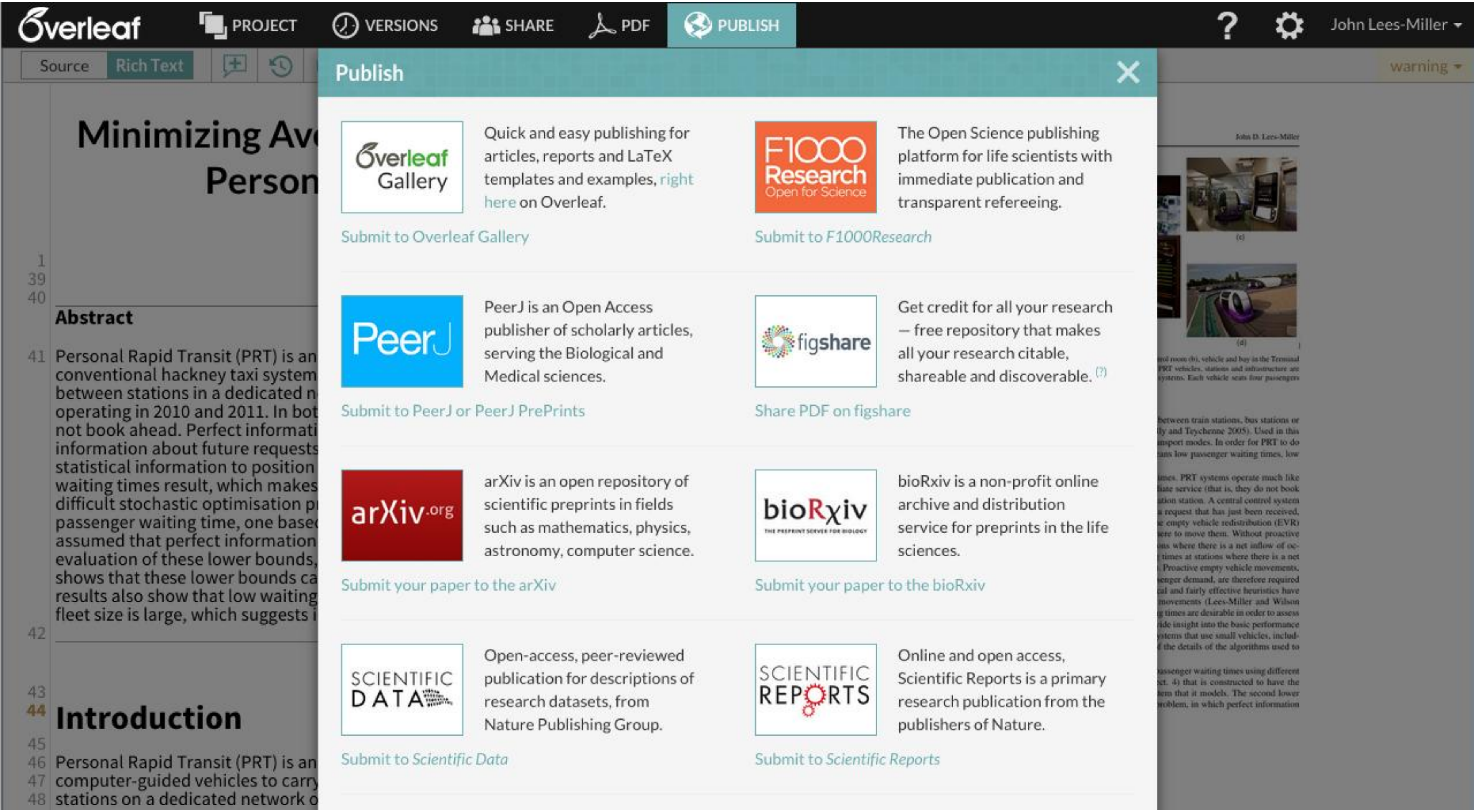
46 Personal Rapid Transit (PRT) is an emerging urban transport mode. It uses small



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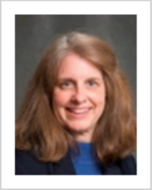

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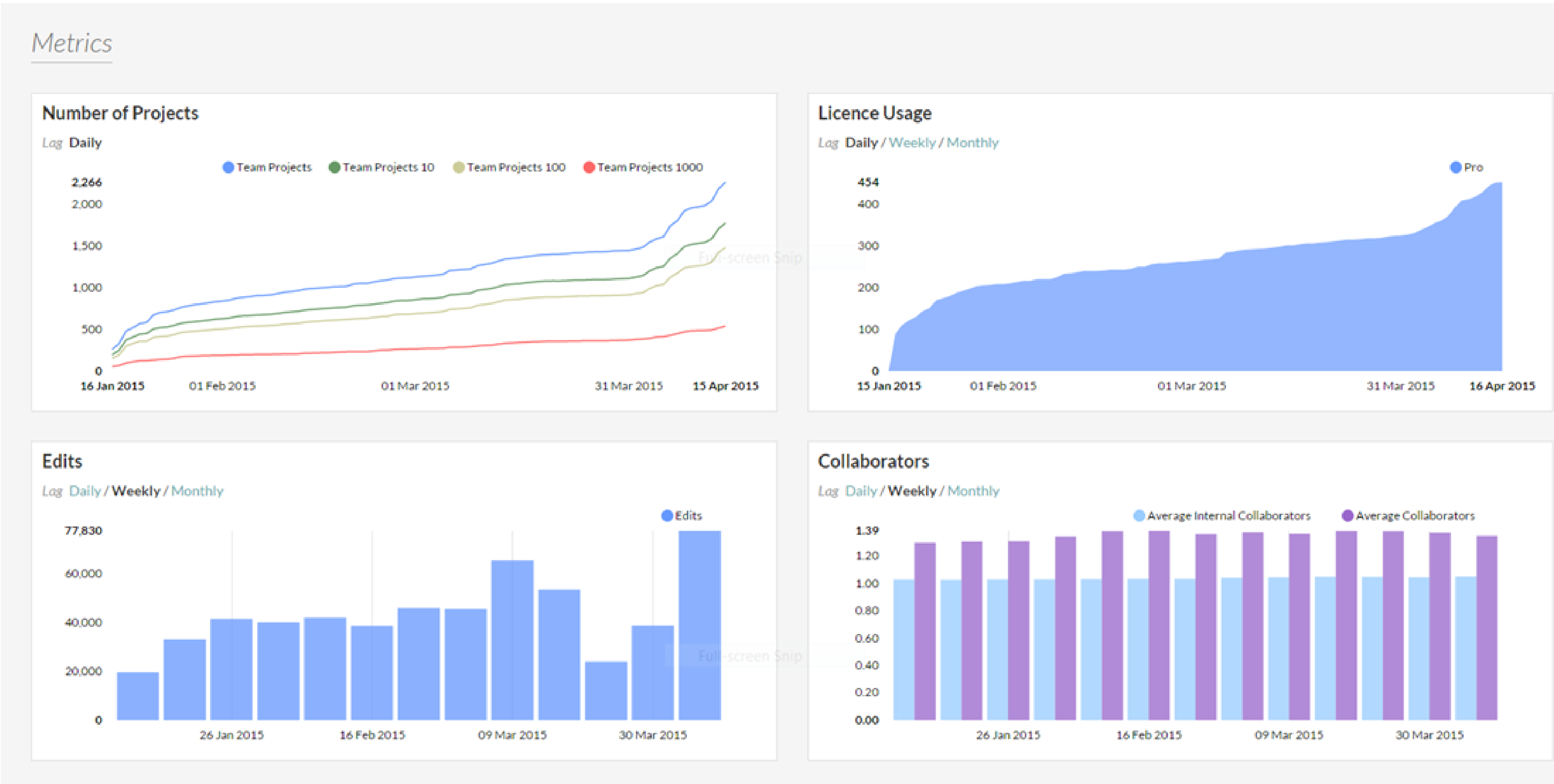

Thanks!

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